Hydrogeology and Water Quality of the Clinton Street-Ballpark Aquifer near Johnson City, New York

By William F. Coon, Richard M. Yager, Jan M. Surface,
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CONVERSION FACTORS, ABBREVIATED WATER-QUALITY UNITS, AND VERTICAL DATUM

Multiply	By	To Obtain
	Length	
inch (in.)	2.54	centimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
	Area	
square foot (ft^2)	0.09290	square meter
square mile (mi^2)	2.590	square kilometer
acre	0.40483	hectare
	Volume	
cubic feet (ft^3)	0.02832	cubic meter
	Flow	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
million gallons per day (Mgal/d)	3.785	cubic meters per day
gallons per minute (gal/min)	0.06309	liter per second
gallons per second (gal/s)	0.001052	liter per second
	Hydraulic Conductivity	
foot per day (ft/d)	0.3048	meter per day
	**Transmissivity*	
foot squared per day (ft^2/d)	0.09290	meter squared per day

***Transmissivity:** The standard unit for transmissivity is cubic foot per day per square foot times foot of aquifer thickness [$(ft^3/d)/ft^2$]ft. In this report, the mathematically reduced form, foot squared per day (ft^2/d), is used for convenience.

Concentrations of chemical constituents in water are given either in:
milligrams per liter (mg/L) ≈ micrograms per gram (µg/g) = parts per million (ppm); or
micrograms per liter (µg/L) ≈ micrograms per kilogram (µg/kg) = parts per billion (ppb)

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25°C).

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

Altitude, as used in this report, refers to distance above or below sea level.

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Abstract

The Clinton Street-Ballpark aquifer, in the Susquehanna River valley in southern Broome County, N.Y., supplies drinking water to the Village of Johnson City near Binghamton. The hydrogeology and water quality of the aquifer were studied in 1994-95 to identify the source area of 1,1,1-trichloroethane, which was detected at the Johnson City Camden Street wellfield in 1991.

The aquifer is generally 100 to 150 ft thick and consists primarily of ice-contact deposits of silty sand and gravel that are overlain by outwash deposits of sand and gravel. These two types of deposits are separated by lacustrine silt and clay of variable thickness into an upper and a lower layer of the aquifer. The coarse deposits form a single aquifer in areas where the lacustrine deposits are absent.

Synoptic water-level surveys indicated that ground water moves from upgradient areas flanking the aquifer boundaries toward two major pumping centers—the Anitec wellfield in Binghamton and the Camden Street wellfield in Johnson City. Areas contributing recharge to municipal and industrial wells in the aquifer were delineated by a previously developed ground-water-flow model. The residence time of ground water within the area contributing recharge to Johnson City well no. 2 in the Camden Street wellfield was estimated to be less than 6 years.

1,1,1-Trichloroethane, trichloroethene, and their metabolites were detected in ground water at several locations in and near Johnson City. Relatively high concentrations of 1,1,1-trichloroethane were found in ground water about 3,000 ft north of the Camden Street wellfield. The suspected source is an area bordered on the south by Field Street, on the north by Harry L. Drive, on the east by New York State Route 201, and on the west by Marie Street. A trichloroethene metabolite, *cis*-1,2-dichloroethene, appears to be migrating westward from U.S. Air Force Plant 59 toward the Camden Street well-field, 1,000 ft southwest of the plant, although this compound has not been detected in water pumped by municipal wells, possibly because it has become diluted by ground water from other locations within the contributing area to the wells.

INTRODUCTION

The Village of Johnson City near Binghamton, N.Y., obtains most of its drinking water from the Clinton Street-Ballpark aquifer, an unconsolidated glacial aquifer that underlies 3 mi^2 of a highly urbanized part of the Susquehanna River valley that extends 3 mi from the western part of Binghamton to Johnson

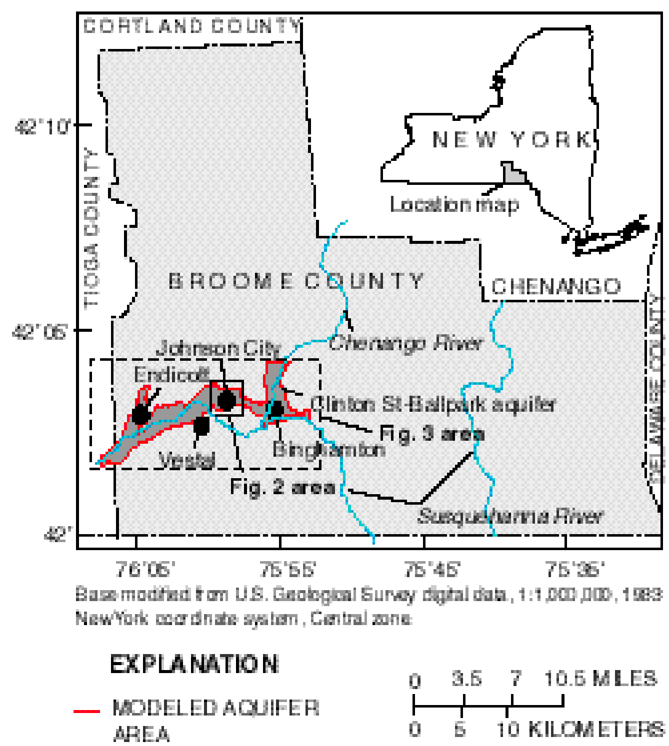


Figure 1. Location of Clinton Street-Ballpark aquifer and of study area, Broome County, N.Y.

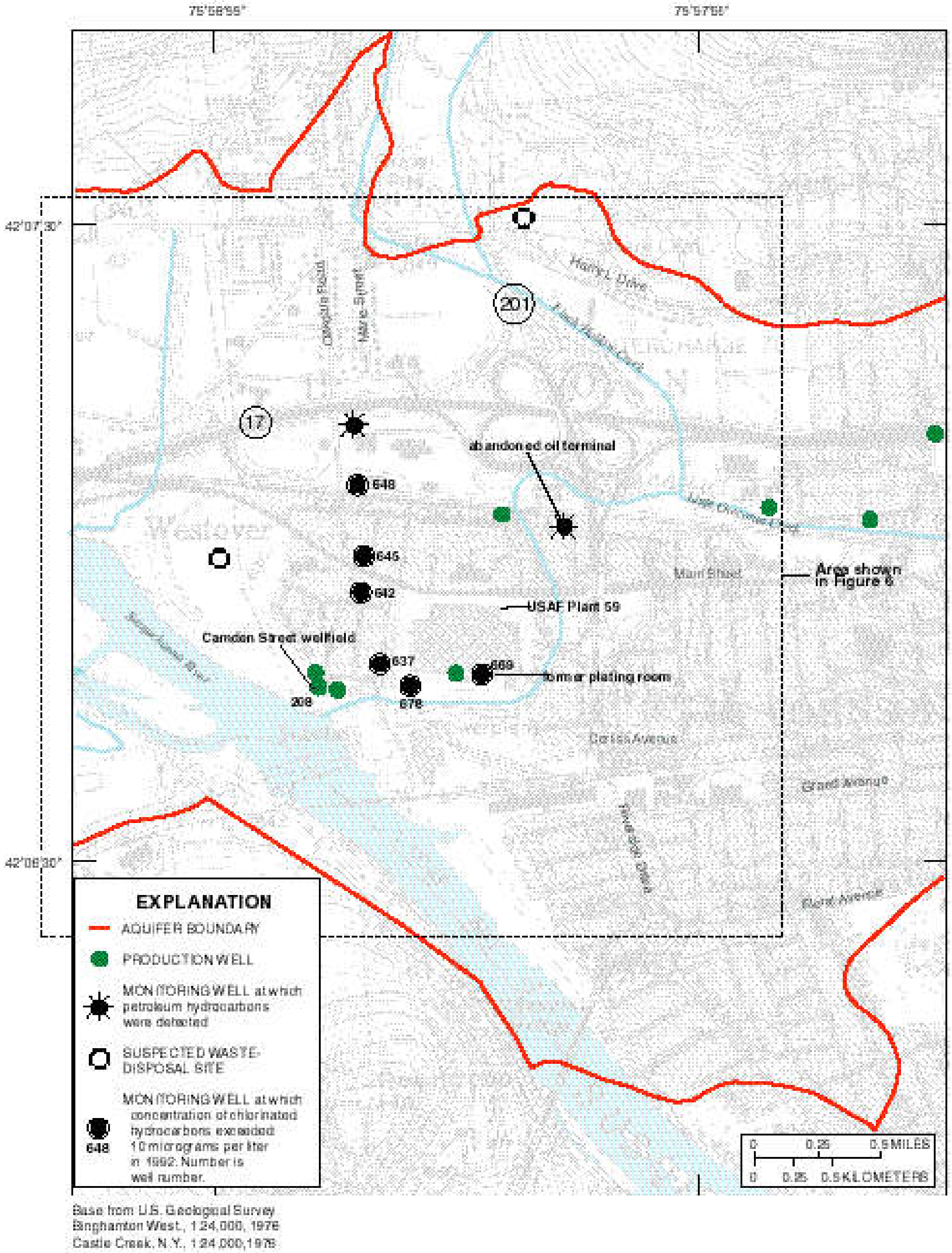


Figure 2. Locations of potential sources of contamination by organic compounds in Johnson City, N.Y.

City (fig. 1). In 1991, a chlorinated hydrocarbon, 1,1,1-trichloroethane (1,1,1-TCA), was detected in well no. 2 in Johnson City's Camden Street wellfield (fig. 2) at concentrations that exceeded the New York State drinking-water standard of 5 μg/L (Ronald Brink, Broome County Health Department, written commun., 1994). Several potential sources of contaminants that threaten the wellfield have been identified by the New York State Department of Environmental Conservation (NYSDEC), among them the U.S. Air Force (USAF) Plant 59, which is 1,000 ft northeast of the wellfield (fig. 2). A supplemental site inspection (Nashold and others, 1994) conducted in 1991-92 under the Air Force Installation Restoration Program (IRP) at USAF Plant 59 detected chlorinated hydrocarbons, including 1,1,1-TCA and trichloroethene (TCE,) in ground water beneath the plant; these contaminants and their metabolites also have been detected in water pumped from the plant's production well since 1986 (Fred C. Hart Associates, 1988). In 1992, the USAF signed a memorandum of understanding with the Village of Johnson City and agreed to provide partial financial support for the installation and operation of an air stripper to treat water pumped from the Camden Street wellfield (George Walters, U.S. Air Force, written commun., 1994).

Subsequent investigations conducted by the NYSDEC under the State Superfund program revealed an area in which concentrations of 1,1,1-TCA increase northward as much as 2,000 ft upgradient from the Camden Street wellfield (URS Consultants, Inc., 1992, 1993). Several suspected contaminant sources were identified, but none were confirmed as the source of 1,1,1-TCA that was contaminating the Camden Street wellfield. These investigations also concluded that USAF Plant 59 probably was not the source of 1,1,1-TCA in the Camden Street wellfield, although the detection of a TCE metabolite, *cis*-1,2-dichloroethene (*cis*-1,2-DCE), in an area between Plant 59 and the wellfield suggested that chlorinated hydrocarbons could be migrating from the plant toward the wellfield. An additional study was begun by the USAF and conducted by Earth Tech in 1994 to define the extent of contamination at Plant 59 and evaluate the risk of contamination to public health (Earth Tech, 1995b). In 1994, the U.S. Geological Survey (USGS), in cooperation with the U.S. Air Force, began a 2-year hydrogeologic study of the Clinton Street-Ballpark aquifer in and near Johnson City to expand the base of knowledge of the aquifer's geologic setting and to locate the probable source of 1,1,1-TCA contamination at the Camden Street wellfield.

Purpose and Scope

This report presents the results of the USGS study. It (1) describes the glacial history and geologic setting of the Clinton Street-Ballpark aquifer; (2) depicts the directions of ground-water flow; (3) delineates the areas that contribute recharge to municipal and industrial wells as defined by a previously developed ground-water-flow model; and (4) depicts the areal distribution of 1,1,1-TCA and TCE and their metabolites in the western part of the Clinton Street-Ballpark aquifer near Johnson City. Tables of ground-water levels, well logs, and ground-water chemical analyses compiled during this study are given in the appendixes.

Study Area

The Clinton Street-Ballpark aquifer, named by Randall (1977), is part of an extensive glacial aquifer system within the Susquehanna River valley in south-central New York. The aquifer is bounded on the north by the bedrock valley wall and on the south by a ridge of till and bedrock that separates the aquifer from the Susquehanna River. Its eastern border is the Chenango River (just north of its confluence with the Susquehanna River), and its western border is the Susquehanna River (fig. 3). The aquifer consists of unconfined deposits of outwash sand and gravel that are underlain by locally confined deposits of ice-contact sand and gravel. A confining layer of fine-grained lacustrine sediment separates the two units in some areas.

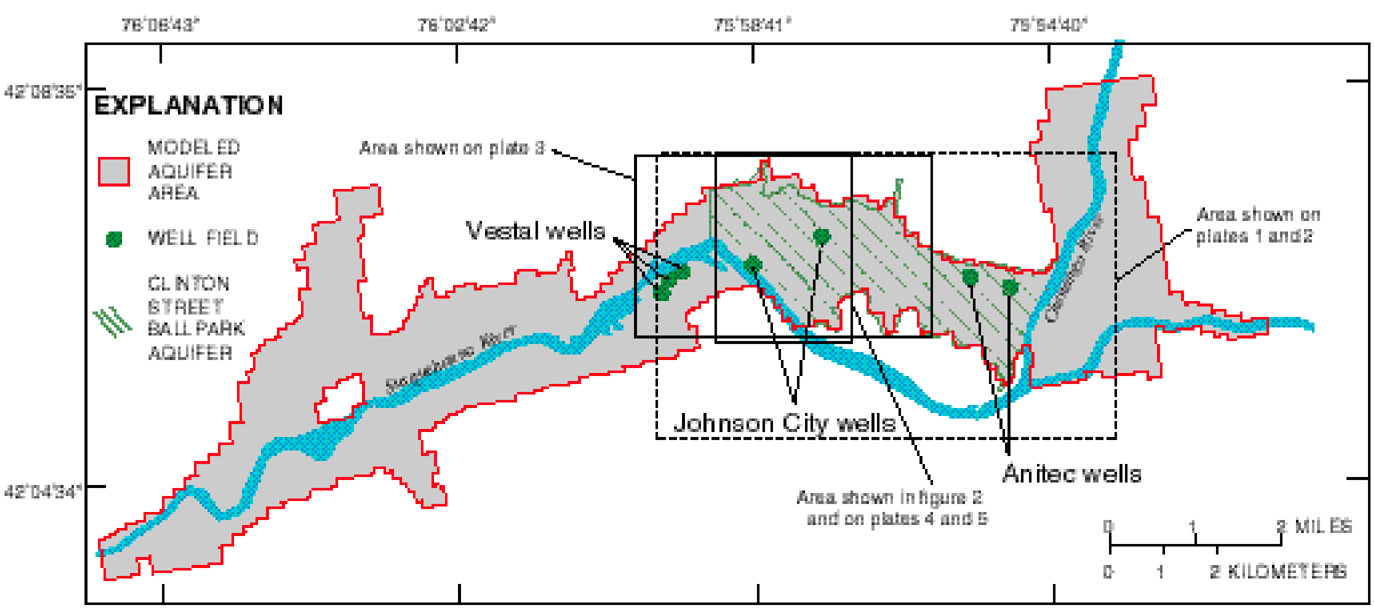
Johnson City contains several industrial facilities, among them USAF Plant 59, which is a government-owned facility that has been operated by several private contractors since its construction in the early 1940's (fig. 2). Aircraft-control systems have been manufactured at the plant throughout most of its operating life, and a variety of waste products, including cutting and lubricating oils, metal-plating acids, and degreasing solvents, were generated there.

The NYSDEC and the Broome County Health Department (BCHD) have identified several potential sources of organic contaminants in Johnson City, such as leaking underground storage tanks at four sites (pl. 3; two sites shown in fig. 2) and two suspected waste-disposal sites (fig. 2) (Gary Peterson, New York State Department of Environmental Conservation, written commun., 1995; Ronald Brink, written commun., 1994). The leaking storage tanks contained petroleum compounds that contaminated the ground water locally with “BTEX” compounds (benzene, ethylbenzene, toluene, and xylenes) and other aromatic hydrocarbons. Three of the four storage-tank sites have been remediated; the fourth is an abandoned oil terminal near the intersection of New York State Routes 17 and 201 (pl. 3; fig. 2) and has not been remediated. The identity of contaminants that may be present at the two suspected waste-disposal sites is unknown.

Previous Studies

The hydrogeology of the Clinton Street-Ballpark aquifer has been described in three previous reports. Randall (1977) described the hydrogeologic characteristics and water quality of the aquifer, and Randall and Coates (1973) and Randall (1978) detailed the glacial history and geologic setting. Randall (1986) developed a flow model of the ground-water system in the Susquehanna River valley near Binghamton. S.W. Wolcott (U.S. Geological Survey, written commun., 1994) used a modified version of Randall’s model to delineate the areas contributing recharge to municipal and industrial wells.

Studies have also been conducted in the vicinity of the Camden Street wellfield (fig. 2) (URS Consultants, Inc., 1992, 1993) and USAF Plant 59 (Nashold and others, 1994) to identify sources of chlorinated hydrocarbons detected in municipal and industrial wells. Monitoring wells were installed at 10 locations in the vicinity of the Camden Street wellfield by URS Consultants, Inc. (1992, 1993) in studies conducted in 1991 and 1992 for the NYSDEC. In December 1992, water samples from the wells were analyzed for volatile organic compounds, metals, and cyanide; concentrations of 1,1-DCA, *cis*-1,2-DCE, 1,1,1-TCA, and TCE are listed in table 1. Direct-push water samples were collected at eight additional locations and analyzed for volatile organic contaminants with a field gas chromatograph. Concentrations of 1,1,1-TCA ranging from 2.4 to 28 µg/L were detected in several wells north of the Camden Street wellfield, and *cis*-1,2-DCE was detected at 49 µg/L near the Camden Street wellfield in well 637 (table 1 and fig. 2). At that time, the only chlorinated hydrocarbon detected in water pumped from Johnson City well no. 2 (well 208) was 1,1,1-TCA, at a concentration of 2 µg/L (Ronald Brink, written commun., 1994).



Base modified from U.S. Geological Survey digital data, 1:100,000, 1983
New York coordinate system, Central zone

Figure 3. Locations of municipal and industrial well fields that tap Clinton Street-Ballpark aquifer in Johnson City study area, Broome County, N.Y. (Location is shown in fig. 1.)

Table 1. Chlorinated hydrocarbons detected in ground water near the Camden Street wellfield in Johnson City, N.Y., December 1992

[Data from URS Consultants, Inc. (1992). Locations shown on pl. 1. Concentrations in micrograms per liter. DCA, dichloroethane; DCE, dichloroethene; TCA, trichloroethane; TCE, trichloroethene; ---, compound not detected; <, less than.]

USGS county well number	Local well identifier[a]	Constituent			
		1,1-DCA	*cis*-1,2-DCE	1,1,1-TCA	TCE
636	URS-1S	---	---	---	---
635	URS-1D	---	---	---	---
638	URS-2S	---	1.3	2.4	3.1
637	URS-2D	---	49	---	---
639	URS-3D	<1	1.9	6.2	2
641	URS-4S	---	---	---	---
640	URS-4D	---	---	---	---
643	URS-5S	<1	---	4.3	<1
642	URS-5D	<1	---	10	1
644	URS-6D	---	---	---	---
645	URS-7S	<1	---	13	2.1
646	URS-8I[b]	<1	---	2.6	1.7
647	URS-9S	<1	---	6.2	<1
648	URS-10S	2.0	---	28	<1

[a] Suffixes, S, D, and I denote shallow, deep, and intermediate well depth, respectively.

[b] Screened in layer between upper and lower aquifer.

Table 2. Chlorinated hydrocarbons detected in ground water from production well at U.S. Air Force Plant 59, Johnson City, N.Y., 1986 and 1992

[Well location is shown on pl. 1. Concentrations in micrograms per liter; <, less than.]

Constituent	September 1986[a]	February 1992[b]
1,1,1-Trichloroethane (TCA)	9	3
1,1-Dichloroethane (DCA)	16	3
Trichloroethene (TCE)	11	7
1,1-Dichloroethene (DCE)	< 1	< 1
1,2-Dichloroethene (*cis* plus *trans*)	66	< 1

[a] Data from Fred C. Hart Associates (1988).

[b] Data from Nashold and others (1994).

Chlorinated hydrocarbons also were detected in water pumped from the production well at USAF Plant 59 in 1986 (table 2), and a 1991-93 study by Argonne National Laboratory for the USAF identified potential sources of ground-water contamination at the plant (Nashold and others, 1994). The USAF Plant 59 site occupies about 30 acres and consists of a single manufacturing building with several small storage facilities. Soil borings from 6 locations and water samples from 16 monitoring wells were analyzed for volatile organic compounds and metals in February 1992. TCE was detected at a concentration of 97 μg/L in ground water underlying a former plating room on the south side of the building (location shown in fig. 2) and at a concentration of 7 μg/L in water from the plant's production well (table 2). Concentrations of 1,1,1-TCA ranging from 10 to 15 μg/L were detected in ground water beneath the southwestern corner of the plant.

Acknowledgments

The cooperation and assistance of several governmental agencies and private companies in locating wells and granting permission to measure water levels and collect water samples for chemical analyses are acknowledged and appreciated. Thanks are extended to the following agencies and private companies: Johnson City Departments of Water and Planning, New York State Departments of Environmental Conservation and Transportation, Town of Union Engineering Department, Town of Vestal Water Department, Broome County Department of Health, New York State Electric and Gas, Anitec (Imaging Products Division of International Paper Company), Earth Tech (consultants, Alexandria, VA), International Business Machines (IBM) Corp., E.H. Titchener and Company, Buckeye Pipeline Company, United Refining Company of Pennsylvania (Kwik-Fill), Sun Oil Company, Barney and Dickenson Inc., Huntingdon Empire (consultants), Wilson Memorial Regional Medical Center, Calvary Cemetery, and Underground Location Center.

METHODS OF INVESTIGATION

An inventory of wells was conducted to identify potential sites for water-level measurements and water sampling. Two synoptic water-level surveys were conducted to obtain data needed to produce a map showing water-table contours and directions of ground-water flow. Eight observation wells were drilled, and the stratigraphy at each was logged. Continuous water-level records were collected for 1 year at four observation wells and at one site on the Susquehanna River and were used (1) to depict water-level variations at selected depths in the aquifer, and (2) to define the relation between ground water and the river. A ground-water-flow model was used to delineate the area contributing recharge to the Camden Street wellfield to limit the search for the source(s) of 1,1,1-TCA detected previously at Johnson City well no. 2 (well 208). Water samples collected from monitoring wells and direct-push tubes were analyzed for major inorganic constituents or volatile organic compounds, or both.

Well Inventory, and Water-level and Stream Discharge Measurements

Of the 151 wells found within the area overlying the Clinton Street-Ballpark aquifer (appendix 1, pl. 1), 49 were identified from the USGS Ground-water Site Inventory (GWSI) database and from data tabulated by Randall (1972, 1977); these included 21 municipal and industrial production wells and 28 observation wells, many of which were previously installed by the USGS. The remaining 102 wells, most of which were drilled within the past 15 years, were found through the records of, or assistance provided by, the NYSDEC in Kirkwood, N.Y., the Johnson City Departments of Water and Planning, New York State Electric and Gas, Anitec (Imaging Products Division of International Paper Company), Town of Vestal Water Department, or from published reports of local environmental studies (URS Consultants, 1992; Nashold and others, 1994; Earth Tech, 1995a). The wells referred to in this report were assigned unique Broome County identifier numbers based on the USGS GWSI well-numbering system. Descriptive information concerning the wells, such as depth, hole diameter, measuring point, and measuring-point description, is given in appendix 1; locations of wells and of stream-surface-elevation and discharge-measurement sites used in this study are shown on plate 1.

Synoptic Water-level and Discharge Measurements

The USGS conducted synoptic ground-water level surveys on August 23, 1994 and May 2, 1995. Ground-water levels were measured at all observation wells used in this study, with either a chalked steel tape or an electric water-level sensor. Surface-water elevations were recorded at nine points along or near the Chenango and Susquehanna Rivers (pl. 1) by measuring down to the water surface from points of known elevations on bridges or from temporary reference marks established along the river’s edge. All water levels were referenced to sea level.

Stream discharge was measured or estimated at 11 locations on streams in the area underlain by the aquifer; these discharge data were used as a basis for estimating seepage losses to the aquifer or ground-water discharge from the aquifer. (Locations are shown on pl 1.) All discharges were measured by standard USGS techniques (Buchanan and Somers, 1969). Discharges less than about 0.10 ft^3/s and in channels in which the flow could be confined to a narrow path were measured by a volumetric method in which the flow was collected in a container for a specified length of time. Discharges up to about 2 ft^3/s and in narrow channels with high banks that would allow ponding behind a weir plate were measured by a flow-over-weir method. A current meter was used for other flow and channel conditions; in this method, discharge was computed as the sum of the products of stream-flow velocities and their respective flow areas in discrete segments across a stream cross section.

Continuous Water-level Measurements

The USGS has recorded water levels continuously since 1947 at observation well 121. This 53-ft deep well is 1,100 ft north of the Johnson City Camden Street wellfield, near the intersection of Main and Camden Streets in Westover. The USGS also maintains a stage-recording station on the Susquehanna River at Vestal, about 4.5 mi downstream from Johnson City. Ground-water levels also were recorded continuously during 1994-95 at a cluster of three wells in the southwestern corner of the USAF Plant 59 property, about 850 ft east of the Camden Street wellfield. Water levels in these wells were measured with strain-gage pressure transducers attached to electronic data loggers.

Well Drilling and Installation

Eight monitoring wells were installed in April 1995 to provide additional information on the stratigraphy of the aquifer and water-level-measurement points in areas sparsely represented by existing wells. A pair of wells was installed at two locations; at each site, one well was screened above, and the other below, the confining layer of silt and clay. The wells were drilled with an auger rig and 4.25-in.-ID (inside-diameter) hollow-stem augers. Soil samples were collected at 5-ft intervals with a 2-in.-diameter, 2-ft-long, split-barrel sampler. A photoionization vapor analyzer was used to detect volatile organic compounds (VOC's) in the split-barrel samples. If VOC's had been detected, drilling would have been discontinued and the hole sealed with bentonite pellets. No VOC concentrations above the instrument's sensitivity of 9 mg/L (in air) were detected at any of the drilling sites.

When augering was completed to the desired depth, the screen and casing were installed through the center of the hollow-stem auger. The screens consisted of 2-in.-ID PVC (polyvinyl chloride) with a slot size of 0.01 in. and were typically 10 ft long. Two-in.-ID, PVC flush-joint casings were installed from the top of the screen to land surface. As the augers were extracted from the borehole, the natural formation was allowed to collapse around the screen. Then, as the augers were further extracted above the screen, bentonite pellets were added to the annular space to form a 2- to 5-ft-thick seal above the screened part of the well and at depths where fine-grained sediments were penetrated during drilling. The annular space from above the seal to 3 ft below land surface was filled with cuttings from drilling, and the annular space from 3 to 1 ft below land surface was filled with bentonite pellets to prevent surface runoff from readily flowing down along the side of the casing. Cuttings were used to fill the remaining 1 ft of annular space. Wells were completed flush with land surface and protected by either locking caps or flush-mount covers. Where possible, the land surface was graded away from the well to reduce surface-water seepage.

Ground-Water-Flow Model

A ground-water-flow model, originally developed by Randall (1986), was modified and used to delineate the areas that contribute recharge to municipal and industrial wells screened in the Clinton Street-Ballpark aquifer. The model developed by Randall used a computer program written by Trescott and Larson (1976) and represents a 14-mi reach of the Susquehanna River valley that includes Binghamton, Johnson City, Endicott, and Vestal (fig. 1). The model was converted by S.W. Wolcott (written commun., 1994), using a routine developed by Prudic (1989), for use with the computer program MODFLOW (McDonald and Harbaugh, 1988) to represent recharge from tributary streams that cross the valley floor. A recently available subroutine of the MODFLOW program that allows model cells to become resaturated after going dry was also added to the model (McDonald and others, 1992). These changes and other minor adjustments based on newly acquired geologic information necessitated recalibration of the model, but the resulting directions and rates of ground-water flow remained virtually the same as in the original model.

S.W. Wolcott (written commun., 1994) used the particle-tracking routine MODPATH (Pollock, 1989) to compute ground-water flowpaths from hydraulic heads and flow rates computed by the modified flow model; the modified model also was used in this study to delineate areas that contribute recharge to the municipal wells in Johnson City, as well as to the Anitec and Vestal wellfields (fig. 3).

Ground-Water Sampling

The USGS collected water samples from monitoring wells and through direct-push tubes in August and November of 1994 and May 1995. All samples were analyzed for 1,1,1-TCA, TCE, and other VOC's; the samples from wells also were analyzed for major inorganic constituents.

Monitoring Wells

Water samples were collected in August 1994 from 27 monitoring wells within the Camden Street wellfield's ground-water-contributing area that was delineated by the ground-water flow model; a water sample from the Johnson City production well no. 2 at Camden Street also was collected. All samples were analyzed for VOC's, metals, and other inorganic constituents. Information on wells sampled is given in appendix 1; well locations are shown on plate 1.

Sample Collection

The procedures for collecting water samples depended on the casing diameter and use of the well. Most wells had a 2- to 4-in.-diameter casing and were screened just below the water table. These were evacuated with a 1.75-in.-OD (outside diameter) submersible pump equipped with 0.5-in.-ID Teflon tubing. Three wells that had 6-in.-diameter casings and were screened many feet below the water table were also evacuated with this pump, but 1-in.-ID flush-threaded PVC pipe was used as a discharge line to allow greater discharge rates than permitted by the 0.5-in. tubing. Johnson City production well no. 2 was sampled at a small-diameter valve near the well head during pumping.

The pump is constructed of stainless steel and Teflon and delivers water through a positive-displacement impeller system that provides electrically controlled flow rates. The pump intake was positioned just above the well screen, and at least three casing volumes were evacuated (about 1 hour of pumping at most wells) before sampling. The following field data were recorded: depth to water, well depth, pump-intake depth, pumping rate, and drawdown. Specific conductance, pH, temperature, and dissolved oxygen concentration were measured periodically during evacuation and were allowed to stabilize, and drawdown was allowed to reach equilibrium, before sample collection.

Samples collected for inorganic-ion and trace-element analyses were filtered in the field through 0.45-μm cellulose filters attached directly in-line with the discharge tubing at land surface. Samples for total alkalinity and nutrient analysis (which were not filtered) also were taken at the surface-discharge point. All samples were immediately chilled to 4˚C and shipped daily to the Quanterra Environmental Services laboratory (which was contracted by the USAF under the Installation Restoration Program) in Denver, Colo. through chain-of-custody procedures (U.S. Air Force, 1993).

After well evacuation and sampling procedures for inorganic-constituent analysis had been completed and the pump had been removed from the well, a 3-ft long, 1.5-in. Teflon bottom-emptying bailer was used to collect samples for VOC analyses. At least three bailer volumes of water were removed as a rinse; then, a final bailer volume was collected, and a bottom-emptying Teflon spigot was used to fill four 40-mL amber septum vials with a minimum of air entrainment. The samples were immediately chilled to 4˚C and shipped daily to the Denver laboratory.

All sampling equipment was cleaned with a Liquinox detergent solution with deionized (DI) water before sample collection. DI water was used for the main rinsing, and Type II reagent-grade hexane was used for a final rinse. Equipment was then air dried. After cleaning, reagent-grade organic-free water was periodically used to collect equipment blanks from the bailer. Reagent-grade inorganic-free water was used to collect equipment blanks from the pump and tubing.

Ten percent of field samples were submitted as duplicates for analysis for all constituents. Trip blanks were included with sample shipments to the laboratory (for VOC analysis only). Ten percent of the samples included additional water for a matrix-spike analysis in the laboratory. The sampling and quality-assurance procedures were done according to U.S. Air Force (1993) guidelines.

Three additional monitoring wells were bailed and sampled in May 1995 for VOC analysis at an onsite laboratory operated by Target Environmental Services. These wells (nos. 696, 698, and 699; see appendix 1 and pl. 1) were screened near the water table. Water in Finch Hollow Creek (pl. 1) was also sampled at four locations near these wells during base-flow conditions to provide an indication of the chemical quality of ground-water discharge near the northern edge of the aquifer, about 1,400 ft upgradient of the highest detected concentrations of 1,1,1-TCA. None of these (three ground-water and four base-flow samples) contained detectable quantities of any VOC.

Sample Analysis

The analytical procedures used for analysis of ground-water samples at the Quanterra Environmental Services laboratory met the U.S. Air Force (1993) guidelines, and all quality controls were within established limits. The following U.S. Environmental Protection Agency (USEPA) methods were used: method 524 for priority pollutant volatile-organic-compound analysis through gas chromatography; method 6010 for inorganic cations and trace elements through inductively coupled plasma (ICP) techniques; method 300.0 for inorganic anions through ion chromatography; and method 310.0 for alkalinity titration.

Direct-Push Sampling

On November 5-8, 1994 and May 16-19, 1995, Target Environmental Services (1994, 1995), under the direction of USGS personnel, installed direct-push tubes in the vicinity of Johnson City, collected ground-water samples, and analyzed the samples for VOC's. Sampling locations, shown on plates 4 and 5, were selected on the basis of information obtained from NYSDEC, results of previous sampling done by URS Consultants, Inc. (1993), and proximity to suspected sources of organic contaminants (fig. 2). The first 48 ground-water samples were collected November 5-8, 1994, and another 31 were collected during May 16-19, 1995.

Sample Collection

In November 1994, a hydraulic probe was used to push 1-in.-OD steel casing below the water table at 48 locations. The steel casing was removed, and 3/4-in.-diameter slotted PVC pipe connected to one or more 5-ft sections of PVC riser pipe was inserted and pushed to the open depth of the hole to obtain a water sample from the water table or just below it. Water levels inside the PVC pipes were allowed to stabilize, then a 21-in.-long, 7/16-in.-diameter stainless steel bailer was lowered into the push-tube hole to obtain a sample. If the hole collapsed above the desired sampling depth before the PVC pipe was inserted, either the hole was re-pushed, or a new hole was made. At a few troublesome sites, an expendable tip preceded the hydraulic probe, which, at the proper depth, was raised several inches to open the bottom of the casing to the water table. The sample was then bailed directly from within the steel casing. Samples were placed in 40-mL glass vials, acidified to pH 2 with a 50-percent HCl solution, sealed, labeled, and transferred to Target's onsite mobile laboratory for analysis.

In May 1995, 1.5-in.-OD steel casing was hydraulically pushed below the water table. Samples were bailed with a 7/16-in.-diameter stainless steel bailer directly from within the steel casing after the casing was raised several inches, or the steel casing was pulled back 2 ft, and a 2-ft section of 1/2-in.-ID slotted CPVC pipe with an O-ring was pushed out the bottom of the casing with steel push rods. The sample was then bailed from within the bottom section of casing and treated as in the November 1994 sampling.

Prior to each day's field activities and after collection of each sample, the steel casing, the bailer, and the push rods were decontaminated by washing with a solution of Liquinox and distilled water, rinsing with distilled water, and drying with clean paper towels. PVC casing was used once, then either decontaminated (solid PVC) or discarded (slotted PVC).

Sample Analysis

All ground-water samples were prepared for analysis according to USEPA Method 3810 (modified) by pouring 15 mL of sample into a clean vial and sealing with a Teflon-faced butyl rubber septum. The vial was heated for 10 min at 90˚C to volatilize hydrocarbons from the water. The gas headspace of the prepared sample was then analyzed.

One analysis was conducted on all samples according to USEPA method 8020 (modified) on a gas chromatograph equipped with a flame-ionization detector (GC/FID) and direct injection. Analytes used for standardization were vinyl chloride, acetone, benzene, toluene, ethylbenzene, and *ortho*-, *meta*-, and *para*-xylenes.

Total volatile concentrations were calculated as the sum of the areas of all integrated chromatogram peaks, from the instrument response factor for toluene. Methane concentration was excluded from the calculation of total volatile concentration because interference from biogenic methane presented analytical difficulties.

A second analysis was conducted on all samples according to USEPA Method 8010 (modified) on a gas chromatograph equipped with an electron-capture detector (GC/ECD) and direct injection. Specific analytes standardized for this analysis included:

- 1,1-dichloroethene (1,1-DCE) (November 1994 sampling only),
- methylene chloride (CH_2Cl_2),
- *trans*-1,2-dichloroethene (*trans*-1,2-DCE),
- 1,1-dichloroethane (1,1-DCA),
- *cis*-1,2-dichloroethene (*cis*-1,2-DCE),
- chloroform ($CHCl_3$),
- 1,1,1-trichloroethane (1,1,1-TCA),
- carbon tetrachloride (CCl_4),
- trichloroethene (TCE),
- 1,1,2-trichloroethane (1,1,2-TCA), and
- tetrachloroethene (PCE).

The analytical equipment for USEPA methods 8010 and 8020 was calibrated by a 3-point instrument-response curve and injection of known concentrations of the target analytes. Retention times of the vapor standards were used to identify the peaks in the chromatograms of the field samples, and their response factors were used to determine analyte concentrations.

Field and laboratory quality-control procedures included: (1) collection of field blanks at the end of each day’s sampling by pouring distilled water through the bailer apparatus into a 40-mL vial; (2) preparation and analysis of a duplicate head-space sample after every 10th field sample; and (3) analysis of laboratory blanks of nitrogen gas after every 10th field sample. Results from the field blanks and duplicate samples are given in reports by Target Environmental Services (1994, 1995).

HYDROGEOLOGY

The following sections describe the hydrogeology of the Clinton Street-Ballpark aquifer. A general description of the depositional environment and stratigraphy of the aquifer is included to provide a detail of the aquifer geometry. The hydrologic characteristics of the aquifer are depicted through (1) a regional water-table contour map (pl. 2); (2) discussion of ground-water withdrawals, the relation between surface water and ground water, and water-table fluctuations resulting from nearby pumping and the influence of the Susquehanna River; and (3) delineation of areas that contribute recharge to municipal and industrial wells that tap the aquifer (pl. 3).

Geologic Setting

The unconsolidated sediments that overlie bedrock in the area of concern (between Harry L. Drive and Corliss Avenue in Johnson City, see fig. 2) are generally 100 to 150 ft thick (Randall, 1977). They were deposited during and after the last deglaciation of this region in a depositional environment characterized by (1) decreasing volumes of stagnant ice, (2) declining levels of ponded water, (3) a greater proportion of rock fragments transported from remote locations than of those derived from local sources, and (4) in the later stages, the presence of organic matter.

Depositional Environment

The earliest stratified sediments were deposited when ice still occupied most of the Susquehanna River valley. Deposition took place in water-filled tunnels, channels, moulins, or crevasses beneath or within the ice and in ponds between the ice margin and the valley walls. Sediments were predominantly coarse grained because meltwater velocities were high; interbedded diamicton layers were deposited from mass movements or where dirty ice melted in place. As melting continued, large, quiet ponds developed in which fine sand, silt, and clay accumulated; these deposits were later capped by coarse deltaic outwash. Continued melting of glacial ice repeatedly allowed adjacent sediment to collapse, creating new ponds. The ponds spilled downvalley (westward) across previously deposited stratified drift, and wherever new sediment aggraded to the water surface, sediment-laden meltwater streams built a westward-sloping depositional surface. The collapse of ice-margin sediments and the erosion of the stratified drift downvalley gradually lowered the level of ponded water and caused subsequent depositional surfaces to be lower than earlier ones; this is why some stratigraphically younger units are at a lower elevation than that at which they were originally deposited and are lower than nearby older units. These processes resulted in a complex stratigraphy of truncated and downwarped units. Although many of the depositional surfaces were thus affected, and others were removed by erosion, enough remain to elucidate the depositional history (as explained in a subsequent section).

The earliest stratified deposits are termed “drab”; that is, nearly all stones and sand grains are fragments of shale and siltstone similar to the gray or olive-gray local bedrock. Later deposits generally contain progressively larger percentages of limestone, chert, quartzite, and other “exotic” types of rock that were derived from regions far to the north and transported southward along the Chenango River valley (Denny and Lyford, l963; Randall, 1978). The youngest outwash in Johnson City is termed “bright” because 30 to 50 percent of the stones are exotic, and the sand is highly calcareous with a mixture of dark shale grains and light-colored grains of quartz and other minerals. Although bright stratified drift is typically younger than drab drift, individual samples of nearly the same age may differ in percentage of exotic material because:

(1) Gravel samples from boreholes commonly include fragments broken by drilling or by driving coring devices; thus, when all fragments are identified as to lithology and counted, several broken fragments of one or two large pebbles could easily distort the percentage of exotic material in that sample.

(2) Exotic materials tend to be more abundant in layers of fine gravel than in coarse gravel.

(3) Drab gravel transported from upland tributaries or by erosion along the Susquehanna River valley upstream from Binghamton locally diluted the bright outwash transported from the Chenango River valley.

Most of the stratified drift in Johnson City was probably deposited during a period of only a few hundred years, when the margin of the ice sheet was retreating northward across Broome County at least 16,500 years ago (Cadwell, 1972). Thereafter, erosion and redeposition of sediments by the Susquehanna River altered the topography, particularly during the next several thousand years, when river flow was augmented seasonally by large volumes of meltwater. Vegetation became established shortly after deglaciation; thus fine-grained sediments that were deposited in postglacial kettle lakes, which formed where large ice blocks melted, commonly contain needles, stems, twigs, and other macroscopic fragments of organic matter, whereas earlier lake-bottom sediments that were deposited during deglaciation do not contain organic matter. Wood fragments buried in fine-grained sediments in Vestal and Binghamton were found to be from 2,649 to 12,060 years old (Martin, 1983, p. 27; Randall and Coates, 1973), indicating that deposition in kettle lakes continued throughout postglacial time.

Table 3. Stratigraphic units in the Susquehanna River valley in and near Johnson City, N.Y.

[Units are referred to in figs. 4 and 5.]

Unit no.	Name	Description
8	Fill	Includes natural materials relocated by man; also trash and ashes.
7	Flood-plain alluvium	Silt to very fine sand; may include organic-rich layers; commonly about 15 feet thick.
6	Alluvial-fan deposits	Gravel, sandy, moderately silty, noncalcareous; most stones fragments are flat pieces of shale or siltstone. Deposited where tributaries enter the Susquehanna River valley.
5	Postglacial channel alluvium	Gravel, chiefly well-rounded pebbles, sandy; bright to moderately bright, noncalcareous.
4	Postglacial lake deposits	Silt and fine to very fine sand, commonly with little clay and coarse sand; contains scattered plant fragments; may grade upward into peat or highly organic silt and contain thin layers of marl.
3C	Outwash	Sandy, pebble gravel and pebbly sand with slight to moderate amounts of silt; highly calcareous, bright. Pebbles of limestone, quartzite, and other exotic lithologic types that originated north of this region generally constitute at least 20 percent of the pebbles, but constitute at least 35 percent of the pebbles in the youngest outwash. Forms gently sloping terraces in some places; elsewhere is gently to severely downwarped.
3B1	Lake-bottom deposits	Silt and very fine sandy silt with layers and partings of reddish-gray clay.
3B2	Deltaic and lake-bottom deposits	Silt, very fine sandy silt, and fine to very fine sand, interbedded in some depth intervals with medium to coarse sand or pebbly sand.
3A	Ice-contact deposits	Sandy, pebble to cobble gravel and pebbly sand with slight to abundant silt; typically includes layers of dense silt-bound gravel and, less commonly, stony silty diamicton (till); typically forms highly irregular topography buried by younger units.
2	Till	Unsorted mixture of silt, clay, stones, and sand; tough and compact; contains rare, scattered lenses of sand and gravel. Only 1 or 2 feet thick over bedrock in many places, but several tens of feet thick in some upland localities; forms rounded hills on the floor or lower sides of the Susquehanna River valley.
1	Bedrock	Siltstone, shale.

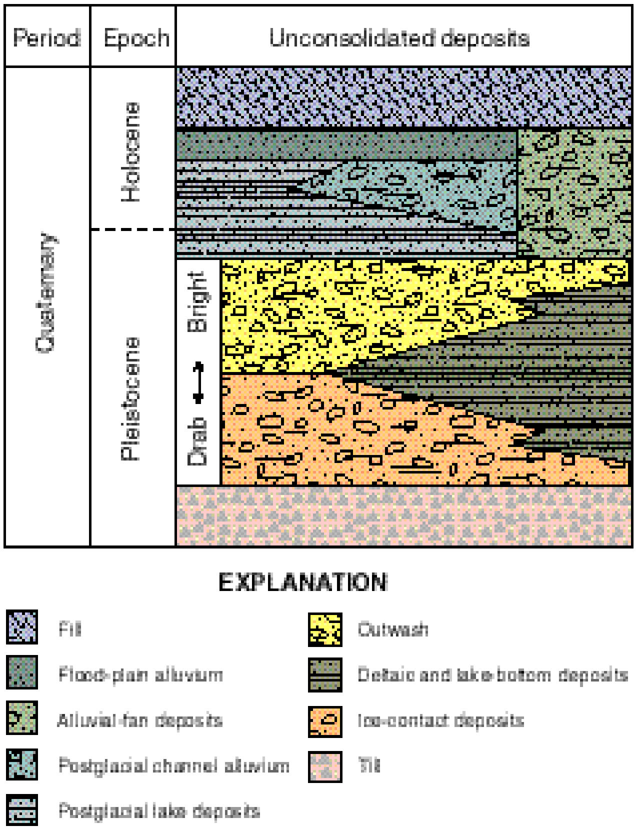


Figure 4. Relative depth and depositional environments of stratigraphic units in the Clinton Street-Ballpark aquifer, Johnson City, N.Y.

Stratigraphy

Several distinct stratigraphic units have been recognized within the unconsolidated sediments in the Susquehanna River valley through examination of exposures, borehole logs, and drilling samples collected during earlier studies (Randall, 1977, 1978, 1986) and the current study. The units are described briefly in table 3; their relative ages are diagrammed in figure 4. The two types of proglacial lake-bottom deposits (3B1, 3B2) presumably differ as a function of lake size and proximity to incoming sediment; no systematic difference in age or stratigraphic position has been recognized.

Depositional History and Aquifer Geometry

Although topography in Johnson City has been considerably altered by excavation and filling, many depositional surfaces and other natural features are identifiable on topographic maps. The following history of sediment deposition is based on interpretation of these geomorphic features, as well as on borehole and well logs. The logs of wells that were drilled by the USGS during April 1995 (wells 695-702, pl. 1) are given in appendix 2, as are previously unpublished logs of wells (533, 598, and 600) and several boreholes referred to on the geologic sections in figures 5, 6, and 9. Logs of other wells and borings referred to on these sections are given in Randall (1972), URS Consultants, Inc. (1992, 1993), Nashold and others (1994), Earth Tech (1996), Martin (1983), and Woodward-Clyde Consultants (1995a and 1995b). The land-surface elevation prior to construction of New York State Routes 17 and 201 is depicted on the geologic sections in figure 5 (p. 14-15).

The earliest ice-contact gravel deposits consist almost entirely of drab local shale fragments. They are exposed at land surface in only a few places, such as along the northern and southern aquifer boundaries in Binghamton (that is, along Prospect Street and south of Main Street, respectively), where they form terraces at altitudes of 880 to 910 ft (Randall, 1977). Virtually all exposures of drab ice-contact gravel are within the areas identified on plate 1 as having only a few feet of saturated thickness. Drab gravel has been penetrated at depth, however, by several boreholes in western Binghamton and Johnson City (Randall, 1972, l978). The numerous boreholes near USAF Plant 59, and others to the north, show that the upper surface of basal sand and gravel deposits is highly uneven, suggestive of mounds or ridges deposited in ice-walled channels and later buried by younger sediment (fig. 5). Several knolls south of Floral Avenue in Johnson City that rise above an altitude of 890 ft seem to consist of till but may also contain gravel and may belong to this early deglacial episode; alternatively, they may have been deposited earlier while ice was still advancing.

Bright outwash gravel forms extensive terraces at an altitude of about 870 ft near Main Street and Grand Avenue in Johnson City and formerly in Vestal across the Susquehanna River from Johnson City, although the latter area has been almost entirely excavated by a gravel-mining operation (Coates, 1963, p. 116; Randall, 1977, pl. 6). The outwash overlies lake-bottom fines or, in a few places, the early ice-contact gravel, and probably constitutes a series of deltas deposited sequentially and close to one another. Lower terraces, at altitudes of 860 to 850 ft along Harry L. Drive and 850 to 840 ft along Riverside Drive and in Westover (fig. 2), are also capped by bright gravel outwash. These terraces formed at a later time, when most meltwater followed the present-day course of the Susquehanna River to Westover, but some meltwater also flowed through the lowland north of Main Street in Binghamton and Johnson City. The terraces at altitudes of 840 to 860 ft in Johnson City are probably of the same age as extensive terraces at altitudes of 860 to 870 ft in eastern Binghamton. The gravel cap of the Westover terrace overlies fines that were likely deposited in the earlier deltaic episode.

A substantial part of Johnson City, between Harry L. Drive and Little Choconut Creek or Main Street (fig. 2), is generally below an altitude of 840 ft. This entire lowland must have been occupied by a mass of ice when the 870-ft deltaic outwash was being deposited near Main Street. Bright gravel, several tens of feet thick, underlies this lowland at shallow depth at several boreholes near and west of Oakdale Road (well 700 and borings 04-38b and 13-39b in fig. 5, section A-A′; and well 701 and boring 05-16b, west of well 701, on pl. 1). This bright gravel is inferred to be an extension of the terrace that was built over buried ice at altitudes of 870 ft or 850 ft and gently downwarped when the ice melted. Well 702 penetrates 50 ft of bright gravel and sand overlying 8 ft of rhythmically interbedded silt and clay, all interpreted as a large, rotated slump block (fig. 5, section C-C′).

All natural surfaces in Johnson City below an altitude of about 835 ft are underlain by several feet of noncalcareous silt deposited during river floods. The silt is generally underlain by bright or moderately bright gravel that contains many well-rounded, exotic pebbles, but it is noncalcareous and virtually devoid of limestone pebbles. This leached bright gravel underlies the channel and flood plain of the Susquehanna River and crops out in the banks as high as 2 ft above low-river stage. The leached bright gravel is 11 to 12 ft thick at four boreholes near Westover and could be interpreted as postglacial channel-bar alluvium in Johnson City and in other reaches of the Chenango and Susquehanna River valleys (Randall, 1977, 1978, 1986). Similar gravel deposits, 5 to 18 ft thick, were penetrated by four boreholes north of Main Street in Johnson City, at locations through which the modern Susquehanna River channel is unlikely to have meandered (wells 696, 699 and borings 04-38b, 13-39b on pl. 1 or fig. 5, section A-A′). Leaching of limestone by infiltrating rain seems unlikely because bright gravel at wells 697 and 700 and in some excavations contains limestone pebbles within 1 to 2 ft of land surface (or surficial silt). A more plausible explanation for the absence of limestone in this bright gravel is that the leaching of bedload in postglacial stream channels is more effective than the leaching of outwash by infiltrating precipitation, and that the Susquehanna River bifurcated temporarily in early postglacial time, flowing partly north of Main Street in Binghamton and Johnson City and spreading a layer of channel alluvium there. Alluvial fans consisting largely of drab local shale fragments constitute the uppermost sediment where tributaries such as Little Choconut and Finch Hollow Creeks enter the Susquehanna River valley.

In section B-B′ (fig. 5), a buried ridge of drab ice-contact deposits is inferred from: (1) a small knoll that reaches an altitude of 840 ft near the line of the section, and two logs (boring 09-09b, well 229) that penetrate 80 to 90 ft of gravel and sand resting on bedrock; and (2) comparable thicknesses of gravel in wells 223 through 228 to the east and west (Randall, 1972). These logs together indicate a large ice-channel filling oriented east-west and centered slightly north of the railroad. The railroad is at the top of a scarp that is inferred to be the lip of a delta of bright outwash at an altitude of 840 ft, now bordered on the north by a small ice-block depression. Information on pebble lithology, carbonates, and organic matter are available only from wells 699 and 697; therefore, correlations in this section cannot be considered certain, and the bedrock surface is poorly defined.

Detailed information on pebble lithology, carbonates, and organic matter along section C-C′ (fig. 5) is available only near the ends of the section. The east end is tentatively interpreted to represent a large, rotated slide block, which would explain the 25-degree dip identifiable in clay layers beneath the bright outwash in well 702, the absence of silt and clay in the log of nearby well 224, and the unusual indentation in the scarp that bounds the adjacent terrace. Collapse may have occurred along multiple faults, however, rather than as a single block. Immediately west of Little Choconut Creek is a buried mound or ridge of gravel that is moderately drab, as indicated by a few samples from well 680. The steep eastward termination of this mound, as indicated by borings 55-12b and 56-12b, seems unusually abrupt.

Several borehole logs east of the Susquehanna River, along section D-D′ (fig. 5), delineate three buried mounds of ice-contact sand and gravel; descriptions of two individual samples from wells 677 and 684 indicate the gravel to be drab. Stratigraphy beneath and west of the Susquehanna River is poorly

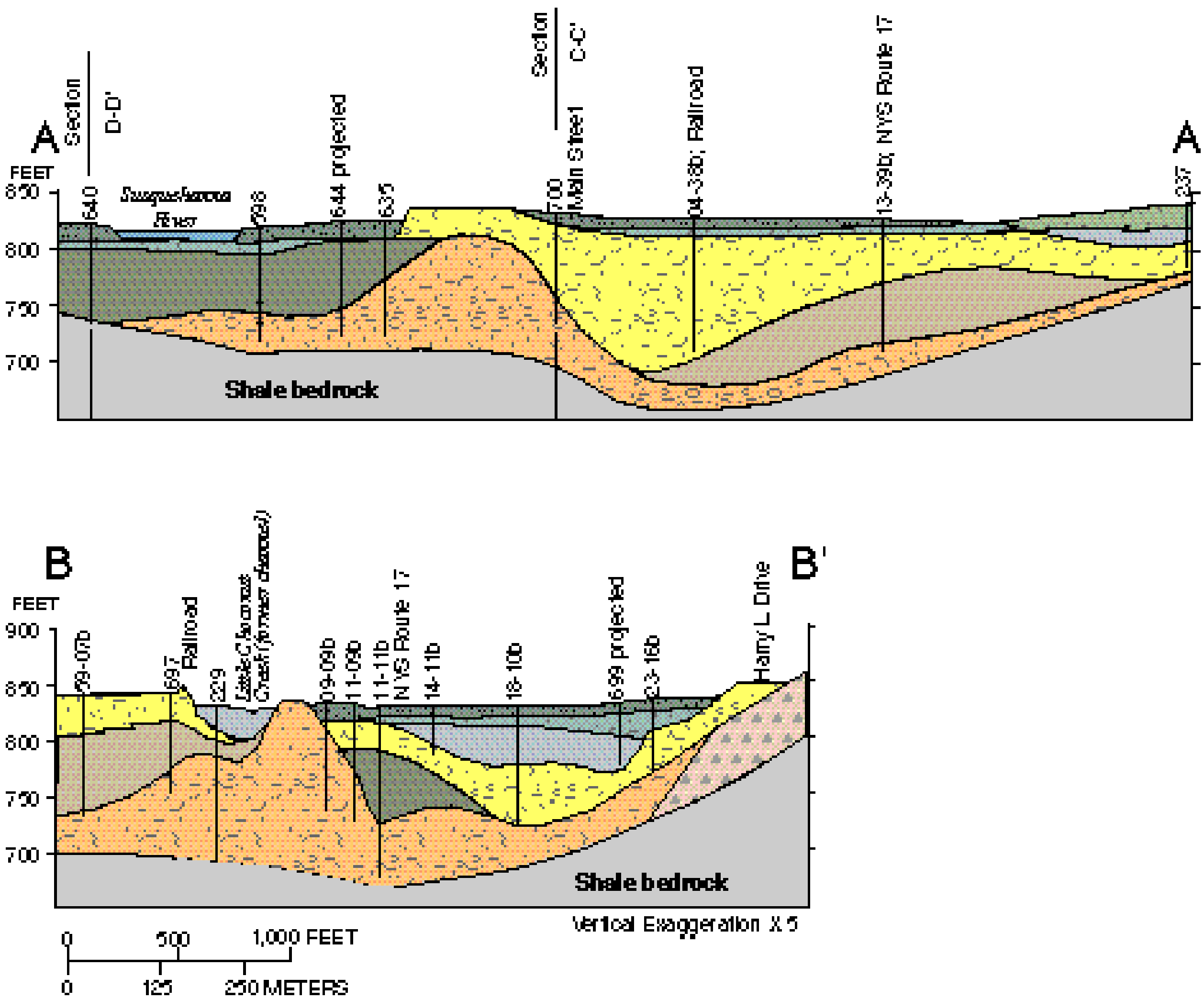


Figure 5. Geologic sections A-A′ and B-B′ through the Clinton Street-Ballpark aquifer, Johnson City, N.Y. (Traces of sections are shown on pl. 1.)

understood. Sediments beneath the river are largely fine grained, but coarse sand and gravel interbedded with the fines at well 600 suggest a deltaic depositional environment. When well 210 (Johnson City production well no. 3) was pumped, the water level in well 601, which is screened in a lens of drab coarse sand at an altitude of 765 ft in the same location as well 600, was lower than the water level in well 600, which is screened in the basal sand (fig. 5, section D-D′). The upward gradient suggests that the sand layer at an altitude of 765 ft is connected to the thick aquifer tapped by well 210 east of the river, but the nature of that connection is unknown. The basal gravel in the Town of Vestal well 706 is described as bright (Martin, 1983, p. 23) and could be collapsed from a higher altitude, as implied in section D-D′. This assumption requires, however, that fine-grained sediments in well 640 and Town of Vestal wells 710, 711, and 712 be younger than the 870-ft outwash terraces to the west, which seems inconsistent with the lenses of drab coarse sediment in well 600. Correlations at the west end of section D-D′ are considered tentative.

Hydrology of Clinton Street-Ballpark Aquifer

The stratified drift in the Clinton Street-Ballpark aquifer comprises an upper, unconfined layer and a lower, confined layer, generally separated by a layer

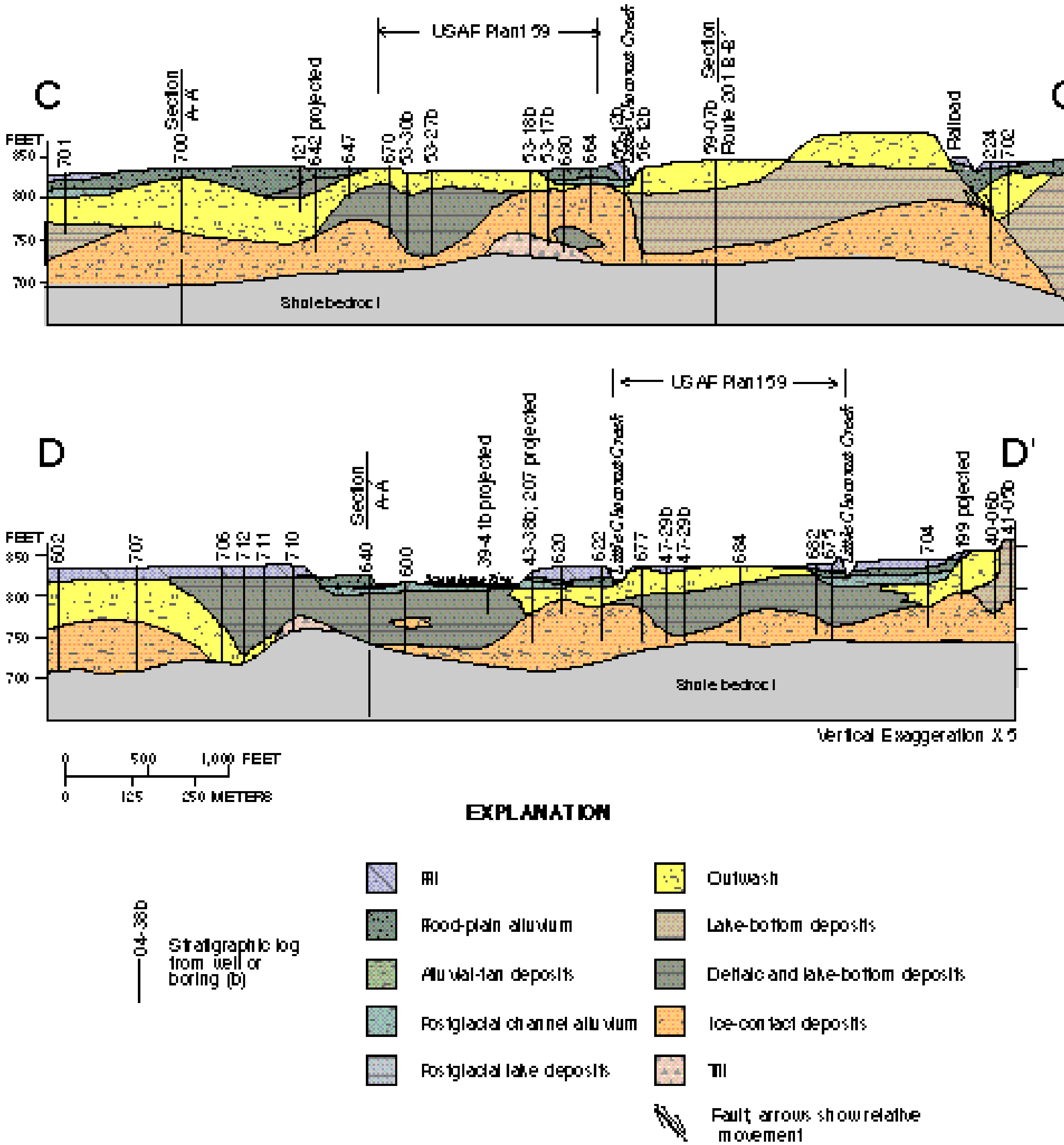


Figure 5 (continued). Geologic sections C-C′ and D-D′ through the Clinton Street-Ballpark aquifer, Johnson City, N.Y. (Traces of sections are shown on pl. 1.)

of fine-grained lake-bottom material but locally in contact with each other. Typically the lower layer consists of coarser, siltier sand and gravel than the upper layer, and contains much less bright material, except in the area north and west of Westover, where it may consist of bright outwash that is downwarped.

The unconsolidated sediments of the Clinton Street-Ballpark aquifer that overlie bedrock in the area between Harry L. Drive and Corliss Avenue in Johnson City (fig. 2) are generally 100 to 150 ft thick (Randall 1977). The aquifer is generally thicker along the center of the valley than at the edges. Yields approaching or exceeding 1 Mgal/d are typical of municipal wells in the Susquehanna River valley, but test drilling has shown that the sand and gravel deposits at many locations are incapable of sustaining such large yields (Randall,1972; Martin, 1981, 1983). Zones of low permeability that function as barriers to flow are found near most municipal or industrial wells in the Susquehanna River valley near Johnson City (Randall, 1986, p. 26).

The hydraulic conductivity of the upper (unconfined) layer of the aquifer is about 130 ft/d, and transmissivity of the lower (confined) layer ranges from 1,000 to 40,000 ft^2/d, as estimated from calibration of an aquifer model by Randall (1986). These transmissivity estimates are lower than those computed from pumping tests and the specific capacity of pumped wells, particularly in areas surrounding major well fields; this also was noted in an earlier study by Randall (1977). These results suggest that thin lenses of fine-grained or poorly sorted sediment of low permeability are common within the sand and gravel deposits and decrease the effective aquifer transmissivity.

The combined transmissivity of the upper and lower layers of the aquifer in the vicinity of the Camden Street wellfield ranges from 20,000 to 30,000 ft^2/d, as estimated from a pumping test conducted by URS Consultants, Inc. (1992) of production wells no. 2 (208) and no. 3 (210), screened in both the upper and lower layers. Transmissivity of the lower layer of the aquifer near USAF Plant 59 is estimated to be less than 10,000 ft^2/d, from results of a pumping test conducted by Earth Tech (1995a) at the plant's production well (533) screened in the lower layer.

Table 4. Monthly withdrawals from municipal and industrial wells that tap the Clinton Street-Ballpark aquifer, Broome County, N.Y., 1994

[Locations are shown on pl. 1. Well numbers are U.S. Geological Survey county well numbers; numbers in parentheses are local identifiers.]

	Withdrawal, in million gallons									
	Johnson City wells[a]		Anitec wells[b]						Sum of Town of Vestal[c] wells 160 (V4-2), 186 (V4-3),and 196 (V4-4)
Month 1994	Camden St. wellfield, well 208 (No. 2) only	Well 224 (No. 6) and *well 231 (No. 7)	Well 183 (No. 3)	Well 188 (No. 5)	Well 175 (No. 6A)	Well 161 (No. 7)	Well 166 (No. 10A)	Well 455 (No. 11)	
Jan	83.405	0	17.004	17.208	0	0	27.640	39.756	48.708
Feb	81.626	0	32.150	0	0	0	25.027	36.103	52.101
Mar	87.501	0	0	35.637	0	0	25.881	37.345	58.503
Apr	90.003	2.053	0	29.999	0	0	25.994	37.389	59.842
May	98.944	7.238	26.709	9.999	0	2.460	22.579	34.031	56.515
Jun	89.333	11.220	25.596	9.999	0.0225	25.920	24.752	32.898	63.295
Jul	89.856	16.861	13.200	0.016	0	27.000	24.261	37.500	64.012
Aug	86.610	*16.764	15.300	5.440	0	26.100	37.676	36.516	64.766
Sep	90.195	3.300	0	16.100	0	25.400	2.836	36.500	70.382
Oct	93.378	22.080	12.699	9.610	0	27.600	0	39.200	71.654
Nov	90.478	11.618	0	12.600	0	11.400	24.700	15.900	65.910
Dec	92.974	12.152	1.140	28.700	0	0	28.300	29.200	56.932
Total	1074.303	103.286	143.798	175.308	0.0225	145.880	269.646	412.338	732.620

[a] James Hamm, Johnson City Water Department, written commun., 1995.

[b] Peter Connery, Anitec, Imaging Products Division of International Paper Company, written commun., 1995.

[c] Ronald Brink, Broome County Health Department, written commun., 1995.

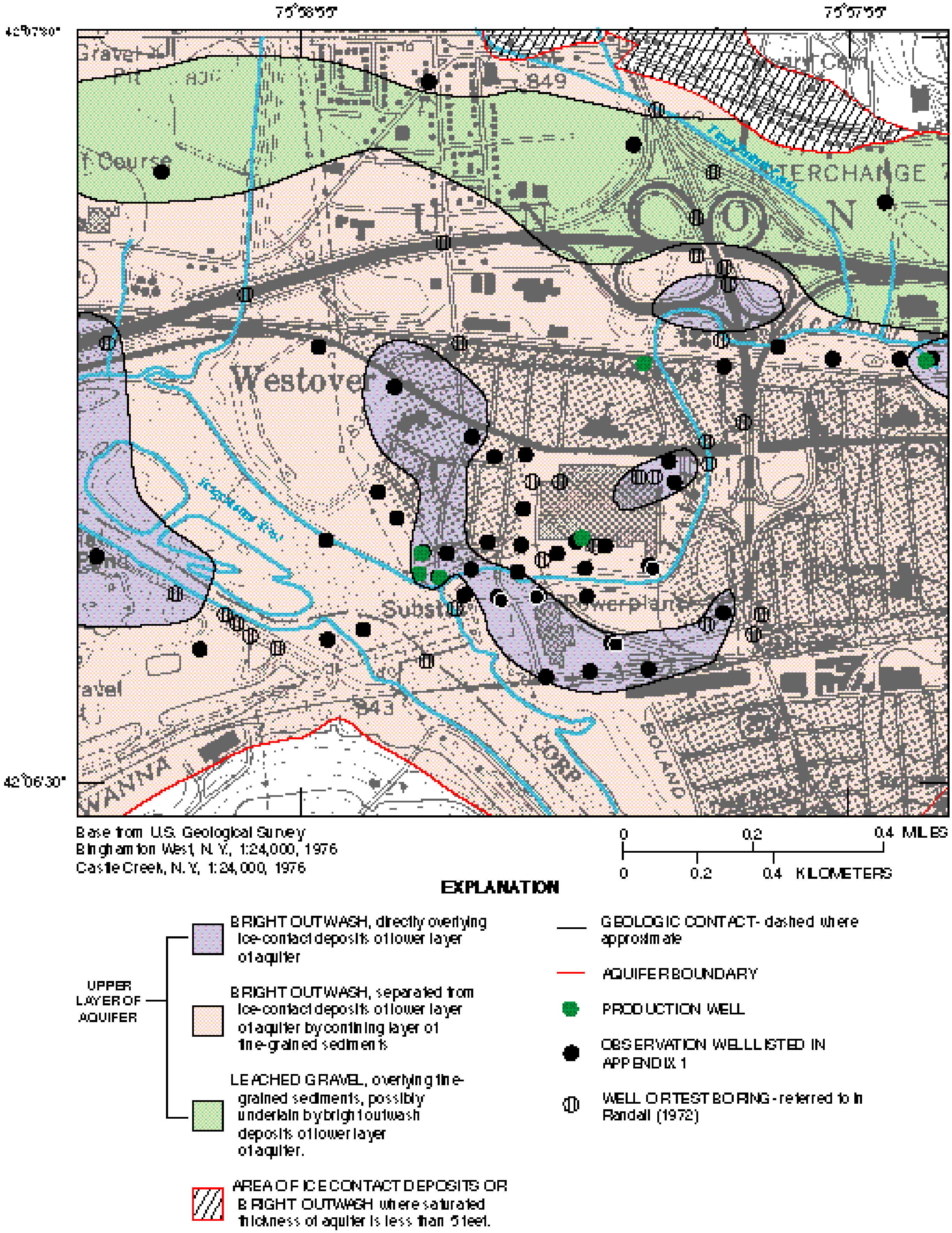


Figure 6. Extent of confining layer that separates the upper and lower layers of the Clinton Street-Ballpark aquifer in the Johnson City area, Broome County, N.Y.

Extent of Confining Layer

Fine-grained confining units consisting of silt, rhythmically interbedded with grayish-red clay (3B1 in fig. 4), were deposited in large proglacial lakes in the area now occupied by Endicott and eastern Binghamton. These units, which occur locally in Johnson City, limit vertical flow of water between the upper and lower layers of the aquifer. In Johnson City, particularly near USAF Plant 59, however, these confining units tend to range from silt to fine sand interbedded with a few feet of coarser sand (a stratigraphy suggestive of deltaic deposits). These units possibly could transmit appreciable amounts of water vertically, particularly if the coarse sand layers are dipping foreset beds that connect the upper and lower layers. Contaminants introduced at land surface could readily migrate downward through dipping coarse-sandy layers in predominantly fine-grained deltaic sediment (3B2, fig. 4). Lateral flow through the upper layer of the aquifer to a point where downward migration can occur is possible throughout the study area.

Areas in which the upper and lower layers of the aquifer are separated by a fine-grained confining unit are depicted in figure 6, which also indicates areas where the confining layer is absent and the upper and lower layers of the aquifer are in contact, such that the entire unconsolidated section is coarse grained. The upper layer in areas north of New York State Route 17 generally is 10 to 15 ft thick and apparently overlies a relatively thick layer of postglacial fine-grained sediment. A lower layer of downwarped bright outwash could underlie the fine-grained sediment, but the stratigraphy at depth in this area is unknown.

Ground-water Withdrawals

Monthly discharges from production wells screened in the Clinton Street-Ballpark aquifer during 1994 are presented in table 4. This pumped

Table 5. Surface-water elevations at selected points during regional water-level surveys on August 23, 1994 and May 2, 1995, Broome County, N.Y.

[Locations are shown on pl. 1. --, no measurement made.]

Local site identifier	Measurement location and description of measuring point	Measuring point, in feet above sea level	Water-surface elevation, in feet above sea level		
			August 23, 1994	August 24,1994	May 2, 1995
Chenango River					
C1	North side of Bevier Street bridge; top of 32nd (from west end of bridge) railing support.	868.76	828.89	827.03	825.29
C2	South side of Court Street bridge; top of 4th (from west end of bridge) railing support.	860.86	827.67	826.17	824.70
Susquehanna River					
S1	Northwest (downstream) side of Route 201 bridge; top of 75th (from northeast end of bridge) railing support.	865.77	819.87	819.68	817.13
S2	NYSEG Goudey power plant; top of rackhouse floor.	830.6	818.7	--	816.52
S3	At USGS well 600 on island downstream of NYSEG dam; top of 1.5-inch coupling.	813.31	--	--	812.68
S4	At USGS well 598; top of 6-inch coupling.	823.69	815.73	814.23	812.93
S5	At confluence with IBM tributary 1; top of survey stake (or lag bolt in tree).	815.63 (820.02)	814.75	813.27	 811.74
S6	North of gravel pit and Town-of-Vestal well 4-4; top of survey stake.	813.91	811.92	809.95	807.8
Barney and Dickenson Gravel Pit					
P1	At west end of pond east of Town-of-Vestal well 4-4 and south of Susquehanna River; top of survey stake.	814.06	812.74	812.71	811.3

water is used for municipal water supply by Johnson City (wells 208, 224, 231) and the Town of Vestal (wells 160, 186, 196) and for industrial purposes by Anitec in Binghamton (wells 161, 166, 175, 183, 188, 455). Estimated discharges from other production wells in the area also are available:

(1) E.H. Titchener, Inc. (well 147) pumps from 5,000 to 11,000 gal/d with an average rate of 9,000 gal/d (Charles Hissin, E.H. Titchener, Inc., oral commun., 1994);

(2) Lockheed-Martin (USAF Plant 59, well 533) has pumped water intermittently for noncontact cooling purposes at an average rate of about 5,000 gal/d (145 gal/min) since May 1994 but is capable of exceeding 400,000 gal/d (320 gal/min) (Earth Tech, 1995a, p. 3-8); and

(3) the IBM Country Club (wells 234 and 236) pumps water at a maximum year-round daytime rate of about 63 gal/min or about 45,000 gal/d for social and recreational activities. During the summer, these wells can also be pumped during a 9-hour nighttime period at a rate of 85 gal/min (about 46,000 gal/d) for golf-course irrigation, as needed (James Ketchuck, IBM, oral commun., 1995).

Direction of Ground-water Flow

Water levels in the observation wells and water-surface levels at the nine measuring points along or

Table 6. Discharge and gain or loss at selected streamflow-measurement sites on tributaries to Susquehanna River, Broome County, N.Y., during regional water-level surveys on August 23, 1994 and May 2, 1995

[Discharges are in cubic feet per second. M, current meter; V, volumetric method; W, flow-over-weir method; I, visual inspection; S, sum of upstream discharges; --, no measurement made. Locations are shown on pl. 1.]

Local site identifier	Location of discharge measurement	August 23, 1994		March 15, 1995		May 2, 1995	
		Discharge and method	Gain (+) or loss (-)	Discharge and method	Gain (+) or loss (-)	Discharge and method	Gain (+) or loss (-)
1	Little Choconut Creek at Airport Road	4.88 / M		--		7.33 / M	
2	Little Choconut Creek at NYS Route 17	6.15 / M	+ 1.27[a]	--		7.73 / M	+ 0.40[a]
3	Glenwood Creek at Lester Avenue	0.06 / V		--		0.10 / V	
3A	Little Choconut Creek below Glenwood Creek (Site 2 plus site 3)	6.21 / S				7.83 / S	
4	Little Choconut Creek above Finch Hollow Creek	4.89 / M	- 1.32[b]	--		7.51 / M	- 0.32[b]
5	Finch Hollow Creek above Oakdale Mall	1.83 / W		7.64 / M		2.42 / M	
6	Finch Hollow Creek tributary at Reynolds Road	0.04 / W		0.42 / M		0.04 / V	
6A	Finch Hollow Creek below tributary at Reynolds Road (Site 5 plus site 6)	1.87 / S		8.06 / S		2.46 / S	
7	Finch Hollow Creek at mouth near Brown Street	1.28 / M	- 0.59[c]	7.73 / M	- 0.33[c]	2.81 / M	+ 0.35[c]
7A	Little Choconut Creek below Finch Hollow Creek (Site 4 plus site 7)	6.17 / S				10.3 / S	
8	Little Choconut Creek near Main Street	7.27 / M	+ 1.10[d]	--		11.0 / M	+ 0.7[d]
9	IBM tributary 1 near IBM golf course driving range	0.0 / I		--		<0.01 / I	
10	IBM tributary 2 near IBM Country Club maintenance barn	0.07[e] / W		--		0.38 / M	
11	IBM tributary 2 near IBM Country Club swimming pool	--[f]		--		--[f]	

[a] Site 2 minus site 1.
[b] Site 4 minus site 3A.
[c] Site 7 minus site 6A.
[d] Site 8 minus site 7A.
[e] Measured on August 24, 1994. Channel was dry about 500 feet downstream from measument site.
[f] Inflow was observed from several golf course drainage pipes downstream from Site 10.

near the Susquehanna and Chenango Rivers were converted to elevations above sea level (appendix 3 and table 5) and contoured for analysis of ground-water flow direction. Only those water levels measured in wells screened in the upper, unconfined layer of the aquifer or in wells in areas where no confining layer is present were used in the automated contouring routine; contours were adjusted manually where necessary. The aquifer boundary was reproduced from Randall (1986, pl. 1).

Water-table contours for May 2, 1995 (pl. 2) indicate that ground water generally moves from upgradient areas along the aquifer boundaries toward two major pumping centers—the Anitec wellfield in Binghamton, and the Camden Street wellfield in Johnson City . A ground-water divide (pl. 2) is located near the municipal boundary between Binghamton and Johnson City; ground water east of the divide flows toward the Anitec wellfield, and ground water west of the divide flows toward the Camden Street wellfield. Water-table contour maps for September 25, 1958, October 6, 1967, and April 6-7, 1981 (Randall, 1977, 1986) also show a divide near the municipal boundary and indicate flow toward the same major pumping centers. Because total pumpage was somewhat greater before 1994 than at present (1995), and some of the Johnson City municipal wells north of Main Street were operating regularly, flow patterns in the Johnson City area in 1995 were different from those during the earlier studies, especially in areas east of Oakdale Road and Riverside Drive, where capture of ground water by the wells north of Main Street was indicated.

Randall (1977, p. 17) noted that infiltration of water from the Susquehanna and Chenango Rivers into the Clinton Street-Ballpark aquifer has been induced by pumping from municipal and industrial wells near the rivers; the water-level contours on plate 2 suggest that water from the Chenango River flows toward Anitec wells 6, 7, and 10 (wells 175, 161, and 166, respectively) and that water from the Susquehanna River recharges the aquifer in the vicinity of the Camden Street wellfield in Johnson City. Randall (1977, p. 17) also measured seepage losses from Little Choconut and Finch Hollow Creeks during 1966-68 (U.S. Geological Survey, 1970) and inferred that water was infiltrating into the aquifer because the water table was several feet below the channels of these streams where they flow over it. Stream-discharge measurements made at 11 sites in the Little Choconut Creek basin (table 6 and pl. 1) on August 23, 1994 and March 15 and May 2, 1995 confirmed seepage losses from Little Choconut and Finch Hollow Creeks.

Ground-water conditions during the May 2, 1995 water-level survey were near equilibrium throughout most of the aquifer, except near Johnson City municipal wells 2, 6, and 7 (wells 208, 224, and 231, respectively). The pump at well 208 at the Camden Street wellfield was shut off at 1000 hours on May 1 because of a motor problem. The backup well 231 on North Broad Street was pumped from 1100 to 2015 hours on May 1 and turned on again at 1220 hours on May 2. A drawdown test was conducted at well 224 near Brown Street, which discharged water from 1630 hours on May 1 to 1230 hours on May 2. Antecedent weather conditions were dry; water levels in wells adjacent to the Susquehanna River were in a slow decline from a minor rise in river stage on April 29. (See fig. 7C, p. 23.) Streamflow in the Susquehanna River during April and May was less than 50 percent of the long-term average flow (data on file in the Ithaca, N.Y., office of the USGS).

Synoptic water-level measurements on August 23-24, 1994 (appendix 3) showed a flow pattern similar to that depicted on plate 2; water levels then were somewhat higher than on May 2, 1995 near the Susquehanna River (reflecting higher river stage) and lower than on May 2, 1995 in the northern and eastern parts of the aquifer in Johnson City (a reflection of intermittent pumping from Johnson City wells north of Main Street during the previous months). Precipitation on August 13-15, 18-19, and 21-22 caused a rise in ground-water levels in the aquifer, especially in areas adjacent to the Susquehanna River, which was at medium-to-high stage on August 23. The pumping rate at well 208 remained constant before and during this survey. Well 231 was not pumped on August 22, but was pumped during August 23-24.

Effect of River Levels and Pumping on Ground-water Levels

Water levels were recorded at wells 677, 678, and 679, all about 740 ft from the Susquehanna River in the southwestern corner of the USAF Plant 59, and at well 121 at the corner of Main and

Camden Streets, 1,400 ft from the river (pl. 1). Well 677 (DW9) is screened in the lower, confined layer of the Clinton Street-Ballpark aquifer, and well 678 (SW9) is screened in the upper, unconfined layer. Well 679 (IW9) is screened in a thin, permeable sand layer within the 30 to 40 ft of fine sand and silt that separates the two layers of the aquifer, and well 121 is about as deep as well 679 but is in an area where no confining layer is present. Water-level records from these wells for most of the year (August 24, 1994 through August 25, 1995) are presented in figure 7 along with concurrent records of precipitation at the Broome County Airport, north of Johnson City (National Oceanic and Atmospheric Administration, 1994, 1995) and surface-water elevations from the USGS stage-recording station at Vestal, 4.5 mi downstream from Johnson City. A comparison of Susquehanna River water-surface elevations measured during the synoptic water-level surveys (see previous section) indicates that the Susquehanna River near the Johnson City Camden Street wellfield was about 7 ft higher on August 23, 1994, and 9 ft higher on May 2, 1995, than it was in Vestal, as shown in figure 7.

The Susquehanna River is the ultimate point of discharge for ground water that is not captured by production wells and, in the vicinity of the Camden Street wellfield, it is a source of induced recharge to municipal wells (Randall, 1977, 1986). Water levels in all wells near the river respond to changes in river stage (fig. 7). Well 678 (SW9), screened in the upper layer of the aquifer, appears to be most responsive; the water level in this well rises promptly when river stage rises. The water-level response to large increases in river stage in January and March 1995 (fig. 7B) is greater in magnitude and begins sooner in wells 677 (DW9) and 678 (SW9) than in well 679 (IW9), indicating that the upper and lower layers of the aquifer have more direct connections to the river than the thin, sandy lens within the confining layer tapped by well 679.

Ground-water withdrawal from USAF Plant 59 production well (533) between May 1994 and June 1995 at a maximum rate of about 145 gal/min (Earth Tech, 1995a) caused a decline of about 0.7 ft in the water level in well 677 (DW9), about 500 ft to the southwest; both wells are screened in the lower layer of the aquifer. This drawdown was recorded repeatedly twice per day during intermittent operation of the pump from mid-January through mid-June 1995 (fig. 7B, 7C), except for a monthlong period of continuous pumping from mid-April to mid-May. Continuous pumping at this rate during a 5-week period in August and September 1994 (fig. 7A), caused drawdown to persist for several days. The rate of withdrawal increased to a maximum non-metered rate of about 320 gal/min (Earth Tech, 1995a) in late June 1995 and caused a prolonged drop in water level of about 1.8 ft. Withdrawals from well 533 appear to have had no effect on water levels in the other wells (678 and 679), indicating a poor hydraulic connection between the upper and lower layers of the aquifer at this point. This conclusion is supported by Earth Tech (1995a), which found that pumping well 533 in 1994 had no effect on water levels in wells screened in the upper layer more than 300 ft away from well 533.

Ground-water withdrawal from Johnson City production well no. 2 (well 208), which is screened in both the upper and lower layers of the aquifer, averages 3 Mgal/d and causes drawdown in wells 677 and 678 (pl. 1), about 850 ft to the east, and in well 121, about 1,200 ft to the north. The cessation of pumping at well 208 during May 1-10, 1995 (James Hamm, Johnson City Water Department, oral commun., 1996) resulted in about a 4-ft rise in water levels in the three wells (677, 678, and 121), followed by a drop in water level once pumping resumed (fig. 7C). No record is available for well 679 during this period.

Also apparent in figures 7A and 7D are small diurnal increases in water levels in well 678, screened in the upper layer of the aquifer and (less pronounced) in well 679, screened in the confining layer. The magnitude of these increases ranges from 0.1 ft to almost 1 ft and averages about 0.4 ft. These water-level fluctuations, evident in August and October 1994 and from June through August 1995, may be due to daily discharges of water to Little Choconut Creek, which lies about 30 ft south of the well, but the source of this suspected discharge is unknown.

Areas Contributing Ground Water to Municipal and Industrial Wells

The ground-water-flow model developed by Randall (1986) and modified by S.W. Wolcott (written commun., 1994) (outlined in fig. 1) represents the aquifer that occupies a part of the stratified drift in the Susquehanna River valley from the City

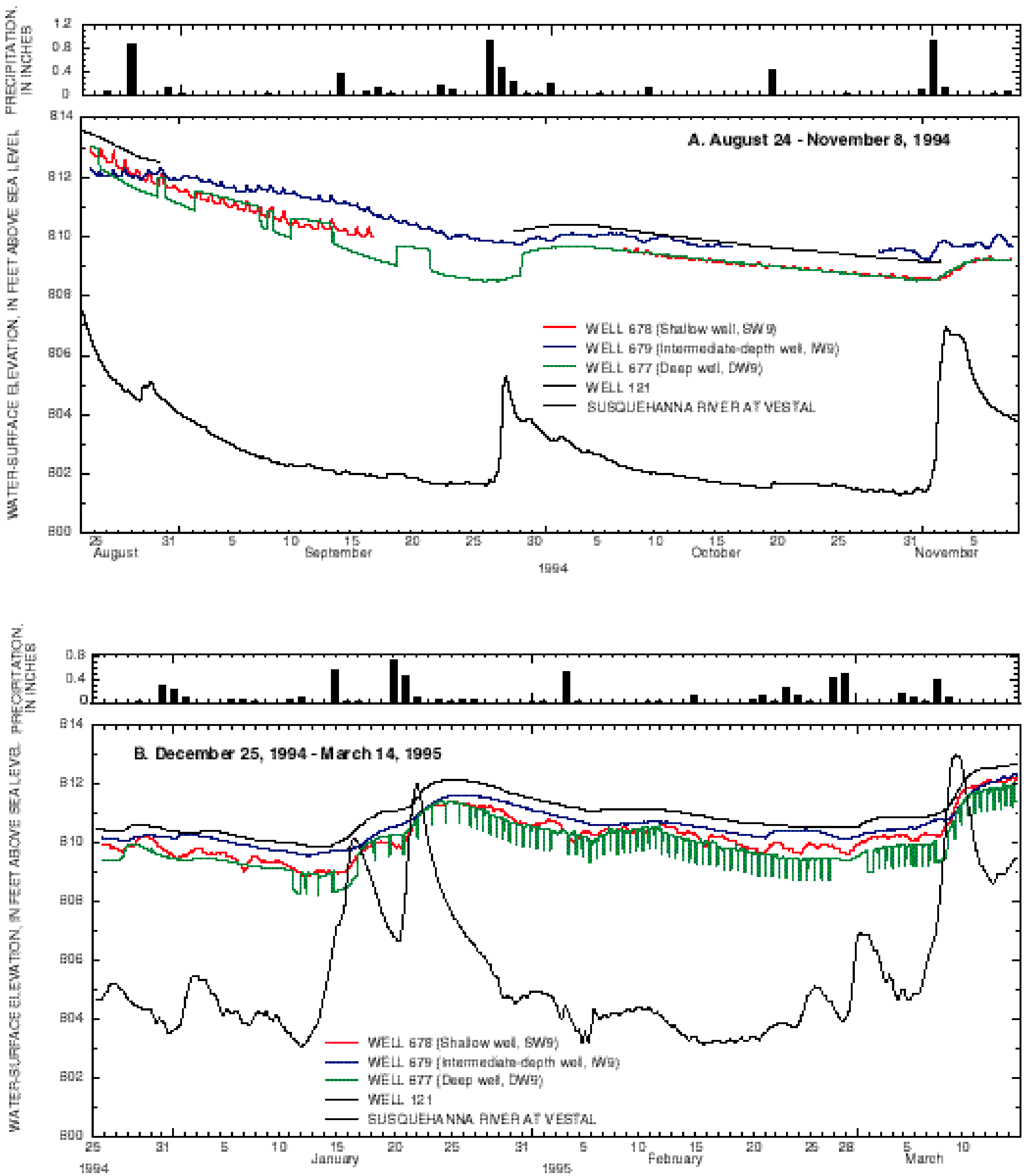


Figure 7. Water levels in Susquehanna River and in selected wells near the Camden Street wellfield, Johnson City, N.Y., with concurrent precipitation record: A. August 24 through November 8, 1994; B. December 25, 1994 through March 14, 1995. (Well locations are shown in plate 1.)

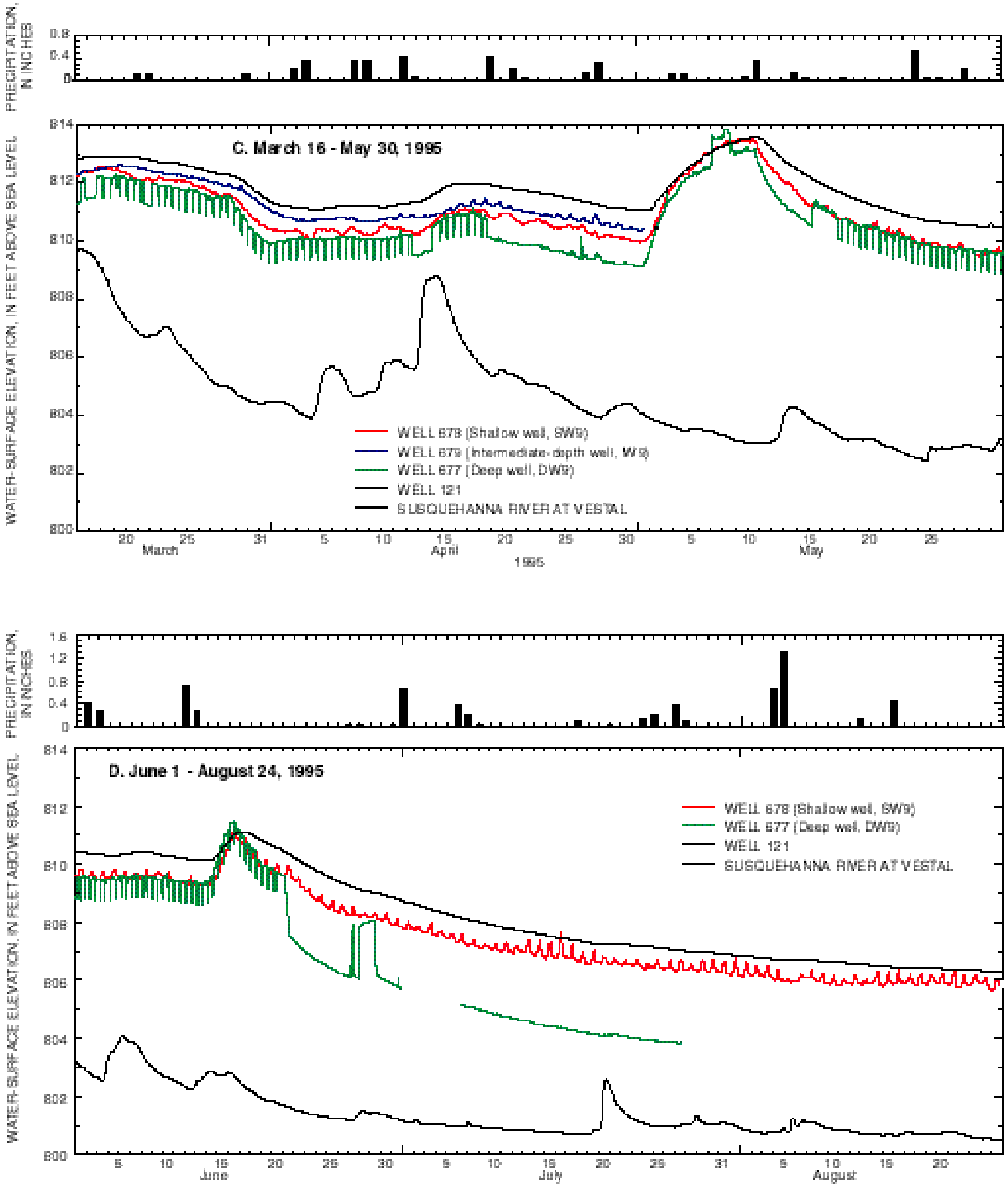


Figure 7. (continued). Water levels in Susquehanna River and in selected wells near the Camden Street wellfield, Johnson City, N.Y., with concurrent precipitation record: C. March 16 through May 30, 1995; D. June 1 through August 24, 1995.

of Binghamton to the western end of Broome County. The model represents the two layers of the aquifer—an upper, unconfined layer with variable thickness that extends throughout the valley, and a lower, confined layer that is discontinuous and locally separated from the upper layer by a layer of lake sediments with relatively low permeability. The two layers of the aquifer are represented by two model layers that are hydraulically connected by vertical leakage through the confining layer of lake sediments. The rate of vertical leakage between the upper and lower layers simulated in the model is determined by the difference in head between them and the vertical conductance, which is proportional to the vertical hydraulic conductivity of the confining layer and inversely proportional to its thickness. Vertical conductance is low where the confining layer is thick, moderately low where the confining layer is thin, and high where the confining layer is absent.

The model grid has 61 rows and 157 columns, with cell sizes ranging from 0.5 acre to more than 70 acres. Model boundaries are specified to represent recharge from precipitation and upland runoff, and discharge from wells, based on pumpage reported in 1981. Rivers and perennial streams that cross the upper layer of the aquifer are represented by boundaries with a specified stream stage that provides either (1) recharge to the aquifer if the water table is lower than the stream stage, or (2) discharge from the aquifer if the water table is higher than the stream stage.

The model was calibrated through trial-and-error adjustment of hydraulic properties specified in the model to minimize the difference between hydraulic heads computed in a steady-state simulation and ground-water levels measured during April 1981, when river stage and ground-water levels were close to steady-state conditions. The April 1981 river stage specified in the steady-state simulation approximated the stage that corresponded to the long-term median river flow as measured at Vestal (S. W. Wolcott, oral commun., 1996). The absolute difference between measured and computed heads was less than 8 ft at 90 percent of the 130 wells measured, and the standard error was 5.6 ft. The ground-water budget derived from the steady-state simulation indicated that sources of recharge to the aquifer include precipitation (35 percent), infiltration from the Susquehanna and Chenango Rivers (29 percent), and runoff from upland areas (36 percent). About two-thirds of the ground-water flow is discharged through pumping wells, and the remainder is discharged into the Susquehanna and Chenango Rivers and tributary streams (S.W. Wolcott, written commun., 1994).

Areas contributing ground water to municipal and industrial wells screened in the Clinton Street-Ballpark aquifer (pl. 3) were delineated from the results of a steady-state simulation, in which the average rates of withdrawal during 1994 from production wells (table 7) were substituted for the April 1981 rates used in model calibration. The term “contributing area” as used in this report refers to the areal projection at land surface of the volumetric

Table 7. Withdrawal rates for production wells in the Clinton Street-Ballpark aquifer, Broome County, N.Y., as specified in steady-state simulation

[Annual withdrawal rate computed as total withdrawal during 1994 (table 4) divided by number of minutes per year. Well locations are shown on pl. 1.]

Production well		Pumpage data (gallons per minute)	
USGS county well number	Local well identifier	Maximum pump-operating rate	1994 Annual withdrawal rate
Johnson City wells			
208	JC2	2,100	2,000
224	JC6	2,000	200
Vestal wells:			
160	V4-2	900	900
186	V4-3	800	250
196	V4-4	800	250
Anitec wells:			
183	AN-G3	1,260	300
188	AN-G5	1,400	300
161	AN-G7	1,500	300
166	AN-G10A	1,500	500
455	AN-G11	1,000	800
USAF Plant 59[a]			
533	GE1	320	130

[a] Average withdrawal rate from Earth Technology, Inc. (1995b)

portion of the aquifer from which water is diverted to a pumped well. Contributing areas to wells screened in the upper (unconfined) model layer and the lower (confined) model layer were delineated by tracing ground-water flow paths from each cell to a point of discharge. Although recharge from precipitation and upland runoff enters the aquifer through the upper layer, some of the area in the upper model layer discharges to streams and rivers; therefore, the contributing areas for the lower layer (shown in pl. 3) are generally larger than those for the upper layer and represent the maximum contributing area.

The contributing areas delineated by the steady-state simulation are only approximate because average pumping rates are used. Because the size and shape of contributing areas change in response to changes in pumping and the timing of recharge events, the contributing areas for wells that are continuously pumped would probably be larger than the areas depicted on plate 3. Conversely, the contributing area for a well that is pumped intermittently, such as the USAF Plant 59 production well (well 533), is probably smaller than the area depicted on plate 3. When well 533 is not being pumped, the water contained in the contributing area of well 533 probably discharges to Johnson City well no. 2 (well 208).

The area contributing recharge to Johnson City well no. 2 (well 208) covers about 1.5 mi^2 and is bordered on the east and west by the contributing areas to the Anitec and Vestal wellfields, respectively; it also encompasses the contributing area to well 533. Ground-water traveltime was estimated as the average linear velocity (specific discharge) calculated from flow rates generated by the steady-state simulation and an assumed median aquifer porosity of 0.3, a value obtained from S.W. Wolcott (written commun., 1994). Distances traveled by ground water in 1 year along selected flow paths toward well 208 are indicated by the arrows in plate 3. Ground-water velocity and distance traveled are inversely proportional to the porosity of aquifer material; thus the velocity and distance would be greater if the true porosity were less than 0.3. Model results indicate that the residence time of ground water within the area contributing recharge to well 208 is less than 6 years.

GROUND-WATER QUALITY

In August 1994, the USGS collected water samples from 28 wells in the area that contributes recharge to Johnson City well no. 2. The samples were analyzed for VOC's and selected inorganic constituents; results (Enseco, 1994) are given in appendixes 4 and 5, respectively. In December 1994, Earth Tech collected 26 ground-water samples at the USAF Plant 59 and analyzed them for VOC's, semi volatile organic compounds, pesticides, PCB's, and select inorganic constituents (Earth Tech, 1995b). Concentrations of VOC's detected in the samples are listed in appendix 6.

In November 1994 and May 1995, Target Environmental Services, under the direction of the USGS, collected ground-water samples for analysis through direct-push sampling (Target Environmental Services, 1994, 1995). VOC concentrations were measured in the field through analysis of sample headspace gases by portable gas chromatography (appendix 7). Carbon tetrachloride (CCl_4) and 1,2-dichloroethane occur as a coeluting pair, but all samples were below detection limits. Trichlorotrifluoroethane (TCTFA) and 1,1-dichloroethene (1,1-DCE) also occur as a coeluting pair and are reported in appendix 7B as concentrations of 1,1-DCE. The samples were also analyzed for CH_2Cl_2, $CHCl_3$, CCl_4, and 1,1,2-trichloroethane, but none of these constituents were detected.

Quality Assurance

The sampling and quality-assurance procedures used in this study met U.S. Air Force (1993) guidelines. Results of analyses of the equipment blanks demonstrated that sample-collection equipment was not a source of contaminants in water samples that were collected from wells during this study, and analyses of trip blanks detected no VOC's.

Inorganic Constituents

A network of 27 monitoring wells and Johnson City well no. 2 (well 208) were sampled in August 1994 to measure the range in concentrations in inorganic chemical constituents in ground water around USAF Plant 59; results are summarized in appendix 5. The ground water is predominantly a calcium-bicarbonate type. Water at only three wells–all shallow wells that are completed in the upper layer of the aquifer, was classified differently—water from wells 237 and 652 is a calcium-chloride type, and that from well 630 is a sodium-chloride type. The median specific conductance (971 µS/cm) of the ground water is relatively high, mainly because of chloride in the water, which reflects the high degree of urbanization in the Johnson City area. Dissolved oxygen concentrations are low relative to saturation concentrations; the median concentration is 0.9 mg/L, and a concentration of 0 was observed at five wells. The median concentration for iron is less than the reporting limit (0.04 mg/L), and the median for manganese is 0.014 mg/L, but relatively high concentrations of at least one of these metals (iron greater than 0.3 mg/L or manganese greater than 0.5 mg/L) were detected at 9 wells where dissolved oxygen concentration is low (less than 0.25 mg/L). The median nitrate concentration is less than the reporting limit (0.5 mg/L), and the maximum is 2.8 mg/L.

The median concentration of chloride in samples from the 10 wells that tap the lower layer of the aquifer was 40 mg/L, which is low relative to the 123-mg/L median for samples from the 16 wells that tap the upper layer of the aquifer. Randall (1977) observed that ground water was more mineralized, harder, and higher in chloride in the central part of the aquifer than near the Chenango and Susquehanna Rivers. During low flow, river water has averaged about 6 mg/L chloride upstream from Binghamton and 19 mg/L downstream from Binghamton. Specific conductance at low flow has been about 290 µS/cm upstream from Binghamton in the Chenango River, and 175 µS/cm upstream from Binghamton and 235 µS/cm downstream from Binghamton in the Susquehanna River (Ku and others, 1975, p. 60-61). This difference is ascribed to the induced infiltration of relatively unmineralized river water into the aquifer near the rivers at both ends of the aquifer. The same pattern is evident in results of this study (appendix 5)—all wells with less than 100 mg/L calcium (the main cause of hardness) and less than 85 mg/L chloride are near the Susquehanna River or the lowermost reach of Little Choconut Creek.

Randall (1977, figs. 9 and 10) documented trends of increasing hardness and chloride in the Clinton Street-Ballpark aquifer from 1950 through 1968. Chloride concentrations in 1950 ranged from about 10 to 15 mg/L, but current (1994) data (appendix 5) indicate that chloride concentrations have continued to increase since 1968, most notably in Johnson City well no. 2 (well 208). Chloride represents at least 18 percent of the anionic mass in all but one sample in this study, and more than 30 percent in more than half the samples. Elevated chloride concentrations can be ascribed to increased use of deicing salts, increased urbanization in general, and partly, perhaps, to changes in patterns of pumping (Randall, 1977). Leakage of water from sanitary sewers appears not to be a source of chloride because nitrate concentrations in the ground water are low.

Results of the chemical analyses (appendix 5) suggest that the areal distribution of inorganic constituents in Johnson City ground water does not parallel the distribution of VOC's (as discussed in the following section). This indicates that the source of the VOC contamination is probably associated with the release of a free-VOC (dense nonaqueous-phase liquid VOC) product rather than with a waste-disposal area because contamination from the latter source would have associated inorganic constituents that would be spatially correlated with the VOC's. A lack of inorganic indicators of the presence of VOC in ground water has been observed at several sites on Long Island, N.Y. (Eckhardt and Pearsall, 1989), where a free-VOC source was assumed.

Chlorinated Hydrocarbons

The distribution of chlorinated hydrocarbons in the vicinity of the Camden Street wellfield in Johnson City is shown on plates 4 and 5. The concentrations shown are those measured in water samples collected from wells and by direct-push sampling. The headspace analysis of the direct-push samples in the field by a gas chromatograph with flame-ionization and photo-ionization detectors is less reliable than laboratory analysis by purge-and-trap methods and by gas chromatograph with mass spectrometer, but the similarity of 1,1,1-TCA concentrations in split samples analyzed by field and laboratory methods (fig. 8) indicates that qualitative comparisons are valid. Lines of equal concentration on plate 4 circumscribe an area where concentrations of chlorinated hydrocarbons are above background levels and indicate the part of the contaminated area that has the highest concentrations.

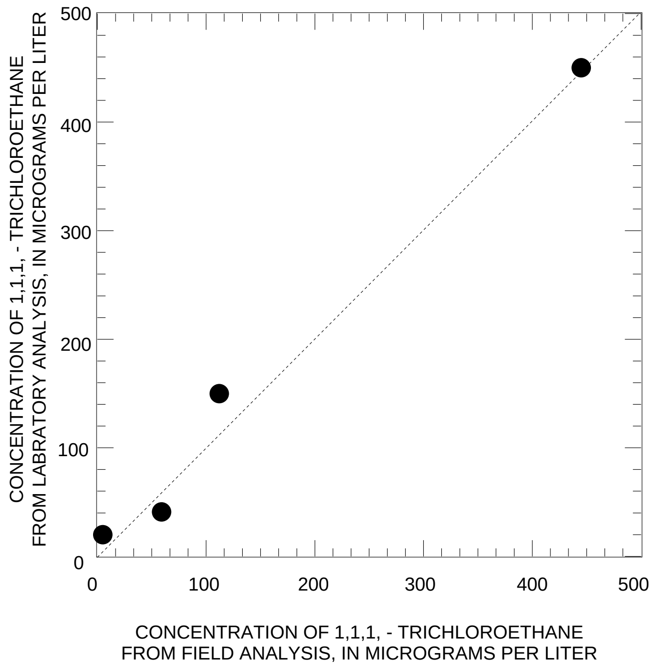


Figure 8. Concentrations of 1,1,1-trichloroethane as measured in split samples by portable and laboratory gas chromatographs

Trichloroethane (1,1,1-TCA) and Metabolite

Concentrations of 1,1,1-trichloroethane in the upper layer of the aquifer increase northward and upgradient of the Camden Street wellfield, parallel to the ground-water flow path indicated on plate 3. Concentrations range from 6 µg/L at Johnson City well no. 2 to 450 µg/L at direct-push sample site F-8 along Field Street (pl. 4). 1,1,1-TCA was detected in the upper and lower layers of the aquifer near the Camden Street wellfield south of Main Street; no wells are screened in the lower layer north of Main Street. The source of the 1,1,1-TCA is unknown but probably is within the area bounded on the south by Field Street, on the north by Harry L. Drive, on the east by State Route 201, and on the west by Marie Street (pl. 4). Field Street has two small industrial facilities; continuing investigations have detected 1,1,1-TCA along the northern and eastern boundaries of these sites (Thomas Suozzo, New York State Department of Environmental Conservation, written commun., 1996).

Only a few direct-push samples were obtained along Harry L. Drive because the saturated part of the aquifer in this area was thin, and till was recovered from the sampling probe in several locations. None of the samples collected along Harry L. Drive contained VOC's at a concentration greater than 5 µg/L, but contaminants could have entered the aquifer in this area from a suspected waste-disposal site north of Harry L. Drive during periods when ground-water levels were higher than when the direct-push samples were collected in May 1995.

1,1,1-Trichloroethane was also detected east of the Camden Street wellfield in the upper layer of the aquifer at USAF Plant 59 (Earth Tech, 1995b; appendix 6) at concentrations ranging from 1.2 to 20 µg/L. Unlike the 1,1,1-TCA concentrations that were measured in the area north of the Camden Street wellfield, these 1,1,1-TCA concentrations do not delineate a plume directed along the hydraulic gradient. A metabolite of 1,1,1-TCA—1,1-dichloroethane (1,1-DCA)—was detected at a concentration of 30 µg/L in the upper aquifer at well 674 (SW7), near the plant's production well (533), and at a concentration of 13 µg/L at the southwestern corner of the plant, in well 679 (IW9), which is screened in a zone between the upper and lower layers of the aquifer that responds relatively slowly to changes in ground-water levels. (See fig.7.) Concentrations of 1,1,1-TCA and 1,1-DCA in water from the plant's production well (screened in the lower layer) were 1 and 2 µg/L, respectively.

Trichloroethene (TCE) and Metabolite

Trichloroethene was detected in the upper layer of the aquifer north of the Camden Street wellfield, primarily along Field Street, where the highest concentration (68 µg/L) was at direct-push sample site F-13 (pl. 5). Trichloroethene concentrations downgradient of Field Street were less than 5 µg/L along Azon Road and less than 2 µg/L further downgradient, south of Main Street. The source of TCE contamination north of Field Street is unknown but probably lies within the same area indicated above as the source of 1,1,1-TCA contamination, that is, the area bounded by Field Street, Harry L. Drive, State Route 201, and Marie Street (pl. 5). Concentrations of TCE decrease sharply south of Azon Road, unlike concentrations of 1,1,1-TCA, which were measured at 5 to 10 µg/L along a flow path to the Camden Street wellfield.

Trichloroethene was also detected east of the Camden Street wellfield at USAF Plant 59 (Earth Tech, 1995b; appendix 6). The highest concentration (370 µg/L) was in a sample from well 669 (SW4) screened in the upper layer of the aquifer (appendix 6 and pl. 5). TCE concentrations in the lower layer of the aquifer were less than 2 µg/L, although the concentration at well 679 (IW9), screened in the zone between the upper and lower layers, was 20 µg/L. The highest concentrations of a TCE metabolite, *cis*-1,2-DCE, were 110 µg/L in the upper layer of the aquifer at well 674 (SW7) and 40 µg/L in the lower layer at well 666 (DW3). Concentrations of TCE and *cis*-1,2-DCE in water from the plant's production well (533), screened in the lower layer of the aquifer, were 4 and 13 µg/L, respectively.

Probable Sources of Contaminants in the Camden Street Wellfield

The area contributing ground water to the Camden Street wellfield contains two sites that have been contaminated with chlorinated hydrocarbons and four sites contaminated with petroleum hydrocarbons (see pls. 3, 4, and 5). 1,1,1-Trichloroethane is the only contaminant that has been detected at concentrations greater than 1 µg/L at Johnson City well no. 2 (well 208) since 1982 (Ronald Brink, written commun., 1994) and is also the contaminant that has migrated the farthest through the aquifer—from an unidentified source area north of Field Street, southward 3,000 ft to the Camden Street wellfield (section E-E′, fig. 9). The 1,1,1-TCA in water pumped from Johnson City well no. 2 is likely to have originated from this source. Additional direct-push sampling by the NYSDEC in 1996 has detected 1,1,1-TCA near the two industrial facilities along Field Street, but the source has still not been identified (Thomas Suozzo, written commun., June, 1996). Some of the 1,1,1-TCA detected in the Camden Street wellfield could have originated from the USAF Plant 59, but no clearly delineated plume of 1,1,1-TCA can be traced from the plant to the wellfield.

The principal contaminants at USAF Plant 59 are TCE and its metabolite, *cis*-1,2-DCE. These two compounds have not been detected (reporting limit of 1 µg/L) in water pumped from Johnson City well no. 2 (well 208), although the areas contaminated with these compounds at USAF Plant 59 are within 1,000 ft of the well (section F-F′, fig. 9). An aquifer test conducted by Earth Tech (1995a) at USAF Plant 59 demonstrated that drawdowns affected ground-water levels in the upper layer of the aquifer when the production well (533, screened in the lower layer) was pumped, indicating that the upper and lower layers are hydraulically connected near the plant. Well 533 was pumped for about 8.5 months from August 1994 through August 1995, as indicated by the water-level responses shown in figure 7. The area with the highest concentration of TCE (near the former plating room) is upgradient of well 533, suggesting that contaminants in the upper layer of the aquifer migrate downward to the lower layer during the months in which well 533 is pumped, and when well 533 is not pumped, contaminants in both the upper and lower layers migrate laterally toward Johnson City well no. 2.

The presence of *cis*-1,2-DCE in the lower layer of the aquifer at well 666 (DW3) along the western boundary of USAF Plant 59 and in the upper and lower layers of the aquifer at wells 638 and 637 (URS-2D and URS-2S) in the area between the plant and the Camden Street wellfield indicates some migration of *cis*-1,2-DCE from Plant 59 toward Johnson City well no. 2, probably when the production well at the plant (533) is not being pumped. The presence of *cis*-1,2-DCE and the absence of TCE at these locations suggest that degradation of TCE is occurring along a path from the upper layer of the aquifer to the lower layer beneath the plant. The observed distribution of contaminants suggests that much of the water pumped by Johnson City well no. 2 is derived from areas to the north, west, and south, where the aquifer thickness and, therefore, the aquifer transmissivity, is greater than beneath USAF Plant 59. The combined transmissivity of the upper and lower layers of the aquifer in the vicinity of the Camden Street wellfield is about 30,000 ft^2/d (URS Consultants, Inc., 1992), whereas the transmissivity of the lower layer beneath Plant 59 is only about 8,000 ft^2/d (Earth Tech, 1995a). Accordingly, water from Johnson City well no. 2 (well 208) that is derived from beneath Plant 59 is considerably diluted by water from other sources, and any resulting concentration of *cis*-1,2-DCE in water pumped from well 208 is below the reporting limit of 1 µg/L.

No aromatic hydrocarbons (benzene, ethylbenzene, toluene, and xylenes, referred to as BTEX compounds) that are derived from petroleum hydrocarbons have been detected at the Camden Street wellfield, even though these compounds are present in the upgradient areas along Azon Road in which 1,1,1-TCA was detected. This result is not surprising, in that BTEX compounds have been shown to bio-degrade within 1 to 2 years under anaerobic as well as aerobic conditions (Chapelle, 1993). The BTEX compounds probably created an anaerobic reducing environment within the upper layer of the aquifer, as suggested by the absence of dissolved oxygen in water sampled from well 651 (appendix 5 and pl. 1). Reductive

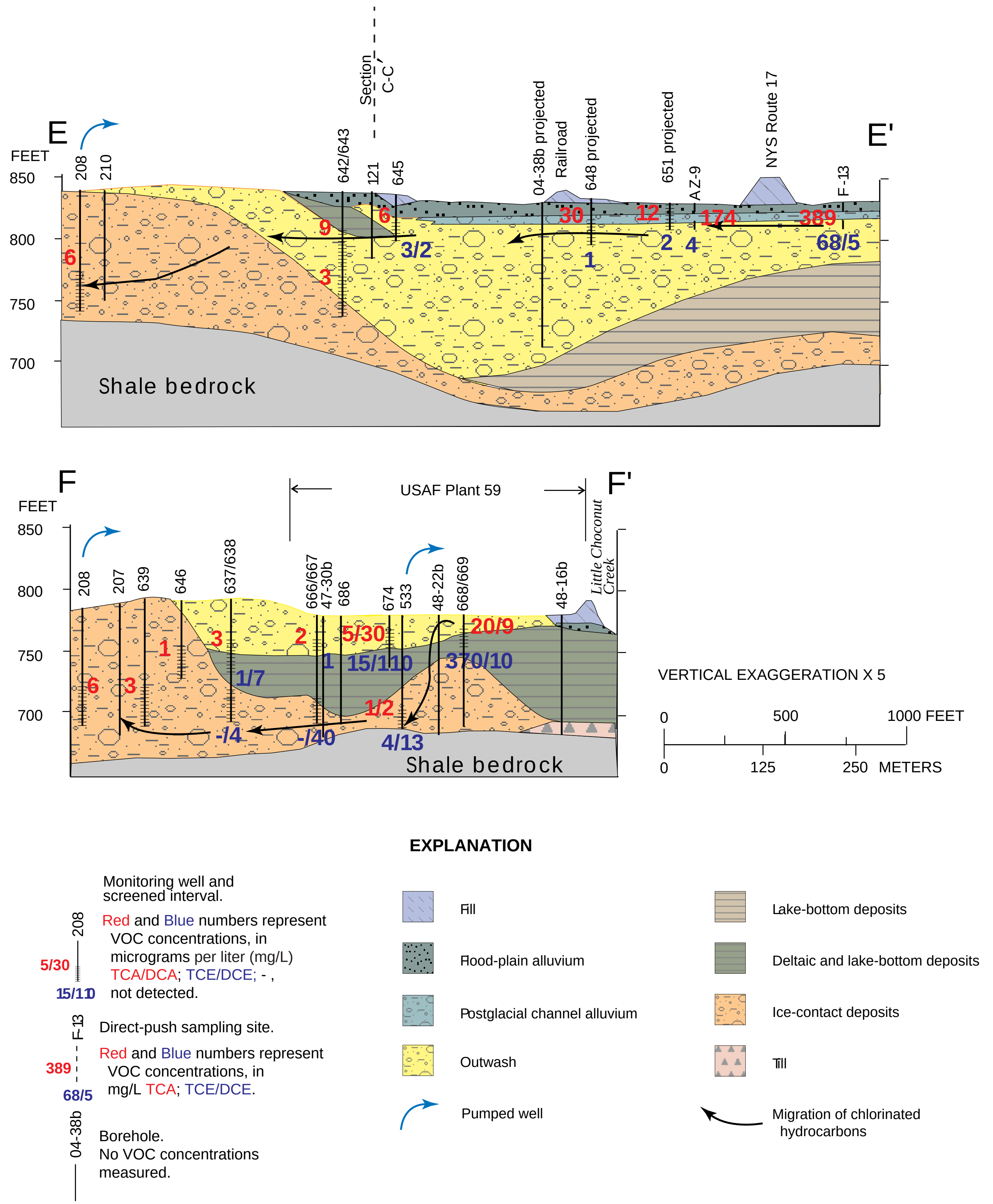


Figure 9. Geologic sections E-E′ and F-F′ extending from Camden Street wellfield, Johnson City, N.Y., showing concentrations of chlorinated hydrocarbons in upper and lower layers of the aquifer. (Trace of sections is shown on pl. 1.)

dechlorination of TCE can proceed within a reducing environment (Beeman and others, 1994) and would explain the limited migration of TCE from upgradient areas along Azon Road.

SUMMARY

The Clinton Street-Ballpark aquifer, which underlies a highly urbanized part of the Susquehanna River valley and extends from the western part of Binghamton to Johnson City, is the source of drinking water to the Village of Johnson City. In 1991, a chlorinated hydrocarbon, 1,1,1-trichloroethane (1,1,1-TCA), was detected at the Johnson City Camden Street wellfield in concentrations that exceeded New York State drinking-water standards. Several studies were conducted during 1991-95 to locate the source of 1,1,1-TCA contamination. Beginning in 1994, the USGS broadened the areal extent of the previous studies and collected water-level and water-quality data to delineate the areas that contribute ground water to municipal and industrial wells screened in the aquifer and to determine the areal distribution of 1,1,1-TCA in the western part of the aquifer.

The aquifer, which is generally 100 to 150 ft thick, consists primarily of extensive ice-contact deposits of silty sand and gravel that are overlain by sand and gravel outwash (Randall, 1986). These upper and lower layers are separated in some areas by lacustrine silt and clay deposits of variable thickness, which confine the lower unit. The lacustrine deposits have a lower vertical hydraulic conductivity than the ice-contact and outwash deposits and limit the vertical flow of water between them; in some places they contain minor coarse sand layers, however, which could provide a hydraulic connection between the upper and lower layers of the aquifer. Continuous recordings of water levels of the Susquehanna River and in four wells near the Camden Street wellfield and USAF Plant 59 were used to document the presence or absence of hydraulic connections between (1) the aquifer and the river; (2) the aquifer and the production wells at the Camden Street wellfield and USAF Plant 59; and (3) the upper and lower layers of the aquifer.

Ground water generally moves from upgradient areas along the aquifer boundaries toward two major pumping centers—the Anitec wellfield in Binghamton and the Camden Street wellfield in Johnson City. A ground-water divide near the municipal boundary between Binghamton and Johnson City separates areas of eastward flow toward the Anitec wellfield from areas of westward flow toward the Camden Street wellfield. A ground-water-flow model was used to delineate areas contributing recharge to municipal and industrial wells in the aquifer. The rate of ground-water movement through the aquifer was computed, and the residence time of ground water within the area contributing recharge to Johnson City production well no. 2 was calculated to be less than 6 years.

Water samples from wells were analyzed for selected inorganic constituents, and samples from wells and direct-push sampling sites were analyzed for volatile organic compounds (VOC's). The distribution of inorganic-chemical constituents does not parallel that of VOC's, indicating that the VOC's are probably derived from the release of a free-VOC product rather than from a waste-disposal area. Concentrations of 1,1,1-trichloroethane (1,1,1-TCA) in the upper layer of the aquifer increase northward and upgradient of the Johnson City Camden Street wellfield, parallel to the ground-water-flow path. The source of the 1,1,1-TCA is unknown but probably lies within the area bounded on the south by Field Street, on the north by Harry L. Drive, on the east by New York State Route 201, and on the west by Marie Street. 1,1,1-Trichloroethane was also detected east of the Camden Street wellfield in the upper layer of the aquifer at USAF Plant 59 at concentrations ranging from 5 to 20 µg/L, but no 1,1,1-TCA plume (identified by concentrations greater than 5 µg/L) can be delineated along the hydraulic gradient between the plant and the Camden Street wellfield.

Trichloroethene (TCE) was detected in the upper layer of the aquifer north of the Camden Street wellfield, primarily along Field Street. Concentrations of TCE decrease sharply south of Azon Road, unlike concentrations of 1,1,1-TCA. The source of TCE north of Field Street is unknown but probably lies within the area suspected as the source of 1,1,1-TCA. Trichloroethene was also detected east of the Camden Street wellfield at USAF Plant 59.

The principal contaminants at USAF Plant 59 are TCE and its metabolite *cis*-1,2-DCE, neither of which have been detected at levels greater than 1 µg/L in water pumped from Johnson City well no. 2. The presence of *cis*-1,2-DCE in the lower layer of the aquifer along the western boundary of USAF Plant 59 and in both the upper and lower layers in the

area between the plant and the Camden Street wellfield indicates that the upper and lower layers of the aquifer are hydraulically connected near the plant's well (533) and that c*is*-1,2-DCE has migrated from USAF Plant 59 toward Johnson City well no. 2. The relatively low concentrations of *cis*-1,2-DCE near the Camden Street wellfield (1 to 7 µg/L) are probably due to dilution of *cis*-1,2-DCE to below the detection limit by ground water from other parts of the area contributing recharge to Johnson City well no. 2.

The area contributing recharge to the Camden Street wellfield contains two sites that have been contaminated with chlorinated hydrocarbons and four sites contaminated with petroleum hydrocarbons. No aromatic hydrocarbons (BTEX compounds) that are derived from petroleum hydrocarbons have been detected at the Camden Street wellfield, although these compounds are present in the upgradient areas along Azon Road in which 1,1,1-TCA was detected.

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APPENDIXES

Appendix 1. Locations and descriptions of wells screened in Clinton Street-Ballpark aquifer, Broome County, N.Y.

[Locations are shown on pl. 1. , in., inch; ft, feet; NYS, New York State; JC, Johnson City; --, data not available.]

Well no.[1]	Latitude	Longi-tude	Local well identifier[2]	Owner[3]	Source of well log[4]	Well depth, in feet below land surface	Well diameter (inches) and casing material[5]	Well location and measuring point[6]	Elevation, in feet above sea level: Measuring point	Elevation, in feet above sea level: Land surface
121	420657	755835	BM121	USGS	A	53.0	6/S	Camden and Main St.; floor of recorder shelter.	838.86	835.4
143	420612	755547	BM117	USGS	A	50.0	6/S	Jarvis and Balcom St.; top of 2-in. hole in plug embedded in concrete	867.0	867.0
*147	420616	755519	--	Titchener	--	110	6/--	E.H. Titchener and Company, 67 Clinton St.	--	855
149	420617	755520	BM114	USGS	A	60.0	6/S	At curb side, 9 Titchener Place; top of 6-in. coupling.	855.8	856
152	420621	755625	BM101	USGS	A	42.0	6/S	Minerva St., in Jefferson schoolyard; top of 2-in. hole in plug atop 6-in. casing.	869.4	869
155	420626	755457	GS_K	USGS	A	107	6/S	Backyard, 259 Front St.	837.9	838
156	420627	755447	GS_J_D	USGS	A	118	6/S	At toe of dike behind 290 Front St.	843.5	842
*160	420628	755954	V_4-2	Vestal	X	138	16/--	Prentice Rd., Town of Vestal	--	856
*161	420629	755451	AN_G7	Anitec	A	106	24/--	276 Front St.	--	840
*166	420630	755518	AN_G10	Anitec	A	110	16/S	Elm and Mygatt St.; in pumphouse cellar.	831.2	840
*173	420631	755457	AN_G8	Anitec	A	123	24/S	Karlada Dr.; in pumphouse cellar.	833.4	842
*174	420631	755505	AN_G9	Anitec	A	100	24/S	Elm and Oak St.; in pumphouse cellar.	836.4	843
*175	420631	755513	AN_G6	Anitec	A	109	24/S	Elm and Spruce St.	---	838
176	420632	755455	BM115	USGS	A	49.0	6/S	At bend in Karlada Dr., northeast curb; top of 2-in. hole in plug atop bent 6-in. casing, low side.	840.5	840.3
180	420634	755644	BM116	USGS	A	61.0	2/S	Park St. and Grand Blvd.; top of 2-in. hole in plug atop 6-in. casing.	875.8	875.9
*183	420636	755542	AN_G3	Anitec	A	93.0	16/--	On property, Anitec, 40 Charles St.	--	851
*186	420637	755950	V_4-3	Vestal	A	113	16/--	Prentice Rd., Town of Vestal	--	827.0
*188	420638	755546	AN_G5	Anitec	A	118	18/--	On property, Anitec, 40 Charles St	--	845.0

1. Well number is a serial number assigned by the USGS to a well stored in the USGS Ground-water Site Inventory database; a separate series is used in each county. Asterisk (*) indicates a production well.
2. Local well identifier is a number assigned by its owner. Paired or nested wells are distinguished by the suffixes S, shallow; D, deep; or I, intermediate-depth.
3. Anitec, Imaging Products Division of International Paper Company (formerly GAF Corp.); Buckeye (Oil) Pipeline Company; IBM, International Business Machines Corp; JCPD, Johnson City Police Dept.; JCWD, Johnson City Water Dept.; Lockheed-Martin (formerly U.S. Air Force Plant 59); NYSDEC, New York State Department of Environmental Conservation; NYSEG, New York State Electric and Gas; (E.H.) Titchener and Company; United (Oil) Refining Company (Kwik Fill); USAF, U.S. Air Force; USGS, U.S. Geological Survey; Vestal, Town of; Wilson, Wilson Memorial Regional Medical Center.
4. Well logs can be found in: A. Randall (1972); B. This report, appendix 2; C. Martin (1983); D. Woodward-Clyde Consultants (1995b); E. Woodward-Clyde Consultants (1995a); F. URS Consultants, Inc. (1992); G. URS Consultants, Inc. (1993); H. Nashold and others (1994); I. Earth Tech (1996); and X. In files of owner.
5. S, steel; P, PVC.
6. Measuring point is top of casing unless otherwise specified. Detailed location information is available in Randall (1977) or in the files of the USGS, Ithaca, N.Y.

Appendix 1. Locations and descriptions of wells screened in Clinton Street-Ballpark aquifer, Broome County, N.Y. (continued)

Well no.[1]	Latitude	Longi-tude	Local well identifier[2]	Owner[3]	Source of well log[4]	Well depth, in feet below land surface	Well diameter (inches) and casing material[5]	Well location and measuring point[6]	Elevation, in feet above sea level	
									Measuring point	Land surface
190	420639	755520	BM113	USGS	A	49.8	6/S	Mygatt and Cypress St.; top of 2-in. well extension.	852.4	852.4
195	420642	755739	BM118	USGS	A	44.0	6/S	St Charles St.; top of 2-in. hole in plug atop 6-in. casing.	842.5	841.0
*196	420642	755944	V_4-4	Vestal	A	137	16/--	Prentice Rd., Town of Vestal	--	830.0
198	420643	755559	AN_G21T	Anitec	A	69.0	6/S	Backyard, 12 Jones St., top of 6-in. coupling.	842.3	839.9
199	420643	755809	BM119	USGS	A	53.0	6/S	Taylor St. and Riverside Dr.	842.57	843.0
201	420644	755605	AN_G23T	Anitec	A	44.0	2/S	Backyard, 47 Hazel St.,	841.2	841.0
203	420645	755613	AN_G24T	Anitec	A	54.0	2/S	Side yard, 11 Johnson St.	841.3	840.2
204	420646	755731	WH	Wilson	A	60.0	12/S	Baldwin St. and Corliss Av.; high point of casing.	846.2	847.0
*207	420646	755840	JC1	JCWD	A	100	25/S	Center air-line gage in pumphouse.	842.2	839
*208	420646	755842	JC2	JCWD	A	101	25/S	Center air-line gage in pumphouse.	838.9	835
*210	420647	755842	JC3	JCWD	A	89.0	25/S	Center air-line gage in pumphouse.	840.6	838
211	420651	755617	BM111	USGS	A	61.0	6/S	Lorraine Av., in Wilson schoolyard; top of 3-in. hole in plug atop 6-in. casing.	875.2	875.1
223	420702	755732	JC4	JCWD	A	98.0	20/S	Top of 1-in. hole in pump base.	839.99	838.5
*224	420703	755746	JC6	JCWD	A	117	20/S	Center air-line gage in pumphouse. Top of air-line hole in pump base plate.	839.9 839.95	838
225	420703	755749	JC4T	JCWD	A	101	6/S	Top of coupling.	837.10	836
226	420703	755757	JC3T	JCWD	A	117	6/S	High point of torch-cut casing.	838.95	831
*227	420703	755817	JC5	JCWD	A	109	15/S	Center air-line gage in pumphouse. Top of 1-in. pipe for air line in pump base.	838.5 836.08	834
228	420704	755803	JC2T	JCWD	A	115	6/S	Bottom edge of torch-cut hole in side of casing.	833.36	830
229	420704	755809	JC1T	JCWD	A	82.0	6/S	West of NYS Route 201. Well not found.	--	830
*231	420711	755724	JC7	JCWD	A	80.0	25/S	Center air-line gage in pumphouse. Top of 1-in. air-line hole in pump base plate.	842.52 841.19	840
233	420715	755655	GS_HLD	USGS	A	25.0	5/S	Harry L Dr. and Almond St.	857.1	857
*234	420716	755913	IBM1	IBM	A	46.0	8/S	Near northwest corner of east parking lot, IBM Country Club; bottom of vertical torch-cut slot in casing.	829.51	828
*236	420719	755910	IBM2	IBM	A	69.0	8/S	North of east parking lot, IBM Country Club; top of vent hole in sanitary seal.	828.46	828
237	420726	755841	BM120	USGS	A	53.0	6/S	Oakdale Rd. and Harry L Dr.; top of 2-in. hole in plug atop 6-in. casing.	841.53	841.5
*455	420640	755558	AN_G11	Anitec	A	91.0	16/--	Colfax Av. near intersection with May St.	--	841

Appendix 1. Locations and descriptions of wells screened in Clinton Street-Ballpark aquifer, Broome County, N.Y. (continued))

Well no.[1]	Latitude	Longi-tude	Local well identifier[2]	Owner[3]	Source of well log[4]	Well depth, in feet below land surface	Well diameter (inches) and casing material[5]	Well location and measuring point[6]	Elevation, in feet above sea level: Measuring point	Elevation, in feet above sea level: Land surface
*533	420649	755826	GE1	Lockheed-Martin	B	94.6	13/S	Along south wall, Lockheed-Martin Plant, 600 Main St.	--	829
596	420711	755724	--	JCWD	A	64.0	18/S	10 ft east of well 231 (JC7); top of 2-in. well extension in square depression in pumphouse floor.	840.1	840
597	420627	755447	GS_J_S	USGS	A	20.0	2.5/S	At toe of dike behind 290 Front St.	842.8	842
598	420648	755850	GS_HP_D	USGS	B	92.7	6/S	In Town of Union Hill Park.	823.69	819
599	420648	755850	GS_HP_S	USGS	B	24.0	1/S	do.	824.43	819
600	420641	755848	GS_IS_D	USGS	B	77.4	2/P	On island in Susquehanna River.	813.31	813
601	420641	755848	GS_IS_S	USGS	B	53.4	2/S	do.	814.00	813
602	420647	755917	TOV_4-23	Vestal	C	123	6/S	On property Barney and Dickenson gravel pit; chiseled square on east rim of 3-ft diameter concrete pipe. Well is about 8 ft below land surface.	841.16	841.2
603	420639	755906	TOV_4-28	Vestal	C	79.0	6/S	do; top of east side of casing.	821.10	819.4
604	420638	755608	AN_G25T	Anitec	A	90.0	6/S	Vacant lot at 12 Stanley St.; floor of recorder shelter.	860.2	860.0
605	420639	755630	AN_G27T	Anitec	A	75.0	2/S	Rear parking lot, 6 Emma St.	862.5	861.7
606	420641	755540	AN_NY-02D	Anitec	D	75.0	2/P	On property, Anitec, 40 Charles St.	846.50	846.83
607	420641	755540	AN_NY-02S	Anitec	D	38.0	2/P	do.	846.58	846.89
608	420621	755549	AN_8-02S	Anitec	D	43.0	2/P	Clinton and Jarvis St.	859.24	857.24
609	420633	755543	AN_30-01D	Anitec	D	74.0	2/P	On property, Anitec, 40 Charles St.	850.96	851.40
610	420633	755543	AN_30-01S	Anitec	D	39.0	2/P	do.	850.65	851.16
611	420627	755537	AN_32-02D	Anitec	D	102	2/P	do.	855.06	853.16
612	420630	755532	AN_105-01D	Anitec	D	67.0	2/P	do.	843.61	843.93
613	420630	755532	AN_105-01S	Anitec	D	33.0	2/P	do.	843.41	843.86
614	420637	755828	NYSEG_7601S	NYSEG	E	32.0	1/P	On property, Goudey Power Plant.	842.82	---
615	420644	755826	NYSEG_7603S	NYSEG	E	25.5	1/P	do.	834.57	---
616	420644	755822	NYSEG_8102S	NYSEG	E	31.5	4/P	do.	835.17	---
617	420644	755829	NYSEG_8501D	NYSEG	E	77.0	2/P	do.	834.85	---
618	420644	755830	NYSEG_8501S	NYSEG	E	37.0	2/P	do.	835.70	---
619	420644	755824	NYSEG_8504D	NYSEG	E	72.0	2/P	do.	835.26	---
620	420645	755837	NYSEG_8507D	NYSEG	E	48.0	2/P	do.	835.48	---
621	420645	755837	NYSEG_8507S	NYSEG	E	35.0	2/P	do.	835.77	---
622	420645	755836	NYSEG_8802D	NYSEG	E	55.0	2/P	do.	837.97	---

Appendix 1. Locations and descriptions of wells screened in Clinton Street-Ballpark aquifer, Broome County, N.Y. (continued)

Well no.[1]	Latitude	Longi-tude	Local well identifier[2]	Owner[3]	Source of well log[4]	Well depth, in feet below land surface	Well diameter (inches) and casing material[5]	Well location and measuring point[6]	Elevation, in feet above sea level	
									Measuring point	Land surface
623	420645	755834	NYSEG_8802S	NYSEG	E	30.0	2/P	do.	837.91	---
624	420638	755818	NYSEG_9009D	NYSEG	E	62.0	2/P	do.	838.86	---
625	420638	755818	NYSEG_9009S	NYSEG	E	---	2/P	do.	838.97	---
626	420641	755822	NYSEG_9010D	NYSEG	E	77.0	2/P	do.	836.79	---
627	420641	755822	NYSEG_9010S	NYSEG	E	---	2/P	do.	836.80	---
628	420712	755855	BPC_1	Buckeye	X	20.0	2/P	On property, Buckeye (Oil) Pipeline Co., Harry L Drive	831.63	829.10
629	420712	755856	BPC_5	Buckeye	X	20.0	2/P	do.	826.43	823.71
630	420709	755855	BPC_6	Buckeye	X	20.0	2/P	South of NYS Route 17 and Buckeye Oil facility.	825.36	822.62
631	420712	755854	BPC_7	Buckeye	X	20.0	2/P	On property, Buckeye (Oil) Pipeline Co., Harry L Drive	824.82	822.49
632	420648	755718	JCPD2	JCPD	X	66.5	2/P	South side of JC Police Department.	875.96	---
633	420648	755722	JCPD5	JCPD	X	55.0	2/P	At curb side, 52-58 Broad St.	873.70	---
634	420649	755719	JCPD11	JCPD	X	60.0	2/P	Between Goodwill Theater and Amsterdam Restaurant.	877.16	---
635	420653	755847	URS_1D	NYSDEC	F	91.0	2/S	In Town of Union Hill Park	824.92	824.91
636	420653	755847	URS_1S	NYSDEC	F	43.0	2/S	do.	824.91	825.12
637	420648	755834	URS_2D	NYSDEC	F	90.0	2/S	Backyard, 44 Avon St.	842.82	843.16
638	420648	755834	URS_2S	NYSDEC	F	60.0	2/S	do.	842.94	843.21
639	420647	755839	URS_3D	NYSDEC	F	95.0	2/S	On property, JC Water Department, Camden St.	844.17	841.70
640	420641	755854	URS_4D	NYSDEC	F	57.5	2/S	West bank, Susquehanna River.	824.85	822.43
641	420641	755854	URS_4S	NYSDEC	F	30.0	2/S	do.	824.31	822.00
642	420655	755836	URS_5D	NYSDEC	F	91.0	2/S	In front of garage adjacent to 9 Camden St.	835.24	835.53
643	420655	755836	URS_5S	NYSDEC	F	56.0	2/S	do.	835.12	835.57
644	420651	755845	URS_6D	NYSDEC	F	96.0	2/S	In Town of Union Hill Park.	824.28	824.70
645	420658	755836	URS_7S	NYSDEC	G	35.0	2/P	Main St. and Oakdale Rd.	835.49	---
646	420646	755836	URS_8I	NYSDEC	G	59.5	2/P	South end of Berwin St.	841.97	---
647	420655	755833	URS_9S	NYSDEC	G	30.0	2/P	Side yard, 8 Dayton St.	834.58	---
648	420705	755836	URS_10S	NYSDEC	G	34.5	2/P	South side of building, 100 Oakdale Rd.	829.93	---
649	420710	755836	AZON_1	NYSDEC	X	19.5	2/P	Parking lot, south side of Azon Rd.	827.27	---
650	420709	755836	AZON_2	NYSDEC	X	19.9	2/P	do.	827.36	---
651	420708	755835	AZON_3	NYSDEC	X	19.5	2/P	do.	826.40	---
652	420712	755837	AZON_6	NYSDEC	X	23.0	2/P	Vacant lot, 733 Azon Rd.	827.80	---
653	420711	755837	AZON_7	NYSDEC	X	23.0	2/P	do.	826.60	---

Appendix 1. Locations and descriptions of wells screened in Clinton Street-Ballpark aquifer, Broome County, N.Y. (continued))

Well no.[1]	Latitude	Longi-tude	Local well identifier[2]	Owner[3]	Source of well log[4]	Well depth, in feet below land surface	Well diameter (inches) and casing material[5]	Well location and measuring point[6]	Elevation, in feet above sea level: Measuring point	Elevation, in feet above sea level: Land surface
654	420657	755825	PED3	Pediatrics	X	25.0	2/P	639 Main St., west side of front parking lot.	833.89	834.18
655	420658	755825	PED2	Pediatrics	X	20.0	2/P	do; back of property.	828.81	829.14
656	420708	755911	SN2	Sun Oil	X	24.2	4/P	Sun Oil Co., Watson Blvd., rear of property.	839.13	835.70
657	420711	755912	SN4	Sun Oil	X	20.6	4/P	do, front of property.	834.11	831.00
658	420615	755519	TR1	Titchener	X	48.0	2/P	E.H. Titchener Co., 67 Clinton St.; low point of casing.	860.92	858.60
659	420617	755518	TR2	Titchener	X	43.0	2/P	do., low point of casing.	855.12	852.80
660	420615	755512	TR5	Titchener	X	44.0	2/P	do.	860.16	857.80
661	420722	755721	KF1	United	X	23.5	4/P	Kwik Fill station, Harry L Drive; low point of casing.	853.04	853.00
662	420721	755720	KF2	United	X	24.5	2/P	do; top of 2-in. tee.	853.46	853.70
663	420720	755721	KF8	United	X	21.2	2/P	do; low point of casing.	840.41	840.30
664	420655	755814	ARG_DW1	USAF	H	61.5	4/P	On property, Lockheed-Martin, 600 Main St.	834.57	831.83
665	420655	755814	ARG_SW1	USAF	H	28.3	2/P	do.	834.48	831.90
666	420649	755830	ARG_DW3	USAF	H	88.0	4/P	do.	829.04	829.42
667	420649	755830	ARG_SW3	USAF	H	29.8	2/P	do.	830.97	829.40
668	420649	755821	ARG_DW4	USAF	H	85.0	4/P	do.	828.78	829.05
669	420649	755821	ARG_SW4	USAF	H	29.0	2/P	do.	828.85	829.05
670	420656	755829	ARG_DW5	USAF	H	83.0	4/P	do.	835.97	836.24
671	420656	755829	ARG_SW5	USAF	H	30.5	2/P	do.	835.84	836.24
672	420651	755830	ARG_DW6	USAF	H	66.5	4/P	do.	828.51	828.95
673	420651	755830	ARG_SW6	USAF	H	29.0	2/P	do.	828.49	828.95
674	420649	755825	ARG_SW7	USAF	H	26.5	2/P	do.	831.89	828.88
675	420647	755817	ARG_DW8	USAF	H	93.0	4/P	do.	829.70	830.20
676	420647	755817	ARG_SW8	USAF	H	23.0	2/P	do.	829.85	830.20
677	420647	755831	ARG_DW9	USAF	H	88.0	4/P	do.	831.31	828.80
678	420647	755831	ARG_SW9	USAF	H	25.0	2/P	do.	831.38	828.80
679	420647	755831	ARG_IW9	USAF	H	51.0	2/P	do.	831.52	828.62
680	420653	755815	ET_DW10	USAF	I	90.3	2/P	do.	830.57	830.90
681	420653	755815	ET_SW10	USAF	I	25.0	2/P	do.	830.58	830.86
682	420648	755817	ET_DW11	USAF	I	79.3	2/P	do.	828.90	829.17
683	420648	755817	ET_SW11	USAF	I	23.5	2/P	do.	829.20	828.67
684	420647	755823	ET_DW12	USAF	I	84.8	2/P	do.	829.17	829.46

Appendix 1. Locations and descriptions of wells screened in Clinton Street-Ballpark aquifer, Broome County, N.Y. (continued)

Well no.[1]	Latitude	Longi-tude	Local well identifier[2]	Owner[3]	Source of well log[4]	Well depth, in feet below land surface	Well diameter (inches) and casing material[5]	Well location and measuring point[6]	Elevation, in feet above sea level: Measuring point	Elevation, in feet above sea level: Land surface
685	420647	755823	ET_SW12	USAF	I	27.0	2/P	do.	829.14	829.50
686	420648	755828	ET_DW13	USAF	I	84.3	2/P	do.	828.42	828.78
687	420648	755828	ET_SW13	USAF	I	28.7	2/P	do.	828.32	828.75
688	420648	755828	ET_IW13	USAF	I	35.8	2/P	do.	828.36	828.76
689	420648	755729	WH1	Wilson	X	---	2/P	On property, Wilson Hospital.	860.16	860.89
690	420648	755731	WH2	Wilson	X	---	2/P	do.	851.76	852.10
691	420649	755730	WH3	Wilson	X	---	2/P	do.	864.29	864.78
692	420652	755733	WH4	Wilson	X	---	2/P	do.	866.02	866.48
693	420652	755731	WH5	Wilson	X	---	2/P	do.	868.60	868.95
694	420649	755733	WH6	Wilson	X	---	2/P	do.	857.95	858.77
695	420715	755751	GS_9501D	USGS	B	53.0	2/P	Dedrich Av., west side of North Side Park.	837.76	837.76
696	420715	755751	GS_9501S	USGS	B	21.0	2/P	do.	837.48	837.83
697	420703	755809	GS_9502D	USGS	B	90.0	2/P	Riverside Dr. and Endwell St.	844.08	844.08
698	420703	755809	GS_9502S	USGS	B	26.0	2/P	do.	843.97	844.03
699	420721	755818	GS_9503	USGS	B	42.5	2/P	Southeast of Wegmans, Harry L Dr.	830.02	829.90
700	420701	755845	GS_9504	USGS	B	92.0	2/P	Main St., west of YMCA.	833.35	833.63
701	420704	755852	GS_9505	USGS	B	54.0	2/P	Route 17C, at Riverside Plaza.	827.91	828.19
702	420703	755746	GS_9506	USGS	B	60.0	2/P	At JC well No. 6.	837.89	838.02
703	420638	755824	NYSEG_9012S	NYSEG	E	39.0	2/P	On property, Goudey Power Plant.	839.33	---
704	420643	755814	NYSEG_8801D	NYSEG	E	76.0	2/P	do.	835.08	---
705	420641	755950	TOV_4-20	Vestal	C	119	6/S	On property Barney and Dickenson gravel pit.	--	--
706	420641	755906	TOV_4-21	Vestal	C	118	6/S	do.	--	--
707	420644	755912	TOV_4-22	Vestal	C	128	6/S	do.	--	--
708	420636	755907	TOV_4-24	Vestal	C	70	6/S	do.	--	--
709	420637	755908	TOV_4-25	Vestal	C	70	6/S	do.	--	--
710	420639	755901	TOV_4-26	Vestal	C	76	6/S	do.	--	--
711	420640	755903	TOV_4-27	Vestal	C	80	6/S	do.	--	--
712	420641	755904	TOV_4-29	Vestal	C	114	6/S	do.	--	--

APPENDIX 2. Logs of selected wells and boreholes in the Johnson City, N.Y. area

A. Wells logged by U.S. Geological Survey

[Locations of wells are shown on pl. 1. Logs of wells are based on examination of drill cuttings and cores by A.D. Randall (USGS). GWSINO, Ground-water Site Inventory well number; lat, latitude; long, longitude; ft, feet; in., inch; diam, diameter; gal/min, gallons per minute; PC, count of pebble-sized fragments, identified by lithology; local = gray or olive-gray shale or siltstone, similar to local bedrock; ls = limestone. Color described according to Munsell system as illustrated in Goddard and others (1970). Depths are in feet below land surface.]

IDENTIFICATION: **GWSINO 598**, local well identifier GS_HP_D

Location: Lat 42˚06´48˝, long 075˚58´50˝, in Town of Union Hill Park, Johnson City.

Driller, date drilled and method: Cato Pump and Well Drilling, November 1980 with cable tool.

Finished 6-in.-diam steel observation well, screened from about 83 to 93 ft with 5-in.-diam slotted PVC screen.

Depth to water at time of drilling: about 21 ft.

Land-surface elevation: 823 ft in 1980 (819 ft in 1995 due to river bank erosion).

Measuring point: Top of 6-in.-diam coupling; elevation, 823.69 ft.

Shallow well set in same hole: **GWSINO 599**, local well identifier GS_HP_S

Finished 1.25-in.-diam steel casing screened from 22 to 24 ft with 2-ft galvinized steel screen.

Measuring point: Top of 1-in.-diam coupling; elevation, 824.43 ft.

Depth interval	Materials penetrated
0 - 13 ft	Sand, very fine, and silt.
13 - 24 ft	Gravel, predominantly pebbles and small cobbles (60%), some coarse to very coarse sand varying from loose with trace of silt (less than 3%) to dense and firm with a little silt (greater than 5%); noncalcareous, oxidized, brown to light olive brown, water yielding. PC 86 local/ 0 ls/ 30 other.
24 - 28 ft	Sand, predominantly fine to medium (top), medium to very coarse (base); a few pebbles, loose, calcareous, predominantly shale-grain sand, water yielding. PC 61 local/ 6 ls/ 14 other.
28 - 30 ft	Silt, gray, unoxidized.
30 - 54 ft	Silt to silty fine to very fine sand, probably layered, unoxidized, dark gray, calcareous, shale-grain sand.
54 - 66 ft	Sand, fine to very fine, some silt, oxidized, olive brown, calcareous, water yielding (10 gal/min) 56 to 58 ft, siltier below.
66 - 76 ft	Silt, coarse, unoxidized, olive gray, calcareous.
76 - 81 ft	Sand, fine to very fine with some coarser sand and small well-rounded pebbles, shale-grain sand, calcareous; water yielding, bailed 30 gal/min for 20 min. with hole open 76 to 83 ft. PC 44 local/ 0 ls/ 4 other.
81 - 98 ft	Gravel and sand, predominantly silty to very silty but in part water yielding, and till; sand is drab, nearly all shale grains; stones are predominantly angular local shale that suggest transport by ice rather than water, augmented by a few well-rounded exotics and/or locals whose number seems to increase with depth. Overall PC 109 local/ 12 ls/ 12 other. Detailed subdivision approximately as follows. 81 - 83.5 ft: Sand, coarse to very coarse, and granule gravel, probably silty; water yielding, bailed 30 gal/min with hole open 76 to 83 ft. PC 10 local/ 0 ls/ 0 other. 83.5 - 88.4 ft: Till: stony sandy clayey silt, unoxidized, gray, weakly calcareous at top with thin streaks of weakly oxidized silty sand, PC 19 local/ 0 ls/ 0 other; calcareous at base, PC 27 local/ 2 ls/ 3 other. 88.4 - 93 ft: Sand, poorly sorted, predominantly fine with some coarser sand and a few pebbles, probably silty but water yielding, bailed 10 gal/min for 10 minutes with hole open 86 to 88.5 ft; bailed 30 gal/min briefly with hole open 89 to 90 ft. PC 24 local/ 3 ls/ 7 other. 93 - 98.5 ft: Gravel and coarse sand with 10 to 15% silt, dense and coherent from 94 to 94.5 ft and 98 to 98.5 ft, too stony for typical till; intervening sediment may contain less silty layers; bailed 3 gal/min with hole open 93 to 95 ft, again 3 gal/min with hole open 96 to 98 ft. PC 29 local/ 7 ls/ 2 other.

A. Wells logged by U.S. Geological Survey--continued

IDENTIFICATION: **GWSINO 600**, local well identifier GS_IS_D

Location: Lat 42˚06´41˝, long 075˚58´48˝, on gravel-bar island in Susquehanna River near Johnson City Camden Street wellfield.

Driller, date drilled and method: Parratt Wolff, Inc., November 1980 by rotary wash boring.

Finished 1.5.-in.-diam PVC casing 0 to 77 ft, screened from 77 to 85 ft with 1.5-in.-diam slotted PVC screen. Six-in.-diam, 5-ft steel sleeve and 4-in.-diam 22-ft steel sleeve placed around well at land surface to provide protection from debris.

Land-surface elevation: 813 ft.

Measuring point: Top of 1.5-in.-diam PVC coupling; elevation, 813.31 ft.

Shallow well set: **GWSINO 601**, local well identifier GS_IS_S

Finished 1.50-in.-diam steel casing 0 to 21 ft, PVC casing 21 to 45 ft, screened from 45 to 53 ft with 1.5-in.-diam slotted PVC screen.

Measuring point: Top of casing; elevation, 814.00 ft.

Depth interval	Materials penetrated
0 - 11 ft	Gravel (50 to 75%), includes large pebbles, and sand, mostly medium to very coarse with trace (1%) silt, except near the base where sand is fine to very coarse with somewhat more silt; noncalcareous, oxidized; sand is moderately drab, mostly shale grains, but some variety. PC 91 local/ 0 ls/ 18 other.
11 - 19 ft	Sand, medium to fine, clean to small trace silt, loose, oxidized, noncalcareous, predominantly drab, a few small pebbles. PC 6 local/ 0 ls/ 2 other.
19 - 20 ft	Gravel, small pebbles; some sand, mostly medium to very coarse, noncalcareous, virtually drab; a little silt (5%). Sand and pebbles are predominantly olive gray, unoxidized. PC 6 local/ 0 ls/ 2 other.
20 - 24 ft	Sand, probably fine, loose.
24 - 26 ft	Gravel and sand, drab, noncalcareous, unoxidized.
26 - 45 ft	Layered silt, very fine sandy silt, and fine to very fine sand, mostly unoxidized; coarser layers oxidized at 30 ft; medium to coarse sand layer at 30 ft; reddish gray clay layer 0.59 in. thick at 35 ft. All layers calcareous, sand is drab.
45 - 55 ft	Layered medium to coarse, fine to coarse, fine to medium, and very fine sands; variably silty, drab, calcareous, unoxidized.
55 - 76 ft	Silt, unoxidized, calcareous, with layers of silty fine to very fine sand 55 to 65 ft and layers of reddish-gray clay throughout.
76 - 80 ft	Sand, probably fine to very fine, a little silt, yields some water.
80 - 85 ft	Till, gray, unoxidized, drab, almost noncalcareous, contains angular shale stones.
85 - 87 ft	Bedrock, shale.

IDENTIFICATION: **GWSINO 695**, local well identifier GS_9501D

Location: Lat 42˚07´15˝, long 075˚57´51˝, at west end of Dedrich Street, North Side Park, Johnson City.

Driller, date drilled and method: USGS, April 24, 1995 with hollow-stem auger.

Finished 2-in.-diam PVC observation well, screened from 43 to 53 ft with 2-in.-diam, 0.01-in.-slotted PVC screen.

Depth to water at time of drilling: 17.4 ft

Land-surface elevation: 837.8 ft

Measuring point: Top of casing; elevation, 837.76 ft.

Shallow well set: **GWSINO 696**, local well identifier GS_9501S

Finished 2-in.-diam PVC well, screened from 11 to 21 ft with 2-in.-diam, 0.01-in.-slotted PVC screen.

Depth of water at time of drilling: 15.4 ft

Measuring point: Top of casing; elevation, 837.48 ft

A. Wells logged by U.S. Geological Survey--continued

Depth interval	Materials penetrated
0 - 6 ft	Fill, not sampled.
6 - 13 ft	Silt, traces of sand and pebbles, faint regular laminations, organic fibres, noncalcareous, very dark greyish brown.
13 - 22.5 ft	Gravel, well-rounded pebbles (75%); and sand, poorly sorted, silty, noncalcareous (top) to weakly calcareous (base), moderately bright. PC 41 local/ 0 ls/ 11 other.
22.5 - 23.5 ft	Sand, fine, trace of coarser sand, small fragments of organic matter, calcareous, brown; layer of light-gray fine sand with abundant organic matter (stems).
23.5 - 35 ft	Silt, laminated, calcareous, olive gray; layers of fine silt alternate with coarse silt to very fine sand. A few layers contain coarser sand; one layer with many small organic fragments and a few contorted pinkish-gray clay partings observed at 33 ft.
35 - 43 ft	Sand, predominantly fine (top), fine to coarse (base), bright, highly calcareous, generally clean.
43 - 45 ft	Sand, fine to coarse, pebbly, trace of silt, firm, calcareous, moderately bright. PC 24 local/ 2 ls/ 4 other.
45 - 54 ft	Gravel, coarse; some sand, moderately bright, calcareous; dense and silty. Samples are largely broken or ground-up fragments of rounded pebbles or cobbles, nearly all of which are local but include oxidized and unoxidized shale and siltstone lithologies. Sand contains more coarse to very coarse shale fragments than in samples above, but still includes bright particles of quartz and carbonates. Although the samples are quite dense and silt-bound, they are much stonier than upland till and contain all or mostly rounded stones. They provide no evidence that bedrock was reached. PC 40 local/ 0 ls/ 11 other.
At 56 ft	Refusal.

IDENTIFICATION: **GWSINO 697**, local well identifier GS_9502D

Location: Lat 42˚07´03˝, long 075˚58´09˝, about 140 ft northeast of intersection of Riverside Drive and Endwell Street.

Driller, date drilled and method: USGS, April 25, 1995 with hollow-stem auger.

Finished 2-in.-diam PVC observation well, screened from 80 to 90 ft with 2-in.-diam, 0.01-in.-slotted PVC screen.

Depth to water at time of drilling: 35.6 ft

Land-surface elevation: 844 ft

Measuring point: Top of casing; elevation, 844.08 ft.

Shallow well set: **GWSINO 698**, local well identifier GS_9502S

Finished 2-in.-diam PVC well, screened from 21 to 26 ft with 2-in.-diam, 0.01-in.-slotted PVC screen.

Measuring point: Top of casing; elevation, 843.97 ft.

Depth interval	Materials penetrated
0 - 15 ft	Gravel (65%), nearly all less than 1 inch, well rounded; and sand, fine to very coarse, bright, calcareous; slight trace of silt; traces of lime cement on some stones. PC 56 local/ 41 ls/ 32 other.
15 - 26.5 ft	Gravel and sand, as above except finer sand sizes are more abundant and silt content somewhat greater (about 3%). PC 58 local/ 13 ls/ 13 other.
26.5 - 70 ft	Silt, finely laminated, calcareous, oxidized dark yellowish brown; 26.5 to 30 ft, unoxidized olive gray below 30 ft to gray below 55 ft; interbedded with clay layers 0.20 to 0.98 in. thick, spaced 4 to 18 in. apart, weakly calcareous to noncalcareous, weak red to pinkish gray.
70 - 75 ft	Sand, poorly sorted but mainly coarse to very coarse, drab, weakly calcareous; and rounded gravel, pebble size (40%); silty (5%), dense and coherent; unoxidized gray. PC 14 local/ 2 ls/ 3 other.
75 - 90 ft	Gravel, coarse (60 to 80%); and sand, poorly sorted, drab, weakly calcareous, silty (5%), gray. PC 65 local/ 2 ls/ 5 other; most stones are broken fragments of large rounded pebbles.
At 90 ft	Refusal.

A. Wells logged by U.S. Geological Survey--continued

IDENTIFICATION: **GWSINO 699**, local well identifier GS_9503

Location: Lat 42˚07´21˝, long 075˚58´18˝, 70 ft southeast of southeast corner of Wegmans Supermarket parking lot on Harry L Drive, near toe of NYS Route 17 on-ramp embankment.

Driller, date drilled and method: USGS, April 25, 1995 with hollow-stem auger.

Finished 2-in.-diam PVC observation well, unscreened sump from 42.5 to 52.5 ft, screened from 32.5 to 42.5 ft with 2-in.-diam, 0.01-in.-slotted PVC screen.

Depth to water at time of drilling: 11.0 ft

Land-surface elevation: 829.9 ft

Measuring point: Top of casing; elevation, 830.02 ft.

Depth interval	Materials penetrated
0 - 7 ft	Silt, coarse, noncalcareous, brown grading down to yellowish brown.
7 - 10 ft	Silt, coarse, noncalcareous, mottled light gray and yellowish brown.
10 - 28 ft	Gravel (65%), mostly small pebbles and granules; some sand, mostly medium to very coarse, moderately bright, noncalcareous; trace of silt (2%), loose. PC 86 local/ 0 ls/ 25 other; most local stones from 24 to 25 ft unoxidized olive gray.
28 - 29(?) ft	Marl: light gray silt, dissolves totally in acid; thickness inexact because too little sample was recovered.
29 - 45 ft	Sand, loose, clean, calcareous, sparsely pebbly; upper few feet include medium to coarse sand, also fine to very fine sand interlayered with silty very fine sand, dark olive gray. PC 5 local/ 7 ls/ 3 other.
45 - 54 ft	Silt, laminated; coarse silt with some very fine sand interlayered with fine clayey silt; calcareous, dark gray; contains a few small scattered pebbles and several black layers that contain recognizable leaf and stem fragments, some of which look like spruce needles; organic odor noted throughout.

IDENTIFICATION: **GWSINO 700**, local well identifier GS_9504

Location: Lat 42˚07´01˝, long 075˚58´45˝, on south side of Main Street (Route 17C) in Westover about 100 ft west of the YMCA (740 Main Street).

Driller, date drilled and method: USGS, April 26, 1995 with hollow-stem auger.

Finished 2-in.-diam PVC observation well, unscreened sump from 92 to 97 ft, screened from 82 to 92 ft with 2-in.-diam, 0.01-in.-slotted PVC screen.

Depth to water at time of drilling: 22.8 ft

Land-surface elevation: 833.6 ft

Measuring point: Top of casing; elevation, 833.35 ft.

Depth interval	Materials penetrated
0 - 10.5 ft	Silt, brown, noncalcareous; grading downward to alternating layers 0.1 to 1-in. thick of silt, very fine sand, and one layer of pebbly medium to coarse sand.
10.5 - 22 ft	Gravel (50%), mostly small well-rounded pebbles; and sand, mainly medium to very fine, highly calcareous, bright; some lime cementation, unsaturated, light brown. (One clast of clay, weak red, perhaps derived from erosion of older lake deposits nearby.) PC 79 local/ 26 ls/ 44 other.
22 - 40 ft	Gravel (70% or more), pebble size; and sand, fine to very coarse, bright, highly calcareous, yellowish brown; small trace of silt, loose. PC 84 local/ 16 ls/ 19 other.
40 - 57 ft	Sand, loose, no sample recovery; accepted water readily at 47 ft.
57 - 75 ft	Gravel and sand, bright, highly calcareous; generally loose; silt content as much as 2%; layers of clean coarse sand. PC 46 local/ 9 ls/ 13 other.
75 - 87 ft	Gravel (80%), coarser than that above; some sand, very fine to very coarse, calcareous, predominantly drab; samples firm due to 3 to 5% silt; dark grayish brown. PC 45 local/ 0 ls/ 1 other.
87 - 99 ft	Sand, variably pebbly, very fine to very coarse, predominantly drab, calcareous, oxidized; firm layers with about 3 to 5% silt apparently alternate with layers of loose sand containing only a slight trace of silt; accepted water readily at 97 ft. PC 52 local/ 4 ls/ 3 other.

A. Wells logged by U.S. Geological Survey--continued

IDENTIFICATION: **GWSINO 701**, local well identifier GS_9505

Location: Lat 42˚07´04˝, long 075˚58´52˝, on south side of Route 17C near River Plaza, Westover, about 100 ft west of powerlines.

Driller, date drilled and method: USGS, April 27, 1995 with hollow-stem auger.

Finished 2-in.-diam PVC observation well, screened from 44 to 54 ft with 2-in.-diam, 0.01-in.-slotted PVC screen.

Depth to water at time of drilling: 17.0 ft

Land-surface elevation: 828.2 ft

Measuring point: Top of casing; elevation, 827.91 ft.

Depth interval	Materials penetrated
0 - 7 ft	Fill: soil, dark brown, overlying dark brown loamy gravel, overlying olive gray till (pebbly sandy silt).
7 - 17 ft	Silt, dark yellowish brown, noncalcareous.
17 - 29 ft	Gravel, pebble size, and sand, mainly medium to very coarse, bright, noncalcareous (top) to very weakly calcareous; loose and clean, dark yellowish brown. PC 27 local/ 0 ls/ 7 other.
29 - 60 ft	Gravel (80%), coarser than above; some sand, very fine to very coarse, calcareous, bright; loose, small trace (about 1 to 2%) silt; one layer of silt 0.16 in. thick and a few layers of firm gravel with greater silt content. May grade to pebbly sand 42 to 50 ft. PC 79 local/ 22 ls/ 31 other.
60 - 69 ft	Silt, laminated, noncalcareous, oxidized at top but unoxidized grayish brown below 62 ft; one layer red clay, 0.47 in. thick, included in samples.

IDENTIFICATION: **GWSINO 702**, local well identifier GS_9506

Location: Lat 42˚07´03˝, long 075˚57´4˝, 32 ft northeast of northeast corner of Johnson City pumphouse number 6.

Driller, date drilled and method: USGS, April 26, 1995 with hollow-stem auger.

Finished 2-in.-diam PVC observation well, unscreened sump from 60 to 70 ft, screened from 50 to 60 ft with 2-in.-diam, 0.01-in.-slotted PVC screen.

Depth to water at time of drilling: 16.2 ft

Land-surface elevation: 838.0 ft

Measuring point: Top of casing; elevation, 837.89 ft.

Depth interval	Materials penetrated
0 - 5 ft	Fill: loamy gravel.
5 - 8.5 ft	Silt, finely laminated, noncalcareous, grayish-brown, some layers silt with very fine sand; rusty mottling except near base.
8.5 - 9 ft	Silt, as above, with multiple peat layers that range from 0.47 in. thick to discontinuous partings with indistinct boundaries.
9 - 12 ft	Silt (inferred from auger operation).
12 - 30 ft	Gravel, variably large to small pebbles (65%); and fine to very coarse sand, bright, highly calcareous; large trace of silt (about 3%). Matrix color varies from weak red to reddish gray to brown. PC 53 local/ 44 ls/ 26 other.
30 - 35 ft	Sand, predominantly fine to coarse, bright, highly calcareous, clean to small trace of silt (1%), a few pebbles.
35 - 53 ft	Gravel, predominantly small pebbles (60%); and fine to very coarse sand, bright, highly calcareous; samples vary from nearly clean (less than 1% silt) to coherent with large trace of silt (3%); matrix in part reddish gray, in part brown. PC 34 local/ 29 ls/ 22 other.
53 - 63 ft	Sand, fine to very coarse, bright, highly calcareous, with 40% small pebbles, variably silty; interbedded with medium to fine sand and fine to very fine sand. PC 22 local/ 12 ls/ 2 other.

A. Wells logged by U.S. Geological Survey--continued

63 - 64 ft	Silt, coarse, some very fine sand, oxidized yellowish brown, noncalcareous, a few red partings, probably clayey.
64 - 68 ft	Silt, presumably; may be interlayered with sparsely pebbly fine sand.
68 - 71 ft	Silt, olive gray, calcareous, laminated; interbedded with clay, pinkish gray, as massive layers 0.12 to 0.20 in. thick and multiple very close partings, spaced 1 to 3 in. apart, calcareous. From 69 to 71 ft, laminations dip at about 25 degrees, suggesting collapse deformation.

B. Boreholes and wells logged by driller

[Locations of boreholes and wells are shown on pl. 1 and figs. 5, 6, or 9. Logs were recorded by driller. Lat, latitude; long, longitude; ft, feet; in., inch; diam, diameter; gal/min, gallons per minute; lb, pound. Local identifier is seconds of latitude and longitude. Depths are in feet below land surface.]

IDENTIFICATION: **GWSINO 533**, local well identifier GE1

Location: Lat 42˚06´49˝, long 075˚58´26˝, along south wall of U.S. Air Force Plant 59 (currently Lockheed-Martin, formerly General Electric Co.) at 600 Main St., 350 ft east of southwest corner of plant.

Driller, date drilled and method: Ehmke Well Drillers, May 1974 with cable tool.

Finished 13.25-in.-diam steel water-supply well, screened from 74.6 to 94.6 ft with 11.4-in.-diam slotted stainless steel screen (top 5 ft with no. 40 slot; bottom 15 ft with no. 80 slot).

Depth to water at time of drilling: 15.35 ft

Water yield: 24-hour pump test yielded 562 gal/min with drawdown of 45 ft.

Land-surface elevation: 829 ft

Measuring point: None.

Depth interval	Materials penetrated
0 - 1 ft	Top soil under sod.
1 - 20 ft	Sand and gravel, dry.
20 - 27 ft	Sand with large gravel, some water.
27 - 58 ft	Clay and gravel, dry.
58 - 65 ft	Gravel with some clay, some water.
65 - 94.6 ft	Sand and gravel, water bearing.
94.6 - 95.6 ft	Bedrock, shale.

IDENTIFICATION: local identifier **48-16**; other identifier B1

Location: Lat 42˚06´48˝, long 075˚58´16˝, southeast corner of U.S. Air Force Plant 59, 600 Main St.

Driller, date drilled and method: Catoh Environmental Companies, Inc., Nov. 25-27, 1985 with hollow-stem auger.

Depth interval	Materials penetrated
0 - 8 ft	Coarse to fine sand, little to some gravel, brown.
8 - 18 ft	Silt, fine sandy, trace gravel, brown (top) to gray, saturated at l5 ft.
18 - 79 ft	Silt, trace clay, gray; trace to little clay 50 to 65 ft.
79 - 82 ft	Sand, fine, silty, gray.
82 - 88 ft	Silt, trace clay, gray.
88 - 94 ft	Silt and gravel, gray, little sand, gray; 34 to 62 blows (with 140-lb hammer, 30-in. drop each blow) to drive 2-in.-diam sampler 0.5 ft.
97.5 ft	Refusal; drilled with 4-in. tricone rotary bit 92 to 97.5 ft.

B. Boreholes and wells logged by driller (continued)

IDENTIFICATION: local identifier **47-30**; other identifier B2

Location: Lat 42˚06´47˝, long 075˚58´30˝, 70 ft out from southwest corner of U.S. Air Force Plant 59, 600 Main St.

Driller, date drilled and method: Catoh Environmental Companies, Inc., Nov. 27, 1985 with hollow-stem auger.

Depth interval	Materials penetrated
0 - 8 ft	Gravel, coarse to fine, and sand, coarse to fine; little silt, brown; no spoon samples.
8 - 25 ft	Sand, silty, trace gravel, trace clay, brown; one spoon sample 20 to 22 ft.
25 - 47 ft	Sand, fine, brown; trace gravel at top; some silt at bottom; saturated.
47 - 51 ft	Sand and gravel, silty, brown, saturated.
51 - 65 ft	Silt, trace clay, gray.
65 - 80 ft	Sand, fine, silty, gray.
80 - 87 ft	Sand, fine, brown, saturated.
87 - 104 ft	Sand, fine, silty, trace gravel; sand and gravel, some silt; gray; 61 to 100 blows (with 140-lb hammer, 30-in. drop each blow) to drive 2-in.-diam sampler 0.5 ft.
104 ft	Refusal; drilled with 4-in. tricone rotary bit 90 to 104 ft.

IDENTIFICATION: local identifier **47-29**; other identifier B3

Location: Lat 42˚06´47˝, long 075˚58´29˝, 100 ft south of southwest corner of U.S. Air Force Plant 59, 600 Main St.

Driller, date drilled and method: Catoh Environmental Companies, Inc., Dec. 9-11, 1985 with hollow-stem auger.

Finished 2-in.-diam galvanized steel casing from 0.5 to 70 ft, screened from 70 to 75 ft with 2-in.-diam stainless steel screen.

Depth interval	Materials penetrated
0 - 8 ft	Ashes, cinders, sand, clay: fill.
8 - 28 ft	Sand, silty, little gravel, trace clay, brown; one spoon sample 18 to 20 ft.
28 - 33 ft	Sand, gravelly, brown; saturated.
33 - 38 ft	Sand, fine, trace silt, brown, saturated.
38 - 43 ft	Sand, gravelly, brown, saturated.
43 - 49 ft	Sand, fine, trace gravel, trace silt, brown, saturated.
49 - 70 ft	Sand, fine, trace silt, brown, wet.
70 - 82 ft	Silt, trace fine sand, trace clay, gray.
82 - 94 ft	Sand and gravel, silty, some clay, gray, wet; drilled with 4-in. tricone rotary bit 83 to 94 ft; 39 to 82 blows (with 140-lb hammer, 30-in. drop each blow) to drive 2-in.-diam sampler 0.5 ft.

IDENTIFICATION: local identifier **53-27**; other identifier B4

Location: Lat 42˚06´53˝, long 075˚58´27˝, 185 ft east of northwest corner of U.S. Air Force Plant 59, 600 Main St. (at inner corner on plant perimeter).

Driller, date drilled and method: Catoh Environmental Companies, Inc., Feb. 17-19, 1986 with hollow-stem auger.

Depth interval	Materials penetrated
0 - 20? ft	Gravel, coarse to fine, and sand, trace clay, brown; one spoon sample at 10 to 12 ft.
20? - 30? ft	Clay, fine silty, trace fine gravel and sand, gray.
30? - 100 ft	Sand, fine, silty, trace clay, gray; seam of medium to fine sand at 65 ft.
100 ft	Refusal.

B. Boreholes and wells logged by driller (continued)

IDENTIFICATION: local identifier **53-30**; other identifier B5

Location: Lat 42˚06´53˝, long 075˚58´30˝, 70 ft west of northwest corner of U.S. Air Force Plant 59, 600 Main St.

Driller, date drilled and method: Catoh Environmental Companies, Inc., Feb. 19, 1986 with hollow-stem auger.

Depth interval	Materials penetrated
0 - 26 ft	Sand, coarse to fine, some to little fine gravel, brown.
26 - 38 ft	Clay, silty, trace gravel at top, gray, wet.
38 - 56 ft	Sand, silty, trace clay, gray, wet.
56 - 68 ft	Sand, coarse to fine, trace fine gravel, little silt, gray; sand, fine, silty, trace gravel, gray; fine gravel, sandy, trace silt, gray; sand, coarse to fine, trace gravel, gray; gravel, sandy, layered with silty fine sand; continuous spoon samples in this interval.
68 - 94 ft	Silt, little clay, gray.
94 ft	Refusal.

IDENTIFICATION: local identifier **53-18**; other identifier B6

Location: Lat 42˚06´53˝, long 075˚58´18˝, 175 ft west of northeast corner of U.S. Air Force Plant 59, 600 Main St., (at inner corner on plant perimeter).

Driller, date drilled and method: Catoh Environmental Companies, Inc., April 1-3, 1986 with hollow-stem auger.

Depth interval	Materials penetrated
0 - 30 ft	(No spoon samples.)
30 - 45 ft	Gravel, medium to fine, sandy, brown, saturated.
45 - 57 ft	Sand, medium to fine, brown, saturated.
57 - 63 ft	Gravel, silty, little sand, few cobbles, brown, wet.
63 - 77 ft	Sand, fine, silty, gray, saturated.
77 - 98 ft	Gravel, sandy, some to little silt and clay, gray; 41 to 100 blows (with 140-lb hammer, 30-in. drop each blow) to drive 2-in.-diam sampler 0.5 ft.
98 - 98.2 ft	Shale, gray.

IDENTIFICATION: Local identifier **53-17**; other identifier B7

Location: Lat 42˚06´53˝, long 075˚58´17˝, 75 ft west of northeast corner of U.S. Air Force Plant 59, 600 Main St.

Driller, date drilled and method: Catoh Environmental Companies, Inc., May 6-8, 1986 with hollow-stem auger.

Depth interval	Materials penetrated
0 - 8 ft	Sand, fine, silty, trace clay, brown.
8 - 25 ft	(No spoon samples.)
25 - 35 ft	Sand, coarse to fine, and medium to fine gravel, trace silt, brown, saturated.
35 - 40 ft	Gravel, medium to fine, and fine sand, trace silt, brown, saturated.
40 - 63 ft	Sand, silty, little gravel; silt, sandy, little gravel; sand and gravel, silty; brown, wet.
63 - 85 ft	Sand, silty, little to trace gravel, brown.
85 - 87 ft	Silt, clayey, little sand and gravel, gray; 35 to 90 blows (with 140-lb hammer, 30-in. drop each blow) to drive 2-in.-diam sampler 0.5 ft.

B. Boreholes and wells logged by driller (continued)

IDENTIFICATION: Local identifier **48-22**; other identifier B8

Location: Lat 42˚06´48˝, long 075˚58´22˝, south side of U.S. Air Force Plant 59, 600 Main St., near center of building.

Driller, date drilled and method: Catoh Environmental Companies, Inc., May 8-12, 1986 with hollow-stem auger.

Depth interval	Materials penetrated
0 - 23 ft	Gravel, sandy, brown; no spoon samples.
23 - 36 ft	Silt, trace clay, gray, wet.
36 - 50 ft	Sand, coarse to fine, little medium to fine gravel, trace silt, brown.
50 - 65 ft	Sand, coarse to fine, trace gravel, brown; medium to fine sand with no gravel at 53 ft.
65 - 70 ft	Sand, fine, silty, brown, wet.
70 - 83 ft	Silt, gray, wet; trace very fine sand at base.
83 - 87 ft	Silt, little medium to fine gravel, gray.
87 - 92 ft	Sand, coarse, silty, trace clay, gray.
92 - 97 ft	Silt, some sand and gravel, gray; 60 to 90 blows (with 140-lb hammer, 30-in. drop each blow) to drive 2-in.-diam sampler 0.5 ft.
97 ft	Refusal.

IDENTIFICATION: Local identifier **41-05**; other identifier DH1

Location: Lat 42˚06´41˝, long 075˚58´05˝; near intersection of Riverside Drive and Corliss Ave.

Driller and date drilled: New York Department of Transportation, April 16-20, 1970.

Depth to water at time of drilling: 39 ft

Land-surface elevation: 858.6 ft

Depth interval	Materials penetrated
0 - 6 ft	Sand, some silt and gravel, very soft, nonplastic, brown.
6 - 20 ft	Sand and gravel, some silt, very loose, nonplastic, brown.
20 - 25 ft	Sand, some silt, trace gravel, soft, nonplastic, brown.
25 - 75 ft	Sand, some silt, soft, nonplastic, brown.
75 - 82 ft	Sand and gravel, some silt, medium compact, nonplastic, gray.

IDENTIFICATION: Local identifier **40-06**; other identifier DH2

Location: Lat 42˚06´40˝, long 075˚58´06˝; near intersection of Riverside Drive and Corliss Ave.

Driller and date drilled: New York Department of Transportation, April 21-23, 1970.

Depth to water at time of drilling: 18 ft

Land-surface elevation: 838.0 ft.

Depth interval	Materials penetrated
0 - 5 ft	Sand and gravel, some silt and fiber, trace wood, very loose, brown.
5 - 25 ft	Sand and gravel, some silt, very loose, nonplastic, brown.
25 - 30 ft	Sand, trace silt and gravel, soft, nonplastic, brown.
30 - 70 ft	Sand, some silt, soft, nonplastic, brown.

Appendix 3. Ground-water elevations during regional water-level surveys in the Johnson City - Binghamton, N.Y., area, August 23, 1994, and May 2, 1995

Locations are shown on pl. 1.   --, water level not measured.]

Well Number	Local well identifier	Ground-water elevation, in feet above sea level	
		August 23, 1994	May 2,1995
121	BM121	813.57	811.20
143	BM117	851.30	850.95
152	BM101	845.72	846.03
155	GS_K	826.21	824.78
156	GS_J_D	828.58	825.14
166	AN_G10	801.37	823.99
173	AN_G8	823.95	823.82
174	AN_G9	824.70	825.28
180	BM116	831.11	828.78
190	BM113	---	823.30
195	BM118	830.38	828.47
198	AN_G21T	821.24	819.92
199	BM119	821.19	820.69
201	AN_G23T	821.35	819.70
203	AN_G24T	822.12	820.60
204	WH	829.18	827.45
208	JC2	802.90	--
210	JC3	805.60	806.10
211	BM111	826.22	824.01
223	JC4	---	822.31
224	JC6	791.00	--
225	JC4T	---	817.60
226	JC3T	821.76	821.18
227	JC5	813.50	816.27
228	JC2T	---	818.22
231	JC7	819.50	823.22
233	GS_HLD	840.75	840.45
234	IBM1	---	816.81
237	BM120	821.69	823.49
597	GS_J_S	828.58	824.94
598	GS_HP_D	812.07	810.48
599	GS_HP_S	815.43	812.61
600	GS_IS_D	---	811.22
601	GS_IS_S	---	811.05
602	TOV_4-23	817.61	816.70
603	TOV_4-28	812.54	810.95
605	AN_G27T	827.36	828.23
606	AN_NY-02D	824.12	823.37
607	AN_NY-02S	824.17	823.49
608	AN_8-02S	826.78	827.17
609	AN_30-01D	823.33	823.42
610	AN_30-01S	823.11	823.33
611	AN_32-02D	823.91	825.34
612	AN_105-01D	823.81	825.65
613	AN_105-01S	823.64	825.43
614	NYSEG_7601S	816.90	814.93
615	NYSEG_7603S	813.82	811.39
616	NYSEG_8102S	815.71	813.88
617	NYSEG_8501D	813.51	810.54
618	NYSEG_8501S	813.19	810.95
619	NYSEG_8504D	814.81	812.09
620	NYSEG_8507D	811.58	810.13
621	NYSEG_8507S	812.31	809.81
622	NYSEG_8802D	811.68	809.67
623	NYSEG_8802S	811.71	809.62
624	NYSEG_9009D	818.50	817.03
625	NYSEG_9009S	818.58	817.18
626	NYSEG_9010D	815.73	813.81
627	NYSEG_9010S	815.95	814.13
628	BPC_1	---	816.09
629	BPC_5	815.23	815.33
630	BPC_6	814.56	814.54
631	BPC_7	816.17	--
632	JCPD2	829.49	827.24
633	JCPD5	829.04	827.04
634	JCPD11	829.60	827.56
635	URS_1D	812.83	810.85
636	URS_1S	813.34	811.08
637	URS_2D	812.31	810.15
638	URS_2S	812.24	810.21
639	URS_3D	808.88	809.44
640	URS_4D	814.70	812.45

Appendix 3. Ground-water elevations during regional water-level surveys in the Johnson City - Binghamton, N.Y., area, August 23, 1994, and May 2, 1995 (continued)

Well Number	Local well identifier	Ground-water elevation, in feet above sea level		Well Number	Local well identifier	Ground-water elevation, in feet above sea level	
		August 23, 1994	May 2,1995			August 23, 1994	May 2,1995
641	URS_4S	815.42	812.76	673	ARG_SW6	813.30	810.97
642	URS_5D	813.39	811.24	674	ARG_SW7	813.45	811.06
643	URS_5S	813.34	811.02	675	ARG_DW8	816.00	814.06
644	URS_6D	811.12	809.75	676	ARG_SW8	817.31	816.85
645	URS_7S	813.86	811.57	677	ARG_DW9	812.88	810.37
646	URS_8I	811.45	809.76	678	ARG_SW9	812.89	810.70
647	URS_9S	813.39	811.11	679	ARG_IW9	812.16	810.47
648	URS_10S	814.57	812.75	680	ET_DW10	---	830.57
649	AZON_1	---	815.57	681	ET_SW10	---	830.58
650	AZON_2	816.16	--	682	ET_DW11	---	813.78
651	AZON_3	815.70	814.99	683	ET_SW11	---	816.49
652	AZON_6	816.17	816.06	684	ET_DW12	---	829.17
654	PED3	---	813.83	685	ET_SW12	---	829.14
655	PED2	---	814.51	686	ET_DW13	---	828.42
656	SN2	814.55	814.18	687	ET_SW13	---	828.32
657	SN4	814.79	814.57	688	ET_IW13	---	828.36
658	TR1	821.24	824.03	689	WH1	827.98	826.48
659	TR2	821.24	824.03	690	WH2	828.02	826.50
660	TR5	825.28	827.25	691	WH3	827.94	864.29
661	KF1	837.34	836.49	692	WH4	827.42	826.00
662	KF2	837.46	837.48	693	WH5	827.52	826.03
663	KF8	826.40	827.86	694	WH6	827.87	826.39
664	ARG_DW1	816.29	814.89	695	GS_9501D	---	821.78
665	ARG_SW1	816.23	814.86	696	GS_9501S	---	821.96
666	ARG_DW3	813.66	810.26	697	GS_9502D	---	817.97
667	ARG_SW3	813.27	810.95	698	GS_9502S	---	820.44
668	ARG_DW4	815.52	813.33	699	GS_9503	---	819.04
669	ARG_SW4	815.55	813.61	700	GS_9504	---	811.24
670	ARG_DW5	814.35	812.21	701	GS_9505	---	811.64
671	ARG_SW5	813.43	811.84	702	GS_9506	---	822.91
672	ARG_DW6	813.61	811.02	703	NYSEG_9012S	---	815.50

Appendix 4. Volatile organic compounds detected in ground-water samples from monitoring wells in and near Johnson City, N.Y., August 19-25, 1994

[Locations of all wells are shown on pl. 1. Locations of wells where concentrations exceeded detection limit of the plotted constituent are shown on pls. 4 and 5. Suffixes, S, D, and I, where given in local well identifier, denote shallow, deep, and intermediate-depth wells, respectively. Concentrations in micrograms per liter, µg/L. Detection limit is 1.0 µg/L for all constituents. DCA, dichloroethane; DCE, dichloroethene; TCA, trichloroethane; TCE, trichloroethene; ---, no detection.]

Well Number	Local well identifier	Date sampled (1994)	Time	Methylene chloride	1,1-DCA	*cis*- and *trans*-1,2-DCE	Chloroform	1,1,1-TCA	Bromo-dichloro-methane	TCE	Dichloro-difluoro-methane
651	Azon-3	8/19	1030	---	---	---	---	12	---	2.0	---
652	Azon-6	8/22	0915	---	---	---	---	150	---	---	---
630	BPC-6	8/22	1205	1.1	---	---	---	---	---	---	---
636	URS-1S	8/16	0940	---	---	---	---	---	---	---	---
635	URS-1D	8/16	1250	---	---	---	---	---	---	---	---
638	URS-2S	8/17	1635	---	1.4	7.2	---	2.7	---	1.4	2.1
637	URS-2D	8/17	1530	---	---	3.7	---	---	---	---	---
639	URS-3D	8/17	0950	---	---	1.4	---	3.0	---	1.2	---
640	URS-4D	8/22	1515	---	---	---	---	---	---	---	---
641	URS-4S	8/22	1605	---	---	---	---	---	---	---	---
643	URS-5S	8/18	1600	---	---	---	---	8.6	---	---	---
642	URS-5D	8/18	1430	---	---	---	---	3.4	---	---	---
644	URS-6D	8/17	1250	---	---	---	---	---	---	---	---
645	URS-7S	8/18	1000	---	1.6	1.9	---	6.2	---	2.9	---
646	URS-8I	8/18	1220	---	---	---	8.5	1.2	2.4	---	---
647	URS-9S	8/19	1310	---	---	---	---	4.0	---	1.5	3.2
648	URS-10S	8/19	0850	---	1.6	---	---	30	---	1.3	---
208	JC-2	8/25	1125	---	---	---	---	5.5	---	---	---
615	NYSEG-7603S	8/23	1040	---	---	---	---	---	---	---	---
618	NYSEG-8501S	8/23	0830	---	---	---	---	---	---	---	---
617	NYSEG-8501D	8/23	0910	---	---	---	---	---	---	---	---
616	NYSEG-8102S	8/23	0945	1.1	---	---	---	---	---	---	---
621	NYSEG-8507S	8/23	1140	---	---	---	---	---	---	---	---
620	NYSEG-8507D	8/23	1215	---	---	---	---	---	---	---	---
195	BM118	8/25	0950	---	---	---	---	---	---	---	---
237	BM120	8/24	1315	---	---	---	---	---	---	---	---
599	GS-HP-S	8/23	1530	---	---	---	---	---	---	---	---
598	GS-HP-D	8/23	1620	---	---	---	---	---	---	---	---

Appendix 5. Inorganic water-quality constituents in ground-water samples from monitoring wells in and near Johnson City, N.Y., August 19-25, 1994

[Locations shown on pl. 1. Suffixes S, D, and I in local well identifier denote shallow, deep, and intermediate-depth wells, respectively. Concentrations are dissolved values, in milligrams per liter, mg/L, unless otherwise noted. DO, dissolved oxygen; spec. cond., specific conductance, in microsiemens per centimeter, µS/cm, at 25º C; Alk, total alkalinity; $CaCO_3$, calcium carbonate; Cl^-, chloride; NO_3^-, total nitrate; $SO_4^=$, sulfate; Ba, barium; Ca, calcium; Fe, iron; Mg, magnesium; Mn, manganese; Ni, nickel; K, potassium; Na, sodium; <, less than; ---, analysis not performed.]

Well no.	Local well identifier	Date sampled 1994	Tem-perature (˚C)	pH units	DO	Spec. cond. (µS/ cm)	Alk (mg/L as $CaCO_3$)	Cl^-	NO_3^-	$SO_4^=$	Ba	Ca	Fe	Mg	Mn	Ni	K	Na
651	Azon-3	8/19	15.5	6.6	0.0	1,020	254	176	<0.5	34.2	<0.10	106	3.3	18.7	2.1	<0.040	<5.0	70.3
652	Azon-6	8/22	14.5	6.8	0.6	972	231	173	1.20	31.4	<0.10	106	<0.04	18.8	<0.01	<0.040	<5.0	69.6
630	BPC-6	8/22	15.4	6.6	1.5	1,900	254	579	0.60	38.1	0.12	170	<0.04	24.8	<0.01	<0.040	<5.0	233
636	URS-1S	8/16	12.4	5.9	2.6	321	97	22.6	1.80	33.5	<0.10	42.0	<0.04	8.8	<0.01	<0.040	<5.0	16.4
635	URS-1D	8/16	16.0	7.2	0.3	376	120	40	<0.5	13.0	<0.10	51.6	0.077	8.1	0.37	<0.040	<5.0	14.1
638	URS-2S	8/17	16.0	7.2	3.3	1,080	255	137	0.95	124	<0.10	146	<0.04	23.2	0.014	0.059	<5.0	59.4
637	URS-2D	8/17	16.0	7.1	0.1	944	290	89.9	<0.5	104	<0.10	135	0.88	30.5	0.66	<0.040	<5.0	26.4
639	URS-3D	8/17	15.5	7.1	1.9	986	297	123	0.79	64.2	0.11	128	0.059	24.8	<0.01	<0.040	<5.0	48.9
640	URS-4D	8/22	12.8	7.5	0.2	239	82	17.9	<0.5	13.5	<0.10	30.5	<0.04	<5.0	1.40	<0.040	<5.0	11.5
641	URS-4S	8/22	13.5	6.1	0.2	207	68	15.9	<0.5	12.6	<0.10	24.7	0.064	<5.0	1.50	<0.040	<5.0	10.3
643	URS-5S	8/18	13.8	6.8	2.2	1,160	346	170	0.85	46.0	0.12	140	0.062	23.9	0.01	0.094	<5.0	68.8
642	URS-5D	8/18	13.5	7.1	0.9	1,100	341	150	<0.5	41.0	0.14	144	<0.04	27.2	<0.01	<0.040	<5.0	55.7
644	URS-6D	8/17	14.5	7.5	0.2	334	112	26.9	<0.5	19.0	<0.10	45.4	0.054	8.3	0.18	<0.040	<5.0	10.5
645	URS-7S	8/18	13.0	6.5	2.4	1,180	341	160	0.84	61.8	<0.10	151	<0.04	27.3	<0.01	<0.040	<5.0	71.5
646	URS-8I	8/18	15.3	7.2	3.7	1,080	262	148	1.30	113	<0.10	142	<0.04	22.5	<0.01	<0.040	<5.0	62.3
647	URS-9S	8/19	15.5	6.6	4.0	974	296	132	0.88	39.7	0.10	123	<0.04	19.5	<0.01	<0.040	<5.0	65.1
648	URS-10S	8/19	14.0	7.0	0.2	926	302	123	0.51	36.2	0.21	121	<0.04	22.1	0.051	<0.040	<5.0	37.0
208	JC-2	8/25	18.8	7.2	1.7	657	218	85	0.56	40.9	<0.10	98.9	<0.04	16.4	<0.01	<0.040	<5.0	34.4
618	NYSEG-8501S	8/23	15.5	6.1	0.0	1,430	329	142	<0.5	284	0.11	208	16.7	27.6	1.6	<0.040	5.9	55.1
617	NYSEG-8501D	8/23	15.0	6.6	0.0	1,270	411	66.4	<0.5	304	<0.10	212	2.80	49.6	2.6	<0.040	<5.0	26.0
616	NYSEG-8102S	8/23	11.5	6.5	3.5	356	129	24.2	<0.5	32.4	<0.10	51.0	<0.04	8.1	<0.01	<0.040	<5.0	18.1
621	NYSEG-8507S	8/23	15.0	7.5	0.5	545	200	40.4	0.88	50.6	<0.10	91.2	<0.04	10.9	<0.01	<0.040	<5.0	19.1
620	NYSEG-8507D	8/23	15.4	7.4	0.2	828	224	80.1	<0.5	126	<0.10	125	0.04	14.5	0.96	<0.040	<5.0	34.0
195	BM118	8/25	14.0	7.2	0.0	971	253	177	<0.5	61.2	0.11	140	0.18	31.7	0.87	<0.040	<5.0	37.7
237	BM120	8/24	16.0	7.2	1.1	1,350	210	329	2.80	47.4	<0.10	128	<0.04	24.3	0.011	<0.040	<5.0	127
599	GS-HP-S	8/23	21.4	7.2	0.0[a]	229	78	14.1	<0.5	13.9	<0.10	27.8	1.80	<5.0	0.23	<0.040	<5.0	15.1
598	GS-HP-D	8/23	15.0	8.1	0.1	225	88	18.7	<0.5	10.7	0.14	34.5	0.088	6.7	0.19	<0.040	<5.0	6.2
Susquehanna River		[b]	26.0	8.8	10.9	175	58	11	---	15	---	24	17	3.1	3	---	1.2	6.4

[a] DO assumed to be zero based on Fe concentration. Sample was too turbid to show color change.

[b] Surface-water sample collected near Kirkwood, N.Y. on August 31, 1984, and analyzed by U.S.Geological Survey National Water Quality Laboratory in Arvada, Colo.

Appendix 6. Volatile organic compounds detected in ground-water samples from monitoring wells at U.S. Air Force Plant 59, Johnson City, N.Y., December, 1994

[Data from Earth Tech (1995b). Locations of all wells are shown on pl. 1; locations of wells where concentrations exceeded detection limit of the plotted constituent are shown on pls. 4 and 5. Prefixes, S, D, and I, in local well identifier, denote shallow, deep, and intermediate-depth wells, respectively. Concentrations in micrograms per liter, µg/L; DCA, dichloroethane; DCE, dichloroethene; TCA, trichloroethane; TCE, trichloroethene; dup, duplicate sample, ---, no detection.]

		Constituent and method detection limit (µg/L)							
Well number	Local well identifier	1,1-DCA (0.18)	1,1-DCE (0.17)	*trans*-1,2-DCE (0.18)	*cis*-1,2-DCE (0.22)	1,1,1-TCA (0.10)	TCE (0.10)	Chloro-ethane (0.12)	Vinyl Chloride (0.13)
533	DPW	2.4	---	---	13	1.2	4.0	---	---
665	SW1	---	---	---	---	---	---	---	---
664	DW1	---	---	---	1.8	---	---	---	---
667	SW3	---	---	---	---	0.36[a]	1.2	---	---
666	DW3	0.26[a]	---	---	40[a]	---	---	---	0.28[a]
666	DW3-dup	---	---	---	36	---	---	---	---
669	SW4	8.5	2.1[a]	---	19	20	370	---	---
668	DW4	---	---	---	0.28[a]	---	1.2	---	---
671	SW5	---	---	---	---	---	---	---	---
670	DW5	---	---	---	---	---	---	---	---
673	SW6	1.6	---	---	10	2.3	1.8	---	---
672	DW6	---	---	---	---	---	---	---	---
674	SW7	30	1.0	0.3	110[a]	4.6	15	4.2	6.2
674	SW7-dup	33	---	---	150	5.2[a]	18	4.6	6.4[a]
676	SW8	---	---	---	0.75	---	0.47[a]	---	---
675	DW8	---	---	---	---	---	---	---	---
678	SW9	0.62[a]	---	---	0.67	1.8	2.4	---	---
679	IW9	13	---	---	5.4	---	20	0.51	1.0
677	DW9	---	---	---	---	---	---	---	---
681	SW10	2.2	2.0	---	---	10	21	---	---
680	DW10	---	---	---	---	0.35	---	---	---
683	SW11	6.0	---	---	2.6	9.1	0.34[a]	0.67	0.36[a]
683	SW11-dup	5.9	---	---	2.5	8.9	---	0.66[a]	---
682	DW11	---	---	---	---	---	---	---	---
685	SW12	---	---	---	0.50	---	---	---	0.30[a]
684	DW12	---	---	---	---	---	---	---	---
687	SW13	---	---	---	---	---	---	---	---
688	IW13	---	---	---	---	---	---	---	---
686	DW13	---	---	---	---	---	---	---	---

[a.] Analyte detected, but concentration is estimated.

Appendix 7. Volatile organic compounds detected in ground water obtained through direct-push sampling in and near Johnson City, N.Y., November 1994 and May 1995

[Locations of sampling sites where concentrations exceeded detection limit of the plotted constituent are shown on pls. 4 and 5. Concentrations in micrograms per liter, µg/L. Detection limit is 1.0 µg/L for all constituents except total FID volatiles, which is 10 µg/L. Xylenes concentrations are the sums of *ortho*-, *meta*-, and *para*-xylene concentrations for each sample. FID, flame ionization detector; ---, no detection.]

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A. Detection by gas chromatograph with flame-ionization detector

Sample identi-fication	Date	Time	Vinyl chloride	Acetone	Benzene	Toluene	Ethyl-benzene	Xylenes	Total FID volatiles[1]
5-1	11/5/94	1455	---	---	---	---	---	---	---
5-2	11/5/94	1528	---	---	---	---	---	---	---
5-3	11/5/94	1550	---	1.5	---	---	---	---	---
5-4	11/5/94	1632	---	13	---	---	---	---	---
5-5	11/5/94	1705	---	14	---	---	---	---	---
5-6	11/6/94	1408	---	---	---	---	---	---	---
5-7	11/6/94	1430	---	24	---	---	---	---	25
5-8	11/6/94	1455	---	137	---	---	---	---	138
5-8-A	11/8/94	1402	---	---	---	---	---	---	---
5-9	11/6/94	1535	---	3,710	---	---	---	---	2,800
5-9-A	11/9/94	0940	---	---	---	---	---	---	---
5-10	11/6/94	1605	---	---	---	---	---	---	---
5-11	11/6/94	1635	---	---	---	---	---	---	---
5-12	11/6/94	1702	---	20	---	2.6	---	2.6	76
AZ-1	11/6/94	0745	---	---	---	---	---	---	---
AZ-2	11/6/94	0810	---	10	20	30	69	119	1,580
AZ-3	11/6/94	0825	---	9.7	17	107	138	374	638
AZ-4	11/6/94	0907	774	4,010	1,890	7,840	3,790	16,200	185,000
AZ-5	11/6/94	0932	---	36	1.8	6.4	3.2	18	250
AZ-6	11/6/94	0950	---	---	---	---	---	---	---
AZ-7	11/6/94	1030	---	---	---	---	---	---	---
AZ-8	11/6/94	1048	---	---	---	---	---	---	---
AZ-9	11/6/94	1120	---	25	---	---	---	3.9	30
AZ-10	11/6/94	1145	---	---	---	---	---	---	---
AZ-11	11/6/94	1215	---	---	---	---	---	---	---
D-2	11/7/94	1245	---	---	---	---	---	---	---
D-3	11/7/94	1300	---	---	---	---	---	---	---
D-4	11/7/94	1340	---	9.3	---	---	---	---	---
D-5	11/7/94	1400	---	112	---	---	---	---	---
D-6	11/7/94	1425	---	---	---	---	---	---	---
D-7	11/7/94	1442	---	---	---	---	---	---	---
D-8	11/7/94	1500	---	1.3	---	---	---	---	---
D-9	11/7/94	1520	---	---	---	---	---	---	---
E-1	11/8/94	1505	---	---	---	---	---	---	---
E-2	11/8/94	1525	---	---	---	---	---	---	---
E-3	11/8/94	1550	---	---	---	---	---	---	---

Appendix 7. Volatile organic compounds detected in ground water obtained through direct-push sampling in and near Johnson City, N.Y., November 1994 and May 1995 (continued**)**

A. Detection by gas chromatograph with flame-ionization detector

Sample identi- fication	Date	Time	Vinyl chloride	Acetone	Benzene	Toluene	Ethyl- benzene	Xylenes	Total FID volatiles[1]
F-1	11/8/94	0740	---	1.2	---	---	---	---	---
F-2	11/8/94	0809	---	---	---	---	---	---	---
F-3	11/8/94	0828	---	---	---	---	---	---	---
F-4	11/8/94	0855	---	---	---	---	---	---	---
F-5	11/8/94	0910	---	---	---	---	---	---	---
F-6	11/8/94	0945	---	---	---	---	---	---	---
F-7	11/8/94	1017	---	---	---	---	---	---	---
F-8	11/8/94	1038	---	---	---	---	---	---	---
F-9	11/8/94	1100	---	---	---	---	---	---	---
F-10	11/8/94	1125	---	---	---	---	---	---	---
F-11	11/8/94	1207	---	---	---	---	---	---	---
F-12	11/8/94	1233	---	---	---	---	---	---	---
F-13	5/16/95	1520	12	2.7	---	---	---	---	145
F-14	5/16/95	1545	---	1.4	---	---	---	---	51
F-15	5/16/95	1615	---	---	---	---	---	---	19
F-16	5/16/95	1635	---	---	---	---	---	---	66
F-17	5/16/95	1730	---	---	---	---	---	---	68
F-18	5/16/95	1700	---	---	---	---	---	---	---
GF-1	5/19/95	1330	---	---	---	---	---	---	---
GF-2	5/19/95	1405	---	---	---	---	---	---	---
GF-3	5/19/95	1425	---	---	---	---	---	---	---
GF-4	5/19/95	1445	---	---	---	---	---	---	---
GF-5	5/19/95	1540	12	1.8	---	---	---	---	---
GF-6	5/19/95	1600	---	---	---	---	---	---	---
GW-1	5/18/95	1230	---	---	---	---	---	---	---
GW-2	5/18/95	1330	---	---	---	---	---	---	---
GW-3	5/18/95	1435	---	---	---	---	---	---	---
HL-1	5/16/95	1210	---	---	---	---	---	---	---
HL-12	5/18/95	1010	---	1.3	---	---	---	---	13
HL-13	5/18/95	0845	---	1.9	---	---	---	---	21
HL-14	5/17/95	1415	12	2.4	---	---	---	---	35
HL-15	5/17/95	1455	15	2.7	---	---	---	---	38
HL-16	5/17/95	1550	---	---	---	---	---	---	---
NP-1	5/19/95	0825	---	1.0	---	---	---	---	---
NP-2	5/19/95	0905	---	2.0	---	---	---	---	18
NP-3	5/19/95	0930	11	1.9	---	---	---	---	26
NP-4	5/19/95	1010	13	2.6	---	---	---	---	36
NP-5	5/19/95	1035	11	2.0	---	---	---	---	27
NP-6	5/19/95	1255	---	---	---	---	---	---	---
SW-1	5/19/95	1035	12	---	---	---	---	---	---
SW-2	5/19/95	1040	13	---	---	---	---	---	---
SW-3	5/19/95	1050	33	---	---	---	---	---	---
SW-4	5/19/95	1100	22	---	---	---	---	---	---

[1] Calculated from the sum of all integrated chromatogram peaks and the instrument response factor for toluene.

Appendix 7. Volatile organic compounds detected in ground water obtained through direct-push sampling in and near Johnson City, N.Y., November 1994 and May 1995 (continued)

[Locations of sampling sites where concentrations exceeded detection limit of constituent are shown on pls. 4 and 5. Concentrations in micrograms per liter, µg/L. Detection limit is 1.0 µg/L for all constituents. DCE, dichloroethene; DCA, dichloroethane; TCA, trichloroethane; TCE, trichloroethene; PCE, tetrachloroethene; NR, not reported; ---, no detection.]

B. Detection by gas chromatograph with electron-capture detector (continued)

Sample identifi-cation	Date	Time	1,1-DCE	*trans*-1,2-DCE	1,1-DCA	*cis*-1,2-DCE	1,1,1-TCA	TCE	PCE
5-1	11/5/94	1455	NR	---	---	---	---	---	---
5-2	11/5/94	1528	NR	---	---	---	1.5	---	---
5-3	11/5/94	1550	NR	---	---	---	---	---	---
5-4	11/5/94	1632	NR	---	---	---	---	---	---
5-5	11/5/94	1705	NR	---	---	---	---	---	---
5-6	11/6/94	1408	NR	---	---	---	1.2	---	---
5-7	11/6/94	1430	NR	---	---	---	---	---	---
5-8	11/6/94	1455	NR	---	---	---	---	---	---
5-8-A	11/8/94	1402	NR	---	---	---	---	---	---
5-9	11/6/94	1535	NR	---	---	---	---	---	---
5-9-A	11/9/94	0940	NR	---	---	---	---	---	---
5-10	11/6/94	1605	NR	---	---	---	---	---	---
5-11	11/6/94	1635	NR	---	---	---	---	---	---
5-12	11/6/94	1702	NR	---	---	---	---	---	---
AZ-1	11/6/94	0745	NR	---	---	---	55	---	---
AZ-2	11/6/94	0810	NR	---	---	---	9.7	---	---
AZ-3	11/6/94	0825	NR	---	---	---	12	---	---
AZ-4	11/6/94	0907	NR	---	---	---	18	1.3	1.3
AZ-5	11/6/94	0932	NR	---	---	---	12	---	---
AZ-6	11/6/94	0950	NR	---	2.3	---	23	---	---
AZ-7	11/6/94	1030	NR	---	---	---	158	2.3	---
AZ-8	11/6/94	1048	NR	---	---	---	136	3.5	---
AZ-9	11/6/94	1120	NR	---	---	---	174	4.0	1.6
AZ-10	11/6/94	1145	NR	---	---	---	53	1.5	---
AZ-11	11/6/94	1215	NR	---	---	---	31	4.7	3.3
D-2	11/7/94	1245	NR	---	---	---	---	---	---
D-3	11/7/94	1300	NR	---	---	---	---	---	---
D-4	11/7/94	1340	NR	---	---	---	---	---	---
D-5	11/7/94	1400	NR	---	---	---	---	---	---
D-6	11/7/94	1425	NR	---	---	---	---	---	---
D-7	11/7/94	1442	NR	---	---	---	---	---	---
D-8	11/7/94	1500	NR	---	---	---	---	---	---
D-9	11/7/94	1520	NR	---	---	---	---	---	---
E-1	11/8/94	1505	NR	---	---	---	---	---	---
E-2	11/8/94	1525	NR	---	---	---	---	---	---
E-3	11/8/94	1550	NR	---	---	---	---	---	---
F-1	11/8/94	0740	NR	---	---	---	---	---	---

Appendix 7. Volatile organic compounds detected in ground water obtained through direct-push sampling in and near Johnson City, N.Y., November 1994 and May 1995 (continued)

B. Detection by gas chromatograph with electron-capture detector (continued)

Sample identification	Date	Time	1,1-DCE	*trans*-1,2-DCE	1,1-DCA	*cis*-1,2-DCE	1,1,1-TCA	TCE	PCE
F-2	11/8/94	0809	NR	---	---	---	---	---	---
F-3	11/8/94	0828	NR	---	---	---	---	---	---
F-4	11/8/94	0855	NR	---	---	---	---	---	---
F-5	11/8/94	0910	NR	---	---	---	1.8	---	---
F-6	11/8/94	0945	NR	---	---	---	4.9	---	---
F-7	11/8/94	1017	NR	---	---	---	37	1.1	---
F-8	11/8/94	1038	NR	---	---	---	445	---	---
F-9	11/8/94	1100	NR	---	---	---	104	13	---
F-10	11/8/94	1125	NR	---	---	---	170	24	---
F-11	11/8/94	1207	NR	---	---	---	112	31	---
F-12	11/8/94	1233	NR	---	---	---	79	34	---
F-13	5/16/95	1520	19	---	---	5.0	389	68	---
F-14	5/16/95	1545	3.6	---	---	1.8	99	40	---
F-15	5/16/95	1615	1.4	---	---	---	41	16	---
F-16	5/16/95	1635	---	---	---	---	9.7	2.9	---
F-17	5/16/95	1730	---	---	---	---	10	2.5	---
F-18	5/16/95	1700	---	---	---	---	---	---	---
GF-1	5/19/95	1330	---	---	---	---	---	---	---
GF-2	5/19/95	1405	---	---	---	---	---	---	---
GF-3	5/19/95	1425	---	---	---	---	---	---	---
GF-4	5/19/95	1445	---	---	---	---	---	---	---
GF-5	5/19/95	1540	---	---	---	---	---	---	---
GF-6	5/19/95	1600	---	---	---	---	---	---	---
GW-1	5/18/95	1230	---	---	---	---	---	---	---
GW-2	5/18/95	1330	---	---	---	---	---	---	---
GW-3	5/18/95	1435	---	---	---	---	---	---	---
HL-1	5/16/95	1210	---	---	---	---	---	---	---
HL-12	5/18/95	1010	---	---	---	---	---	---	---
HL-13	5/18/95	0845	1.2	---	---	---	---	---	---
HL-14	5/17/95	1415	---	---	---	1.2	---	---	---
HL-15	5/17/95	1455	---	---	---	---	1.7	---	---
HL-16	5/17/95	1550	---	---	---	4.3	---	---	---
NP-1	5/19/95	0825	---	---	---	---	---	---	---
NP-2	5/19/95	0905	---	---	---	---	---	---	---
NP-3	5/19/95	0930	2.1	---	---	---	1.3	1.1	---
NP-4	5/19/95	1010	1.7	---	---	---	1.1	---	---
NP-5	5/19/95	1035	---	---	---	---	---	---	---
NP-6	5/19/95	1255	---	---	---	---	---	---	---
SW-1	5/19/95	1035	---	---	---	---	---	---	---
SW-2	5/19/95	1040	---	---	---	---	---	---	---
SW-3	5/19/95	1050	---	---	---	---	---	---	---
SW-4	5/19/95	1100	---	---	---	---	---	---	---