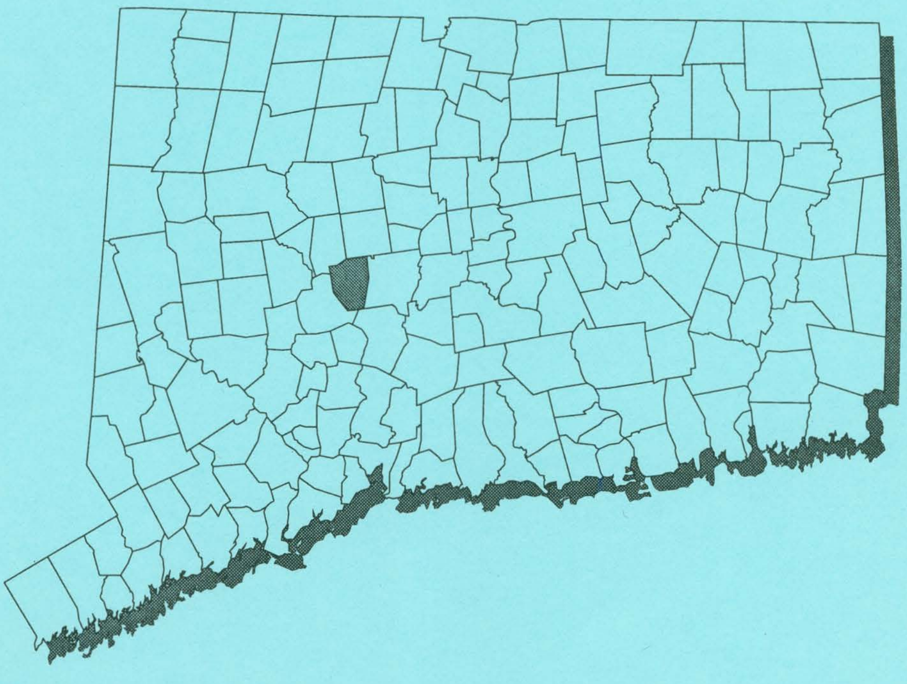
Preliminary Hydrogeologic Assessment of a Ground-Water Contamination Area in Wolcott, Connecticut

U.S. GEOLOGICAL SURVEY

Open-File Report 97-219



Prepared in cooperation with

THE TOWN OF WOLCOTT, CONNECTICUT

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By Janet Radway Stone, George D. Casey, Remo A. Mondazzi, and Timothy W. Frick

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Hartford, Connecticut
1997

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
Gordon P. Eaton, Director

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CONTENTS

PLATES

[Plates are in pocket]

FIGURES

TABLES

CONVERSION FACTORS

Multiply	By	To obtain
inch (in)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
foot per day (ft/d)	0.3048	meter per day
foot squared per day (ft^2/d)	0.09290	square meter per day
cubic feet per second (ft^3/s)	0.02832	cubic meter per second
cubic foot per second per square mile ($ft^3/s/mi^2$)	0.01093	cubic meter per second per square kilometer
foot per mile (ft/mi)	0.1894	meter per kilometer
gallon per minute (gal/min)	0.06309	liter per second
million gallons per day (Mgal/d)	0.04381	cubic meter per second

Temperature in degrees Fahrenheit (°F) can be converted to degrees Celsius (°C) as follows:
°C = 5/9 (°F - 32).

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.

Other abbreviations used:

mg/L, milligrams per liter
(ft^3/s)/mi, cubic feet per second per square mile
µS/cm, microsiemens per centimeter at 25 degrees Celsius

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ABSTRACT

Contamination of ground water by volatile organic compounds and inorganic constituents has been identified at a number of industrial sites in the Town of Wolcott, Connecticut. Contamination is also present at a municipal landfill in the City of Waterbury that is upgradient from the industrial sites in the local ground-water-flow system.

The study area, which lies in the Western Highlands of Connecticut, is in the Mad River Valley, a tributary to the Naugatuck River. Geohydrologic units (aquifer materials) include unconsolidated glacial sediments (surficial materials) and fractured crystalline (metamorphic) bedrock. Surficial materials include glacial till, coarse-grained and fine-grained glacial stratified deposits, and postglacial floodplain alluvium and swamp deposits. The ground-water-flow system in the surficial aquifer is complex because the hydraulic properties of the surficial materials are highly variable. In the bedrock aquifer, ground water moves exclusively through fractures. Hydrologic characteristics of the crystalline bedrock—degree of confinement, hydraulic conductivity, storativity, and porosity—are poorly defined in the study area. Further study is needed to adequately assess ground-water flow and contaminant migration under current or past hydrologic conditions.

All known water-supply wells in the study area obtain water from the bedrock aquifer. Twenty households in a hillside residential area on Tosun Road currently obtain drinking water from private wells tapping the bedrock aquifer. The extent of contamination in the bedrock aquifer and the potential for future contamination from known sources of contamination in the surficial aquifer is of concern to regulatory agencies.

Previous investigations have identified ground-water contamination by volatile organic compounds at the Nutmeg Valley Road site area. Contamination has been associated with on-site disposal of heavy metals, chlorinated and non-chlorinated volatile organic compounds, and cyanide. Concentrations of volatile organic compounds detected in water samples collected from bedrock wells during 1981-95 at the Nutmeg Valley Road site area show a general downward trend through time. Water samples collected from wells completed in surficial materials were not collected systematically, and a trend in concentration cannot be identified.

INTRODUCTION

Ground-water contamination by volatile organic compounds (VOC's) and inorganic constituents has been identified in an industrialized area along the Route 69 corridor near the Wolcott/Waterbury town line. The 0.75-mi^2 site area (informally referred to as "Nutmeg Valley") in the Town of Wolcott, Connecticut, contains light industrial and rural residential properties. Approximately 43 industries and 25 residences use ground water as a source of drinking water in the site area, and contamination at the industrial sites has been implicated in the subsequent contamination of residential wells. In addition, a Waterbury municipal landfill (North End Disposal Area), upgradient in the ground-water-flow system, may have affected the water quality of the area.

In response to several reportedly contaminated wells and to a hazardous-waste inventory conducted by the Connecticut Department of Environmental Protection (DEP), an investigation into the nature, extent, and probable source(s) of the ground-water contamination was conducted by State and local officials during 1979-81. During this study, 21 of 90 wells sampled were found to contain contaminants above the Connecticut site-action levels (Connecticut Department of Health Services, 1981). Several of these wells were located in Nutmeg Valley. In 1984, the Chesprocott Health District received preventative health block-grant funds from the State of Connecticut for a water-supply testing program. Sampling under this block-grant contract during 1984-85 confirmed that ground-water contamination was present in several wells and identified four additional contaminated wells in Nutmeg Valley (Chesprocott Health District, 1985). On March 31, 1989, an area around Nutmeg Valley Road, near the Nutmeg Screw Machine Products Company[1] (15 Nutmeg Valley Road) (plate 1), was listed as a Superfund site on the U.S. Environmental Protection Agency (USEPA) National Priorities List (NPL). Another water-quality survey conducted by USEPA and DEP in 1995 indicated VOC contamination at 4 of 36 wells sampled (Connecticut Department of Environmental Protection, 1995; U.S. Environmental Protection Agency, 1995).

In 1995-96, the U.S. Geological Survey (USGS), in cooperation with the Town of Wolcott and the USEPA, reviewed existing hydrogeologic and water-quality information and collected new hydrogeologic data near the contaminated areas. The results of the investigation are presented in this report, which summarizes the geology, hydrology, and history of ground-water contamination at the site, as well as the geohydrologic framework of the regional area. This report presents information that is known or can reasonably be inferred about water quality and hydrogeologic conditions in the site area. This information was used to develop a preliminary conceptual model of ground-water flow near the contaminated areas; the conceptual model was developed to guide future geohydrologic and geochemical data collection to improve the understanding of ground-water flow and contaminant migration in the area.

In this report, the term "Nutmeg Valley Road site area" or "site area" refers to the area near Nutmeg Valley Road, Tosun Road, Tosun Road Extension, Town Line Road, Wolcott Road (Rt. 69), Venus Drive, and Swiss Lane in the Town of Wolcott. The term "Wolcott study area" or "study area" refers to the larger, regional geohydrologic setting in which the site area is located that includes part of the City of Waterbury.

[1]The use of trade, product, industry, or firm names in this report is for descriptive or location purposes only and does not constitute endorsement of products by the U.S. Government nor impute responsibility for any present or potential effects on the natural resources.

GEOLOGIC FRAMEWORK

The Wolcott study area is located in central Connecticut, near the eastern edge of the Western Highlands of Connecticut (fig. 1). The study area straddles the boundary between the Southington and Waterbury 7.5' quadrangles (USGS 1:24,000-scale topographic maps).

Physiography

The Western Highlands are formed by till-blanketed bedrock hills that reach altitudes from 600 to 1,000 ft near the study area and relatively narrow bedrock valleys that are partially filled with glacial meltwater deposits (stratified drift). The study area is in the drainage basin of the Naugatuck River, a major south-flowing tributary to the lower Housatonic River (fig. 1), and centers around the confluence of the Mad River and its tributary, Old Tannery Brook (fig. 2). North of the study area, the Mad River occupies a narrow, steep-gradient bedrock valley; it descends from an altitude of about 900 ft at its headwaters in southwestern Bristol over a distance of about 4 mi to an altitude of 500 ft as it exits Scovill Reservoir at the village of Woodtick, just northeast of the site area. Old Tannery Brook descends from an altitude of 650 ft at its headwaters in Chestnut Hill Reservoir over a distance of 1.5 mi to an altitude of 475 ft at USGS streamflow-gaging station 01208280 (station 4 in fig. 2). These are steep gradients of about 100 ft/mi.

In the site area, the valley widens to approximately 0.5 mi, and the Mad River and Old Tannery Brook have much lower gradients and flow over glacial stratified deposits. From the northern end of the site area and continuing for about 1 mi to the south, the Mad River and its adjacent flood plain slope from about 465 ft altitude to 455 ft—a gradient of only 10 ft/mi. Steep hillsides rise from the valley floor to the west,

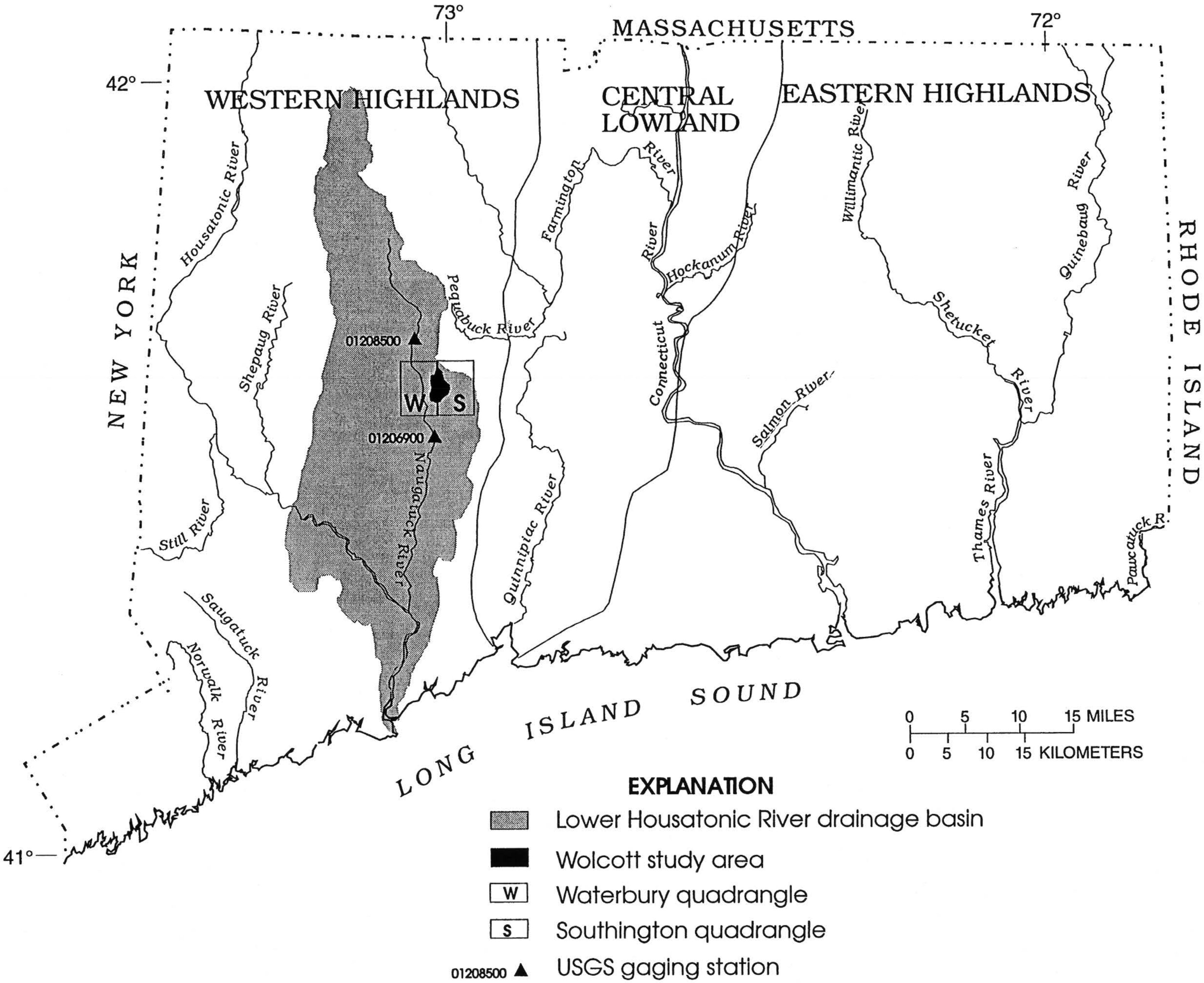


Figure 1. Physiographic subdivisions of Connecticut, the lower Housatonic River Basin, and the Wolcott study area.

north, and east of the site area. The top of a hill on the western side of the site area reaches 730 ft in altitude and is occupied by a Waterbury municipal landfill (North End Disposal Area). Another hilltop to the north of the site is at 650 ft altitude; Bald Hill, to the east, reaches altitudes of 620 to 650 ft.

Bedrock

Metamorphic bedrock in the study area is early Paleozoic (probably Ordovician) in age and consists of gray granulitic gneiss and granofels with subordinate schist. On the Bedrock Geological Map of Connecticut (Rodgers, 1985), the major rock unit in the study area is classified as the Taine Mountain Formation—one of a group of variously folded metasedimentary rock units that stratigraphically overlie the Waterbury Gneiss Dome in the Connecticut Valley synclinorium. On earlier published bedrock geologic maps of the Southington quadrangle (Fritts, 1963) and the Waterbury quadrangle (Gates and Martin, 1967), other geologic formation names were used. Although these names are superseded by the terminology of Rodgers (1985), the quadrangle maps give more detailed information than the State map about the distribution of bedrock outcrops, structural measurements at individual outcrops, and local mineralogic and textural variations within particular rock units.

In the study area, the Mad River valley lies at or near the axis of a large-scale, northeast- trending, northeast-plunging anticlinal structure in the Taine Mountain Formation and adjacent units. Consequently, structural trends in the bedrock, such as strike of foliation or compositional layering, are north-northeast in the hills to the east of the valley, swing around to north-northwest at the north end of Bald Hill and the 650-ft hill to the north of the valley, and become northwest to west-northwest in the area to the west of the valley. The compositional layering is very steeply dipping and is commonly vertical. Specific information on the rock chemistry at the site is not available, but the basic minerals in the gneissic bedrock in the area are, in generally decreasing order, quartz, biotite, muscovite, plagioclase, kyanite, garnet, microcline, and magnetite; other accessory minerals are apatite, zircon, tourmaline, rutile, chlorite, epidote, and chalcopyrite (Fritts, 1963; Gates and Martin, 1967). In the site area, the bedrock surface is exposed in a shallow excavation under the power lines just north of Tosun Road. At this locality, the rock is a medium gray granofels and lacks distinct foliation.

Currently, little is known about the orientation and distribution of fractures or fracture zones specific to the bedrock in the site area. It is likely that where the bedrock has a distinct compositional layering (foliation), some fractures will exist along foliation planes; the dip of foliation is oriented at high angles, locally vertical in the study area. It is likely that subvertical and subhorizontal fractures that cut across foliation also are present. Preferred orientations of brittle fracturing are likely to exist as a result of the particular stress fields that have affected the bedrock through the later part of geologic time.

Surficial Materials

The surficial (unconsolidated) materials (fig. 3) overlying the bedrock in the study area consist predominantly of glacial sediments deposited during advance and retreat of the last (late Wisconsinan) ice sheet. Locally, deposits of an earlier (probably Illinoian) ice sheet are preserved, mostly in the subsurface. These geologic units are described on the Surficial Materials Map of Connecticut (Stone and others, 1992) and on the surficial geologic map of the Southington quadrangle (LaSala, 1961). Deposits include glacial till, deposited directly by glacial ice during advance of the ice sheets, and glacial stratified deposits laid down by meltwater streams and in glacial lakes during retreat of the last ice sheet. Postglacial deposits include those primarily on modern floodplains (alluvium) and in wetland areas (swamp deposits; peat and muck). Postglacial deposits are commonly thin (less than 5 ft) and generally overlie glacial deposits.

Till

Glacial ice-laid deposits (till) overlie the bedrock surface in most places in the study area. Logs of wells and test borings and interpretation of aerial photographs indicate that till is generally less than 10 to 15 ft thick over much of the study area (fig. 3); areas where till is thicker than 10 to 15 ft are shown as "thick till" in figure 3. Till is locally absent where bedrock is at land surface or where the bedrock surface is overlain directly by glacial stratified deposits. Till in the study area was deposited predominantly as basal till beneath continental ice sheets during the late Wisconsinan and earlier (Illinoian) glaciations. Its color and lithology closely

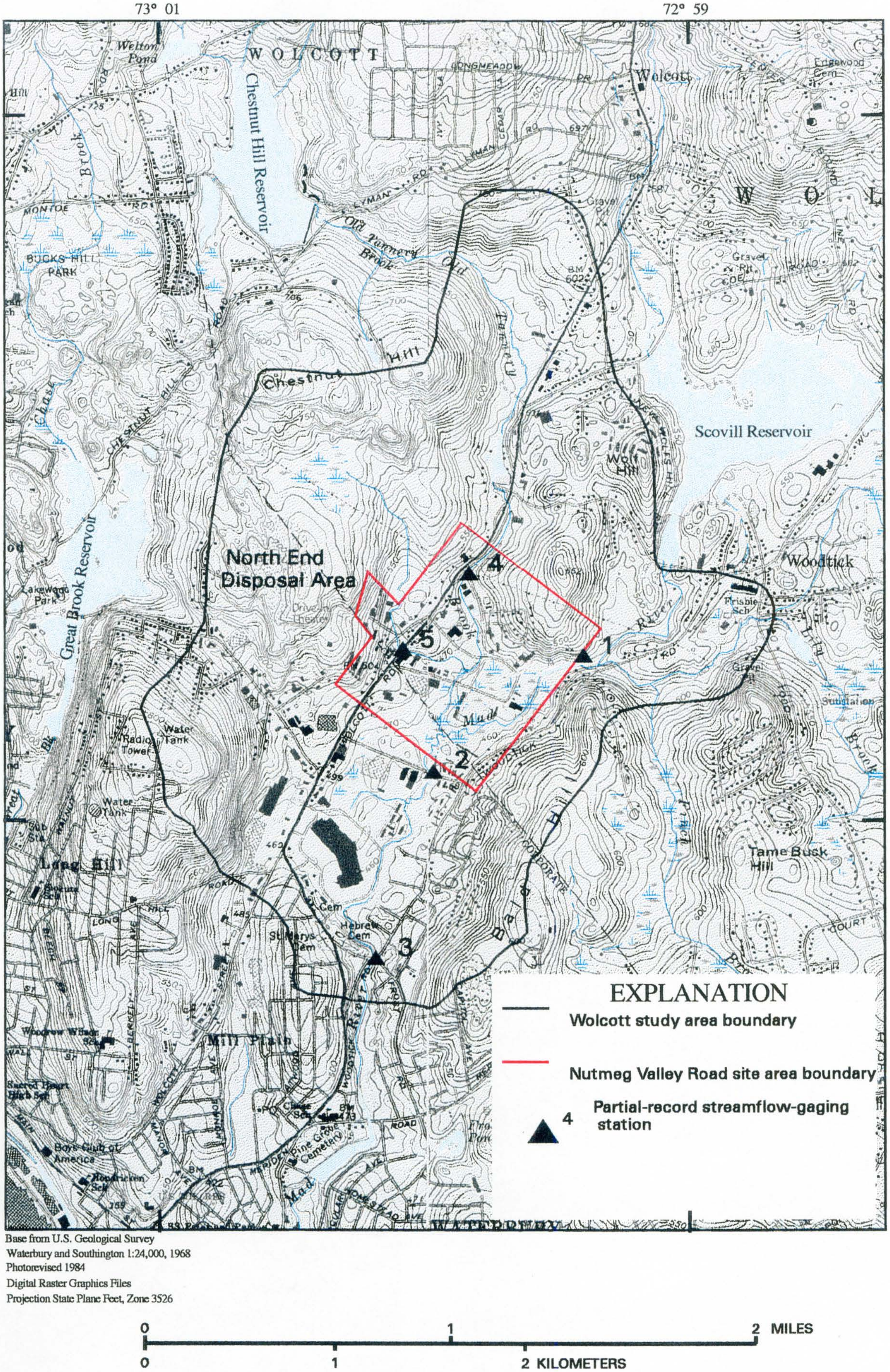
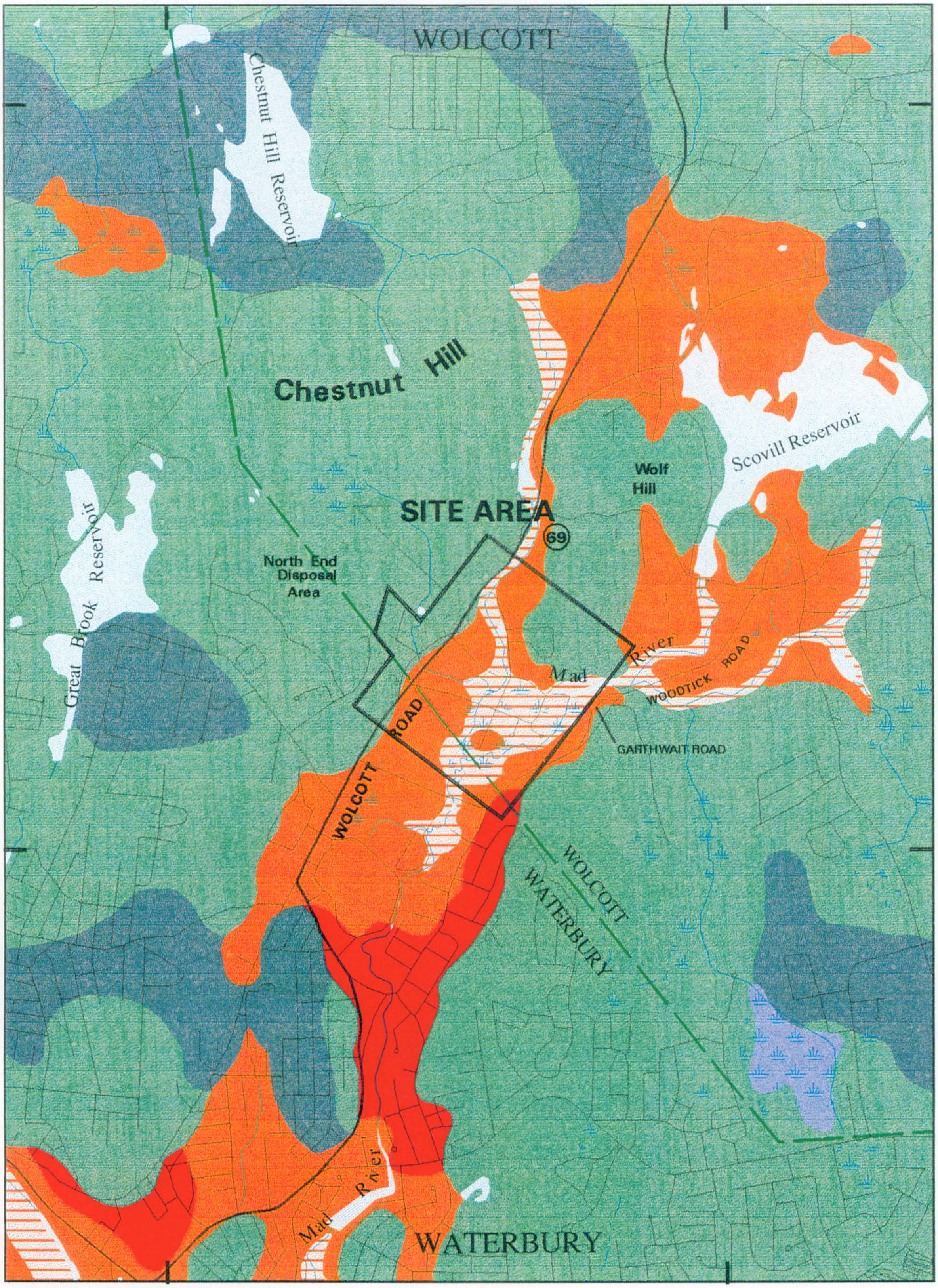


Figure 2. Locations of regional study area, site area and partial –record streamflow –gaging stations, Wolcott, Conn.



Base from U.S. Geological Survey Digital Line Graphs
Scale 1:24,000
Projection State Plane Feet, Zone 3526

Geology from Stone and others, 1992

Figure 3. Surficial materials of the regional study area, Wolcott, Conn.

EXPLANATION

POSTGLACIAL DEPOSITS

ALLUVIUM OVERLYING SAND AND GRAVEL—Sand, gravel, silt, and some organic material, on the flood plains of modern streams; overlies glacial sand and gravel described below.

SWAMP—Muck and peat that contain minor amounts of sand, silt, and clay, accumulated in poorly drained areas.

GLACIAL MELTWATER DEPOSITS

All sorted and stratified sediments composed of gravel, sand, silt, and clay laid down by flowing meltwater during retreat of the last ice sheet; and including minor lenses of flowtill and other diamict sediment.

GRAVEL—Composed mainly of gravel-sized particles; cobbles and boulders predominate; lesser amounts of sand within the gravel matrix and as separate layers.

SAND AND GRAVEL—Composed of mixtures of gravel and sand within individual layers and as alternating layers. Sand and gravel layers generally range from 25 to 50 percent gravel particles and from 50 to 75 percent sand particles.

GLACIAL ICE-LAID DEPOSITS

TILL DEPOSITS—poorly sorted, generally nonstratified mixture of grain-sizes ranging from clay to large boulders; the matrix of most tills is composed dominantly of sand and silt.

THIN TILL—areas where till is generally less than 10–15 ft thick and including areas of bedrock outcrop where till is absent.

THICK TILL—areas where till is greater than 10–15 ft thick and including drumlins in which till thickness commonly exceeds 100 ft (maximum recorded thickness is about 200 ft).

WATER BODY

resemble the underlying crystalline bedrock from which it was derived. Till in the Western Highlands is typically gray and consists of a nonsorted, nonlayered mixture of grain sizes with a matrix of 65 to 85 percent sand, 20 to 30 percent silt, and 5 to 10 percent clay; larger rock fragments (clasts) generally constitute 20 to 30 percent of the total volume of the material (Melvin and others, 1992b). No exposures or samples of till in the study area were examined during this study.

Stratified deposits

Glacial stratified deposits, as much as 85 ft thick, overlie till and bedrock in the Mad River valley (fig. 3). These deposits consist of both coarse-grained sediment (gravel, sand and gravel, and sand) and fine-grained sediment (very fine sand, silt, and clay). Coarse-grained deposits were laid down locally as ice-marginal fluvial sediments, deltas, and lacustrine fans graded to a series of small glacial lakes that developed sequentially northward in the Mad River valley as the ice margin retreated. Fine-grained deposits accumulated locally as lake-bottom sediments in the small glacial lakes (Stone and others, 1992). The water level in this series of lakes was at about 500 ft in altitude and was controlled by drift dams at the south end of each lake. The stratified deposits reach altitudes of 500 ft on the western side of the valley and 520 to 530 ft on the eastern side. A flat-topped delta just northeast of the site area at Woodtick is at 505 to 515 ft altitude. To the south of the site area, stratified deposits in the valley are predominantly coarse grained (gravel, sand and gravel, and sand) throughout their entire thickness. Near the site, however, logs of inventoried wells and test holes indicate that a body of fine-grained material (very fine sand, silt, and clay) overlies sand and gravel in the central part of the valley. The glaciolacustrine sediments consist predominantly of thin-layered fine sand and silt but in places may consist of rhythmically-laminated (varved), alternating layers of silt and clay. This fine-grained unit is not mapped on the published surficial materials map (Stone and others, 1992; fig. 3). The distribution of glacial stratified deposits near the site area and the location of geologic section lines are shown on plate 2. The sections illustrate the subsurface distribution of coarse- and fine-grained stratified deposits in the area surrounding the site as interpreted from existing well and test-hole information. Geologic section A-A' (fig. 4) is drawn in an east-west direction; section B-B' (fig. 5) is drawn in a north-south direction. Locally, geologic sections (figs. 4 and 5) show more detailed information about the distribution of surficial materials than is shown on plate 2 and figure 3.

Postglacial deposits

Flood-plain alluvium and swamp deposits are present locally in the study area (fig. 3). These materials are relatively thin (less than 10 ft thick) and overlie glacial deposits. Alluvial deposits are present in the site area on the flood-plain surfaces along Mad River and Old Tannery Brook. This material consists predominantly of sand and gravel but may consist locally of fine sand, silt, and clay and may contain organic debris.

HYDROLOGIC FRAMEWORK

Precipitation and Evapotranspiration

The regional hydrology of a 557-mi^2 area of the lower Housatonic River Basin in western Connecticut, including the basins of two major tributaries—the Pomperaug and Naugatuck Rivers—has been previously described (Grossman and Wilson, 1970; Wilson and others, 1974). Mean annual precipitation in the basin for the reference period October 1931 through September 1960 was estimated to be 47 in. Mean annual runoff for the same period was estimated to be 25 in. (1.84 $ft^3/s/mi^2$), and evapotranspiration, which is calculated as the difference between mean annual precipitation and mean annual runoff, was 22 in. Precipitation exceeds evapotranspiration in late autumn and winter, so that more water is stored in streams, impoundments, aquifers, and soils. Evapotranspiration increases in late spring and summer, so less water is stored.

Surface Water

The Mad River, Old Tannery Brook, and other small streams drain land and receive discharge from the ground-water-flow system in the area. Old Tannery Brook, which flows through the site area, is a tributary to the Mad River; the confluence of Old Tannery Brook and Mad River is about 900 ft south of Town Line Road, which services the Nutmeg Valley industrial area. The headwaters of Old Tannery Brook are in Chestnut Hill Reservoir in Wolcott. The Mad River flows into and out of Scovill Reservoir in Wolcott near Woodtick. The Mad River is a tributary to the Naugatuck River; the confluence of Mad River and Naugatuck River is about

3 mi southwest of Town Line Road. The eastern half of the site area lies in the flood plain of Mad River and Old Tannery Brook. The projected 100-year flood attains altitudes of 470 ft to 463 ft north to south through the site area (Federal Emergency Management Agency, 1982). Flood waters at this height extend as far west as 15 Nutmeg Valley Road and 17 Town Line Road and eastward to the base of the slope rising up to Woodtick Road.

Continuous streamflow records for the Naugatuck River are collected at two USGS streamflow-gaging stations outside the study area—about 6 mi north of the area at Thomaston (USGS station 01206900) and about 10.5 mi south of the area at Beacon Falls (USGS station 01208500; fig. 1). Streamflow has been measured at the Thomaston gage since October 1959 and at the Beacon Falls gage since June 1918; records of daily discharge have been published in the annual series of USGS data reports titled "Water Resources Data for Connecticut." Streamflow is regulated upstream from both stations.

Five partial-record streamflow-gaging stations (fig. 2) were established in August 1996 to provide data on flow characteristics near the site area. Three stations were established on Mad River, which flows along the eastern side of the site. Station 1 is approximately 200 ft below the confluence with Finch Brook, station 2 is at bridge #5042 at Sharon Road, and station 3 is at bridge #4163 at Frost Road. The station at Frost Road had to be re-established after three discharge measurements were made because the gage datum was removed during a slope stabilization project. Station 4 is located on Old Tannery Brook at Tosun Road, and station 5 is on an unnamed brook at Wolcott Road. Drainage areas for the five stations are shown in table 1. Using the estimated mean annual runoff described earlier ($1.84\ ft^3/s/mi^2$) for the Lower Housatonic River Basin, mean annual streamflow for the five stations is $22.9\ ft^3/s$ at station 01208270, $29.6\ ft^3/s$ at station 01208290, $31.3\ ft^3/s$ at station 01208295, $5.1\ ft^3/s$ at station 01208280, and $0.84\ ft^3/s$ at station 01208285. From August 22, 1996 to January 15, 1997, measured discharge at all stations ranged from 0.006 to $128\ ft^3/s$ (table 1). The discharge measurements on the Mad River are higher than those on the stations at either Old Tannery Brook or the unnamed brook and reflect the size of the drainage area.

Table 1. Discharge at streamflow-gaging stations, Wolcott study area, Wolcott, Connecticut

[All discharge measurements are in cubic feet per second; see fig. 2 for locations of stations; USGS, U.S. Geological Survey; D.A., drainage area; mi^2, square miles; --, not measured; *, gage destroyed during bank stabilization project, re-established new gage datum on 12/2/96]

Date of measurement	Station 1 Mad River below Finch Brook (USGS 01208270) D.A. 12.4 mi^2	Station 2 Mad River at Sharon Road (USGS 01208290) D.A. 16.0 mi^2	Station 3 Mad River at Frost Road (USGS 01208295) D.A. 16.9 mi^2	Station 4 Old Tannery Brook at Tosun Road (USGS 01208280) D.A. 2.74 mi^2	Station 5 Unnamed Brook at Wolcott Road (USGS 01208285) D.A. 0.453 mi^2
08-22-96	2.19	2.5	2.45*	0.34	0.006
09-23-96	--	70.2	--	5.07	--
09-26-96	27.6	--	28.5*	34.7	.01
10-21-96	--	--	--	--	4.06
10-24-96	--	82.8	90.1*	--	--
11-26-96	--	--	--	--	4.42
12-02-96	--	--	116.0	--	--
12-12-96	55.5	--	--	13.4	--
12-20-96	--	128.0	108.0	17.0	--
01-14-97	19.4	--	--	--	--
01-15-97	--	--	22.6	--	--

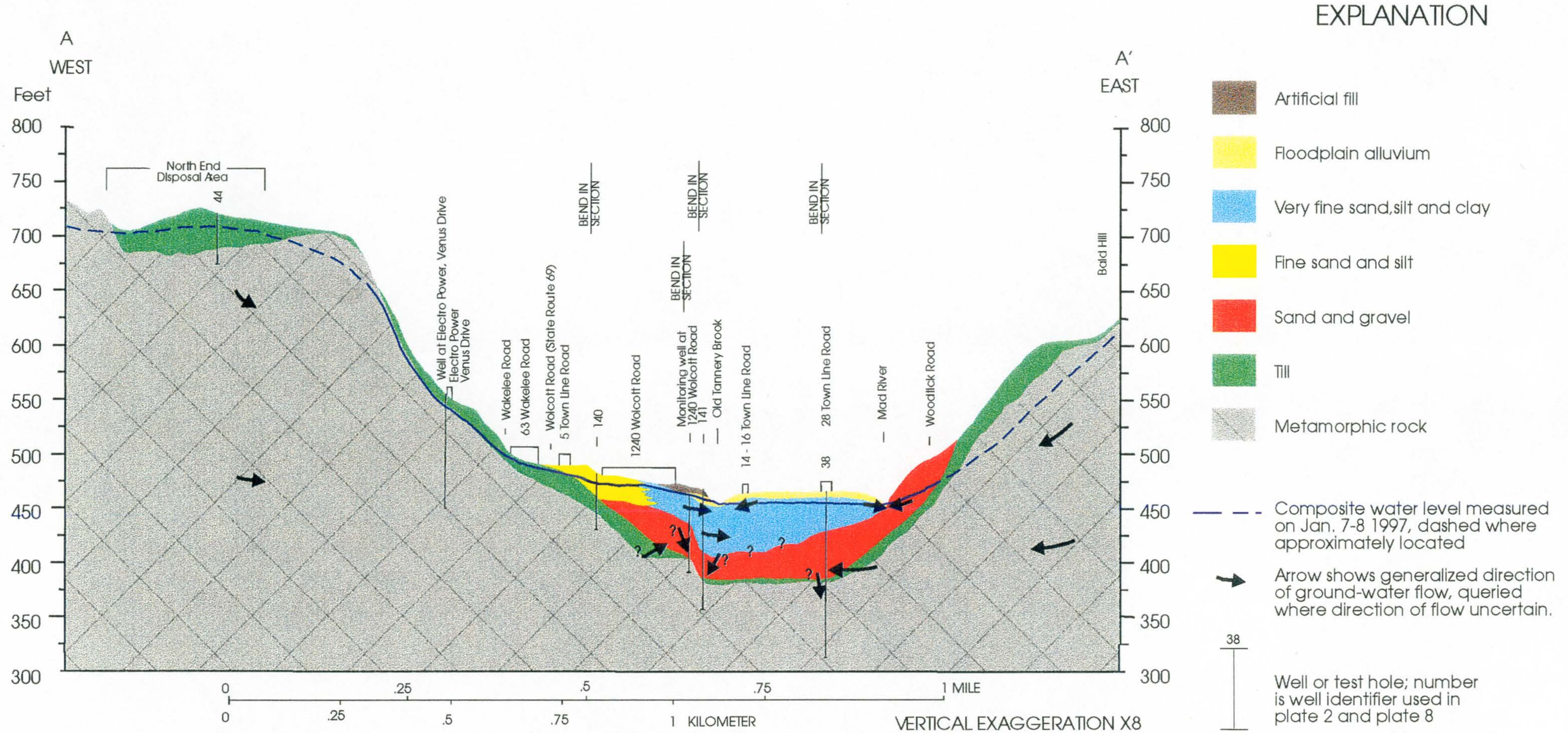


Figure 4. Geohydrologic section A - A' Nutmeg Valley Road site area, Wolcott Conn. See plate 2 for location of section.

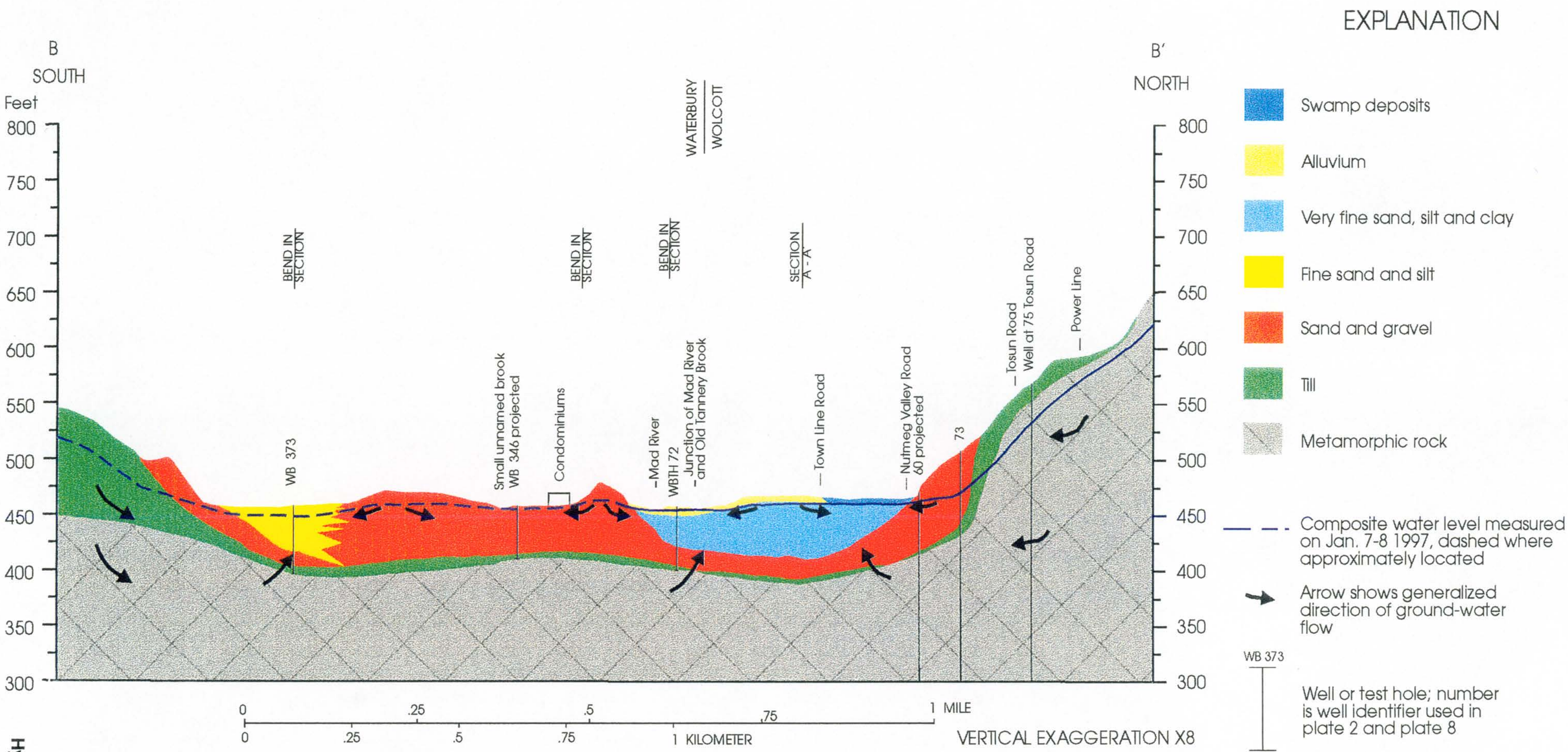


Figure 5. Geohydrologic section B - B′ Nutmeg Valley Road site area, Wolcott Conn. See plate 2 for location of section.

Ground Water

Hydraulic properties and well yields

Hydrogeologic units present in the site area include glacial till, coarse-grained and fine-grained glacial stratified deposits (stratified drift), and fractured crystalline bedrock. The subsurface distribution of hydrogeologic units is shown in figures 4 and 5.

Till in the Nutmeg Valley Road site area is relatively thin in most places and is probably not an important aquifer; however, the eastern part of the hill occupied by the North End Disposal Area is underlain by till that is 30 to 40 ft thick. Clay content and fracture distribution in the till at the site area are presently unknown. Melvin and others (1992a) report horizontal hydraulic conductivities of tills derived from crystalline rocks of western Connecticut and Massachusetts that range from 9.5×10^{-6} to 2.3×10^{-2} ft/d and vertical hydraulic conductivities that range from 7.5×10^{-3} to 3.4×10^{-2} ft/d. Melvin and others (1992b) found an average range of 0.06 to 2.7 ft/d for hydraulic conductivities of tills derived from crystalline bedrock in Connecticut. Melvin and others (1992a; 1992b) also report an average porosity of about 35 percent in these tills. The values reported by Melvin and others (1992a; 1992b) are similar to those cited by other investigators (Randall and others, 1988; Stephenson and others, 1988). No inventoried supply wells in the study area receive water from the till aquifer. Yields of wells screened in till are typically low but marginally adequate for the domestic needs of most households (Randall and others, 1966; Wilson and others, 1974; Mazzaferro and others, 1979).

Coarse-grained stratified drift, consisting of gravel, sand and gravel, and sand, is present at the surface on the valley sides and beneath fine-grained sediment in the central part of the site area. Estimated horizontal hydraulic conductivity of coarse-grained stratified drift in the lower Housatonic River Basin is 12 to 870 ft/d (Wilson and others, 1974). Randall and others (1988) report typical values of 100 to 650 ft/d for the Northeast Region. Coarse-grained stratified deposits are the most permeable earth materials in the region, and wells tapping the stratified-drift aquifer have relatively high yields. Reported yields of 62 wells screened in stratified drift in the lower Housatonic River Basin range from 100 to 2,500 gal/min, with a median yield of 300 gal/min (Wilson and others, 1974). In the study area, reported yields of four wells screened in coarse-grained stratified drift (WB 344, WB 345, WB 346, and WB 373; see plate 2 and section B-B', fig. 5) range from 115 to 250 gal/min (Grossman and Wilson, 1970; Wilson and others, 1974). Wells WB 344, WB 345, and WB 346 are fairly close together on the southern side of Sharon Road near the Waterbury/Wolcott town line and penetrate coarse-grained materials that are about 45 ft thick and have a saturated thickness of 32 to 39 ft; the wells are cased to about 30 ft and screened between 30 and 40 ft. WB 373, at what is now the Naugatuck Valley Mall, penetrates 34 ft of fine-grained stratified drift overlying 19 ft of coarse-grained material; the well is screened from 34 to 44 ft. Transmissivity values for the coarse-grained stratified-drift aquifer in this area estimated from these four wells range from 2,400 to 5,500 ft^2/d; saturated thickness is 32 to 39 ft, and hydraulic conductivity is 62 to 172 ft/d.

Fine-grained stratified drift in the site area consists of glaciolacustrine deposits that are thinly bedded, very fine to fine sand, silt, and clay. Hydraulic properties of this material have not been measured in the study area but can be estimated from previous studies in the region. Hydraulic conductivities of silty sand have been measured over a broad range of 0.03 to 300 ft/d (Freeze and Cherry, 1979, p. 29). In the Quinnipiac River Basin, Mazzaferro and others (1979, p. 41) report estimated hydraulic conductivity of 5 ft/d for very fine sand, silt, and clay. The mean hydraulic conductivities of several samples of fine-grained (fine sand, silt, and clay) glaciolacustrine deposits, measured using laboratory methods, range from 0.001 ft/d for varved clay samples oriented vertically to 0.82 ft/d for varved clay samples oriented horizontally (Melvin and others, 1992b). Barlow (1994, p. 10) reports hydraulic conductivities for three samples of glaciolacustrine material, consisting of more than 91 percent silt and clay, from Cape Cod, Massachusetts, from 1.6×10^{-4} to 1.1×10^{-3} ft/d for horizontal hydraulic conductivity and 7.0×10^{-5} to 1.0×10^{-3} ft/d for vertical hydraulic conductivity. These empirical data confirm that fine-grained glaciolacustrine deposits (very fine sand, silt, and clay) have low permeability and are poor (low-yield) aquifers.

The hydrologic characteristics of crystalline bedrock in the study area are poorly defined with respect to degree of confinement, hydraulic conductivity, storativity, and porosity. Well yields and hydraulic properties depend primarily on the number, size, and degree of interconnection of water-bearing fractures. Fractured crystalline rock studies conducted by the USGS at Mirror Lake in central New Hampshire (Shapiro and Hsieh, 1991; 1994), using borehole-geophysical techniques and packer testing in bedrock wells, show that one to three fractures in each well produced more than 90 percent of the water when the well was pumped. The remaining fractures were found to be less transmissive by two to five orders of magnitude. The highly transmissive fractures form local clusters that are connected to each other through a network of less transmissive fractures. Preliminary analyses yield transmissivities in the range of 9 to 93 ft^2/d for the highly transmissive fracture clusters, and an equivalent hydraulic conductivity of about 0.00028 to 2.8 ft/d for the surrounding rock mass. Transmissivity estimates for crystalline bedrock in the Quinebaug River Basin in eastern Connecticut range from 31 to 53 ft^2/d, and storativity values are 10^{-3} (Randall and others, 1966).

Reported yields of 294 wells tapping crystalline bedrock in the lower Housatonic River Basin range from less than 1 to more than 20 gal/min, with a median yield of 5 to 6 gal/min; about 75 percent of the wells yield at least 3 gal/min, and less than 10 percent yield 20 gal/min or more (Wilson and others, 1974). Drillers' logs for 64 wells that tap bedrock in the Wolcott study area inventoried during this project indicate well yields ranging from less than 1 to 60 gal/min with a median yield of 6.5 gal/min; well depths range from 29 to 720 ft below land surface.

Recharge and discharge

The primary source of recharge to the ground-water-flow system is precipitation; recharge from wastewater sources and induced infiltration from streams may be secondary sources. A primary component of the water budget is the effective ground-water recharge, which is infiltration minus ground-water evapotranspiration. Several Connecticut water-resources reports (Randall and others, 1966; Thomas and others, 1967; Ryder and others, 1970; Cervione and others, 1972; Mazzaferro and others, 1979), have discussed the relationships between total runoff, basin geology, and ground-water outflow. Ground-water outflow is assumed to equal effective recharge if changes in ground-water storage are small. Effective recharge has been estimated using the relation between ground-water outflow and the percentage of the drainage area underlain by coarse-grained stratified deposits in 28 drainage basins in southern New England (Mazzaferro and others, 1979). The relation is

$$Y = (35 + 0.6X) \quad , \qquad (1)$$

where:

Y is the ground-water outflow, as a percentage of total runoff, and

X is the percentage of total basin underlain by stratified glacial deposits.

The area of the Mad River/Old Tannery Brook drainage system upstream from the site is 15.79 mi^2; stratified deposits underlie 8.42 percent of this area. Using the above equation, ground-water outflow in the basin is 40 percent of total runoff (streamflow). Mean annual runoff as determined from Wilson and others (1974; fig. 4) is 19.23 Mgal/d. Therefore, the average annual ground-water outflow in the Mad River/Old Tannery Brook basin upstream from the site is 7.69 Mgal/d, or 10.1 in/yr over the area of the basin.

Water Use

Water use in the study area is mainly for domestic, commercial, and industrial purposes. Estimates of ground-water withdrawals for domestic use were made by applying a coefficient to population estimates of households and neighborhoods. Estimates of ground-water withdrawals for industrial and commercial use in the study area were made by taking the number of employees at an industrial or commercial facility and applying a coefficient to these numbers based on the standard industrial classification assigned to the business. Preliminary estimates of ground-water withdrawals in the study area are summarized in table 2.

Table 2. Estimated ground-water withdrawals for domestic, industrial, and commercial use in the Wolcott study area, Wolcott, Connecticut

[Values are rounded to three significant figures; values may not add to totals because of independent rounding; Mgal/d, million gallons per day]]

Location	Withdrawals for domestic use (Mgal/d)	Withdrawals for industrial/commercial use (Mgal/d)	Total withdrawals (Mgal/d)
Wolcott part of study area	0.056	0.027	0.084
Waterbury part of study area	0	0.003[1]	0.003
Total	0.056	0.033	0.087

[1] Includes water for irrigation purposes.

Domestic Use

Residences along approximately 13 roads in the Town of Wolcott use private wells for domestic supply and are included in the ground-water withdrawal estimates. A preliminary estimate of the volume of ground water withdrawn by the residents in this area is 0.056 Mgal/d. This estimate includes water withdrawn (0.02 Mgal/d) by the apartment and condominium complexes located off Wolf Hill Road (R.J. Black and Son Inc., Water Systems, oral commun., January 1997). Tosun Road residents were canvassed door to door because this residential neighborhood lies inside the Nutmeg Valley Road site area. Estimated ground-water withdrawal from the Tosun Road neighborhood is 0.006 Mgal/d.

A new housing subdivision known as Wolcott Hills (northwest of the site area) was not included in the estimates because it is served by public water. All residences in the Waterbury part of the study area also are served by public water. All areas described are served by public sewers and connected to the Waterbury Wastewater Treatment Facility, with the exception of the Garthwait Road area, which uses septic systems (C.M. Joseph, Sewer and Water Administrator, Town of Wolcott, oral commun., December 1996). In addition, three apartment/condominium clusters on Wakelee Road in the site area are publicly supplied and sewered by the City of Waterbury (Mark Rinaldi, Waterbury Water Department, oral commun., January 1997).

Commercial and Industrial Use

A number of industrial facilities in the Nutmeg Valley Road site area are served by public suppliers (plate 1). Some of these establishments continue to use wells that tap the bedrock aquifer for their bathroom facilities, vehicle maintenance, or irrigation of the grounds around their buildings.

Approximately 27 commercial/industrial facilities in the site area do not have public water and withdraw ground water for their operations. Estimated ground-water withdrawal by these facilities is approximately 0.027 Mgal/d. The commercial/industrial establishments use public sewers, so most of the water withdrawn from the ground-water aquifer is transferred out of the basin, treated at the Waterbury Wastewater Treatment Facility, and released to the Naugatuck River.

Other industrial/commercial facilities concentrated along Rt. 69 (Wolcott Road) have not yet been inventoried. Although no major facilities are present, the number of small establishments, some of which are concentrated in a strip-mall arrangement, makes it desirable to conduct further investigation to refine ground-water withdrawal estimates for the study area. The area along Rt. 69 is also publicly sewered; therefore, most water removed from the ground is likely to be transferred out of the basin.

Industrial/commercial facilities in the Waterbury part of the study area are served by public-water supply and sewers from the City of Waterbury. Cly Del Manufacturing on Sharon Road in Waterbury withdraws ground water from a well (WB 346, plate 2) for irrigation purposes. The estimated water withdrawn for this purpose is 0.003 Mgal/d.

There are two large surface-water impoundments in the study area—Scovill and Chestnut Hill Reservoirs. Currently, no water is being diverted from these reservoirs for any purpose (Robert Gilmore, Connecticut Department of Environmental Protection, Inland Water Resource Management, Diversion Permit Section, oral commun., January 1997).

HISTORY OF GROUND-WATER CONTAMINATION

The following discussion is based solely on documents available to the authors at the time this report was written. The facilities described in this section may not be the only sources of contamination. The USGS did not perform any water-quality sampling as part of this investigation.

Contamination at the Nutmeg Valley Road site was first documented in 1980 (Connecticut Department of Environmental Protection, 1980) at 15 Nutmeg Valley Road (Nutmeg Screw Machine Products and Alpine Electronic Components; plate 1). Contamination at this property was associated with industrial machining and degreasing. Chlorinated solvents were disposed of at land surface, and although there is some question as to the particular contaminants involved, they probably included 1,1,1-trichloroethane (1,1,1-TCA), trichloroethene (TCE), carbon tetrachloride, oily waste, and acid (Metcalf and Eddy, 1992). Solvent disposal began in 1966 and continued until 1980 (Connecticut Department of Environmental Protection, 1984a; 1984b).

Concentrations of VOC's detected in water samples collected from bedrock water-supply wells during

1981-95 at the Nutmeg Valley Road site area are shown on plates 3 to 7. The 1981 samples were collected by the Connecticut Department of Health Services (plate 3); the 1985 and 1991 samples were collected by the Chesprocott Health District (plates 4 and 5); and the 1995 samples were collected by the Connecticut DEP and the USEPA (plate 6). Different wells were sampled in each sampling round because of accessibility for sample collection and because specific wells were targeted on the basis of the likelihood and history of contamination. Therefore, there is some overlap between years in the wells sampled. Detected VOC's include (in order of decreasing frequency) TCE, tetrachloroethylene (PCE), 1,1,1-TCA, toluene, methylene chloride, ethylbenzene, benzene, carbon tetrachloride, ethyl ether, xylene, 1,2 dichloroethene, chloroform, pentane, and 1,1,2,2 tetrachloroethane. Twenty-five wells were sampled during more than one sampling round (plate 7). Of these, 13 wells did not contain detectable concentrations of VOC's. The remaining 12 wells showed a general trend of decreasing concentrations of the various VOC contaminants from the time of the measured peak to the last sample tested (plate 7).

Water-quality information presented here is based on data from many different sources, gathered at different times, over a long period of time. Although data from some bedrock wells show decreasing concentrations of VOC's over time, little is known about concentrations of VOC's in the surficial aquifer over time, except that concentrations are currently high in some places. The following discussion presents the available information on contamination at specific sites.

Ground-water contamination by VOC's was documented at 31 Tosun Road (Par Finishing, Specialty Coil, Simon & Gagnon Moving, Industrial Mailing Systems, and Ultimate Services Lawn Care) and in a vacant lot across Tosun Road from this address. Contamination was found in wells screened in surficial materials (HRP Associates, Inc., 1984), and the contaminants in ground water included PCE, TCE, and cyanide. Contaminants identified in soil samples included PCE, xylenes, toluene, oil and grease, and cyanide (Roy F. Weston, Inc., 1994a). Ground-water contamination also was documented in the bedrock aquifer at 31 Tosun Road—PCE at a concentration of 6.9 µg/L. Ground-water samples from the wells completed in the surficial materials have not been collected at the site since October 1992 (Roy F. Weston, Inc., 1994a).

Ground-water contamination by VOC's at a facility on Venus Drive (Electro Power) was first documented in 1984; contaminants identified in soil samples included 1,1,1-TCA, PCE, toluene, and polychlorinated biphenyls (PCBs). No monitoring wells have been installed at this location, but ground-water contamination by VOC's was detected in the bedrock water-supply well. Contaminants included TCE, PCE, and methylene chloride—all of which are solvents known to be used at this location in the past (Connecticut Department of Health Services, 1981; Roy F. Weston, Inc., 1994b). This facility was connected to municipal water service in 1992, and water samples have not been collected from the well since October 1992.

Ground-water contamination by VOC's at 10 Venus Drive (Venus Consolidated Industries, Infodex) was first documented in 1981; contamination in the bedrock aquifer was first documented in March 1981. The VOC's in the bedrock aquifer at this facility included 1,1,1-TCA, PCE, TCE, methylene chloride and 1,2-DCE (Connecticut Department of Health Services, 1981; Chesprocott Health District, 1985). Contaminants identified in the surficial materials included 1,1,1-TCA, PCE, trans-1,2 dichloroethylene (t1,2-DCE) and TCE (HRP Associates Inc., 1986a). Investigation of this facility indicates that an on-site septic system was used at this site and a former on-site dump, believed to be located under a section of the current structure, received waste materials and liquids from a screw machine operation (HRP Associates Inc., 1986a).

Ground-water contamination by VOC's at 10 Swiss Lane (Marson Fastener Corp.) was documented in 1995. Contaminants identified in the surficial aquifer included carbon disulfide and methylene chloride (Dames and Moore, 1995). No VOC's were detected in the bedrock aquifer at this facility (Chesprocott Health District, 1985, 1991; Connecticut Department of Environmental Protection, 1995). Soil samples obtained during monitoring-well construction contained 1,2,4 trimethylbenzene, napthalene, acetone, methylene chloride and petroleum hydrocarbons (Dames and Moore, 1995).

Ground-water contamination by VOC's at 14-16 Town Line Road (Town Line Commons) was first documented in 1991. Contaminants identified in the surficial aquifer included t1,2-DCE, TCE, and PCE (HRP Associates Inc., 1991). No wells have been completed in the bedrock at this facility.

At 143 Wolcott Road (Wolcott Tool), no VOC contamination was found in the ground water; however, there is evidence of oil and grease contamination in the surficial and bedrock aquifers at this facility (EEW Management Inc. 1994).

Ground-water contamination by VOC's in the surficial aquifer at 1240 Wolcott Road (Highland Manufacturing) was first documented in January 1990. Contaminants identified included TCA, TCE, methylene chloride, chloroform, 1,1 dichloroethane, 1,2 dichloroethane, 1,1,1-TCA, and t1,2-DCE. Concentrations greater than 10,000 μg/L of TCE and 1,000 μg/L of trans-1,2 dichloroethylene were found in ground water in the surficial aquifer at this facility. Ground-water contamination in the bedrock aquifer was first documented in March 1981 (Connecticut Department of Health Services, 1981); VOC's included 1,1,1-TCA, PCE, and TCE (Connecticut Department of Health Services, 1981; HRP Associates Inc., 1996a; HRP Associates Inc. 1996c). Water-quality samples continue to be collected in 1997.

Investigations at several locations in the Nutmeg Valley Road site area included soil analysis. Soil contamination was detected at 30 and 32 Town Line Road (NUS Corporation, 1991a). Reported waste-disposal practices at 30 Town Line Road (Dover Manufacturing, Auto Dynamics, Micro Automatics, Advanced Secondaries, Coils Plus) and at 32 Town Line Road (Fusion Engineering Manufacturing) included disposal of cutting oils, mineral spirits, absorbent products, and metal scraps and cuttings (NUS Corporation, 1991a). Soil samples from these two properties contained methylene chloride, acetone, benzene, naphthalene, acenaphthalene and several other semi-volatile compounds (NUS Corporation, 1991a). Ground-water contamination at 30 Town Line Road was detected in 1991; PCE and TCE were present in the water sample obtained during the 1991 round of sampling (Chesprocott Health District, 1991). Ground-water contamination was not detected during the 1985, 1991, and 1995 sampling rounds at 32 Town Line Road (Chesprocott Health District, 1985, 1991; U.S. Environmental Protection Agency, 1995).

Soil samples also were collected from the facility at 37 Tosun Road (Maur-Mel Automatics, PDI Inc. Care Manufacturing Company) (NUS Corporation, 1991b) and contained benzene, PCE, ethylbenzene and xylene (NUS Corporation, 1991b). Ground-water contamination at 37 Tosun Road was detected in 1985; PCE and 1,1,1 TCA were present in water samples collected at this facility (Chesprocott Health District, 1985; 1991).

At the North End Disposal Area in Waterbury, ground-water contamination is present in bedrock and surficial materials (Advanced Environmental Interface Inc., 1994; Roy F. Weston, Inc., 1994c). Ground-water contamination by VOCs in the surficial aquifer at the North End Disposal Area was documented in September 1992, and contaminants identified included 1,1-DCA and dichloromethane. Contamination by VOC's in the bedrock aquifer included chlorobenzene, chloroethane, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 1,1-dichloroethylene, trichlorofluoromethane and dichloromethane (Roy F. Weston, Inc., 1994c). Samples from the leachate collection system also contained VOCs, including dichloromethane, trichloroethylene, and vinyl chloride (Roy F. Weston, Inc., 1994c).

High concentrations of inorganic compounds and metals were detected in monitoring wells located down gradient from the North End Disposal Area (Advanced Environmental Interface Inc., 1994; Roy F. Weston, Inc., 1994c). It is unknown if these values represent total or dissolved concentrations or how the samples were collected. Monitoring wells in the surficial and bedrock aquifers at the North End Disposal Area are reported to have concentrations of inorganic compounds and metals shown below. The specific conductance of ground water in surficial and bedrock aquifers near the North End Disposal Area ranged from 0.5 to 650 μS/cm and 50 to 1,610 μS/cm respectively (Advanced Environmental Interface Inc., 1994).

	Concentration	
Constituent	**in surficial aquifer**	**in bedrock aquifer**
iron	less than 0.01 to 150 mg/L	less than 0.01 to 160 mg/L
manganese	less than 0.01 to 11.2 mg/L	less than 0.01 to 12 mg/L
magnesium	6.4 to 8.1 mg/L	18 to 29 mg/L
chloride	0 to 52 mg/L	less than 2 to 75 mg/L
sulfate	0 to 130 mg/L	0 to 140 mg/L

The naturally occurring concentrations of dissolved inorganic compounds and metals were reported for the Lower Housatonic River Basin (Wilson and others, 1974) and are shown below. The specific conductance of ground water in surficial and bedrock aquifers ranged from 72 to 236 μS/cm and 38 to 339 μS/cm respectively.

	Concentration	
Constituent	**in surficial aquifer**	**in bedrock aquifer**
iron	0.0 to 0.71 mg/L	0.02 to 0.57 mg/L
manganese	0 to 1.7 mg/L	0 to 0.34 mg/L
magnesium	1.6 to 8 mg/L	5 to 16 mg/L
chloride	3.8 to 18 mg/L	1 to 15 mg/L
sulfate	5 to 23 mg/L	2.3 to 36 mg/L

CONCEPTUAL MODEL OF GROUND-WATER FLOW

A preliminary conceptual model of the ground-water-flow system in the Nutmeg Valley Road site area was developed from the current understanding of the topography, hydrography, lithology and distribution of surficial aquifer materials, depth to bedrock, character of the bedrock, and ground-water-level measurements made during this study. Two scales of ground-water flow exist in the study area. Local ground-water-flow systems are small systems that develop around ponds, small streams, and swamps and may be in existence for only a few months of the year. Local flow systems are not addressed in this report because of their small size and transient nature. A large-scale flow system is defined by the watershed boundaries of the area drained by the Mad River, Old Tannery Brook, and the unnamed brook; this system extends vertically downward to depths at which the bedrock has no interconnected fractures. Data are insufficient at this time to delineate the vertical extent of the large-scale flow system. Most ground-water circulation takes place in the large-scale system; therefore it is significant with respect to hydrologic analyses and is the one most frequently tapped for ground-water supplies.

Water Levels

Water level was recorded continuously in a bedrock well at the junction of Woodtick Road and Nichols Road (see location WC-37, plate 2) to provide information about the response of the ground-water system to precipitation and the hydraulic connection between surficial materials and bedrock in the study area. Water-level fluctuations at well WC-37 and rainfall amounts at a precipitation gage in Burlington, Connecticut (approximately 12 mi north of the study area) between October 1996 and January 1997 are shown in figure 6. Monitoring well WC-37 is cased 25 ft through surficial materials consisting of sand, gravel, and till, and the well is grouted in the upper 3 ft of bedrock; below the casing, the well is open to 25 ft of bedrock. The driller's log for this well reports a yield of 3 gal/min during a compressed-air test. The water-level hydrograph (fig. 6) indicates that the bedrock aquifer in this location responds quickly to precipitation; water levels in the well rose nearly 3 ft in the 2 days following the 4.5-in. rainfall on October 20. At locations such as this one, contamination in surficial material could migrate quickly into the bedrock aquifer system.

Synoptic ground-water level measurements were made in 50 wells in the Nutmeg Valley Road site area on January 7-8, 1997. The synoptic measurements were made to determine area ground-water levels, to make a preliminary delineation of ground-water flow-directions in the site area, and to assess the possibility of head differences between the bedrock aquifer and water levels in the surficial aquifer. The continuous record at well WC-37 (fig. 6) indicates that at the time of the synoptic measurements, ground-water levels were in a decline that began in mid-December, following a rise in early December associated with a period of high precipitation. Locations of the 50 wells are shown on plate 8; well numbers are those listed in table 3. Of the 50 wells, 26 are screened in surficial materials and range in depth from 5 to 49 ft; 23 are bedrock wells and range in depth from 11 to 305 ft; and 1 is unknown. The measured water-level altitudes in each well and other information, including well depth, depth of screened interval, and whether the well is open to bedrock or surficial materials are shown in table 3.

For the purpose of contouring water-level altitudes, it was assumed that the water-level altitudes in bedrock wells were not significantly different from those in surficial wells. At two locations, bedrock and surficial wells are located within a few feet of each other. At 1240 Wolcott Road (Highland Manufacturing), well 115 is screened from 6 to 16 ft in surficial materials, well 124 is screened from 34 to 44 ft in surficial materials, and well 139 is cased through surficial materials and open to bedrock from 50 to 55 ft. Water-level altitudes in the three wells were 464.51 ft, 464.56 ft, and 464.77 ft, respectively. At 143 Wolcott Road, well 69 is a shallow water-table well screened from 3 to 6 ft in surficial materials, and well 68 is open to bedrock from 9 to 14 ft; water-level altitudes in these wells were 511.91 and 511.07, respectively. The upward gradient at the first cluster of wells and the downward gradient at the second cluster may reflect their position in the ground-water-flow system. Gradients are downward in recharge areas and upward in discharge areas. Between recharge and discharge areas, however, vertical gradients may be negligible.

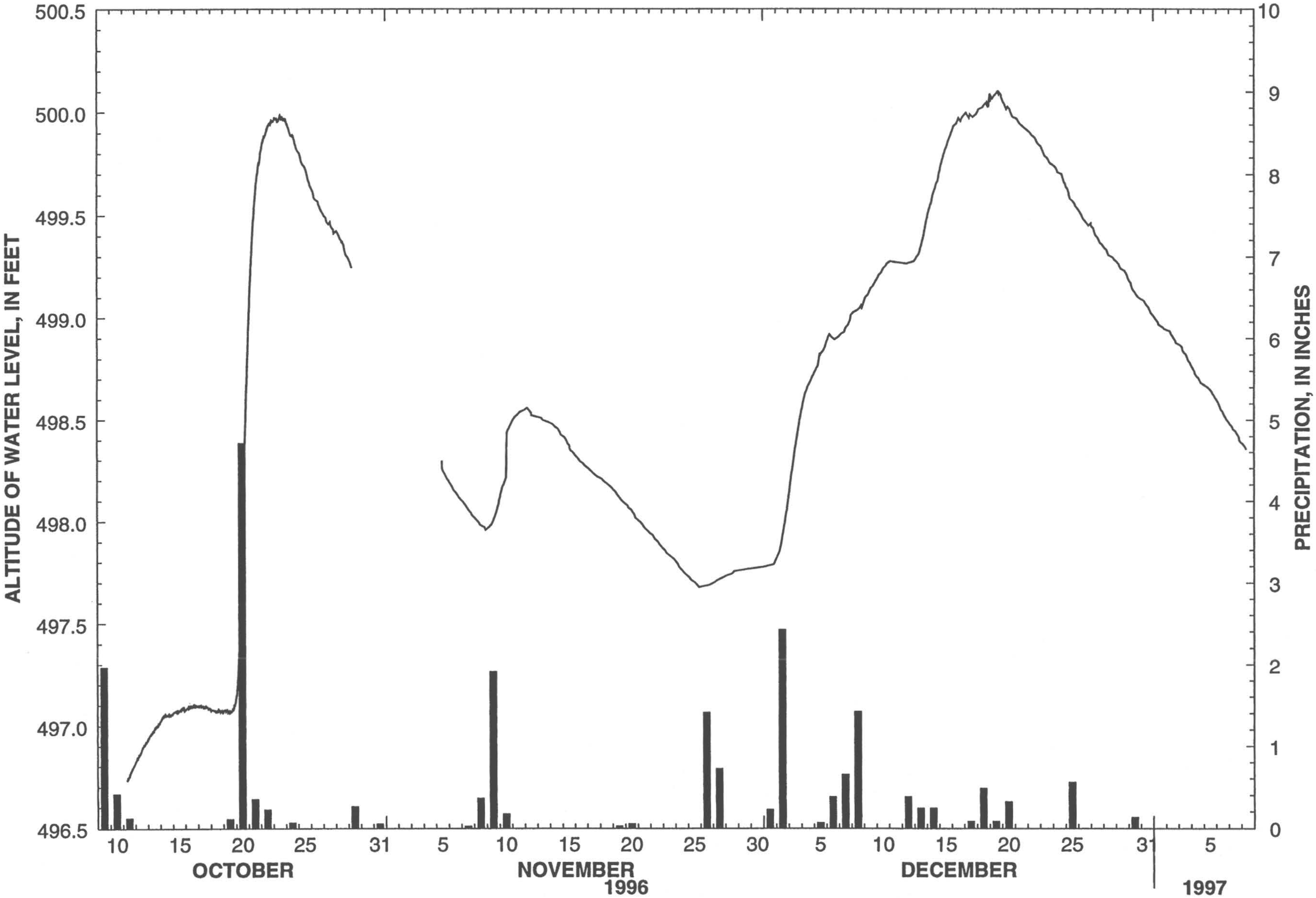


Figure 6. Water-level fluctuations (line) at well WC-37 and rainfall at the Burlington precipitation gage (solid bars), Wolcott study area, Wolcott, Conn. Gap in water-level fluctuation data is when transducer was removed from well.

Table 3. Ground-water level measurements in the Wolcott study area on January 7-8, 1997

[USGS, U.S. Geological Survey; EST, Eastern Standard Time; LSD, land surface datum; Altitudes to sea level datum; B, bedrock; S, surficial deposits; U, unknown]

Well number (plate 8)	Well location	Date - Time measured (EST)	Altitude of LSD, in feet	Depth to water below LSD, in feet	Altitude of water, in feet	Depth of well, in feet	Principal aquifer	Depth of screened interval, in feet
118	1240 Wolcott Road	1/7/97 - 9:10	497.04	7.94	489.10	48.5	S	38.5 to 48.5
117	1240 Wolcott Road	1/7/97 - 9:12	497.37	6.67	490.70	17	S	2 to 17
120	1240 Wolcott Road	1/7/97 - 9:25	484.24	17.13	467.11	38	S	28 to 38
119	1240 Wolcott Road	1/7/97 - 9:26	483.58	16.67	466.91	22.5	S	12.5 to 22.5
140	1240 Wolcott Road	1/7/97 - 9:32	482.00	8.66	473.34	49	B	39 to 49
122	1240 Wolcott Road	1/7/97 - 9:41	481.73	12.74	468.99	45	S	35 to 45
121	1240 Wolcott Road	1/7/97 - 9:42	481.47	12.85	468.62	20	S	10 to 20
116	1240 Wolcott Road	1/7/97 - 9:47	478.77	10.78	467.99	18	S	8 to 18
115	1240 Wolcott Road	1/7/97 - 9:55	475.28	10.77	464.51	16	S	6 to 16
124	1240 Wolcott Road	1/7/97 - 10:00	475.30	10.74	464.56	43.7	S	33.7 to 43.7
139	1240 Wolcott Road	1/7/97 - 10:02	475.23	10.46	464.77	55	B	50 to 55
135	1240 Wolcott Road	1/7/97 - 10:11	464.88	4.45	460.43	20	S	10 to 20
134	1240 Wolcott Road	1/7/97 - 10:17	472.03	12.79	459.24	27	S	17 to 27
141	1240 Wolcott Road	1/7/97 - 10:22	468.14	9.03	459.11	102.5	B	92.5 to 102.5
54	9 Town Line Road	1/7/97 - 10:50	472.30	3.80	468.50	U	B	U
18	14-16 Town Line Road	1/7/97 - 11:00	463.35	4.83	458.52	11.26	S	1.26 to 11.26
19	14-16 Town Line Road	1/7/97 - 11:05	463.61	5.35	458.26	11.74	S	1.74 to 11.74
38	28 Town Line Road	1/7/97 - 11:25	531.72	10.06	521.66	155	B	87 to 155
90	31 Nutmeg Valley Road	1/7/97 - 11:43	463.77	2.47	461.30	13	S	3 to 13
147	72 Tosun Road	1/7/97 - 12:55	537.79	36.89	500.90	U	B	U
146	78 Tosun Road	1/7/97 - 13:00	547.70	35.79	511.91	U	B	U
73	111 Tosun Road	1/7/97 - 13:17	511.57	42.10	469.47	305	B	105 to 305
145	108 Tosun Road	1/7/97 - 13:21	533.97	42.74	491.23	U	B	U
144	114 Tosun Road	1/7/97 - 13:25	537.96	47.84	490.12	U	B	U
15	30 Tosun Road	1/7/97 - 14:00	473.79	2.28	471.51	13	S	3 to 13
16	30 Tosun Road	1/7/97 - 14:05	473.22	3.41	469.81	13	S	3 to 13
17	30 Tosun Road	1/7/97 - 14:15	473.47	4.37	469.10	13	S	3 to 13
151	148 Tosun Road	1/7/97 - 14:23	465.49	3.78	461.71	U	S	U
60	25 Nutmeg Valley Road	1/7/97 - 14:32	468.35	4.17	464.18	175	B	63 to 175
34	10 Venus Drive	1/7/97 - 15:45	513.29	8.20	505.09	15	S	5 to 15
28	10 Venus Drive	1/7/97 - 16:15	520.03	5.58	514.45	14	S	4 to 14

Table 3. Ground-water level measurements in the Wolcott study area on January 7-8, 1997—Continued

[USGS, U.S. Geological Survey; EST, Eastern Standard Time; LSD, land surface datum; Altitudes to sea level datum; B, bedrock; S, surficial deposits; U, unknown]

Well number (plate 8)	Well location	Date - Time measured (EST)	Altitude of LSD, in feet	Depth to water below LSD, in feet	Altitude of water, in feet	Depth of well, in feet	Principal aquifer	Depth of screened interval, in feet
59	31 Nutmeg Valley Road	1/8/97 - 8:20	465.54	3.73	461.81	U	B	U
148	N.End Disposal Area	1/8/97 - 8:49	698.29	0.57	697.72	27	B	21 to 27
44	N. End Disposal Area	1/8/97 - 9:00	709.65	7.27	702.38	36	B	32 to 36
149	N. End Disposal Area	1/8/97 - 9:08	691.60	6.80	684.80	40	S	35 to 40
43	N. End Disposal Area	1/8/97 - 9:25	658.32	18.43	639.89	45.5	B	40.5 to 45.5
150	N. End Disposal Area	1/8/97 - 9:44	574.62	21.52	553.10	U	U	U
52	47 Wolcott Road	1/8/97 - 10:35	507.07	15.73	491.34	205	B	20 to 205
81	32 Wolcott Road	1/8/97 - 10:45	489.00	9.10	479.90	U	B	U
85	16 Wakelee Road	1/8/97 - 10:55	516.41	12.70	503.71	U	B	U
68	143 Wolcott Road	1/8/97 - 12:55	513.35	2.28	511.07	13.9	B	8.9 to 13.9
69	143 Wolcott Road	1/8/97 - 12:56	513.48	1.57	511.91	5.75	S	2.85 to 5.75
67	143 Wolcott Road	1/8/97 - 13:03	515.18	3.92	511.26	12.5	B	4.5 to 12.5
40	143 Wolcott Road	1/8/97 - 13:18	510.08	21.54	488.54	200	B	17 to 200
66	143 Wolcott Road	1/8/97 - 13:25	518.88	3.89	514.99	11.5	B	6.5 to 11.5
80	63 Wakelee Road	1/8/97 - 13:40	497.58	7.52	490.06	18	S	8 to 18
79	63 Wakelee Road	1/8/97 - 13:47	496.77	5.35	491.42	15	S	5 to 15
78	63 Wakelee Road	1/8/97 - 13:54	484.26	4.18	480.08	15	S	5 to 15
77	63 Wakelee Road	1/8/97 - 14:00	486.93	4.15	482.78	17	S	7 to 17
95	41 Garthwait Road	1/8/97 - 15:25	480.00	11.89	468.11	245	B	42 to 245

The water-level measurements were used to construct a map of composite water-level altitudes for the 2-day time period (plate 8). Locations and land-surface altitudes of the 50 wells were surveyed with an electronic total-station instrument. In the Nutmeg Valley Road site area, topographic control used to construct the water-table contours was from a more recent and more detailed map (2-ft contour interval; base from Army Corps of Engineers, 1992) than the 10-ft contour interval USGS topographic base on which plate 8 is displayed; therefore, some stream crossings, contour lines, and well locations may appear in slightly different locations on plate 8 from their actual locations on the 2-ft contour base. The contour map of the water table is, in general, a subdued expression of the land surface. Ground-water flow is eastward from the landfill area and the hilltops to the west of the Nutmeg Valley Road area toward the unnamed brook and Old Tannery Brook. From the hilltop on the northeastern side of the site area, ground-water flow is southwestward toward Old Tannery Brook, southeastward toward Mad River, and southward to wetlands between the two streams. From Bald Hill, flow is westward toward the Mad River.

On January 7-8, 1997, the depth to water in most of the area ranged from 2 to 20 ft. In the Tosun Road residential area, the depth to water measured in wells at five residences ranged from 35 to 48 ft, indicating that daily pumping at 20 households may be lowering the water table in the Tosun Road area.

Recharge

Recharge was calculated for the ground-water-flow system that discharges between streamflow-gaging stations 1, 2, and 4 (along the unnamed brook, Old Tannery Brook, and Mad River; fig. 2). This 0.936-mi^2 area extends to the top of the hill occupied by the North End Disposal Area, northward to the top of Chestnut Hill, southeastward down the hill to below the small unnamed pond on Old Tannery Brook, eastward to hilltop west of Wolf Hill, southward along hilltop, down to the Mad River at USGS station 1, up to the top of Bald Hill, and westward to USGS station 2. Stratified drift underlies 31.9 percent of this area, and the annual effective basinwide recharge, using the estimation technique of Mazzaferro and others (1979) described earlier in this report, is 0.616 Mgal/d or 14 in/yr.

Basinwide recharge can be separated into contributions to stratified drift and to till. Areas underlain by stratified drift receive, on average, 2.7 times more effective recharge than areas underlain by till (Mazzaferro and others, 1979). Equations developed by Mazzaferro (1986) to estimate this relation are:

RECH (s.d.) = RECH (b.w.) / [(TL/K) + SD], and

RECH (till) = RECH (b.w.) / [TL + (SD x K)],

where:

RECH (s.d.) = Recharge rate for stratified-drift areas (in/yr),
RECH (till) = Recharge rate for till areas (in/yr),
RECH (b.w.) = Recharge rate basin wide (in/yr),
SD = Area of stratified drift (percent/100),
TL = Area of till (percent/100), and
K = Ratio of annual, effective recharge rates in stratified-drift areas to those in till areas (equal to 2.7).

Applying these formulas to the area that discharges between stations 1, 2, and 4, the effective recharge rates to each type of deposit are:

RECH (s.d.) = 14 / [(0.681/2.7 + 0.319] = 24 in/yr of recharge to stratified deposits

RECH (till) = 14 / [0.681 + (0.319 x 2.7)] = 9.0 in/yr of recharge to till

These recharge rates expressed in terms of volume (recharge rate times the area of the basin) are 1.7 x 10^7 ft^3/yr to stratified-drift areas and 1.3 x 10^7 ft^3/yr to till areas. This means that 56 percent of the basinwide effective recharge in this area is to stratified-drift areas, and 44 percent is to till areas.

Flow Direction

Ground-water flow begins with recharge at the ground-water surface (plate 8). Recharge in upland till areas produces ground-water flow to streams draining till areas or to stratified-drift areas in the valley by deeper flow (figs. 4 and 5). Recharge in stratified-drift areas produces ground-water flow to streams. Because a large percentage of the study area is underlain by till, the volume of water flowing from till areas to stratified-drift areas may be comparable to the volume of water flowing directly from stratified-drift areas to streams. Recharge to the bedrock aquifer is from till in upland areas and from the stratified drift in the valley. The North End Disposal Area, one source of potential ground-water contamination, is upgradient from the site area in an area underlain by till and bedrock. Most industrial facilities in the site area, many of which are also potential ground-water contamination sources, are in the area underlain by stratified drift.

Ground water in stratified drift flows preferentially in the sand and sand and gravel deposits, rather than in very fine sand, silt, or clay deposits. Semiconfining conditions may occur in the sand and sand and gravel deposits that underlie the very fine sand, silt, and clay. In the bedrock, ground-water flow takes place largely in fractures. Under nonstressed conditions, bedrock wells in the valley would be expected to have higher water levels than nearby wells completed in surficial materials. Under stressed conditions, when bedrock wells in the valley are pumped, flow pathways can be reversed in the areas around the pumped wells (figs. 4 and 5), and ground water in the highly transmissive surficial material recharges the bedrock aquifer. In this way, contamination in the surficial aquifer could move into the bedrock aquifer.

SUMMARY AND CONCLUSIONS

Ground-water contamination by volatile organic compounds (VOC's) has been identified at the Nutmeg Valley Road site area. Contamination has been associated with on-site disposal of heavy metals, chlorinated and non-chlorinated VOC's, and cyanide. Concentrations of detected VOC's which include (in order of decreasing frequency) TCE, tetrachloroethylene (PCE), 1,1,1-TCA, toluene, methylene chloride, ethylbenzene, benzene, carbon tetrachloride, ethyl ether, xylene, 1,2 dichloroethene, chloroform, pentane, and 1,1,2,2 tetrachloroethane, in water samples collected from bedrock wells during 1981-95 at the Nutmeg Valley Road site area show a general trend of decreasing concentrations of the various VOC contaminants from the time of the measured peak to the last sample tested.

Water levels in the bedrock aquifer at the junction of Woodtick Road and Nichols Road indicate that the bedrock aquifer in this location responds quickly to precipitation; water levels in a well at this location rose nearly 3 ft in the 2 days following the 4.5-in. rainfall on October 20. At such locations, contamination in surficial material could migrate quickly into the bedrock aquifer system. Synoptic ground-water level measurements made in 50 wells in the Nutmeg Valley Road site area on January 7-8, 1997 showed that water-level altitudes in bedrock wells were not significantly different from those in surficial wells. In a 0.936-mi^2 ground-water-flow system that discharges between stations 1, 2, and 4 (along the unnamed brook, Old Tannery Brook, and Mad River; fig. 2), annual effective recharge is 14 in/yr. This recharge is separated into contributions to stratified drift (24 in/yr) and to till (9 in/yr). This means that 56 percent of the basinwide effective recharge in this area is to stratified-drift areas, and 44 percent is to till areas.

In general, ground water flows from upland areas to streams in the valley. The North End Disposal Area, one source of potential ground-water contamination, is upgradient from the site area in an area underlain by till and bedrock. Most industrial facilities in the site area, many of which are also potential ground-water contamination sources, are in the area underlain by stratified drift. Under stressed conditions, when bedrock wells in the valley are being pumped, flow pathways can be reversed in the areas around the pumping wells, and ground water in the highly transmissive surficial material recharges the bedrock aquifer. In this way, contamination in the surficial aquifer could move into the bedrock aquifer.

Additional information is needed to provide a comprehensive and up-to-date assessment of the ground-water quality in the bedrock and surficial aquifers and the surface-water quality in Old Tannery Brook, the unnamed brook, and Mad River. The water-quality information presented in this report is based on data from many different sources, gathered at different times, over a long period of time. Although data from some bedrock wells show decreasing concentrations of VOC's over time, little is known about concentrations of VOC's in the surficial aquifer, except that concentrations are currently high in some places. For these reasons, a synoptic, area-wide sampling program would be beneficial.

This investigation points out the need to better define the ground-water-flow system in the Nutmeg Valley Road area, including information on the geologic structure of the surficial and bedrock aquifer, a more detailed delineation of the distribution of coarse-grained and fine-grained stratified deposits, and a better understanding of fracture patterns in the bedrock aquifer. A better definition of the flow system would improve the conceptual model of ground-water flow and contaminant migration in the surficial materials and fractured crystalline bedrock and improve the understanding of the relation between surficial materials and bedrock. Future evaluation of potential sources of ground-water contamination and remediation planning in the site area need to take into account that ground water in the stratified-drift area of the site is being recharged, in part, by ground-water flow from the till and bedrock area. The extent to which ground-water withdrawals from wells in the valley are affecting the hydraulic connection between the bedrock and surficial aquifers could be assessed further by installing paired bedrock/surficial wells at a number of locations in the valley.

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Inventoried wells—PLATE 2
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Locations and occupants - PLATE 1

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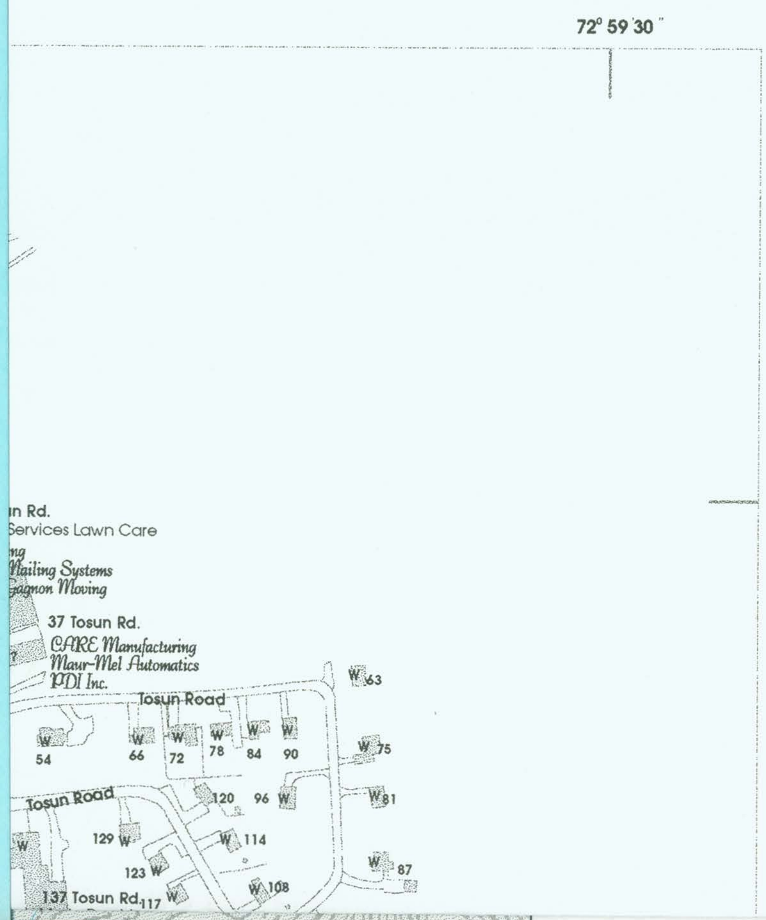

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