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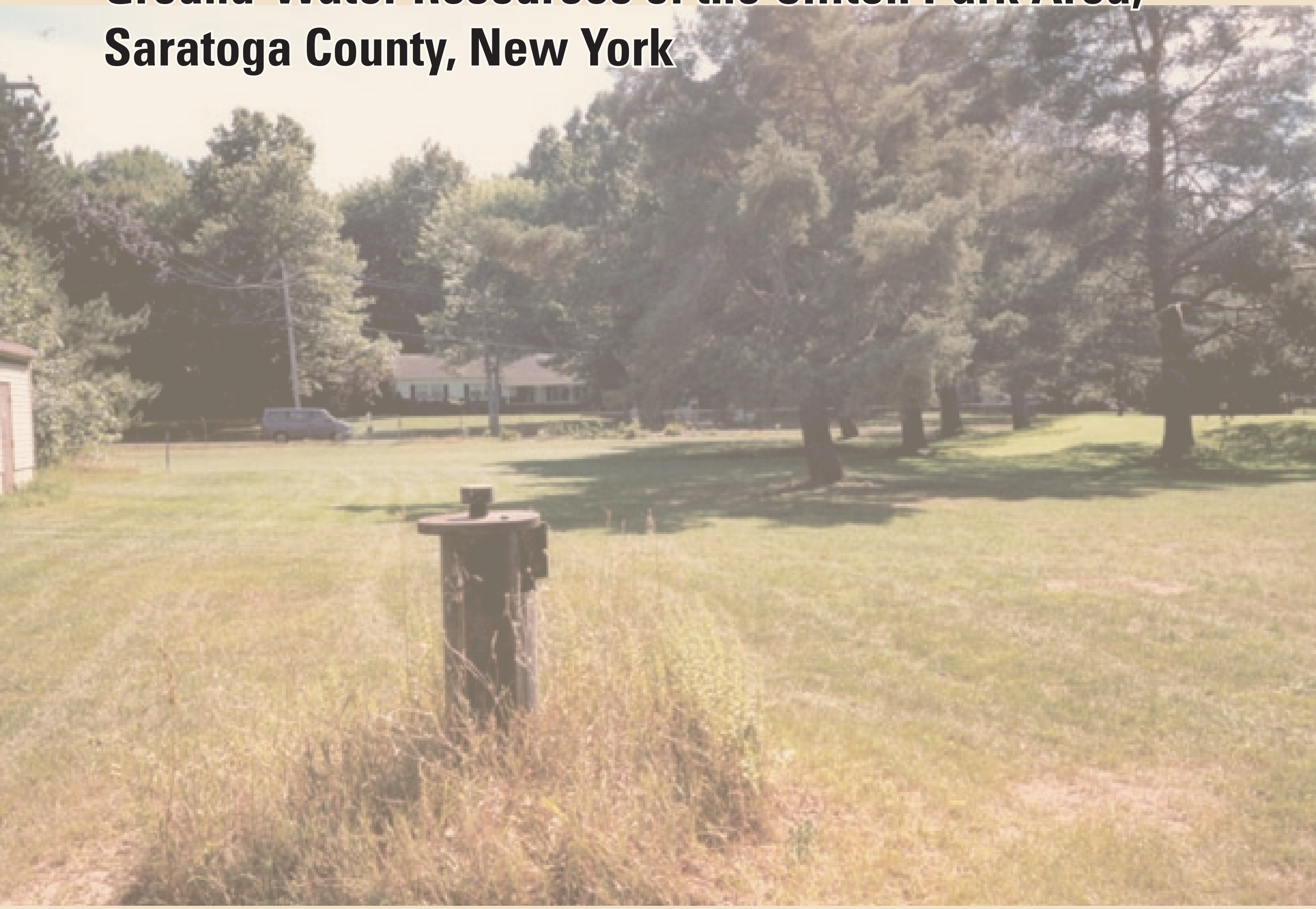
Ground-Water Resources of the Clifton Park Area, Saratoga County, New York



Water-Resources Investigations Report 01-4104

U.S. Department of the Interior
U.S. Geological Survey

Cover photo: View of golf course production well number one (Sa-1273) looking south.

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BY PAUL M. HEISIG

U.S. GEOLOGICAL SURVEY
WATER-RESOURCES INVESTIGATIONS REPORT 01-4104

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Troy, New York
2002

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mile (mi)	1.609	kilometer
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Other Units

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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 the United States and Canada, formerly called Sea Level Datum of 1929.

Ground-Water Resources of the Clifton Park Area, Saratoga County, New York

By Paul M. Heisig

ABSTRACT

Ground water is the sole source of public water supply for Clifton Park, a growing suburban community north of Albany, New York. Increasing water demand, coupled with concerns over ground-water quantity and quality, led the Clifton Park Water Authority in 1995 to initiate a cooperative study with the U.S. Geological Survey to update and refine the understanding of ground-water resources in the area.

Ground-water resources are largely associated with three aquifers in the eastern half of the area. These aquifers overlie or encompass the Colonie Channel, a north-south-oriented bedrock channel that is filled primarily with lacustrine glacial deposits. The three aquifers are: (1) an unconfined lacustrine sand aquifer, (2) the Colonie Channel aquifer, which is confined within the deepest parts of the channel and variably confined and unconfined within the shallower, peripheral channel areas, and (3) an unconfined alluvial aquifer beneath the Mohawk River flood plain, which represents the southern limit of the study area. The lacustrine sand aquifer has little potential for large-scale withdrawals because it is predominantly fine grained and is susceptible to contamination from human activities at land surface. Water from this aquifer can, however, recharge the underlying peripheral parts of the Colonie Channel aquifer where hydraulic connections are present. The Colonie Channel aquifer consists of thin sand and gravel and (or) shallow, fractured bedrock over much of the channel area; discontinuous deposits of thicker (more than 20 feet) sand and gravel are common in the peripheral channel areas. The deepest, or central, channel area of this aquifer is isolated from the overlying lacustrine sand aquifer by a continuous lacustrine silt and clay unit, which is the primary channel-fill deposit. The most productive areas of the Colonie Channel aquifer are typically the shallow peripheral areas, where conditions range from unconfined to confined. The most productive aquifer within the area is the alluvial aquifer, which is sustained to an unknown extent by induced infiltration of Mohawk River water.

The chemical composition of ground water within the Clifton Park area varies widely in response to hydrogeologic setting, pumpage, and contamination from human activities. These chemical differences can be used to deduce ground-water flow paths within and between the unconfined and confined areas of the aquifer system. Six water types are defined; three are naturally occurring and three are the result of human activities.

Precipitation that infiltrates the land surface is the sole source of recharge to the lacustrine sand aquifer; precipitation also recharges the alluvial aquifer and unconfined parts of the Colonie Channel aquifer. Ground-water withdrawals from confined or unconfined peripheral areas of the Colonie Channel aquifer induce flow from recharge areas, from the underlying bedrock, or from other confined aquifer areas.

The rate of recharge to the confined central area of the Colonie Channel aquifer appears to be low. Potentiometric levels as much as 100 feet below water-table levels in the overlying lacustrine sand aquifer indicate two large

depressions in the potentiometric surface; these depressions indicate that withdrawals from this aquifer have cumulatively exceeded the recharge rates. Localized recharge of the central channel area apparently occurs from two peripheral channel areas that are characterized by zones of elevated water levels and (or) by water chemistry that differs from those within the central channel area. Recharge from, or hydraulic connection with, adjoining segments of the Colonie Channel aquifer to the north and south is likely, but the potential for significant recharge is low because the aquifer is thin and poorly permeable.

INTRODUCTION

The Town of Clifton Park, in southern Saratoga County (fig. 1), is a suburban community whose population grew five-fold from the early 1960's to about 30,000 in 1990 (Capital District Regional Planning Commission, 1994). Improved access to jobs in Albany County to the south since the opening of the southern section of the Northway (I-87) in 1961 has made the town a desirable bedroom community. The relatively level land with well-drained sandy soils in the eastern half of the town is favorable for residential development. Residential and commercial development has continued through the 1990's and has

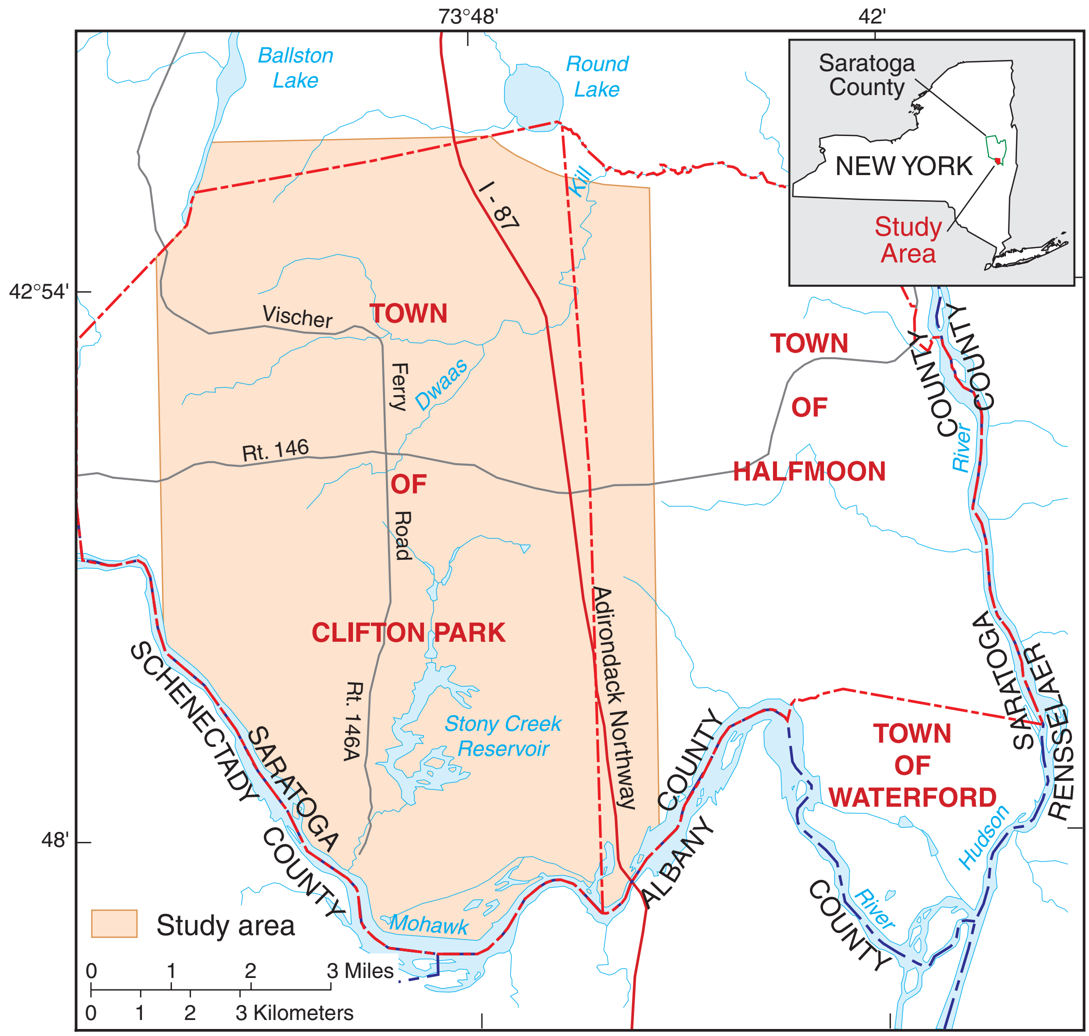


Figure 1. Location and pertinent geographic features of the Clifton Park study area, southern Saratoga County, New York.

been paralleled by an increased water demand. Ground water is the town's sole source of public water supply. In 1997, Clifton Park public-supply wells pumped more than 1 billion gallons of water (D. Connor, Clifton Park Water Authority, written commun., 1999).

Early residential developments were served mostly by low-yield, shallow, drilled wells or wellpoints and large-diameter infiltration wells or galleries. These privately owned systems were plagued by low water pressure and high turbidity, however, and also were susceptible to contamination from human activities at land surface. As development continued, new ground-water sources were sought. From the late 1960's through the early 1990's, deeper, more productive aquifer areas consisting of glacial deposits and shallow fractured bedrock were identified in and around the Colonie Channel (fig. 2), a buried bedrock channel of a former river beneath the eastern part of town (Simpson, 1949; Dineen and Hanson, 1983). The Colonie Channel aquifer subsequently became the primary source(s) of water for the town; initial reports from the most productive wellfields indicated sustainable yields that ranged between 600 and 1,000 gallons per minute (gal/min) (Dunn Geoscience Corporation, 1979, 1985b). The quantity and chemical quality of water withdrawn varies widely among the wellfields, however, and water-level declines in deep confined areas over the years indicate that, in general, ground-water withdrawals have exceeded the rate of aquifer recharge. The most common water-quality complaints from consumers supplied by water from unconfined or locally confined areas of the aquifer have been excessive iron and (or) hardness.

Increasing water demands have necessitated exploration for additional water supplies. Most recently (1996), shallow alluvial deposits along the Mohawk River in the southern part of town (pl. 1A.1) have been tapped as a major new source of water. Initial well yields ranging from 600 to 1,000 gal/min are apparently sustained in part by induced infiltration of water from the Mohawk River (C.T. Male Associates, P.C., 1996, 1999).

In 1991, the Town of Clifton Park established the Clifton Park Water Authority (CPWA) to improve water service to consumers. Existing water-supply systems were consolidated and interconnected, and a program of infrastructure upgrades, water-quality improvement, and water-resource evaluation was instituted.

In 1995, the U.S. Geological Survey (USGS), in cooperation with the CPWA, began a study to refine previous conceptual models of ground-water occurrence and to conceptualize the availability and chemical quality of ground water in the Clifton Park area. This information is critical to support decisions regarding the management and protection of local ground-water resources in the study area and in similar hydrogeologic settings within the region. Whereas previous studies of local geology and hydrogeology (Dineen and Hanson, 1983; Waller, 1983; Reynolds, 1985) have provided information on the hydrogeologic framework and conceptualization of water resources in the Clifton Park area, this study incorporates water-level and water-quality data collected by USGS and CPWA, recent data from drillers' logs, several ground-water exploration and wellfield-analysis reports by private consultants, and water-quality data on file at the New York State Department of Health. During the study, latitude-longitude, well-construction, and hydrogeologic data from 214 wells (local well numbers Sa-1287 through Sa-1500) were added to the USGS National Water Information System (NWIS) database; these data are available upon request from the USGS. A local well number prefixed by "Sa" (for Saratoga County) is listed after the first reference to each well discussed in the text.

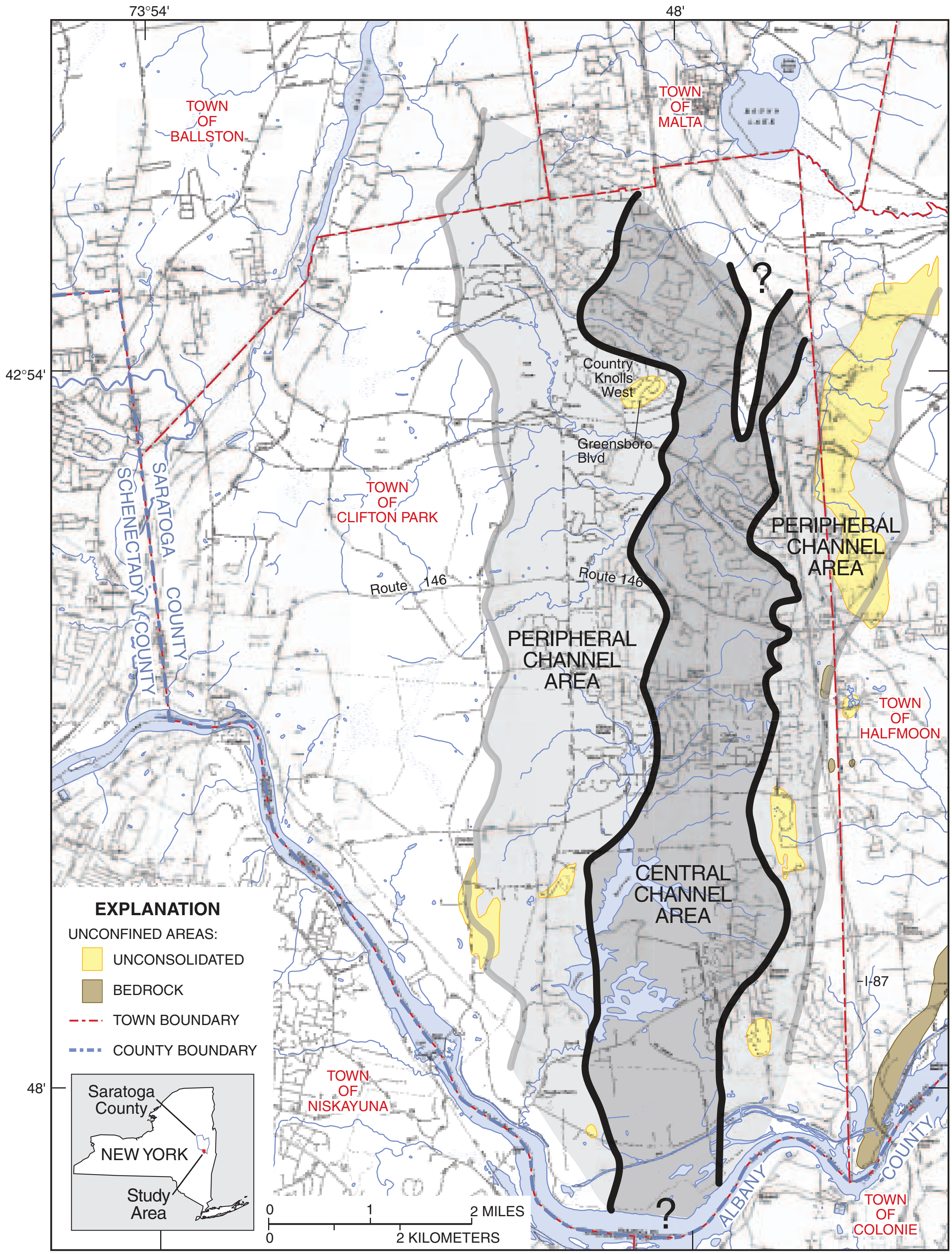
Purpose and Scope

This report (1) documents the hydrogeologic framework, ground-water chemistry, and ground-water levels in the Clifton Park area, with emphasis on the Colonie Channel aquifer on the eastern side of town, and (2) presents a refined conceptual model of the aquifer system.

Maps and a vertical section depict (1) thickness of the lacustrine sand and extent of the alluvial aquifer, and (2) thickness of the Colonie Channel aquifer (glacial deposits only) and the extent and type of overlying confining units. A map and a vertical section show ground-water levels (August and September 1998) and the distribution of water types (1993-98) within the Colonie Channel aquifer.

Acknowledgments

The author thanks the many property owners and businesses that granted permission for water-level



Base from New York State Department of Transportation Digital Planimetric Maps, 1:24,000.
Burnt Hills 1991, Round Lake 1991, Schenectady 1993, Niskayuna 1992

Figure 2. Location of the Colonie Channel aquifer, including the central channel and the peripheral channel areas, Clifton Park, New York.

monitoring and water-sample collection from their wells. Douglas Connor and Walter Schlesier of the Clifton Park Water Authority provided historical pumpage, water-level, and other ancillary data, facilitated access to sites, provided field personnel for collection of ground-water data, and measured the sulfate concentration in selected ground-water samples. The late well driller, Richard Ferraioli, of Dick Ferraioli, Inc., provided many well logs, field assistance in locating wells, and information on drilling conditions at several sites. Eric Hanson, of Continental Placer, Inc., provided several well logs, assisted in well location, and provided information on subsurface conditions in the area. George Hodgson, of the Saratoga Environmental Management Council, provided recent well logs. Janice Baldwin of Hawk Drilling Co., Inc., also provided well-log information.

HYDROGEOLOGIC FRAMEWORK

The Towns of Clifton Park and Halfmoon (fig. 1) are underlain by structurally deformed, fractured Ordovician shale and sandstone (Fisher and others, 1970; Kidd and others, 1995) that are overlain in most areas by Pleistocene (glacial) and Recent sediments. The buried bedrock surface is uneven and has been shaped by the erosive action of rivers, streams, and glacial ice. The most pronounced bedrock-surface feature is the Colonie Channel (Simpson, 1949), which runs north-south through the eastern half of Clifton Park (fig. 2); it consists of a broad, shallow channel about 3 mi wide that is bounded by local bedrock-cored hills, and a 1-mi-wide inner channel, generally defined by lacustrine silt and clay thicknesses greater than 60 ft (pl. 1A.2-3). The deepest part of the channel is typically 150 to 200 ft deeper than the surrounding bedrock surface and is buried beneath as much as 314 ft of glacial deposits (Dineen and Hanson, 1983; Reynolds, 1985). The western side of the town has relatively low bedrock-surface relief (generally less than 50 ft) and thin overlying Pleistocene and Recent deposits (typically less than 50 ft thick).

Areas where bedrock is overlain by minimally saturated or unsaturated unconsolidated deposits are generally poor sources of water in terms of quantity and quality. Water is available primarily from fracture openings within the bedrock; thus, only small amounts of water can be held in storage. Withdrawal of water from water-bearing fractures can result in a large cone of depression that may extend to, and interconnect with, near-surface fractures, which are vulnerable to contamination from surface sources. Wells that tap deep fractures may contain high sodium concentrations (200 mg/L).

Bedrock is successfully tapped as a water source where it is overlain by saturated unconsolidated deposits, particularly within sections of the Colonie Channel. Many wells tap thin, permeable zones of fractured shale just below the bedrock surface or in shale gravel just above it. These permeable bedrock zones typically are in hydraulic connection with local, overlying permeable zones of glacial ice-contact deposits and may provide a hydraulic interconnection among otherwise isolated permeable ice-contact deposits within the channel.

The thickest glacial deposits are in and adjacent to the Colonie Channel; they include (1) till, directly deposited by active ice; (2) coarse-grained ice-contact deposits deposited by meltwaters within, beneath, or adjacent to stagnant ice; and (3) lacustrine silt and clay, lacustrine sand, and deltaic sand and gravel deposited in proglacial lakes during deglaciation. The glacial history of the area has been described by LaFleur (1965, 1979), Hanson (1977), and Dineen and Hanson (1983). The typical sequence of glacial deposits, in ascending order, from top of bedrock is: till and (or) ice-contact deposits overlain by lacustrine silt and clay, which in turn is overlain by lacustrine sand and possibly deltaic sand and gravel. One or more of these units can be missing in any given area.

The study area contains two glacial aquifers: (1) the lacustrine sand aquifer, which is an unconfined (water-table) aquifer composed of saturated lacustrine sand and deltaic sand and gravel deposits, and (2) the Colonie Channel aquifer, which is a mostly confined aquifer composed of ice-contact sand and gravel deposits in hydraulic connection with thin, permeable areas of fractured bedrock or bedrock-derived gravel at or near the bedrock surface. Much of this aquifer is overlain and confined by lacustrine silt and clay and (or) till units within the center of the Colonie Channel.

A third aquifer, composed of productive fluvial sand and gravel, underlies part of the Mohawk River flood plain at the southern end of Clifton Park (pl. 1A.1). It is overlain by about 5 to 15 ft of alluvium, which ranges from silty clay to fine-to-medium sand. Other alluvium deposited by small streams and other Recent deposits, such as aeolian sand, or peat and muck, do not provide useful amounts of water because they are too thin, have low permeability, and (or) are not fully saturated.

Lacustrine Sand Aquifer

The lacustrine sand aquifer is unconfined and is present mostly in the area underlain by the Colonie Channel in the eastern half of Clifton Park (pl. 1A.1-2). Lacustrine and aeolian sand deposits in this area are thin and have little saturated thickness, although they are widespread in other parts of Clifton Park. The aquifer material was deposited by floodwaters from the west (Dineen and Hanson, 1983, Wall, 1995) that scoured and incised channels in till and bedrock on the western side of town and deposited lacustrine-deltaic and blanket-sand deposits as much as 100 ft thick in proglacial lake environments on the eastern side of town (pl. 1A. 1-2).

The lacustrine-deltaic deposits are coarsest (medium to coarse sand and fine gravel) in the area just east of where waters from the Iromohawk River, which preceded the present-day Mohawk River, breached low points among the till and bedrock hills along the western side of the Colonie Channel (pl. 1A.1; Wall, 1995). One of the largest and most productive of these deltaic deposits is about 25 ft thick and underlies the Shenendehowa Central School campus along Rt.146 (pl. 1A.1). This material was apparently deposited by Iromohawk floodwaters that flowed eastward through the channel now occupied by the Dwaas Kill west of Vischers Ferry Road (pl. 1A.1). The lacustrine sands farther east of the breach areas are typically fine grained with some silt and become siltier with depth.

Ground-water levels in the lacustrine sand aquifer generally are less than 20 ft below land surface in areas of low relief but may be as much as 60 ft below land surface in areas where the stream channels are deeply incised or where hydraulic interconnection with the underlying channel aquifer induces downward leakage from the lacustrine sand aquifer. The fine grain-size of the aquifer material has largely restricted pumping; infiltration of fine sand and silt into well pumps has resulted in the abandonment of several wellfields and precludes use of conventional screened wells in most of the aquifer. Reported yields from infiltration wells and galleries range from 20 to 80 gal/min, whereas multiple well-point installations have provided 100 to 300 gal/min. Shallow domestic well points commonly provide enough water for lawn watering.

The lacustrine sand aquifer is most productive where it contains saturated deltaic sand and gravel (pl. 1A.1). Screened wells have been used successfully in several of these areas, including the primary production well for the Shenendehowa Central School campus (300 gal/min) and the Elnora well field (at least 400 gal/min) (pl. 1A.1). The primary concern in withdrawing water from this aquifer is the high potential for contamination from nearby human sources, such as wastewater disposal, fertilizer and pesticide application, road-salt storage and application, and leaking underground fuel-storage tanks.

Colonie Channel aquifer and adjacent areas

The Colonie Channel aquifer, also referred to as the “channel aquifer” herein, has been previously referred to as the “confined aquifer” (Reynolds, 1985) or “deep aquifer” (Waller, 1983). It has been a major source of ground water for Clifton Park since the late 1960's and consists of discontinuous areas of (1) permeable ice-contact deposits generally overlying bedrock, (2) fractured bedrock (near the bedrock surface), or (3) bedrock-derived shaley gravel overlying the bedrock surface (pl. 1A.2-3). The distribution, permeability, and degree of hydraulic interconnection among these materials are locally variable. These deposits are confined by lacustrine silt and clay or till but may be locally unconfined (pl. 1A.2-3) in peripheral channel areas (fig. 2). The channel aquifer is bounded on each side by low, discontinuous, bedrock-cored ridges. The western ridge is breached by several small channels, and the eastern ridge is breached most notably at the Rt. 146 and I-87 interchange.

The aquifer is strongly confined (isolated from the atmosphere) by a thick, continuous lacustrine silt and clay unit (pl. 1A.2-3) over most of the central area of the Colonie Channel (fig. 2), as evidenced by strong ground-water-level responses to changes in atmospheric pressure (high barometric efficiency). The aquifer within the peripheral channel areas, or adjacent to them, is locally confined by till or lacustrine silt and clay or is unconfined, as indicated by weak ground-water-level responses to changes in atmospheric pressure (low barometric efficiency) or by the absence of a confining unit in well-log descriptions. These unconfined areas are much smaller than the confined areas but support the majority of high-yield wellfields. Most of these unconfined areas show no evidence of hydraulic connection with the deeper confined areas.

The Colonie Channel aquifer receives recharge from precipitation in localized areas where ice-contact deposits are unconfined (commonly overlain by lacustrine sand) or where fractured bedrock is at or near land surface. Both types of areas are indicated on fig. 2 and pl. 1A.3. Sporadic bedrock outcrops are present within the western half of town but are not identified in pl. 1A.3.

The most productive areas of the channel aquifer are localized and can be as much as 85 ft thick. These permeable zones consist of ice-contact deposits (sand and gravel) that can provide short-term yields up to about 600 gal/min (Dunn Geoscience Corporation, 1979) (pl. 1A.2-3). These zones can grade into impermeable silt- and clay-bound sand and gravel or till over short distances. The productive areas are most common in peripheral channel areas and are unconfined or locally confined (fig. 2, pl. 1A.2-3). They are tapped by six wellfields in the Town of Clifton Park (Boyack, Oakwood, Lapp, Roosevelt, Berry Farm, Meadows) and by two wellfields (Twin Lakes and Hoffman) in the Town of Halfmoon (pl. 1A.3). The Twin Lakes wellfield is outside the channel, just east of the bedrock ridge that bounds the eastern side of the channel. Its hydrogeologic setting is similar to that at the Oakwood wellfield, on the western side of the same bedrock ridge (pl. 1A.3).

Thick, confined, permeable deposits are present in the center of the channel only north of Rt. 146; this part of the aquifer is tapped by the Plank, Kinns, and Pierce wellfields. South of Rt. 146, the central part of the channel beneath the lacustrine silt and clay is predominantly silt- or clay-bound ice-contact deposits or poorly permeable till with some zones of thin, permeable ice-contact deposits. The only public-supply well in this area is the Moe production well (Sa-1347). Aquifer tests at most wellfields that tap deep, confined channel areas (except Moe) show hydraulic evidence of localized areas of thick aquifer material. An aquifer test at the Moe well indicated a source of recharge beyond the immediate aquifer area (Dunn Geoscience Corporation, 1984a).

Some areas within and adjacent to the Colonie Channel lack thick, permeable ice-contact sand and gravel but contain many wells that tap fractured bedrock or thin shale gravel over bedrock (pl. 1A.2-3). Three of the town's wellfields (Linden, Calico Colony, and Park Lane) tap this channel-aquifer setting; the Linden well (Sa-1328) obtains sustained yields as high as 80 to 100 gal/min. These fractured-bedrock and shale-gravel aquifer settings typically are in hydraulic connection with adjacent ice-contact (or lacustrine sand) deposits and may provide a hydraulic connection among otherwise isolated ice-contact deposits in the Colonie Channel.

Till, which is grouped with poorly permeable ice-contact deposits in pl. 1A.2-3, is the predominant confining unit in areas of bedrock highs, such as in much of the western half of Clifton Park and locally along the eastern and western edges of the Colonie Channel aquifer (pl. 1A.2-3). Till may be a less effective confining unit than lacustrine silt and clay in some areas, in that (1) some recharge appears to reach the underlying bedrock or ice-contact deposits, and (2) till typically is thinner and less continuous than lacustrine silt and clay and may have local permeable zones of sorted material or fractures, or it may be associated with ice-contact deposits that act as “windows” of higher permeability for recharge. Several wells completed in till or poorly permeable ice-contact deposits show water-level responses or water quality characteristic of unconfined or locally confined conditions.

The least productive wells in the study area typically are associated with high areas on the bedrock surface, particularly where overlain by thick till in the western half of town and along the bedrock ridge on the eastern side of the Colonie Channel. Wells completed at or within shallow bedrock in these areas typically yield 5 to 10 gal/min or less.

Alluvial Aquifer

Clifton Park recently has developed a ground-water supply from an alluvial aquifer within the flood plain of the Mohawk River at the southern edge of the town (pl. 1A.1). This aquifer has been referred to as the “Vischers Ferry aquifer” (C.T. Male Associates, P.C., 1996, 1999). Alluvial aquifers can be productive, reliable sources of water, especially if they are in hydraulic connection with an adjacent stream or river (Winslow and others, 1965). Water withdrawals from such aquifers can: (1) intercept natural ground-water flow that would otherwise discharge to the river, and (2) possibly induce river water to infiltrate and flow to the well. This aquifer is typically about 25 ft thick, consists of sediments ranging from fine sand to coarse gravel and cobbles, and is commonly overlain by 5 to 10 ft of recent alluvium (clayey or sandy silt) (C.T. Male Associates, P.C., 1996). The aquifer is considered unconfined in general because the fine-grained alluvium is absent in some areas and because the observed similarity between river stage and ground-water levels near the river suggests hydraulic connection with the Mohawk River.

Four production wells that were installed in this aquifer during the middle to late 1990's yield 450, 600, 800, and 1,125 gal/min (C. T. Male Associates, P.C., 1998, 1999). Water pumped from the Vischers Ferry Preserve wellfield (pl. 1A.1) requires treatment for removal of manganese and sometimes iron. Concentrations of these constituents have increased in all production wells since the initial water samples were collected and analyzed. One of the wells is no longer used because the concentration of manganese in the water (about 7 mg/L) was too high to be adequately lowered during treatment (D. Connor, CPWA, oral commun., 1999).

CHEMICAL COMPOSITION OF GROUND WATER

The chemical composition of ground water in the Clifton Park area varies widely as a result of (1) the natural chemical evolution of ground water with time in the flow system, and (2) human activities that affect water quality, such as road-salt application and ground-water withdrawals. Classification of ground water into water types on the basis of major-ion composition (fig. 3) and selected other characteristics provides a framework for interpretation of ground-water flow and ground-water quality in the Clifton Park area.

Sixty ground-water samples were collected for chemical analysis during the study. All samples were analyzed in the field for pH, temperature, specific conductance, and dissolved oxygen concentration. Thirty-eight of the samples were analyzed for major ions, nutrients, and selected trace elements; 24 of these were collected by USGS personnel and analyzed by the USGS National Water Quality Laboratory in Arvada, Colo., and the remaining 14 were collected with CPWA personnel and sent to the New York State Department of Health (NYSDOH) Laboratory and a commercial laboratory. A subset of 12 samples was analyzed for tritium (^3H) at the USGS tritium laboratory in Menlo Park, Calif., and 22 other samples were analyzed by CPWA for sulfate concentration only.

An additional 56 ground-water analyses were compiled from the USGS National Water-Quality Assessment (NAWQA) program, public water-supply sample analyses on file at the NYSDOH, and water-supply reports from private consultants. Except for the NAWQA samples, most of these 56 samples have incomplete records of major ions and field parameters; however, many of these samples can be assigned to one or more of the chemical water types described below.

Three naturally occurring types of water, and three human-affected types that occur within the channel aquifer are defined below and mapped on plate 1B.1-2. The naturally occurring water types range from relatively young (post-1952) water initially derived from recharge in local unconfined settings to pre-1952 water of unknown source in deeper, strongly confined settings. The human-affected types represent relatively young ground water that has been affected by ground-water withdrawals or by leachate from road-salt application and storage or from landfills.

Natural ground-water evolution is controlled by several processes, including mineral weathering (such as dissolution of calcite or iron sulfide minerals), ion exchange on aquifer material, and microbially mediated oxidation-reduction (redox) reactions. Microbial decomposition of organic matter within the aquifer results in progressively more reducing conditions along ground-water flow paths as dissolved oxygen, nitrate, manganese (IV), iron (III), sulfate, and carbon dioxide are sequentially reduced as they are utilized as electron acceptors in the decomposition process.

Calcium-Magnesium-Bicarbonate Water Type

The calcium-magnesium-bicarbonate (Ca-Mg-HCO3) water type (and related human-affected water types described below) is predominant in the lacustrine sand aquifer, the alluvial aquifer, and the unconfined areas of the Colonie Channel aquifer (pl. 1B.2). Ca-Mg-HCO_3 waters indicate shorter residence times within the ground-water-flow system than most other types described here. Most water samples from areas of residential development show

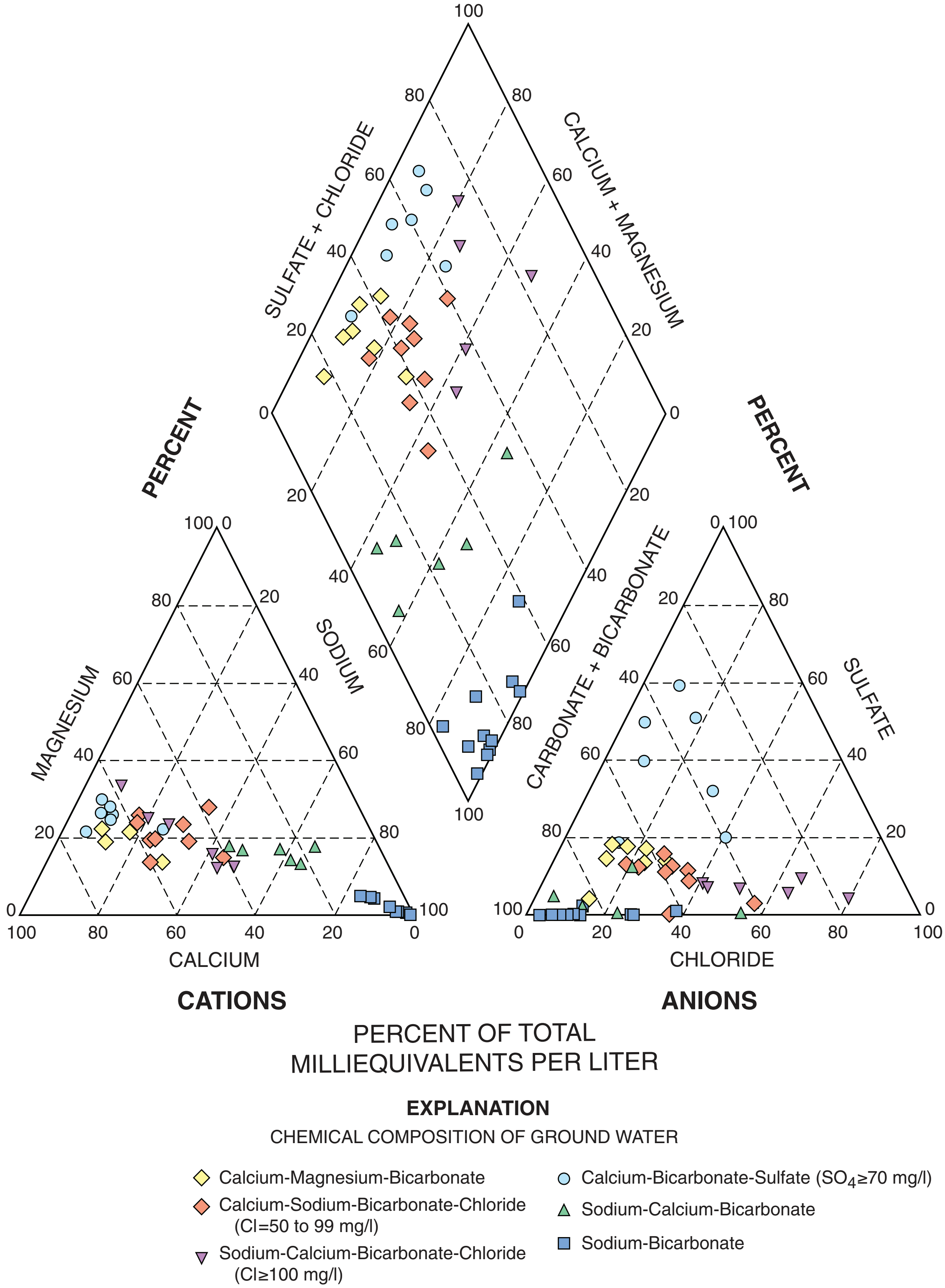


Figure 3. Six chemical ground-water types identified from complete major-ion analyses, Clifton Park area, New York, 1993-98.

minor effects of contamination from road-salt application or storage (chloride concentrations between 10 and 49 mg/L), which indicate a relatively recent origin (post-development) for at least part of the water sample. Ca-Mg-HCO_3 waters in confined areas of the channel aquifer indicate recharge from shallow, unconfined peripheral areas of the channel aquifer and (or) from the lacustrine sand aquifer in favorable settings along the edges of the channel.

Ca-Mg-HCO3 waters have the widest pH range (6.1 - 8.2) of any water type discussed here. Low pH values (6.1 - 6.8) are characteristic of the shallowest ground waters (near the water table) and represent recent infiltration of acidic, oxygenated recharge waters through the unsaturated zone to the upper part of the unconfined aquifer, where calcite is absent or has been largely removed by weathering. Higher pH values (6.8 to 7.6) are most common in unconfined ice-contact deposits (channel aquifer), and also beyond leached zones in the lacustrine sand aquifer, where calcite is present and can undergo some dissolution, raising the pH and increasing concentrations of calcium, magnesium, and alkalinity. The longer the residence time of water in contact with calcite-bearing aquifer material under unconfined conditions, the more calcite dissolution will take place, and the harder the waters will become. Most Ca-Mg-HCO_3 waters are moderately hard to hard (Hem, 1985, p. 159). As these waters enter confined areas of the channel aquifer and become isolated from the atmosphere, pH values may rise to as high as 8.2.

Calcium-Sodium-Bicarbonate-Chloride Water Type

The calcium-sodium-bicarbonate-chloride (Ca-Na-HCO3-Cl) water type represents Ca-Mg-HCO_3 water that has been moderately affected by road-salt leachate and is defined by chloride concentrations of 50 to 99 mg/L. This type of water was found in the lacustrine sand aquifer in shallow observation wells near roads, and at supply wells in peripheral channel areas. Supply wells draw water from a large area, compared to an observation well; therefore, this water type from a supply well is a composite sample that reflects road-salt application over a wide area. These waters range from hard to very hard. Calcium concentrations are potentially increased by the exchange of sodium ions for sorbed calcium ions at exchange sites on clay minerals.

Sodium-Calcium-Bicarbonate-Chloride Water Type

The sodium-calcium-bicarbonate-chloride (Na-Ca-HCO3-Cl) water type represents Ca-Mg-HCO_3 water that has been strongly affected by road-salt or landfill leachate, and is defined by chloride concentrations equal to or greater than 100 mg/L. Sodium typically is the dominant cation where road-salt contamination is present, although all calcium concentrations in this water type exceed 50 mg/L. Calcium is the dominant cation (and magnesium is secondary) in two landfill-monitoring wells. This type of water ranges from hard to very hard. Chloride concentrations of this water, where it is affected by road salt, typically range from 100 to 260 mg/L but can exceed 500 mg/L in areas associated with point sources such as road-salt stockpiles and landfills.

Most occurrences of this water type are samples from a single well or a group of wells within small areas (pl. 1B.1); therefore, the actual distribution of this water type may be much more extensive within the lacustrine sand aquifer and channel aquifer than the limited data indicate. The presence of this water type at the Oakwood supply well (pl. 1B.1), which taps ice-contact deposits in the channel aquifer, suggests high chloride concentrations in areas of the lacustrine sand aquifer that contribute recharge water to that part of the channel aquifer.

The extent of this ground-water type near the town's road-salt-storage facility and the town landfill (John M. McDonald Engineering, P.C., 1998), which is closed, is unknown beyond wells in the immediate vicinity of the sites. The potential is high for movement of ground water with elevated chloride concentrations to areas beyond these two sites.

Calcium-Bicarbonate-Sulfate Water Type

The calcium-bicarbonate-sulfate (Ca-HCO3-SO4) water type, with $SO_4 \geq 70$ mg/L and Ca $\geq$ 100 mg/L, represents Ca-Mg-HCO_3 water that has been affected by ground-water withdrawals at wellfields that tap unconfined or locally confined areas of the channel aquifer (pl. 1B.1). Pumping has altered the direction of local ground-water flow from pre-development conditions, resulting in water-rock interactions that have affected ground-water composition. High hardness and high iron concentrations are the primary water-quality concerns with this water type, although elevated sulfate concentrations are also a concern in some areas. Magnesium concentration is elevated in some samples, but is always lower than that of calcium. Chloride concentrations typically are between 50 and 100 mg/L, presumably as a result of road-salt application.

Initial water analyses (Dunn Geoscience Corporation, 1987A) from wells that currently produce the $Ca-HCO_3-SO_4$ water type indicate that the first water withdrawn from these sites typically was the $Ca-Mg-HCO_3$ type described earlier. The regular withdrawal of ground water at these sites causes a stress to which the local flow system gradually adjusts; specifically, shallow, oxygenated $Ca-Mg-HCO_3$ waters may be drawn downward into an initially anoxic ice-contact deposit or fractured-bedrock environment that contains variable amounts of iron-sulfide minerals such as pyrite and marcasite (FeS_2). The iron-sulfide minerals can be dissolved (oxidized) in the presence of oxygenated water. Oxidation of FeS_2 yields dissolved iron, sulfate, and hydrogen ions. The release of hydrogen ions lowers the pH and results in further dissolution of calcite in the aquifer material. This process was suggested for some wells in the Clifton Park area by Bator (1997) and is described in Drever (1988). The resulting ground water type is defined by calcium concentrations greater than or equal to 100 mg/L and sulfate concentrations greater than or equal to 70 mg/L and is classified as very hard. Hydrogen sulfide is common in this water type, suggesting that mixing with deeper reducing ground water from bedrock has resulted in some reduction of sulfate, or that the ground water in the bedrock initially contained hydrogen sulfide.

The most extreme examples of this water type are at the Lapp (Sa-1380) and Roosevelt (Sa-1282) wellfields (pl. 1B.1), both of which tap the same deposit of unconfined ice-contact material along the eastern side of the channel aquifer. Aquifer tests at these wellfields indicated a limited and apparently isolated local aquifer area and resulted in the dewatering of several local domestic wells that are completed in relatively thin unconsolidated deposits or in bedrock (Dunn Geoscience Corporation, 1987). Dewatering of part of an aquifer area that contributes to a wellfield suggests a strong possibility of interaction between shallow, recently recharged ground water and the upper (fractured) bedrock environment; this would result in more intense oxidation of FeS_2 and more dissolution of carbonate minerals here than in other similar wellfield environments within the study area that have not undergone as much stress from water withdrawals.

Sodium-Calcium-Bicarbonate Water Type

The sodium-calcium-bicarbonate (Na-Ca-HCO3) water type represents an intermediate step in the natural evolution of $Ca-Mg-HCO_3$ water toward $Na-HCO_3$ water, or the mixing of $Ca-Mg-HCO_3$ water with $Na-HCO_3$ water at supply wells in confined settings. Sodium concentrations generally equal or exceed those of calcium; the increase in sodium results from cation exchange for calcium at exchange sites on aquifer materials. The residence time of this water probably is intermediate between that of relatively young $Ca-Mg-HCO_3$ water and that of the relatively older $Na-HCO_3$ water. $Na-Ca-HCO_3$ water is typically present in confined or locally confined settings along the edges and in peripheral areas of the Colonie Channel aquifer (pl. 1B.1), where ground-water withdrawals stress the aquifer and alter flow directions. This intermediate residence-time water type within deep, confined areas of the Colonie Channel indicates recharge from the lacustrine sand aquifer and (or) from unconfined areas of the channel aquifer. Areas that contain this water type include: (1) the channel area immediately east of the Clifton Park Landfill (Sa-1229), (2) the eastern side of the channel (Sa-1500) north of the Moe supply well (Sa-1347) through the Linden (Sa-1328) and Clifton Park Center (south) supply and irrigation wells (Sa-1456, Sa-1308), and (3) the channel area centered around the Plank (Sa-1450) and Kinns (Sa-1197) supply wells (pl. 1B.1).

The longer residence time of this intermediate water type than of Ca-Mg-HCO3 water results in distinct chemical differences. As water flows from recharge areas to confined areas, isolation from atmospheric carbon dioxide allows pH to progressively increase. Waters with pH values of 7.5 to 7.9 are not far removed from recharge areas, whereas those with pH of 8 to 8.8 indicate progressively more time within the confined areas of the channel aquifer. Waters of this type also are more reduced than the $Ca-Mg-HCO_3$ waters — dissolved oxygen and nitrate generally are absent, and reduced iron (II) is typically found in low concentrations (less than 0.3 mg/L), but exceeds 1 mg/L in a few samples. Sulfate concentrations exceed 30 mg/L in relatively young $Na-Ca-HCO_3$ waters but are less than 5 mg/L in deeper (presumably older), more confined settings. Hydrogen sulfide and (or) methane may be present. Chloride concentrations are generally less than 50 mg/L and may be as low as 4 mg/L.

Sodium-Bicarbonate Water Type

The sodium-bicarbonate (Na-HCO_3) water type is the oldest (has the longest residence time) of any type within the channel aquifer. These waters are limited to the deep, most confined areas within the center of the Colonie Channel (pl. 1B.1) and show little or no effect from human activity. Tritium-based ages of selected water samples are pre-1952, which predates most residential development in the area. Sodium (72 to 129 mg/L) is the dominant cation in this type of water, and calcium concentrations are low (1 to 8 mg/L); thus, the water is soft. Sulfate concentrations also are low ($\leq$ 5 mg/L), presumably as a result of microbial reduction, and pH can be extremely high (from 8.2 to 9.4). Iron concentrations generally are low and methane is common. Fluoride concentrations are high (1.3 to 2.2 mg/L) in the deepest areas that have been least disturbed by pumpage stresses (pH $\geq$9, calcium $\leq$3 mg/L). Chloride concentrations range from 3 to 57 mg/L. The low chloride values indicate the absence of road salt in pre-development recharge; the higher values probably represent mixing with deeper ground water in the bedrock.

GROUND-WATER LEVELS

Water levels in observation wells provide information on aquifer responses to natural climatic conditions and to short- and long-term ground-water withdrawals, especially within the channel aquifer. Sources of water-level data include (1) drillers' logs, (2) aquifer tests conducted by private consultants, (3) a USGS-CPWA well network that ranged from 30 to 40 wells in which water levels were measured during 1995-98, and (4) 68 wells in the eastern half of town in which water levels were measured by USGS during August and September 1998.

Unconfined Conditions

The typical annual cycle of water-level fluctuations (fig. 4) is largely controlled by seasonal variations in evapotranspiration (ET). During the growing season (late spring to early fall), vegetation intercepts most precipitation that enters the soil and thereby largely prevents recharge; shallow ground water can also be lost through ET. This loss results in a seasonal water-level decline as ground water continues to discharge to streams, lakes, and wetlands. Under drought conditions, discharge areas such as wetlands and small streams may dry up. During the late fall, ET decreases as vegetation dies off; this allows infiltrating precipitation to recharge the unconfined aquifer areas and raise water levels. Winter recharge is limited by frozen ground and snow accumulation, and water levels tend to gradually decline. In early spring, as the ground thaws and snow melts, ET is minor and recharge resumes, typically raising water levels to their highest point of the year.

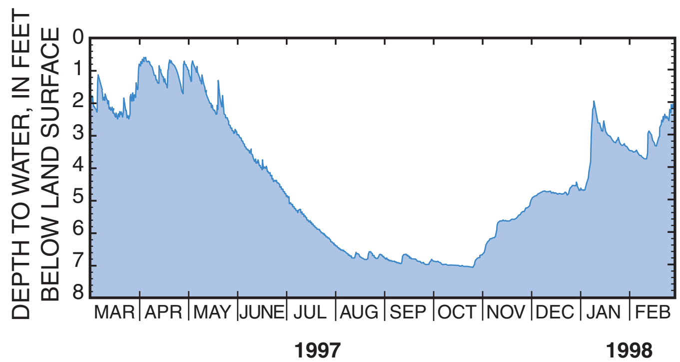


Figure 4. Ground-water levels in the lacustrine sand aquifer at USGS observation well Sa-1285, Clifton Park area, New York, March 1997 through February 1998 (Location is shown on pl. 1A.1)

Confined Conditions

Natural short- and long- term water-level fluctuations in wells that tap confined aquifers differ from those that tap unconfined aquifer settings. Water levels in wells that tap confined parts of the channel aquifer may either show subdued seasonal fluctuations that lag behind those in unconfined areas, or they may show no discernible annual trend, depending on the degree of confinement and the amount of interference from ground-water pumping. Direct recharge from precipitation does not occur; instead, water levels respond to changes in barometric or atmospheric pressure (Todd, 1980). Barometric-pressure effects are greater in confined settings than in unconfined settings. An increase in barometric pressure forces water levels in wells downward; then, as the air pressure decreases, the water levels rise. The largest fluctuations due to barometric-pressure changes in the study area are about 1.5 ft; a 1-in change in barometric pressure, expressed in inches of mercury, is equivalent to a 1.13-ft change in water level in a well that taps a strongly confined area of the aquifer.

Barometric efficiency is a measure of the responsiveness of water levels in wells to changes in barometric pressure and is indicative of the degree of confinement of an aquifer area tapped by a well. A measured change in ground-water level at a given well divided by the corresponding barometric-pressure change (converted from inches of mercury to equivalent feet of water) is expressed as a percent value. The greater the effect of barometric-pressure changes on ground-water levels, the higher the efficiency, and the greater the confinement (distance or degree of hydraulic isolation from unconfined areas). A 100-percent barometric efficiency at a well suggests that the aquifer area it taps has no strong nearby hydraulic connection with recharge (unconfined) areas. Lower barometric efficiencies indicate some degree of hydraulic connection with unconfined settings. Wells that tap locally confined or unconfined settings have barometric efficiencies of less than 30 percent.

Wells that tap the confined central channel area of the Colonie Channel aquifer have barometric efficiencies of 60 to 100 percent. Two wells (Sa-1229, Sa-1500) west-northwest of the Moe supply well (pl. 1A.3) have barometric efficiencies in the low end of this range, indicating a greater hydraulic connection with recharge areas here than in other central-channel areas. Barometric efficiencies of wells that tap some of the peripheral channel-aquifer areas were less than 30 percent; this indicates local confinement or a lack of confinement.

Responses to Pumping Wells

Aquifer tests are required by the New York State Department of Environmental Conservation (NYSDEC) to assess sustainable yields for all new public-supply wells. Semi-log plots of water-level drawdown in an observation well (as a function of time since start of pumping) provide trend lines that give an indication of the continuity of the aquifer material and the potential for induced recharge.

A straight-line plot indicates relatively uniform aquifer thickness and geometry within the aquifer area affected by the pumping. Straight time-drawdown lines were reported at the Roosevelt (Environmental Hydrogeology Corporation, 1989a), Lapp (Dunn Geoscience Corporation, 1987), Calico Colony (Dunn Geoscience Corporation, 1977), Boyack (G.M. Erickson, Johnson Division, written commun., 1973), and Kinns (Dunn Geoscience Corporation, 1978) wellfields.

A decrease (flattening) in the slope of this line (a decrease in drawdown rate per log cycle of time) during a test indicates a positive hydraulic boundary, such as an increase in aquifer permeability or thickness, or an additional source of recharge to the aquifer at some distance from the well. Aquifer tests indicated positive boundaries at the Moe (Dunn Geoscience Corporation, 1985a), Berry Farm (Sa-1339) (Environmental Hydrogeology Corporation, 1990), Meadows (Sa-1342) (Environmental Hydrogeology Corporation, 1990), and Elnora (Dunn Geoscience Corporation, 1984b) wellfields and at an unused production well (Sa-1331) adjacent to the Park Lane wellfield (Environmental Hydrogeology Corporation, 1989b).

An increase (steepening) in the slope of the time-drawdown line suggests a negative hydraulic boundary, such as a decrease in aquifer permeability or thinning of the aquifer in one or more directions away from the supply well. Wells at which tests indicated negative hydraulic boundaries included the Plank (Dunn Geoscience Corporation, 1979) and Linden (C.T. Male Associates, P.C., 1989) wells, both of which tap confined settings within the Colonie Channel.

Water levels were measured weekly by USGS and CPWA during 1995-98 at a network of approximately 35 wells that tap the channel aquifer. Some of these wells were monitored continuously by float-driven graphical recorders or pressure transducers coupled to electronic dataloggers for varying periods during the study. Comparison of water-level hydrographs with supply-well pumpage records can indicate whether or not there is hydraulic interconnection among wells. Wells in which water-level data indicate hydraulic interconnection with a pumping well are connected by dotted lines in pl. 1A.3.

Water Levels in the Colonie Channel Aquifer, August-September 1998

Ground-water levels in 68 wells completed in the Colonie Channel aquifer were measured or estimated during August-September 1998. Water levels in several inaccessible wells were estimated from measurements made within the previous 4 years. Water-level altitudes were calculated from known measuring-point altitudes or from estimated geographic-information-system (GIS) digital-elevation-model (DEM)-generated altitudes derived from a topographic map with a 10-ft contour interval. A water-level (potentiometric-surface and water-table) map was constructed from the data (pl. 1B.1); this map provides a "snapshot" (August -September 1998) of the potentiometric surface of the confined "central channel" and "peripheral channel" areas, and the water-table surface in the unconfined "peripheral channel" areas of the Colonie Channel aquifer.

Interpretation of August-September 1998 water-level data is facilitated through comparison of water levels measured in the most productive areas of the channel aquifer before and during development in the late 1960's through the early 1970's. Drillers' logs and recollections (R. Ferraioli, Dick Ferraioli, Inc., oral commun., 1996) indicate water levels in 1972 were about 21 ft below land surface at the Boyack wellfield (supply well 3) in the southern part of town and, in 1973, were at land surface at the Plank supply well; they also indicate flowing artesian conditions (water level 35 to 40 ft above land surface) in 1968 at the Kinns supply well in the northern end of town (pl. 1B.1). These water levels correspond to altitudes of about 240 to 255 ft above sea level. The several years over which these measurements were made (by unknown means), and the relatively small difference in water-level altitude among these areas suggest generally low hydraulic gradients within the Colonie Channel aquifer. Accurate delineation of pre-development ground-water-flow directions and, thus, of recharge or discharge areas, is not possible from the data. If hydraulic gradients within the aquifer were low, flow into and through this aquifer probably was minor before public-supply withdrawals began in the early 1960's.

The August-September 1998 potentiometric surface in the Colonie Channel aquifer (pl.1B.1) is much lower than its estimated pre-1960's altitude of about 250 ft above sea level—within the confined central channel area, it is as much as 100 ft lower, and is as much as 190 ft below the current (1998) ground-water levels in unconfined peripheral channel areas. Water-level contours of 250 ft and lower are depicted as depression (hachured) contours on plate 1B.1 to show the effects of ground-water withdrawals on the system relative to pre-development conditions. A depressed potentiometric surface relative to pre-development conditions is also evidenced by long-term water-level declines at several supply and observation wells completed in confined areas of the channel aquifer. This net lowering of water levels over time indicates that ground-water withdrawals from the confined areas of the channel aquifer have exceeded the rate of recharge.

The potentiometric surface within the channel aquifer is characterized by two large depressions north and south of a narrow east-west ground-water divide that spans the channel in the southern part of Clifton Park (pl. 1B.1). Ground water in deep, confined areas of the channel aquifer flows northward north of the divide and southward south of the divide. Water levels within the central channel area are highest at the divide, although these levels are at least 20 ft lower than in the pre-development period. The relatively high water levels at the divide suggest that the peripheral areas or the edges of the channel at this locale are a major source of recharge for the deep, confined channel aquifer. The large depressions in the potentiometric surface north and south of the divide indicate that ground-water withdrawals affect large areas within the central channel and that hydraulic continuity exists within each of these areas despite local variability in the type and thickness of aquifer material (pl. 1A.3). In contrast, the large water-level differences (steep gradients) and the chemical water-type differences between the unconfined or locally confined peripheral channel areas and the deep, confined central channel area indicate little or no hydraulic connection and, thus, a low potential for recharge along much of the channel.

The northern depression in the potentiometric surface is the larger and deeper of the two and extends northward beyond the study area for an unknown distance toward or beyond Round Lake (pl. 1B.1). Ground-water levels in much of the northern depression are below 200 ft and are just below 150 ft in a small area around the Kinns supply well (pl. 1B.1). The Plank and Kinns supply wells have been the major ground-water withdrawal points within the northern depression since the early 1970's. The potentiometric surface and the hydrogeologic settings north of the Kinns Supply well are variable and ill-defined, but the earliest reported water levels in this area (flowing artesian) are about 100 ft higher than the level of Round Lake and therefore suggest a lack of hydraulic interconnection between the lake and the deep, confined aquifer. Water may enter the northern depression from deep channel-aquifer areas farther to the north, however.

The southern depression extends an unknown distance southward from the divide to at least the Mohawk River flood plain. The depression is partly a result of ground-water withdrawals within the study area at the Boyack wellfield on the eastern side of the channel (pl. 1B.1). Other potential causes outside of the study area may include (1) the discharge of Colonie Channel aquifer water to the Mohawk River flood plain, where erosion has removed the upper parts of the confining units and perhaps created some degree of hydraulic interconnection between the channel aquifer and overlying flood-plain deposits, or (2) propagation of lowered ground-water levels beneath the river and northward into the Clifton Park area in response to withdrawals from supply wells that tap deep, confined areas of the Colonie Channel aquifer south of the Mohawk River in Albany County (fig. 1).

CONCEPTUAL MODEL OF GROUND-WATER FLOW WITHIN THE LACUSTRINE SAND AQUIFER AND COLONIE CHANNEL AQUIFER

The lacustrine sand and Colonie Channel aquifers differ significantly in their sources of recharge, directions of ground-water flow, and modes of discharge. The aquifers are hydraulically connected in places along the peripheral areas of the Colonie Channel. Ground-water flow is generally downward from the lacustrine sand aquifer to the Colonie Channel aquifer, where ground-water withdrawals are greatest.

Lacustrine-Sand Aquifer

Direct precipitation is the major source of recharge to the lacustrine sand aquifer (fig. 5). Runoff from precipitation that falls on till-covered hillsides adjacent to the channel area may also contribute recharge to this aquifer where water moving downslope infiltrates into the soil, rather than draining to a stream. Most recharge occurs during late fall, and during late winter and early spring (fig. 4) when evapotranspiration (ET) is minimal. Recharge does not occur in ground-water discharge areas such as streams, lakes, wetlands, springs, or seeps.

Two other sources of recharge are leakage from water mains and sewer lines and infiltration of lawn-irrigation water. Historically, most of this water represents a net transfer from the channel aquifer to the lacustrine sand aquifer. Recharge is reduced in developed areas where precipitation falls on impervious (paved) areas and is diverted (lost) to local streams rather than stormwater retention basins, where infiltration and recharge can occur.

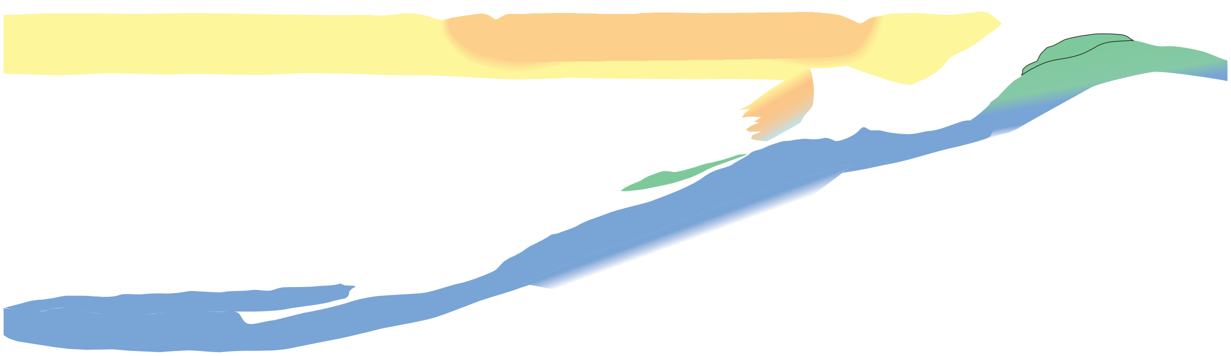
Depth to the water table in the lacustrine sand aquifer ranges from 0 to about 60 ft below land surface, depending on local relief and ground-water withdrawals. Streams, wetlands, and lakes generally represent the intersection of the water table with land surface. Periods of drought, such as in the late spring and early summer of 1997 (fig. 4), cause a marked lowering of water levels. For example, water levels in well Sa-1285 (pl. 1A.1) were less than 1 ft below land surface in the spring of 1997 but declined about 6.5 ft over the next 4 months. As ground-water levels decline during the summer, streams progressively decline in flow and dry up.

Ground-water flow under natural, unconfined conditions generally parallels the local topography and is downgradient toward discharge areas such as streams, wetlands, and lakes (fig. 5). Within the study area, water in the lacustrine sand aquifer discharges mostly to Stony Creek, the Dwaas Kill, and other smaller drainages (fig. 1). Other discharges from the lacustrine sand aquifer include supply-well withdrawals that intercept ground water that would naturally discharge to surface water (fig. 5) and flow into underlying or adjacent channel-aquifer settings, where confining units are locally absent and hydraulic heads (water levels) are lower.

The chemical composition of water from the lacustrine sand aquifer indicates shorter ground-water residence times and greater susceptibility to contamination from human activities at land surface than water in the deeper areas of the Colonie Channel aquifer.

Colonie Channel Aquifer

The part of the Colonie Channel aquifer that lies within the study area may receive local recharge from: (1) direct infiltration of precipitation in peripheral channel areas where surface exposures of ice-contact



Peripheral Channel Areas

The peripheral channel areas (fig. 2) contain unconfined and confined settings that include the majority of high-yield wellfields in the study area. Unconfined settings (pl. 1A.3) include the recharge areas within the peripheral channel areas. Recharge occurs either directly at surface exposures of ice-contact deposits or fractured bedrock, but more commonly through the overlying lacustrine sands.

Unconfined areas are more extensive than depicted in pl. 1A.3; the limited subsurface data probably miss locally unconfined “windows” of permeable sediments within otherwise till-covered areas of low permeability along the channel edges.

Water levels and ground-water types in peripheral channel areas resemble those in the lacustrine sand aquifer more than they resemble those in the central channel area. Water ranges from the Na-Ca-HCO_3 type in some confined areas where residence times are relatively long, or least affected by ground-water withdrawals, to the Ca-Mg-HCO_3 type along with subtypes affected by road salt and pumpage in areas where water-residence times are relatively short (especially where pumping wells induce ground-water flow at higher than natural rates). Areas with relatively young ground water are either unconfined or in hydraulic connection with unconfined areas. Examples of confined peripheral channel areas that appear to derive water from local recharge on the eastern side of the channel include (1) the area from the Rt. 146 and I-87 intersection southward to the area west of the Roosevelt supply well, and (2) the area immediately east of the Moe supply well southward to at least the Oakwood supply well (pl. 1B.1). Examples on the western side of the channel are (1) immediately west of the Stony Creek Reservoir, including the landfill site, and (2) the area just west of the landfill within a shallow side channel that trends northward and is tapped by the Berry Farm (Sa-1339), Meadows (Sa-1342, 1343), Park Lane (Sa-1222, 1223, 1224), and Calico Colony (Sa-1167, 1168) wellfields (pl. 1A.3, 1B.1).

Central Channel Area

The central channel area (fig. 2) contains the deepest and most strongly confined parts of the Colonie Channel aquifer. Large declines in ground-water levels over short distances between peripheral channel areas and the central channel area are indicative of little or no hydraulic interconnection. This is characteristic of much of the Colonie Channel segment in the Clifton Park area (eastern side of section A-A´, pl. 1B.1-2, fig. 5). The most isolated aquifer areas (those not tapped by public-supply wells) are characterized by soft, Na-HCO_3 waters with high pH and elevated fluoride concentrations.

Two zones within the central channel area show evidence of recharge from peripheral channel areas. The first is in the southern half of the channel, immediately south of Englemore Road, as indicated by water-level and water-chemistry data (pl. 1B.1). This zone is apparently recharged by water from peripheral areas on both sides of the channel. Water-level and water-chemistry data suggest that recharge on the eastern side of the channel is not derived from the Lapp wellfield area, but rather from areas slightly to the north (near Grooms Rd.) and south (near the Moe supply well) (pl. 1B.1). Recharge from the western side of the channel appears to be derived from an area that contains the closed town landfill.

The second central-aquifer zone that appears to receive recharge from the peripheral channel areas is in the northern end of town; water from this zone indicates recharge induced by pumping at the Plank and Kinns supply wells. The decline of water levels in this area from 1973-1998 (fig. 6) has resulted in the lowest ground-water levels in the study area. This decline and the absence of definitive ground-water mounding on the potentiometric-surface map, suggest that this zone has a weaker hydraulic connection with recharge areas than does the southern zone. Results of ground-water-age dating with tritium indicate that most Kinns well water entered the aquifer system before 1952 and that water from the Plank well is a mixture of pre- and post-1952 waters. Two possible nearby recharge areas are identified on plate 1A.3.

The first recharge area is in the Country Knolls West area along Greensboro Boulevard (indicated in pl. 1A.3 as a local unconfined area, and in pl. 1B.1 as an area of Ca-Na-HCO_3-Cl water). The lacustrine sand aquifer directly overlies a permeable zone of the peripheral channel area (pl. 1A.3) at this site. A deep ground-water level in 1998 (W. Schlesier, CPWA, oral commun., 1998) at a well (Sa-1464) screened in the permeable zone indicates that the overlying lacustrine sand is unsaturated. Use of shallow domestic well points in other parts of this residential area suggests that water in the lacustrine sand aquifer locally drains through this recharge “window” to the peripheral channel aquifer area below. The deep ground-water

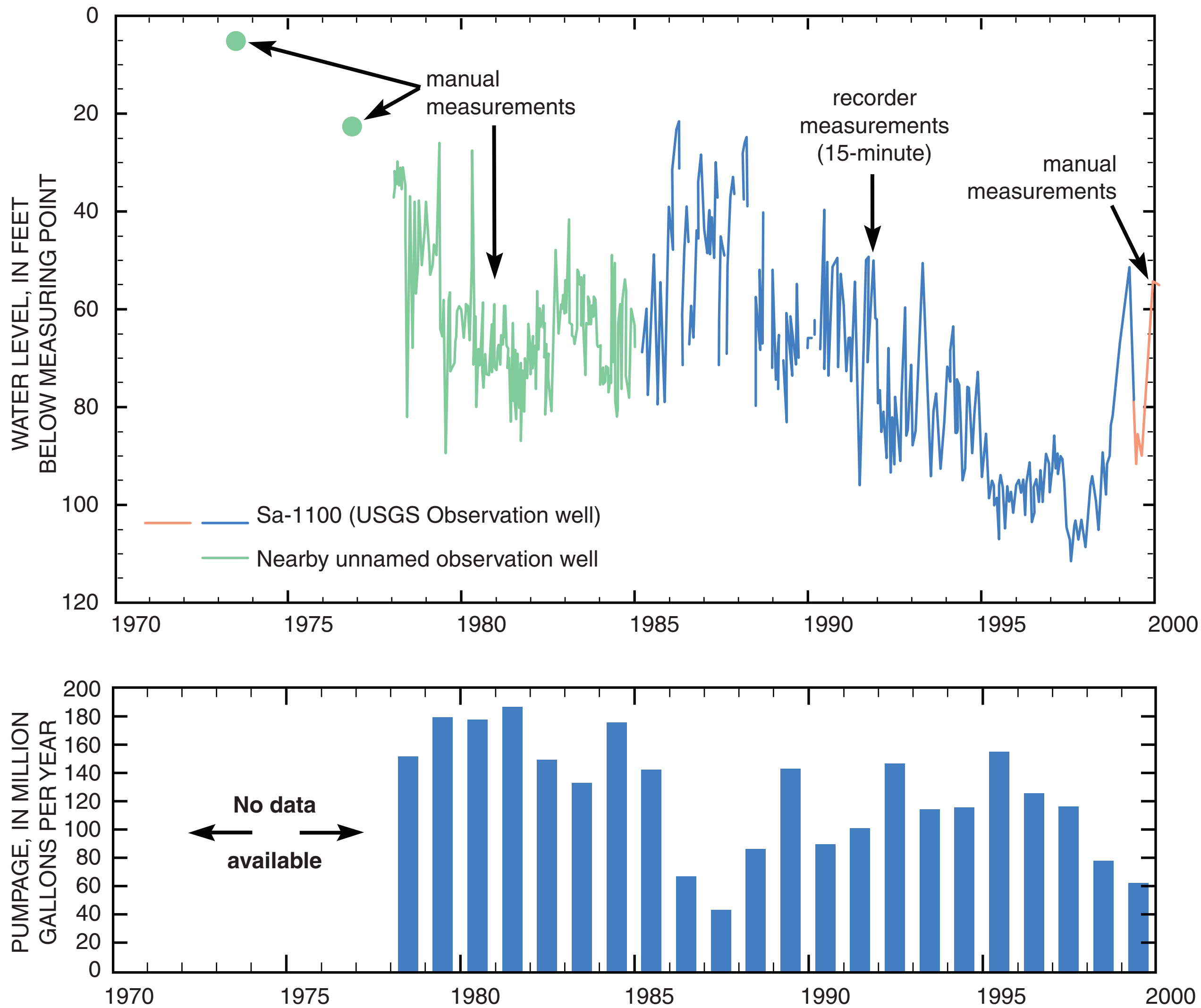


Figure 6. Water-level trends and annual pumpage for 1973-1999 at the Plank wellfield, Clifton Park, New York.

level at well Sa-1464 is consistent with what is expected in that area of the central channel and, therefore, suggests a hydraulic pathway for recharge.

The second potential recharge area (about 0.5 to 1 mi south of Round Lake) is indicated by a till confining unit underlain by a bedrock high within the channel (pl. 1A.3) and by Ca-Na-HCO_3-Cl water immediately south of Round Lake on plate 1B.1. This area is included as a potential recharge area on the basis of its hydrogeologic setting (only one water analysis was performed, and no water-level data from this area were available). A bedrock high (north-south ridge?) within the channel was penetrated during the drilling of several wells in this area; the bedrock at one site is overlain by only 25 ft of till. Hydraulic connection with the underlying central channel area is uncertain, but the possibility is noted because of proximity to the Kinns and Plank wells. A water sample (Ca-Na-HCO_3-Cl type) from well Sa-1441, immediately north of this area (pl. 1B.1), indicates relatively young water beneath 69 ft of confining unit (till and lacustrine silt and clay).

Most ground-water discharge from the central channel area is through withdrawals at supply wells in Clifton Park proper, although some discharge might also occur to the Mohawk River floodplain and perhaps to supply wells tapping central channel areas south of the Mohawk River. Minor discharge to streams or wetlands may occur in unconfined aquifer areas where pumping has not affected water levels. Pumping from the Colonie Channel aquifer since the 1960's has resulted in large, long-term water-level declines that indicate withdrawal rates have exceeded recharge rates (fig. 6). Recovery of water levels in the central channel area can be achieved only by reducing net ground-water withdrawals within the affected channel segments (north and south of the ground-water-flow divide). The beneficial effect of reduced pumpage on water levels is evident at the Plank wellfield; the reduction in 1998-99 pumpage and resultant rise of ground-water levels (fig. 6) started in mid-1998, when a new wellfield in the alluvial aquifer went online.

SUMMARY

Clifton Park's water supply is derived from three aquifers—a lacustrine sand aquifer, the Colonie Channel aquifer, and an alluvial aquifer. All are within the eastern half of the study area. The lacustrine sand aquifer is unconfined and is thickest over the Colonie Channel, a north-south-trending bedrock channel that has been buried by glacial deposits. The aquifer is most productive on the eastern side of the channel, where medium to coarse lacustrine deltaic sand and gravel are locally present. The fine-grained texture of the lacustrine sand throughout most of the aquifer interferes with pump operation and therefore limits water use.

Most supply wells in the area are completed in the Colonie Channel aquifer, which consists of permeable ice-contact sand and gravel and the fractured top of bedrock, which is predominantly shale. Fractured bedrock is a potential aquifer throughout the area, but the highest well yields are associated primarily with ice-contact deposits in the Colonie Channel aquifer. The aquifer is confined by lacustrine silt and clay throughout most of the channel; the degree of confinement is greatest over the central part of the channel. Peripheral areas of the channel range from confined to unconfined. Confining units in these areas include till, impermeable ice-contact deposits, or thin lacustrine silts and clays.

The alluvial aquifer along the Mohawk River at the southern end of the study area has been tapped only since 1998. It consists of fluvial sand and gravel about 25 ft thick that is locally confined by about 10 ft of fine-grained alluvium. This aquifer has the highest sustainable yields of the three aquifers because pumping wells are probably inducing recharge from the Mohawk River and (or) from nearby ponds and wetlands.

Chemical analyses of ground-water samples from the Colonie Channel and lacustrine sand aquifers were grouped into six ground-water types that provide a general indication of the relative residence time of water within the aquifers. The shortest ground-water-residence times are associated with calcium-magnesium-bicarbonate waters and three other related waters—two affected by human activities, such as application of road salt, and one affected by ground-water flow path changes associated with ground-water withdrawals. These waters are most common in the lacustrine sand aquifer or unconfined areas of the channel aquifer. The presence of these waters within confined peripheral channel areas indicates that pumping has induced recharge through local "windows" (areas where confining units are absent) in some of the till-dominated areas. Sodium-calcium-bicarbonate water evolves from calcium-magnesium-bicarbonate water (or mixing) and, thus, may imply increased ground-water residence times; this water type was present in parts of the aquifer channel confined by till as well as in deep central channel areas where ground-water withdrawals have induced recharge from peripheral channel areas. The oldest ground water is the sodium-bicarbonate type, which represents natural (pre-development) conditions; it is present only within the most confined central channel areas, far from supply wells.

Water-level data from aquifer tests and from a monitoring-well network indicate hydraulic interconnection among wells finished in the channel aquifer, which includes ice-contact deposits and shallow fractured bedrock. A potentiometric-surface map based on a 2-month survey (1998) of water levels in the channel aquifer indicated two large water-level depressions within the strongly confined central channel area. These areas are separated by a ground-water-flow divide, which suggests recharge is coming from peripheral channel areas, one of which may include Clifton Park's closed landfill. Comparison of pre- or early-development water-level data with water levels measured in 1998 indicate that water levels have declined significantly in the central channel area of the

aquifer—an indication that, over time, withdrawals have exceeded recharge rates.

A conceptual model of the lacustrine sand and channel aquifers indicates that recharge from precipitation occurs across most of the lacustrine sand aquifer and in limited unconfined or semiconfined areas of the channel aquifer. Most recharge that enters the lacustrine sand aquifer flows through the aquifer and discharges to streams and lakes. Recharge enters confined peripheral channel areas through adjacent unconfined areas. Peripheral channel areas, in turn, provide limited recharge to the central channel area through "windows" of hydraulic interconnection. The central channel area also may receive lateral recharge from channel segments north or south of the Clifton Park area. Discharge from the confined areas of the channel aquifer occurs through ground-water withdrawals at supply wells and possibly as flow beyond the study-area boundaries.

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