

HYDROGEOLOGIC FRAMEWORK OF LONG ISLAND'S NORTH FORK, SUFFOLK COUNTY, NEW YORK

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Introduction

The ground-water-flow systems of Long Island's North Fork (fig. 1) are vulnerable to saltwater intrusion and to upconing at water-supply wells resulting from heavy pumping. In response to the need for a comprehensive analysis of ground-water flow and the freshwater-saltwater interface on the North Fork, the U.S. Geological Survey, in cooperation with the Suffolk County Water Authority, began a 4-year study in 1997 to (1) describe the hydrogeologic framework of this area, and (2) analyze the effects of pumping and drought on ground-water levels and the position of the freshwater-saltwater interface on the North Fork.



Figure 1. Principal geographic features of North Fork study area in eastern Suffolk County, Long Island, N.Y. (From Schubert and others, 2003, fig. 1.)

The hydrogeologic framework of the study area was evaluated from available information and the results of exploratory drilling conducted during this study; detailed information on the study methods and approach is given in Schubert and others (2003). Previously collected information included data from more than 250 boreholes and wells, and maps showing (1) the configuration of the bedrock surface and the upper-surface altitude of Cretaceous hydrogeologic units on Long Island (Smolensky and others, 1989, sheets 2 and 3), (2) the depth to bedrock and to Coastal Plain sediments beneath eastern and east-central Long Island Sound (Lewis and Needell, 1987, fig. 6; and Needell and others, 1987, fig. 6; respectively), and (3) the thickness of glacial-lake deposits and depth to the upper surface of glacial drift in eastern and east-central Long Island Sound (Lewis and Needell, 1987, figs. 10 and 11; and Needell and others, 1987, figs. 10 and 12; respectively).

The extent and thickness of hydrogeologic units were interpreted from available information, which included descriptions of geologic cores and cuttings from 12 borings, borehole geophysical logs from 106 sites, and drillers' logs from 179 boreholes and wells; and from an exploratory drilling program conducted during this

study (which provided additional geologic cores at 10- to 20-ft intervals, gamma-ray logs, and drillers' logs from five borings about 400-ft deep). This information was used to distinguish hydrogeologic units according to geologic age, depositional environment, sediment description, and water-transmitting properties, and to update and refine the previous maps of bedrock and Cretaceous hydrogeologic units and describe and correlate Pleistocene confining units.

The position of the freshwater-saltwater interface was estimated from available information, which included filter-press core samples from 11 borings, water samples from screened augers and wells at 22 sites, and borehole geophysical logs (specifically, electromagnetic induction and normal resistivity) from 51 sites. The exploratory drilling program conducted during this study provided filter-press core samples from selected geologic cores and borehole geophysical logs from the five deep borings. The chloride concentration and (or) specific conductance of filter-press, screened-auger, and well-water samples was correlated with borehole geophysical logs to delineate the position of the freshwater-saltwater interface.

Hydrogeologic Framework

The fresh ground-water reservoir on the North Fork consists of four principal freshwater flow systems (referred to as Long Island mainland, Cutchogue, Greenport, and Orient; fig. 2) within a sequence of unconsolidated Pleistocene glacial and nonglacial deposits and Late Cretaceous Coastal Plain deposits. A generalized section depicting the geometry of hydrogeologic units on the North Fork is presented in figure 3.

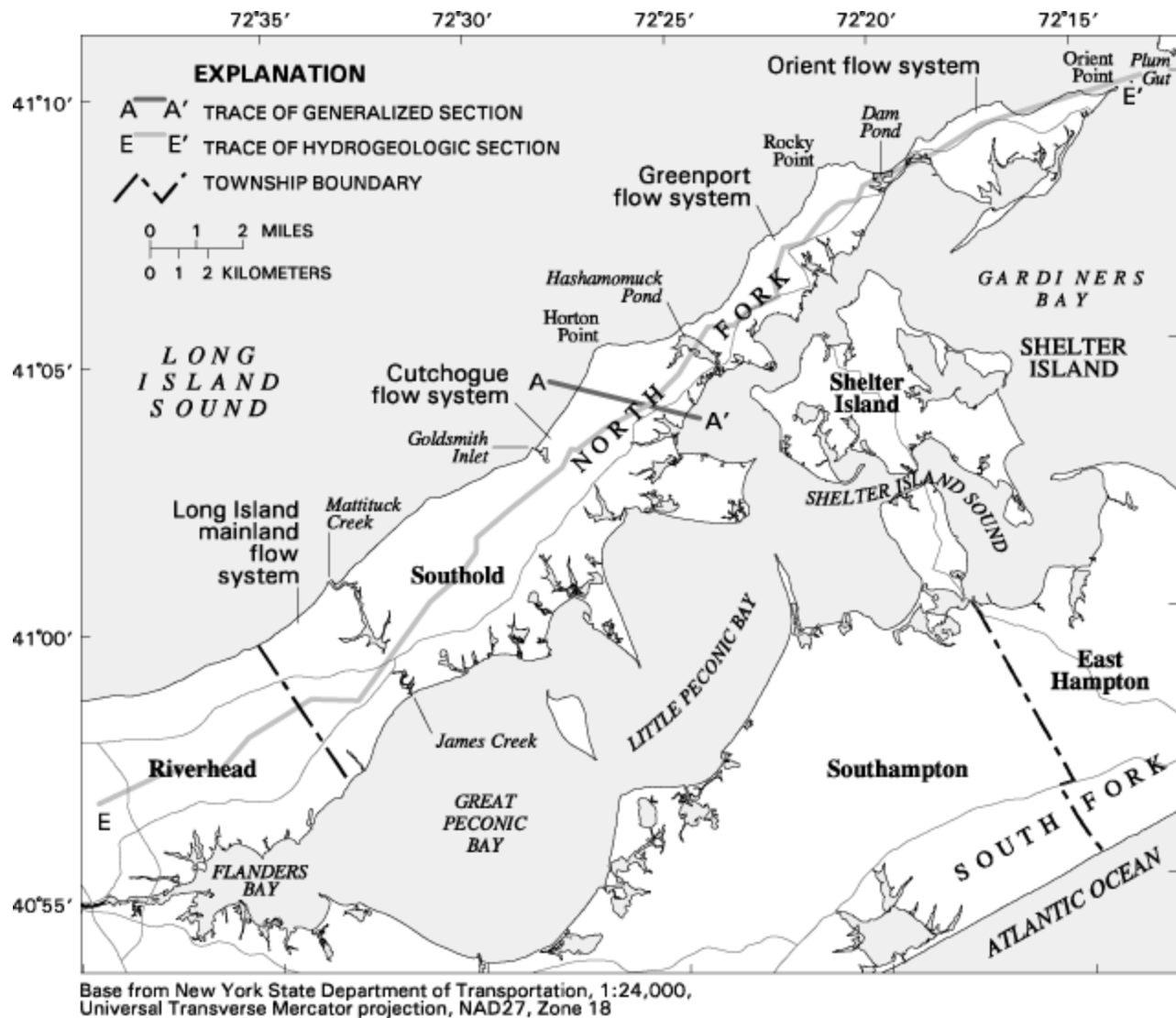


Figure 2. Locations of four hydraulically isolated ground-water-flow systems and sections A-A' (fig. 3) and E-E' (fig. 4) on the North Fork, Long Island, N.Y. (Modified from Schubert and others, 2003, fig. 2.)

Geologic Setting

A thick Pleistocene glacial-lake-clay unit that appears to truncate underlying deposits in three buried valleys was identified locally in borings beneath the northern shore of the North Fork (fig. 4; Schubert and others, 2003). At least five borings on the North Fork have reached this unit, but none have penetrated its full thickness. Similar Pleistocene glacial-lake deposits beneath eastern and east-central Long Island Sound previously were inferred to be younger than the surficial deposits of glacial origin that are exposed along the northern shore of Long Island (Grim and others, 1970; Lewis and Needell, 1987; and Needell and others, 1987). The glacial-lake deposits beneath eastern Long Island Sound fill three buried valleys adjacent to the northern shore—near latitude 41° 05' N., longitude 72° 30' W.; north-northwest of Hashamomuck Pond; and northwest of Dam Pond. The close similarities in thickness and upper-surface altitude between the Pleistocene glacial-lake-clay unit identified locally on the North Fork and the glacial-lake deposits in eastern and east-central Long Island Sound indicate that the two are correlated at least along the North Fork shore. A similar interpretation by Stumm and Lange (1994 and 1996) and Stumm (2001) correlates Pleistocene clay and silt deposits identified locally from borings along the northern shore of western Long Island in Queens County (Chu and Stumm, 1995), Nassau County (Stumm and Lange, 1994 and 1996), and western Suffolk County (Soren, 1971) with deposits beneath

Long Island Sound and Manhasset Bay (fig. 1) that have been described as glacial-lake clay by Grim and others (1970), Lewis and Stone (1991), and Williams (1981).

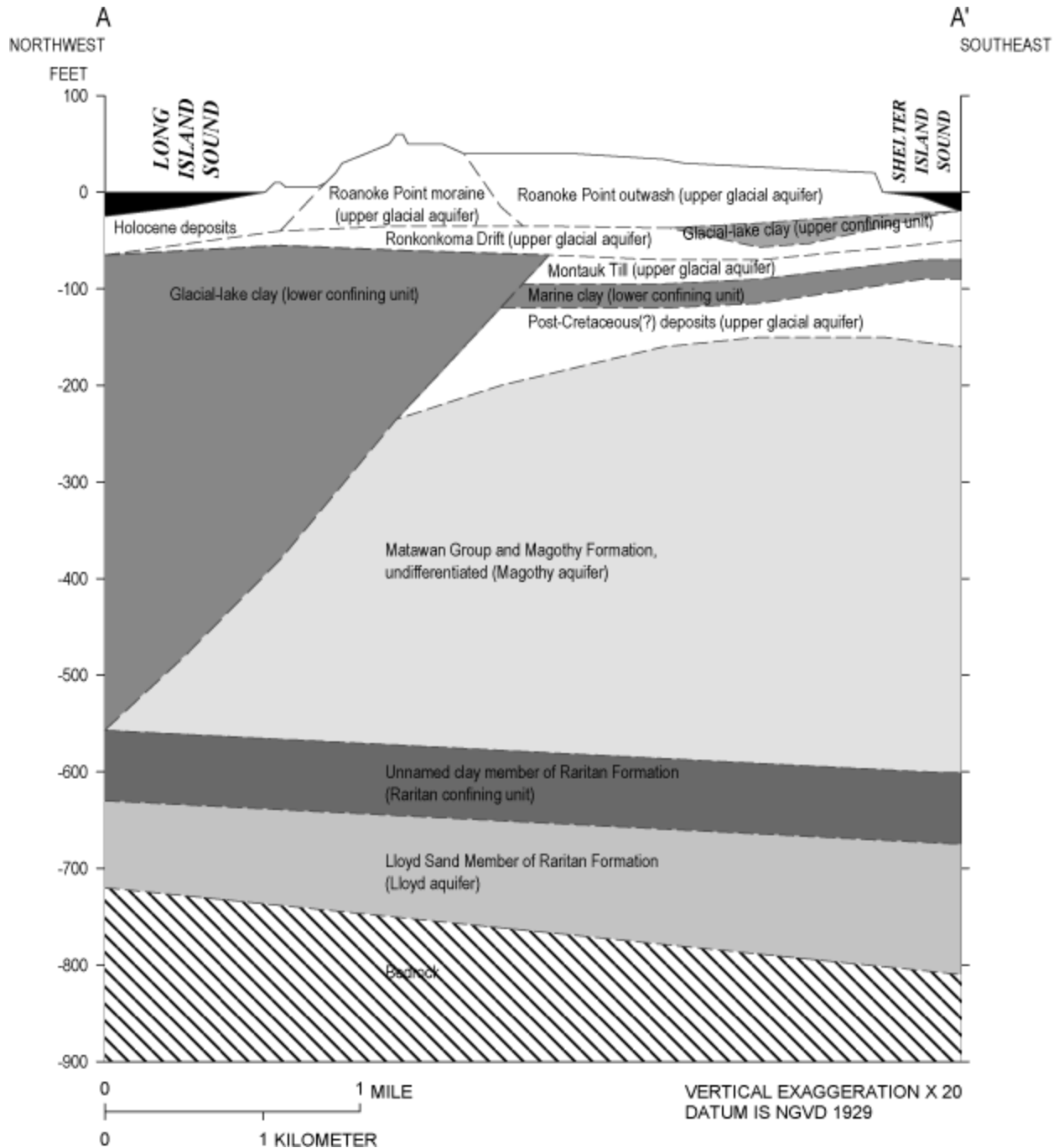


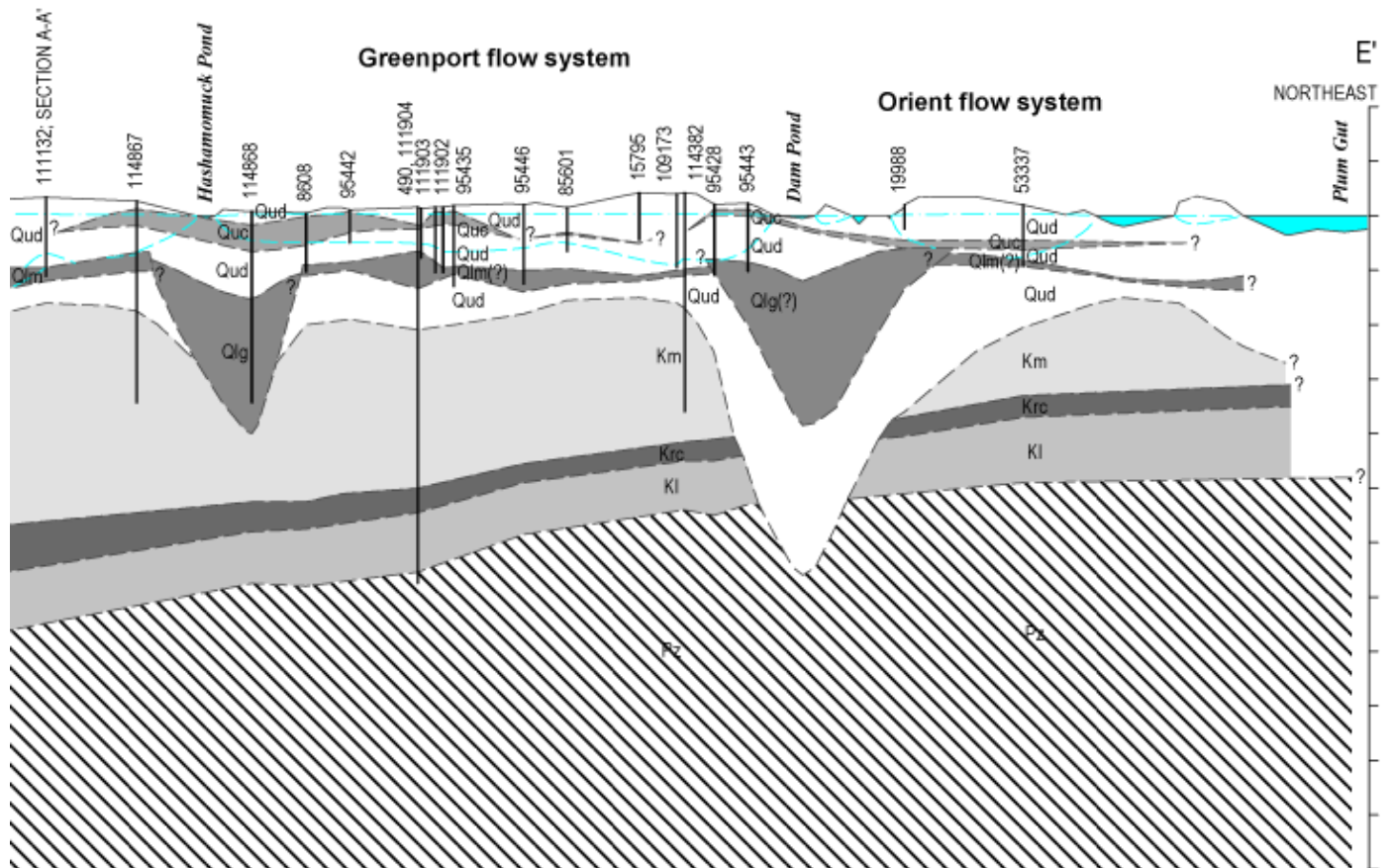
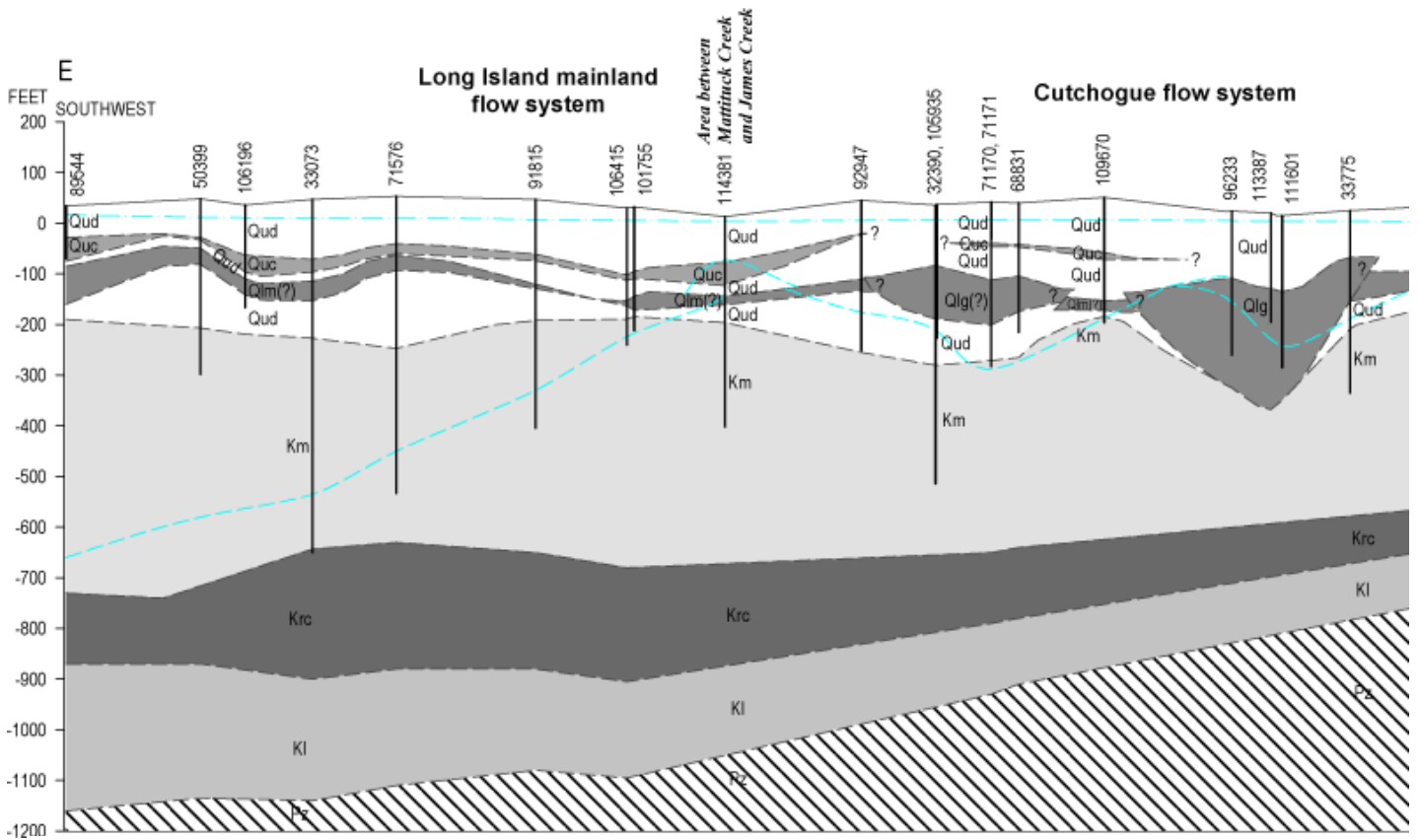
Figure 3. Generalized section A-A' showing geologic and hydrogeologic units on the North Fork, Long Island, N.Y. (Location of section is shown in fig. 2.) (From Schubert and others, 2003, fig. 4.)

The Matawan Group and Magothy Formation, undifferentiated, is the uppermost Cretaceous unit identified north of the southern shore of the main body of Long Island and constitutes the Magothy aquifer. The mapped upper surface of this unit beneath Long Island Sound contains a series of prominent erosional features that can be traced beneath the North Fork (Schubert and others, 2003). Highland areas in the surface of the Magothy aquifer southeast of Rocky Point and Horton Point each form the peak of a northwest-trending buried ridge that extends several miles beneath Long Island Sound. The highland area in this surface southwest of Mattituck

Creek and James Creek forms the crest of a promontory in the inferred irregular, north-facing cuesta slope offshore of this area. The lowland area in the upper surface of the Magothy aquifer northeast of Hashamomuck Pond represents the onshore extension of the bedrock valley north-northwest of this area. The lowland area in this surface east of Goldsmith Inlet represents the onshore extension of the inferred southeast-trending buried valley near latitude 41° 05' N., longitude 72° 30' W.

An undifferentiated Pleistocene-aged confining layer consisting of the Pleistocene glacial-lake-clay unit and apparently contiguous units of marine and nonmarine clay is referred to herein as the lower confining unit; its thickness and uppermost surface altitude are mapped in Schubert and others (2003). Beneath the North Fork, this unit forms an extensive confining layer more than 200 ft thick in buried valleys filled with glacial-lake clay along the northern shore. Elsewhere on the North Fork, it is generally less than 50 ft thick and presumably represents an erosional remnant of marine clay, particularly where the upper surface of the underlying Magothy aquifer is less than 200 ft below sea level. The upper surface of the lower confining unit beneath the North Fork is generally 75 ft or more below sea level above the buried valleys; elsewhere on the North Fork, it is generally 100 ft or less below sea level in areas where marine clay has been identified.

An upper unit of glacial-lake deposits underlies the sequence of late Pleistocene moraine and outwash deposits that extend to land surface on the North Fork (fig. 4). This unit, herein referred to as the upper confining unit, is mapped by Schubert and others (2003) as a local confining layer. The upper confining unit is thickest (more than 45 ft thick) beneath two lowland areas—one near Mattituck Creek and James Creek, the other near Hashamomuck Pond—but pinches out close to the northern and southern shores of the North Fork. The altitude of the upper surface of this unit generally rises to near sea level toward the southern shore of the North Fork.



EXPLANATION

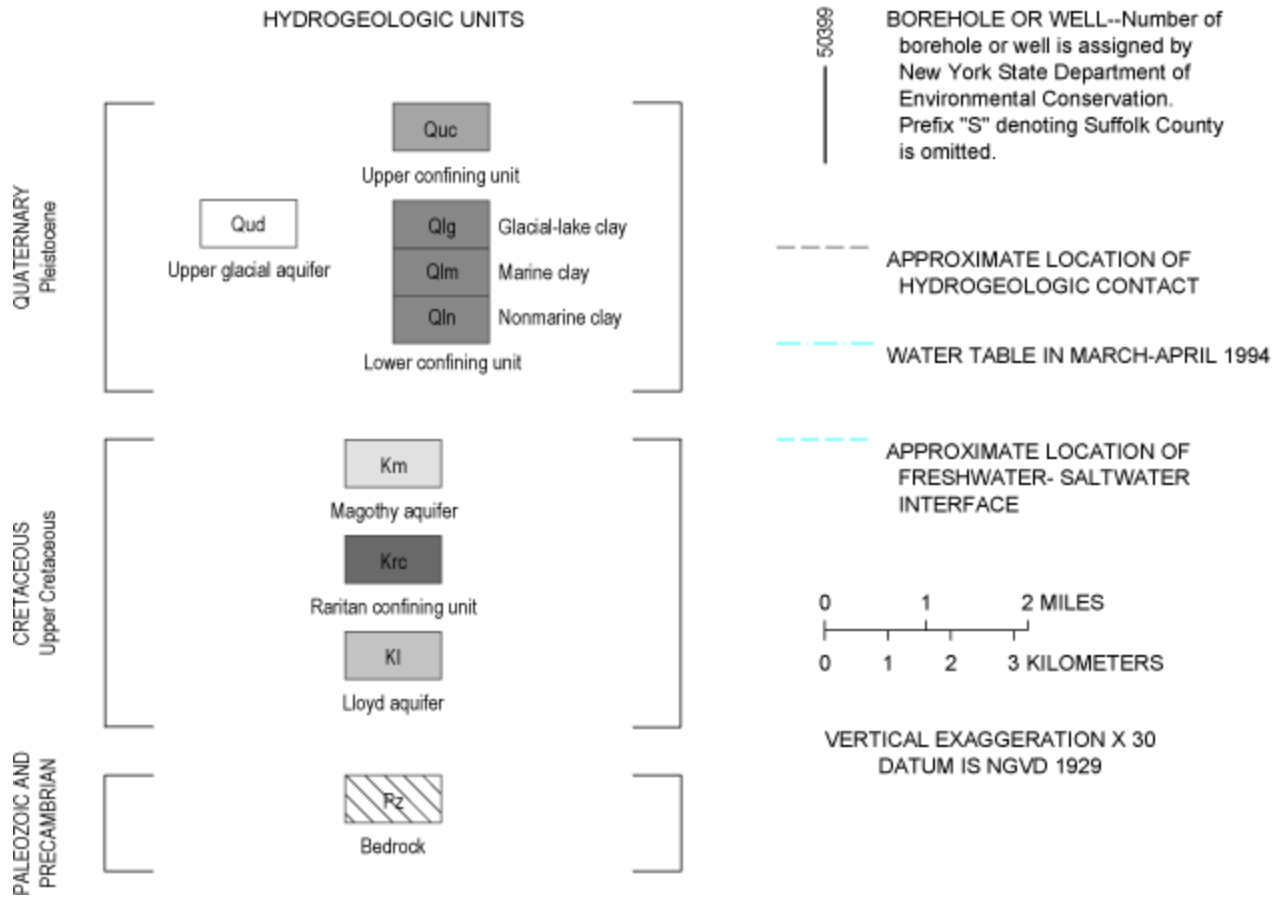


Figure 4. Section E-E' showing hydrogeologic units in the North Fork study area, Long Island, N.Y. (Location of section is shown in fig. 2.) (Modified from Schubert and others, 2003, pl. 1[E].)

Hydrologic Setting

Values of hydraulic conductivity, anisotropy, and specific storativity for the upper glacial and Magothy aquifers, and vertical hydraulic conductivity for Pleistocene confining units on the North Fork, were estimated through a flow-model analysis conducted during this study and are summarized in table 2; more information on the hydraulic properties of water-bearing units is given in Schubert and others (2003) and Misut and others (2004). The hydraulic conductivity values for aquifers and confining units on the North Fork (table 1) indicate that fresh ground water in the upper glacial and Magothy aquifers could be confined locally by the upper and lower confining units, where these units are at least 25 ft thick (Schubert and others, 2003). The upper confining unit probably confines freshwater locally near the western end of the North Fork, near Mattituck Creek and James Creek, and near Hasha momuck Pond. The lower confining unit probably confines freshwater in the Cutchogue flow system and near the western end of the North Fork. Freshwater in the underlying Magothy aquifer probably becomes increasingly confined with depth, as in the Long Island mainland flow system, due to the silt and clay layers within it.

Table 1. Estimated hydraulic values for Pleistocene and uppermost Cretaceous hydrogeologic units on the North Fork, Long Island, N.Y.

[Dashes indicate no value was estimated. From Schubert and others, 2003, table 2]

Hydrogeologic unit		Hydraulic conductivity			Specific storativity (per foot)
		Horizontal (feet per day)	Vertical (feet per day)	Ratio of horizontal to vertical	
Surficial units of upper glacial aquifer	Roanoke Point outwash	200	20	10:1	1.5×10^{-3}
	Roanoke Point moraine	80	8	10:1	1.5×10^{-3}
	Ronkonkoma Drift	200	20	10:1	1.5×10^{-3}
Upper confining unit		--	0.4	--	--
Upper glacial aquifer below upper confining unit		200	20	10:1	1.0×10^{-6}
Lower confining unit		--	0.1	--	--
Upper glacial aquifer below lower confining unit		300	30	10:1	1.0×10^{-6}
Magothy aquifer		50	0.5	100:1	1.0×10^{-6}

The extent of fresh ground water on the North Fork was depicted from the positions of the freshwater-saltwater interface estimated during this study; it is presented in a set of maps and vertical sections by Schubert and others (2003). Freshwater within the upper glacial aquifer occurs above the lower confining unit (where present) in most parts of the North Fork (fig. 4). The hydraulic connection between the Cutchogue flow system and the Long Island mainland flow system above the lower confining unit is limited, but some freshwater can enter the Cutchogue system locally from the main body of Long Island. The absence of any hydraulic connection to the Greenport flow system or the Orient flow system indicates that freshwater within these two flow systems is replenished only through recharge from precipitation. Freshwater above the lower confining unit is hydraulically connected to freshwater beneath this unit in three areas—near Mattituck Creek, southwest of James Creek, and near the northwestern shore of Flanders Bay—where the lower confining unit is absent. Fresh ground water within the lower confining unit (where present) and the underlying part of the upper glacial aquifer occurs only west of Hashamomuck Pond, mostly in the Long Island mainland flow system, but some is within the Cutchogue flow system (fig. 4). The inferred absence of a hydraulic connection within either the lower confining unit or the underlying parts of the upper glacial or Magothy aquifers indicates that freshwater within these zones of the Cutchogue system is replenished only by downward flow.

The position of the freshwater-saltwater interface generally is in accord with the Ghyben-Herzberg principle in most parts of the North Fork, but is complicated by vertical and lateral variations in the hydraulic properties of hydrogeologic units. The depths to which freshwater should theoretically extend were calculated from this principle for the main flow systems on the North Fork. These depths were compared with freshwater-saltwater interface positions estimated from field measurements by Schubert and others (2003) to obtain a measure of the effect of the confining layers on these flow systems.

Freshwater in the center of the Orient flow system is limited to the upper glacial aquifer above the top of the lower confining unit (fig. 4). Freshwater in inland parts of the Greenport flow system generally does not reach the top of the lower confining unit (fig. 4); this indicates that the upper confining unit substantially impedes the downward flow of freshwater. Deep freshwater was found in the east-central part of the Cutchogue flow system (fig. 4), but most of this is within the lower confining unit and probably is residual from a late Pleistocene or early Holocene interval of lower sea level. Freshwater in the west-central part of the Cutchogue flow system reaches the top of the Magothy aquifer (fig. 4), where the upper confining unit is absent or only a few feet thick and does not substantially impede the downward flow of freshwater. The lower confining unit is at least 100 ft

thick within a southeast-trending buried valley in the middle of the west-central part of the Cutchogue flow system (fig. 4), however, and probably impedes the downward flow of freshwater. The hydraulic connection of the western end of the North Fork to the Long Island mainland allows northeastward flow of freshwater into this area from the main body of Long Island.

Detailed information on the hydrogeologic framework of the study area presented in Schubert and others (2003) and summarized in this abstract are useful in an analysis of the effects of pumping and drought on ground-water levels and the position of the freshwater-saltwater interface on the North Fork of Long Island (Misut and others, 2004). This analysis will enable water-resource managers and water-supply purveyors to evaluate a wide range of water-supply management alternatives to safely meet water-use demands. Nevertheless, questions remain on the sequence of unconsolidated Pleistocene and Cretaceous deposits on the North Fork, particularly on the extent and continuity of fine-grained Pleistocene deposits. Additional research, such as sediment dating and nearshore seismic-reflection surveys, would be useful to further define the character and timing of sediment deposition and, therefore, the validity of correlations between geologic and hydrogeologic units.

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