# Hydrogeology of the Tully Trough

## Southern Onondaga County and Northern Cortland County, New York

In Cooperation with Onondaga Lake Cleanup Corporation and U.S. Environmental Protection Agency

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A trough valley near Tully, N.Y. was formed by the same glacial processes that formed the Finger Lake valleys to the west. Glacial ice eroded a preglacial bedrock divide along the northern rim of the Allegheny Plateau and deepened a preglacial valley to form a trough valley. Subsequent meltwater issuing from the ice transported and deposited large amounts of sediment which partly filled the trough. The Tully trough contains three distinct segments—the West Branch valley of the southward-flowing Tioughnioga River in the south, the Valley Heads Moraine near Tully, and the Tully valley of the northward-flowing Onondaga Creek in the north.

The West Branch valley segment south of the moraine contains a two-aquifer system—a surficial unconfined sand and gravel aquifer and a confined basal sand and gravel aquifer that rests on bedrock, separated by a thick, fine-grained glaciolacustrine fine sand, silt, and clay unit. Water quality in the surficial aquifer is generally good, although it is typically hard. Water in the basal, confined aquifer is more mineralized and yields less water to wells than the surficial aquifer.

The Valley Heads Moraine near Tully consists of layers of sand and gravel, fine sand, silt, clay, and till. The land surface contains many kettle-hole lakes, ponds, wetlands, and dry depressions. The moraine contains several aquifers, some of which are discontinuous. Water quality in the shallow aquifers is generally good, although hard. Water quality in the deep aquifer is generally good, although slightly mineralized by water discharging upward from shale.

The Tully valley segment north of the moraine has a confined basal sand-and-gravel aquifer that is overlain by a thick layer of lacustrine silt and clay in the southern part of the valley and becomes interlayered with sand and some fine gravel in the northern part. Most homeowners obtain their water supply from streams or springs along the valley walls or from wells. Water from wells completed in coarse-grained sediment on the north side of the moraine and from the basal aquifer is generally fresh, but water from deep wells finished in the basal aquifer north of Solvay Road contains high concentrations of sodium chloride and calcium sulfate that presumably leached from halite and gypsum minerals within the bedrock.

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## INTRODUCTION

The multiple advances and retreats of glaciers that began about 1.6 million years ago and ended about 10,800 years ago in North America (Rogers, 1991) profoundly altered the landscape of central New York. The glaciers widened and deepened river valleys leaving bedrock troughs and blanketed large areas with gravel, sand, silt, and clay. The Tully trough (figs. 1 and 2) lies within a transition zone between severely eroded uplands with low to moderate relief in the Finger Lakes region to the west and the moderately eroded Appalachian Plateau with moderate to high relief in the Susquehanna River basin to the south and east. The purpose of this report is to characterize the hydrogeology of the Tully trough, including information on glacial history, glacial erosional and depositional processes, glacial stratigraphy, and hydrology of the aquifer systems in the trough segments. The study was performed in cooperation with the Onondaga Lake Cleanup Corporation and the U.S. Environmental Protection Agency - Region 2.

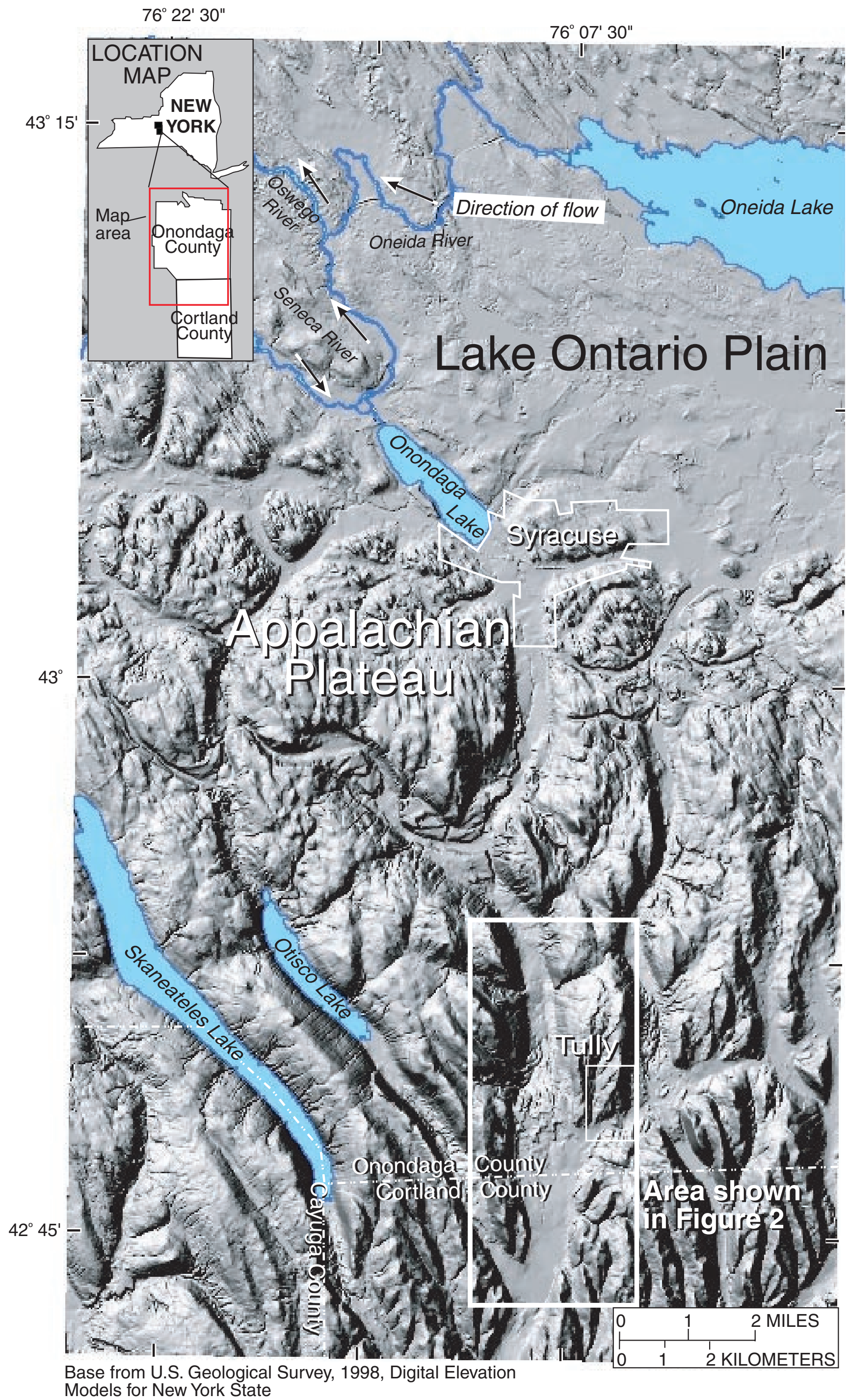



**Figure 1.** Shaded relief map showing the physiographic features surrounding the study area including the Appalachian Plateau, Lake Ontario Plain, and the Skaneateles, Otisco, and Tully troughs.

## GLACIAL HISTORY

The last major period of glaciation in upstate New York (Wisconsian) began about 117,000 years ago (Muller and Calkin, 1993) and ended about 10,800 years ago (Hammer and others, 1986). About 20,000 years ago, the ice front began to melt back from its maximum southern extent in northern Pennsylvania (Muller and Calkin, 1993), and, over the next 5,000 years, the ice front gradually retreated to as far north as the Lake Ontario Plain (fig. 1). At about 14,000 years ago, however, the ice front readvanced southward (Valley Heads Readvance) into the central part of upstate New York, then oscillated back and forth in roughly the same standstill position for a few hundred years in each of the valleys. The continuous deposition of sediment at the ice front during this period resulted in the formation of several types of glacial features including (1) an end moraine (Valley Heads Moraine) at the ice front, (2) lateral moraines at the edges of the ice along the valley walls, and (3) an outwash plain downgradient (south) of the ice front.

The Valley Heads Moraine in each north-south trending valley forms the largest end-moraine complex in central New York and today is the surface-water divide between drainage that flows north to St. Lawrence River and drainage that flows south to Susquehanna River. The ice in the Tully trough came to its standstill position just west of Tully, where it formed the segment of the Valley Heads Moraine shown in figure 2. The surface-water divide within the trough roughly follows the alignment of New York State Route 80 where it crosses the moraine; the ground-water divide is farther to the south, and its position changes seasonally according to local ground-water conditions (Kappel and others, 2001).

The melting of the ice front and the glacial retreat northward from the Valley Heads Moraine resulted in the formation of a proglacial lake between the retreating ice front and the Valley Heads Moraine. Initially, this lake drained to the south through an outlet channel(s) across the Valley Heads Moraine, but as the ice front retreated northward, toward present-day Syracuse, successive outlet channels with progressively lower elevations were exposed along the east side of the valley about 10 miles to the north (Hand, 1978), and sequentially lowered the lake levels. As the ice retreated from the Tully valley segment, large amounts of coarse-grained sediment (sand and gravel) were transported southward through subglacial tunnels; some was probably deposited within ice tunnels as sinuous esker ridges, and the remainder was disgorged into the proglacial lake as subaquatic fans. The finer-grained sediment (fine sand, silt, and clay) was carried out into the lake where it settled to form lake-bottom deposits that buried the older, coarser-grained subglacial sediment. When the Valley Heads ice retreated past Syracuse (about 15 miles north of Tully), the lake drained entirely and glacial deposition in the trough ceased.

Many of the other trough valleys on the north flank of the Appalachian Plateau have a similar deglacial history. The bedrock surface in many of these troughs was eroded so deeply that the glacial material failed to fill them, and the water did not drain completely; the Finger Lakes are remnants of the former proglacial lakes that occupied the northern segments of these troughs.

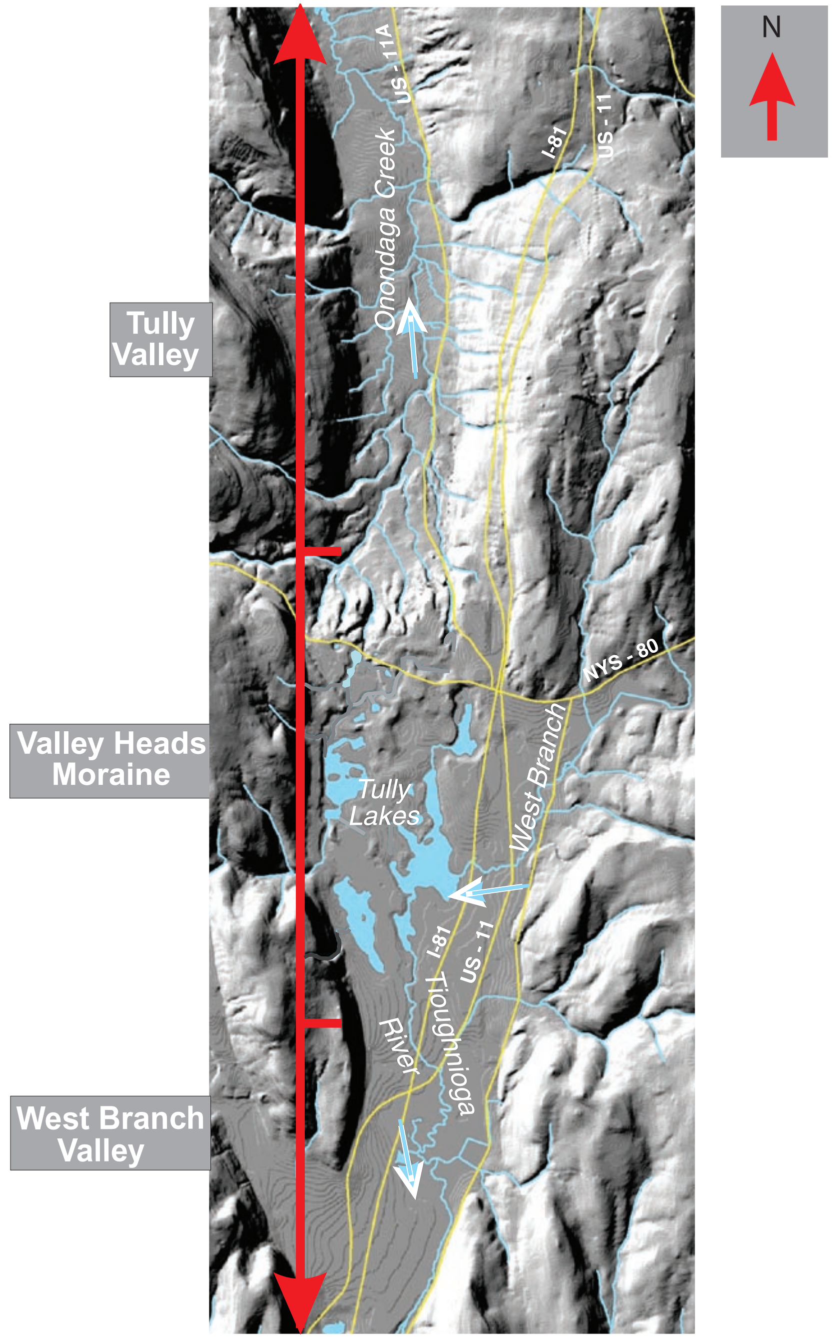



**Figure 2.** Locations of the three major segments of the Tully trough, Onondaga and Cortland Counties, N.Y. White-blue arrows show direction of surface-water flow.

## EROSIONAL PROCESSES

The most notable evidence of glacial erosion in central New York is the large bedrock valleys (troughs) that were carved by ice flowing through pre- and interglacial river valleys. The recession of the melting ice resulted in the transportation and deposition of large amounts of sediment that were generated during the advance of the ice. The end result of these processes is the topography seen in the Finger Lakes region today.

### TROUGHS

The flow of ice in valleys oriented parallel to the direction of ice movement scoured the walls and floor of these valleys, widening and deepening them while truncating bedrock hillsides (spurs) that extended into these valleys. The result was the creation of nearly straight, U-shaped bedrock troughs (fig. 3). Bedrock erosion occurred mainly through quarrying and abrasion by the ice mass, but the material carried by torrents of sediment-laden meltwater under the ice probably eroded bedrock in some areas also (Kor and others, 1991). The most notable bedrock troughs in New York are the many other north-south trending valleys within the northern rim of the Appalachian Plateau, many of which now contain the Finger Lakes (fig. 1). Clayton (1965) referred to the Finger Lake valleys as "intrusive troughs" that were carved when ice that flowed south from the Lake Ontario Plain encountered a landmass of higher elevation (the Appalachian Plateau) and flowed uphill, against the regional slope.

The formation process, size, and shape of a trough are controlled by several variables, such as ice thickness, direction of ice movement, former topography, bedrock structure (fractures and folds), and bedrock lithology (shale, limestone, dolostone). Bedrock troughs are often referred to as U-shaped although many are asymmetrical, with one side steeper than the other.

Many east-west trending valleys that are tributary to deep troughs were not parallel to the direction of ice movement, and, thus, were less deeply eroded. These tributary valleys end at the main valley wall, high above the floor of the trough valley, and are known as "hanging valleys" (fig. 3).

### THROUGH VALLEYS

Some segments of the Finger Lakes and other north-south-trending troughs, such as the Tully trough, contain a "through valley," which is described by Tarr (1905) as follows:

"Along a number of valleys it is possible to pass from one drainage system to the other through open valleys in which the present divides are determined not by rock, but by drift deposits".

Although Tarr (1905) provided the definition, the term "through valley" is attributed to W.M. Davis, who coined the phrase during the discussion of Tarr's paper at the 1904 Geological Society meeting (Tarr, 1905, p. 233). In the Tully trough, the Valley Heads Moraine forms a major surface-water divide between the southward-flowing West Branch Tioughnioga River headwaters (henceforth called the West Branch valley in this report) and the northward-flowing Onondaga Creek headwaters (called the Tully valley in this report, fig. 3), and is the through valley part of the Tully trough.

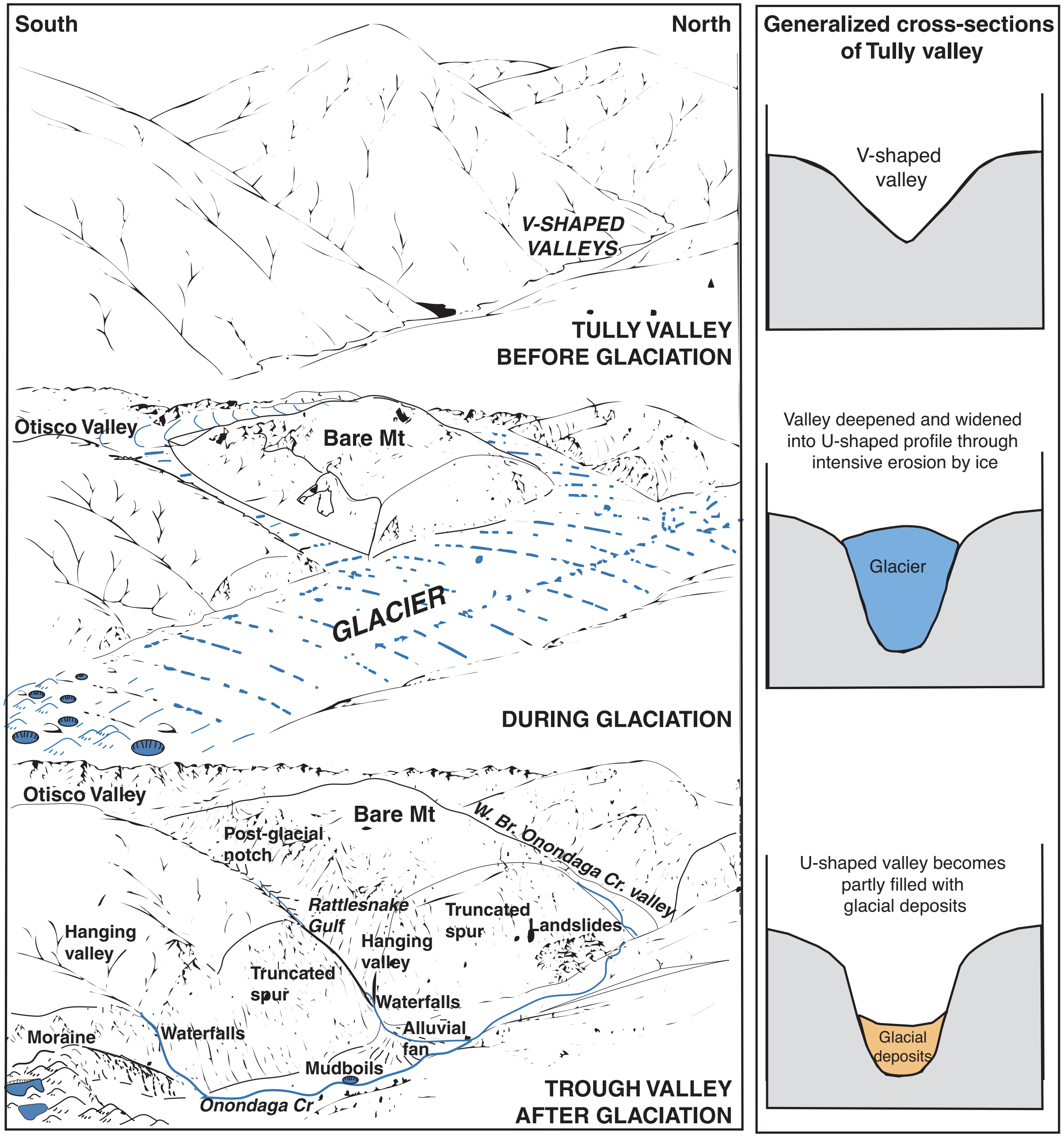
### SADDLES

The present bedrock floor steadily rises southward throughout the study area (fig. 4), however, prior to glaciation, the Tully trough may have contained a bedrock "saddle" or divide several miles north of its present location south of Tully (fig. 1). Several highly erosive ice advances wore the saddle down and shifted it southward (headward erosion) where it is now buried by glacial sediments deposited during the last glacial recession.

## DEPOSITIONAL PROCESSES

Glaciers transported and deposited such large amounts of sediment that, in glaciated areas, nearly all surficial unconsolidated deposits are of glacial origin, and can be hundreds of feet thick. Supraglacial debris (sediment on top of the ice), originated from two processes—(a) mass movement of debris from adjacent hillsides on to the ice and (b) transport of debris by upland streams on to the ice. Englacial debris (sediment within the ice) becomes entrained in the ice where bedrock crops out along edges of the glacier. Supraglacial and englacial debris is carried by the glacier with little or no modification of the particle size or shape. Subglacial (below the ice) meltwater can transport sediment through systems of channels and(or) linked-cavity systems at the base of the ice (Benn and Evans, 1998) and alter the particle size and shape through erosion.

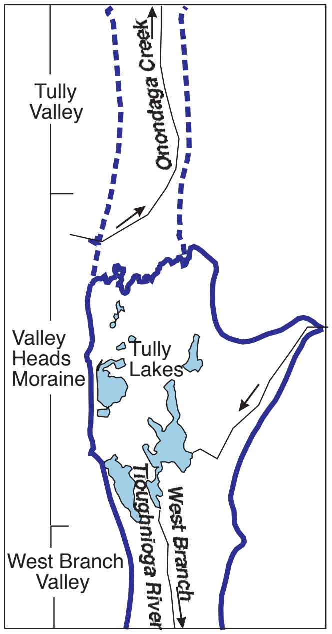
The two most important processes in the reworking of glacial sediment in the Tully trough and elsewhere are gravitational mass movement and transport by water. Flow of debris from steep hillsides onto the ice surface were particularly common because the abundant meltwater saturated the material, allowing it to easily flow to lower elevations. Further reworking of the sediments by meltwater is an effective grain-size sorting process. The coarse-grained sediments were deposited at and near the ice front where meltwater stream gradients were steep and flow was fast upon emerging from the confines of subglacial ice tunnels flowing from the ice front. Subglacial stream 'energy' (fast-moving water) was lost as these ice-tunnel streams emerged from the ice and flowed onto or around disintegrating ice blocks adjacent to the ice front and onto the outwash plain in front of the ice. The finer-grained sediments were carried away southward by meltwater streams and deposited in the West Branch valley.




Modified after W. M. Davis, 1939

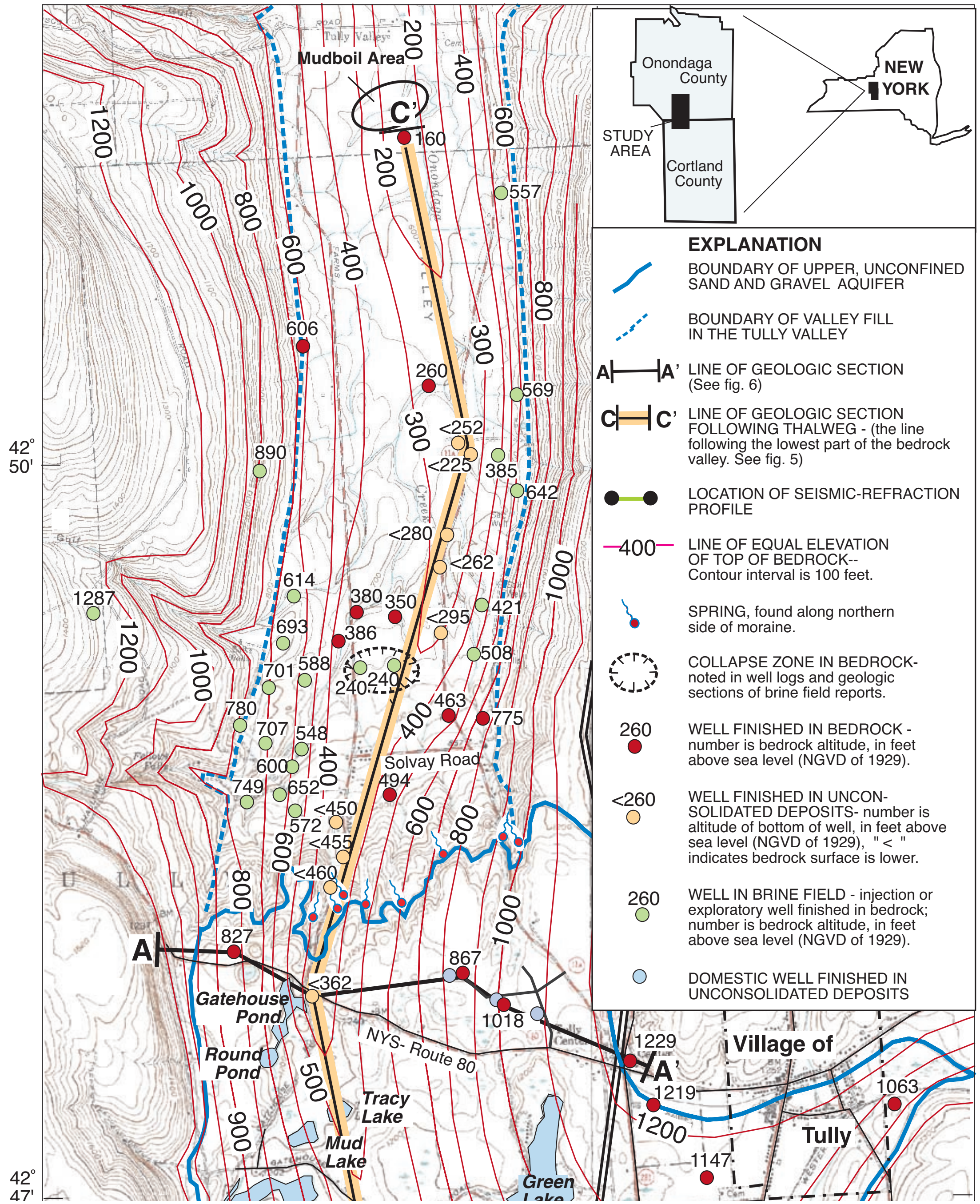
**Figure 3**. Features in the Tully Valley before, during, and after glaciation; and generalized changes in the shape of the bedrock valley.

Physiographic components of the Tully trough near Tully, N.Y. (Arrows show direction of flow)




## HYDROGEOLOGY OF TULLY TROUGH SEGMENTS

The end result of the glacial process described above created three trough segments in the Tully trough; the West Branch valley, the Valley Heads Moraine near Tully (though-valley section), and the Tully valley. The sediments that were eroded during the Valley Heads readvance, and deposited during the extended period of recession, and the older deposits beneath, collectively form a complex depositional sequence within and near the Tully trough. Deep-subsurface data, however, are insufficient to provide more than a generalized depiction of the glacial stratigraphy and the aquifers found within those deposits.

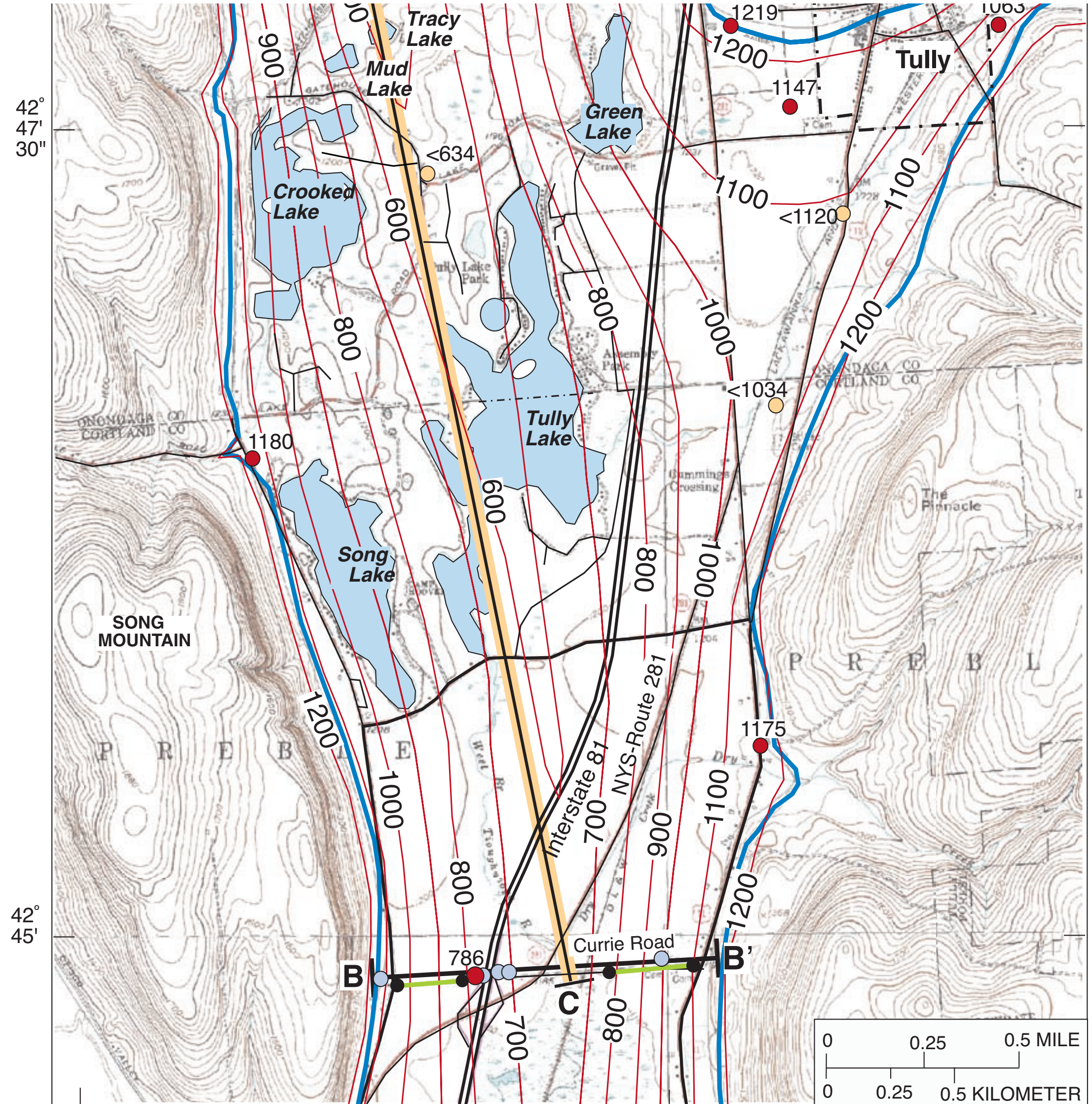


## WEST BRANCH VALLEY (SOUTH OF THE VALLEY HEADS MORAINE)

The bedrock floor of the Tully trough rises southward throughout the study area (figs. 4 and 5) and, according to recent geohydrologic work by USGS in the West Branch valley, it continues to rise southward for several more miles. In most places, the bedrock is overlain by a basal sand and gravel unit that was deposited as pre-Valley Heads ice while it was retreating northward in the West Branch valley. This basal unit is typically overlain by more than 100 feet of lake-bottom sediment (fine sand, silt, and clay) and, in some places, by coarser grained subaquatic fan deposits (sand and pebbly sand).

During the Valley Heads standstill, large amounts of sediment were carried by meltwater streams southward of the Valley Heads ice front in the Tully, Otisco Lake, and Skaneateles Lake troughs (fig. 1) and deposited much of the sediment in a proglacial lake in the West Branch valley. The lake eventually became filled with fine-grained lake sediment and subsequent meltwaters deposited a 40- to 70-foot thick layer of outwash sand and gravel on top of the lake sediments.

A 400-foot deep well (C-601, figs. 5 and 6) drilled by the USGS on Currie Road indicated 46 feet of outwash overlying 19 feet of medium- to coarse-grained deltaic sand that, in turn, overlies 335 feet of lacustrine fine sand, silt, and clay. Bedrock (shale) was penetrated at 400 feet and no basal sand and gravel unit was found at this site. Seismic-refraction surveys completed by the USGS




Base from Otisco Valley and Tully Quadrangles, 1955, 1:24,000

**Figure 4.** Bedrock-surface altitude, locations of wells, and lines of geologic sections (shown in figs. 5 and 6) in the Tully trough, Onondaga and Cortland Counties, N.Y.

along Currie Road east and west of Interstate 81 (fig. 4) indicate that the thalweg (deepest part of the valley) is east of well C-601 and is probably between Interstate 81 and New York State Route 281 (fig. 4). The basal sand and gravel unit, if present, may be in the thalweg because subglacial meltwater channels commonly follow the deepest part of a trough valley.

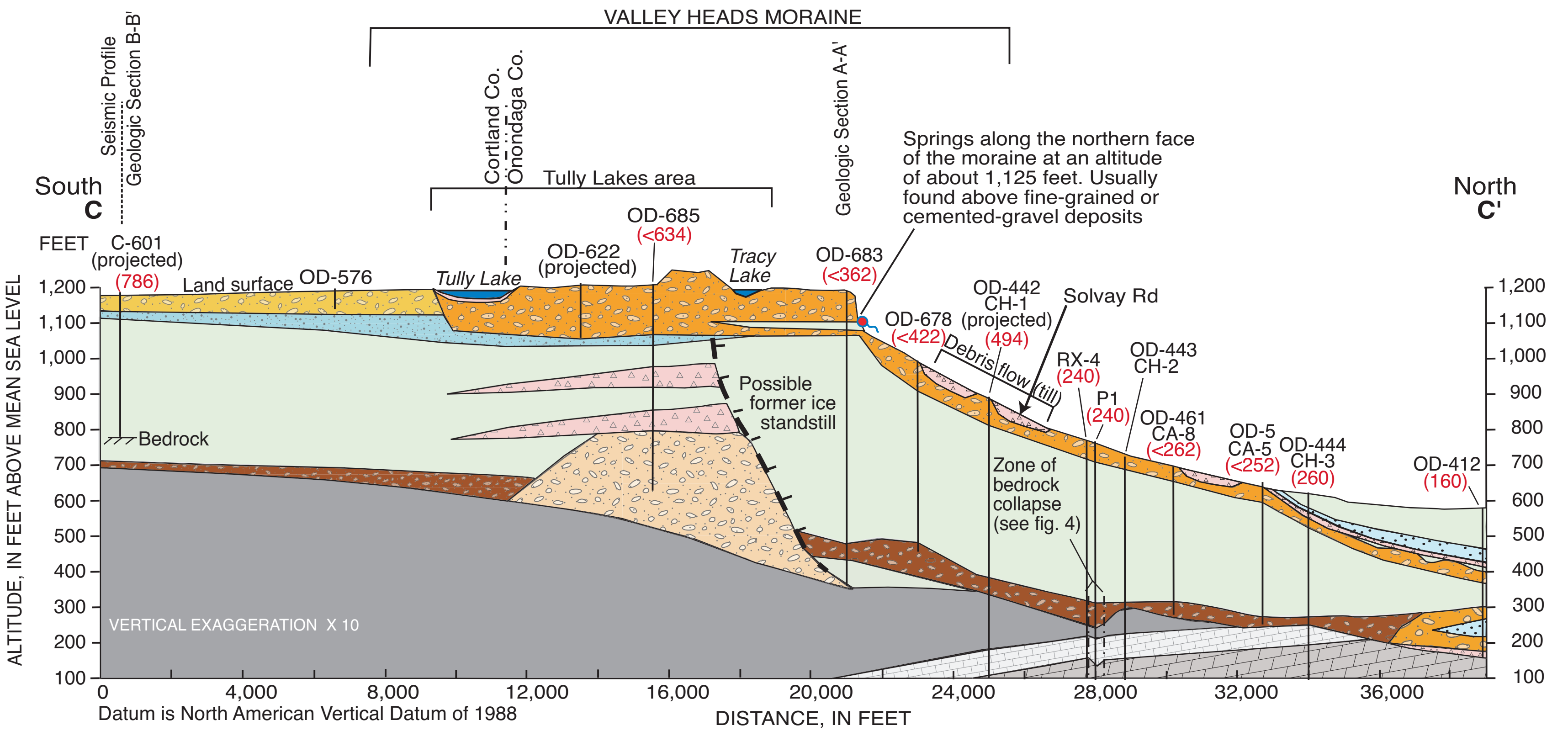
Glacial-drift sediments in the West Branch valley form a two-aquifer system—a surficial (unconfined) sand and gravel aquifer, underlain by a lacustrine confining unit of fine sand, silt, and clay, and a confined basal sand and gravel aquifer on top of bedrock (figs. 5 and 6). The surficial (unconfined) aquifer is capable of supplying ample amounts of water to residents and businesses in the West Branch valley. The water table is typically 10 to 30 feet below land surface and may be as deep as 50 feet in some places. Typical reported yields to open-ended domestic wells range from 20 to 50 gallons per minute. Yields of several hundred gallons per minute or more could be expected from large-diameter screened wells. For example, a 12-inch-diameter screened well near the north end of Song Lake was pumped at a rate of 1,100 to 1,200 gallons per minute during a 48-hour aquifer test (Haley & Aldrich of New York, 1999). The water quality generally is good, but hard. The water-table altitude, direction of ground-water flow, and interaction between the shallow aquifer and the Tully Lakes are described in Kappel and others (2001).

The basal (confined) aquifer is probably continuous along the bedrock floor in the deepest part of the valley (thalweg) and discontinuous along the sides of the valley. The confined aquifer is commonly less permeable than the unconfined aquifer, as indicated by well yields, which are highly variable and generally lower than those in the unconfined aquifer. Water levels in the few wells that have been drilled into the confined aquifer are above those in the surficial aquifer. Water quality in the confined aquifer is similar to that in the underlying shale (highly mineralized with variable amounts of hydrogen sulfide gas). The deep confined aquifer is little used because it is more economical to tap the shallow unconfined aquifer which has better water quality than the confined aquifer.

## VALLEY HEADS MORAINE

Large amounts of sediment accumulated at the ice front as a result of the meltout of englacial material that had been eroded and transported from the bedrock valley floor and walls. In addition, subglacial meltwater discharging from conduits at the base of the ice disgorged sediment as subaqueous fans at the ice front. Meltwater that flowed on top of the ice transported supraglacial material to the ice front in channels on or within the disintegrating ice front. An uneven landscape developed at the ice margin as large amounts of sediment were deposited on the disintegrating ice to form kame, kettle, and glacial karst features. Kame mounds and ridges of glacial drift (mixed glacial sediments) formed across the Valley Heads Moraine; the drift generally consists mostly of coarse-grained sediment (sand and gravel) that settled to the land surface as the ice melted. Kettle hollows sometimes formed between kame mounds as a result of the melting of buried ice masses that became separated from the retreating ice front. Glacial karst formed in areas of relatively thick glacial debris that covered and insulated residual ice masses. Internal drainage networks may then have developed beneath these masses and these drainage conduits slowly enlarged to the point that the overlying ice collapsed to form depressions and sinuous chains of craterlike depressions. Green and Tully Lakes (fig. 4) together have a sinuous form that may reflect a former collapsed meltwater conduit(s) (fig. 4).

Two deep test wells (well OD-685, 560 feet deep; well OD-683, 830 feet deep, fig. 5) were drilled by the USGS on the Valley Heads Moraine and over the deepest part of the valley. Neither well reached bedrock, although the deeper well (OD-683) probably ends close to bedrock. The other well (OD-685) penetrated 135 feet of kame-moraine deposits (sand and gravel) overlying 30 feet of deltaic sand, which is underlain by 240 feet of glaciolacustrine sediments (fine sand, silt, and clay) interbedded with till, and then by 160 feet of silty sand and gravel. This silty sand and gravel unit may be part of a buried moraine of pre-Valley Heads origin, or it may represent an early-Valley Heads standstill position. The thick




## EXPLANATION

UNCONSOLIDATED DEPOSITS

KAME (END) MORAINE (Valley Heads Moraine) - Predominently coarse sand and gravel, but capped by till and debris-flow deposits in some places at crest and north side of moraine.

OUTWASH - Sand and gravel deposited in the valley by glacial meltwater.

DELTAIC DEPOSITS - Medium to coarse pebbly sand deposited by glacial meltwater where it emptied into a proglacial lake.

GLACIOLACUSTRINE DEPOSITS - Fine sand, silt, and clay deposited in a proglacial lake.

TILL - Poorly sorted mixture of very fine sand, silt, clay and stones deposited by ice. Some till units may be reworked lacustrine sediments that ice had overridden.

SUBGLACIAL DEPOSITS - Sand and gravel deposited by meltwater at base of glacier and buried by subsequent sediment deposition.

BURIED MORAINE (pre-Valley Heads?) - Predominantly sand and gravel interbedded with silt and clay.

WATER

BEDROCK

Hamilton Formation (Middle Devonian age) - Shale, siltstone, sandstone, and dolostone.

Onondaga Limestone (Middle Devonian age).

Helderberg Group-(Lower Devonian and Upper Silurian Age) - limestones and dolostones.

OD-412 (160) WELL AND WELL NUMBER - Number assigned by USGS C = Cortland County, OD = Onondaga County Other numbers are locally assigned well numbers. Red number in parentheses is bedrock altitude (also shown in fig. 4).

SPRING, along north side of moraine.

**Figure 5.** North-south geohydrologic section C-C‘ showing locations of selected wells and the glacial stratigraphy in the Tully trough near Tully, NY. Line of section is along the thalweg (deepest part) of the bedrock valley and is shown in fig. 4.

lacustrine unit between the Valley Heads Moraine and the underlying and presumably older moraine indicates the presence of a lake in the Tully trough before the Valley Heads readvance. The lake apparently continued to exist or redeveloped, as indicated by fine-grained sediment that buries this early moraine as well as the older coarse deposits north and south of the moraine. Whether the 160-foot thick silty sand and gravel sequence extends to bedrock and continues with the subglacial deposits of sand and gravel (as shown in figure 5) is uncertain.

Well OD 683 (fig. 5) was drilled to depth of 830 ft and did not reach bedrock. The well penetrated, in descending order, 7 feet of till, 118 feet of kame moraine (mostly sand and gravel), 600 feet of fine-grained lacustrine sediment (fine sand, silt, and clay), 40 feet of sand and gravel, another 60 feet of fine-grained lacustrine sediment, and 3 ft of very coarse gravel which may be part of a subaquatic fan or buried moraine. Testhole data are insufficient to reveal the extent of the hypothesized buried fan or moraine, and do not indicate whether these deposits extend to bedrock, as implied by figure 5.

The complex stratigraphy of the moraine results in a multiaquifer system. The surficial kame-moraine deposits (ice-contact and collapsed outwash) forms an extensive unconfined sand and gravel aquifer (70 to 120 feet thick) that is underlain by a thick sequence of fine-grained glaciolacustrine deposits that, in turn, confine one or more deep sand and gravel aquifers (presumably subglacial conduit deposits and subaquatic fans) of highly variable thickness (15 to 150 feet thick), that may be discontinuous. The moraine also contains large kettle lakes, such as Song, Crooked, Green, and Tully Lakes (fig. 4). The water levels in some of the kettle lakes represent the local water table, whereas, others appear to be perched (Kappel and others, 2001). The bottoms of these perched lakes and ponds are probably lined with poorly permeable sediment and decayed organic material (muck) and(or) till that impedes the downward movement of lake water.

The kame sand and gravel aquifer at the moraine is connected to the surficial outwash sand-and-gravel aquifer in the West Branch valley. Both aquifers typically yield 10 to 50 gallons per minute to open-ended domestic wells. The water quality is generally good, although hard, as would be expected from the high limestone content of the gravel (Ku, and others, 1975, fig. 22; Denny and Lyford, 1963, pl. 3).

Ground water in the northern part of the kame sand and gravel aquifer flows northward and discharges from springs along the north side of the moraine. Some of the springs are perennial, including the springs along Route 11A which are used for a small public-water-supply system for residents in Tully valley, whereas others flow only during the wet season.

Some domestic wells at the crest of the moraine are completed in a sand and gravel layer, about 15 feet thick, that apparently is a thin lens within the upper part of the glaciolacustrine unit (fig. 5). Ground water in this unit probably also discharges to the springs along the northwestern side of the moraine (fig. 4).

Two domestic wells on the crest of the moraine, each about 400 feet deep (OD-675 in the east central part of the moraine and OD-674 on the western side), were drilled through the surficial kame moraine and the lacustrine deposits (with little or no saturation in these areas) and completed in the thin basal aquifer that overlies bedrock (fig. 6A). Water from the confined aquifer is turbid, moderately mineralized, and similar to water in the shale—with a hydrogen sulfide odor and enough iron to cause staining. The surficial sand and gravel aquifer near the crest of the moraine is thinly saturated because springs on the north side of the moraine drain much of the water from this aquifer.

USGS test well OD-683, near the intersection of NYS Route 80 and Gatehouse Road (fig. 4), penetrated an unconfined sand and gravel aquifer between depths of 10 and 85 feet, and a thin sand-and-gravel aquifer (lens?) between 107 and 118 feet which was confined within the upper part of the glaciolacustrine unit. Both aquifers yield more than 10 gallons per minute to domestic wells. Underlying the thick confining unit are two confined sand and gravel aquifers between depths of 730 and 770 feet and 827 and 830 ft. Refusal was encountered at depth 830 ft, but a well could only be installed in the aquifer at 730 feet. The driller estimated the yield from the 730 foot deep aquifer at several hundred gallons per minute. It is uncertain whether the well finished in this aquifer is connected to the basal confined aquifer in the West Branch valley and that found in the Tully valley.

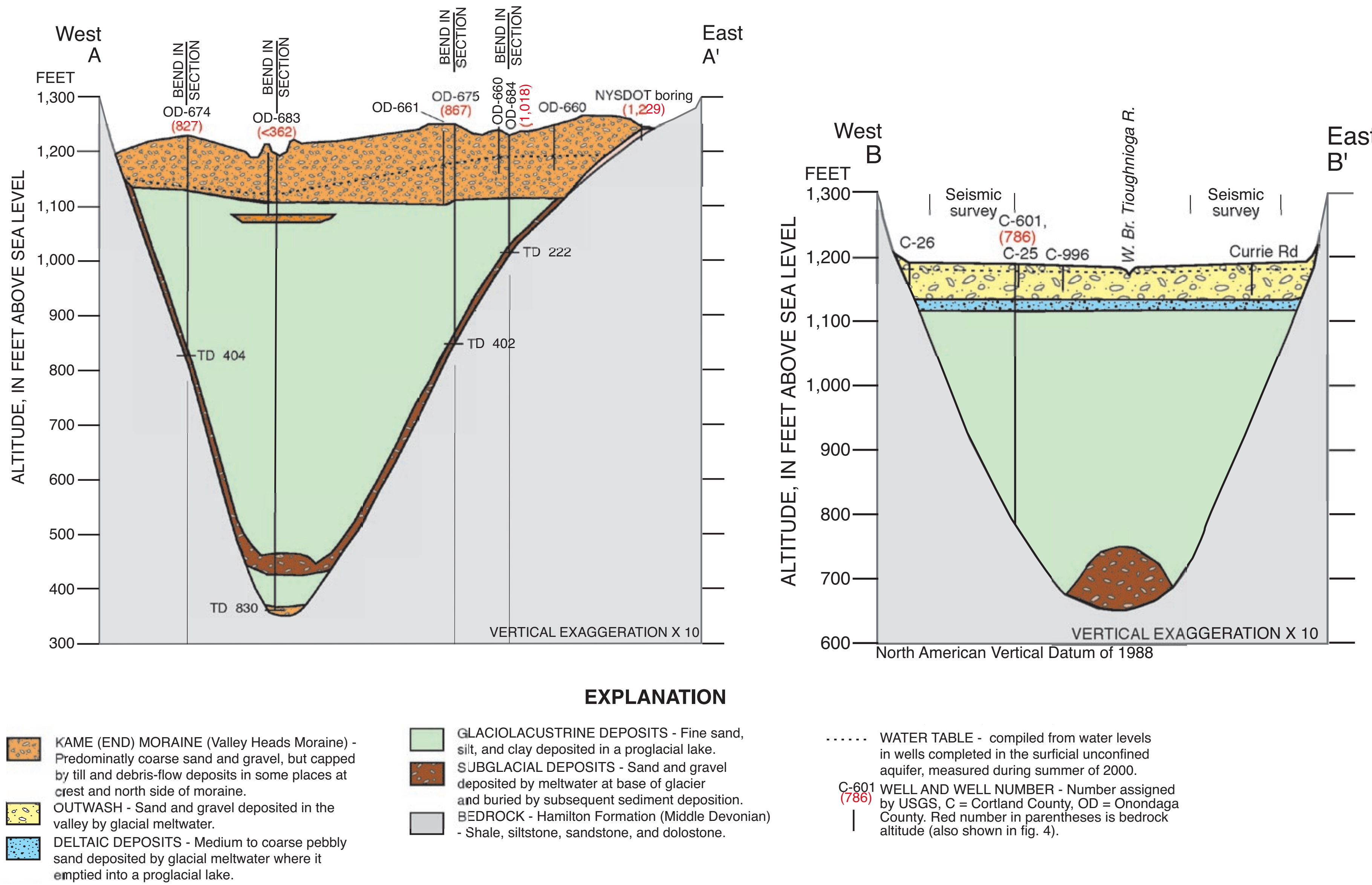



**Figure 6.** Geohydrologic sections A-A', along the crest of Valley Heads moraine, and B-B' along Currie Road. (Lines of section are shown in fig. 4.)

## TULLY VALLEY (NORTH OF THE VALLEY HEADS MORAINE)

The steep northern slope of the moraine (from the crest of the moraine to Solvay Road, fig. 5) is mantled by a layer of kame moraine deposits which are comprised of sand and gravel interbedded with till or till-like debris-flow deposits and some silt and clay beds; collectively they are 55 to 80 feet thick, as indicated by test borings (Continental Placer Inc., 1992). These sediments may have been deposited beneath the ice, perhaps in englacial conduits through which sediment was transported to the crest of the moraine, and perhaps, in part, atop the disintegrating ice, later to collapse to their present position. Farther to the north, these kame moraine deposits either pinch out or are overlain by younger drift that was deposited during the retreat of the Valley Heads ice (fig. 5). The kame moraine deposits on the north side of the moraine overlie a thick sequence of glaciolacustrine fine sand, silt, and clay, that, in turn, overlies a basal confined sand and gravel unit that overlies bedrock. The basal sand and gravel unit may be discontinuous along the sides of the bedrock valley walls but it is commonly found in the deepest part of the valley.

Well OD-412 (fig. 5) and several other deep test wells a few miles farther north in Tully Valley penetrated, in descending order, (1) discontinuous alluvial fan deposits of sand and gravel where upland tributaries flowed onto the main valley, (2) a relatively thick bed of lacustrine fine sand, silt and clay, that may contain a thin layer of till and sand and gravel that may represent a readvance of ice into the proglacial lake, and (3) a confined basal sand and gravel unit containing saline water.

The hydrologic characteristics of aquifers in the Tully valley differ markedly from those in the West Branch valley and in the Valley Heads Moraine. Aquifers that yield water of sufficient quantity and quality are difficult to find. Some homeowners in the southern part of the valley once obtained their water supplies from springs and streams along the valley walls, but some of these supplies were lost due to brine mining operations. Solutioning of salt beds resulted in collapse in overlying bedrock units. The collapse caused fractures to open along the valley walls and these fractures intercepted drainage off the valley walls and routed it into deeper zones in the bedrock. An alternative public water-supply system for homes within the southeastern part of the Tully valley was developed that taps a spring on the north side of the Valley Heads Moraine.

Homes along the southern end of the Tully valley, near the foot of the moraine, obtain water from sand and gravel layers within the surficial kame-moraine deposits, generally at depths less than 100 feet, or from the basal confined aquifer (greater than 400 feet). Most deep wells along Solvay Road (fig. 4) have adequate yields, are artesian (flowing above land surface), and yield potable water. Deep wells north of Solvay Road also have adequate yields and are artesian, but generally have poor water quality, with high concentrations of mineral salts dissolved from halite and gypsum deposits in the bedrock. Additional information on the hydrogeology in the Tully valley is given in Kappel and others (1996).

# SUMMARY

The glacial history of the Tully trough is similar to that of the Finger Lake valleys to the west. Glaciers deepened these valleys and eroded away the preglacial bedrock divides or saddles between the northward- and southward-draining stream valleys. Scouring by glaciers in these preglacial valleys formed bedrock troughs that became partly filled with glacial deposits as the ice melted. The Tully trough contains three segments—the West Branch valley of the Tioughnioga River in the south, the Valley Heads Moraine, and the Tully valley segment drained by Onondaga Creek in the north.

The West Branch valley south of the moraine contains a two-aquifer system—a surficial unconfined aquifer, and a basal confined sand and gravel aquifer that overlies the bedrock. Most of the domestic wells tap the unconfined sand and gravel aquifer. Water quality in this aquifer generally is good, although hard. Water in the basal, confined aquifer is mineralized and well yields are lower than those from the unconfined aquifer.

The Valley Heads Moraine near Tully consists of layers of sand and gravel, fine sand, silt, clay, and till. Its surface contains many kettle-hole lakes, ponds, wetlands, and dry depressions. The unconfined, surficial kame moraine aquifer is connected to the unconfined aquifer in the West Branch valley. The surficial sand and gravel aquifer near the crest of the moraine is thinly saturated because springs on the north side of the moraine drain much of the water from this aquifer. Water quality in the shallow aquifers is generally good, although hard. In some areas, especially in the thalweg of the valley, the basal, confined sand and gravel aquifer beneath the moraine is capable of yielding large amounts of water to wells, but this aquifer thins toward the edges of the valley and yields only small amounts of water to wells there. Water quality in the basal confined aquifer appears to be generally good within the moraine but becomes heavily mineralized to the north.

Homeowners in Tully valley obtain water from streams or springs along the valley walls or from shallow dug or drilled wells. A spring-fed, public-water-supply system along the back side of the moraine has replaced sources of water along the valley-walls in areas adjacent to a former brine-mining operation. Beneath the surficial aquifer on the back side of the moraine is a thick layer of lacustrine fine sand, silt, and clay. Further to the north (north of Solvay Road), there is a discontinuous alluvial fan sand and gravel aquifer deposited where upland tributaries flow onto the main valley and a confined basal sand and gravel aquifer separated by a relatively thick bed of lacustrine sediment. Water in the surficial unconfined aquifer on the north side of the Valley Heads Moraine and in the basal confined aquifer south of Solvay Road is generally fresh (non-saline). However, water in the basal confined aquifer north of Solvay Road contains high concentrations of sodium chloride and calcium sulfate derived from the dissolution of halite and gypsum deposits within the bedrock.

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