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Hydrogeology and Water Quality of Significant Sand and Gravel Aquifers

in parts of Franklin, Oxford, and Somerset Counties, Maine

by

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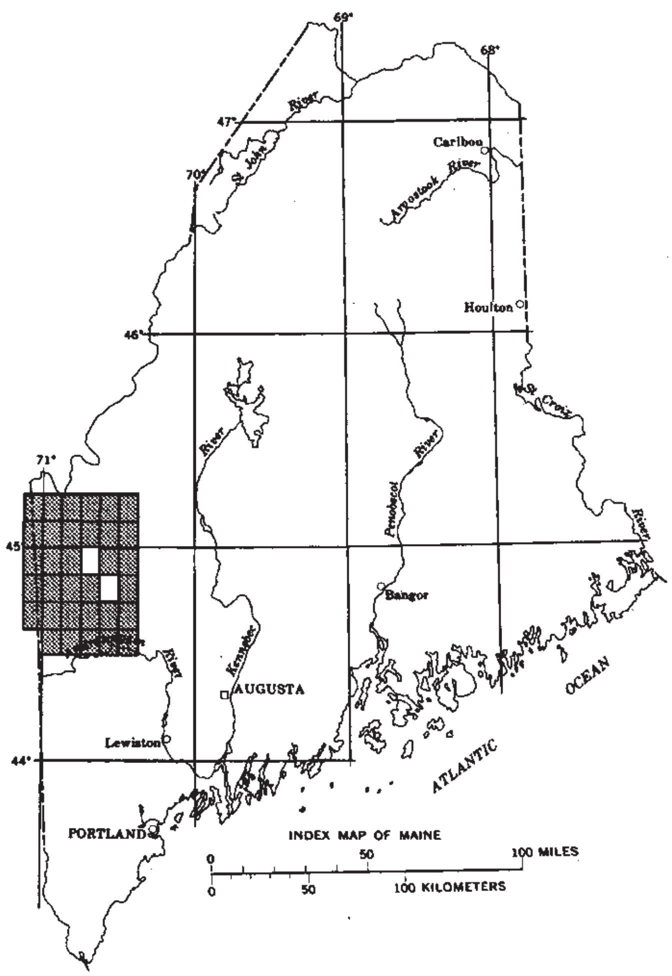

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CONTENTS

ASSOCIATED MAPS
(Available separately)

Significant sand and gravel aquifers maps associated with this report are available for the following quadrangles (1:24,000):

Quadrangle Name	Open-File No.
Andover	95-4
B Pond	95-5
Black Mtn.	95-6
Black Nubble	95-7
Bosebuck Mtn.	95-8
Dixfield	95-9
East Andover	95-10
Ellis Pond	95-11
Houghton	95-12
Kennebago	95-13
Kennebago Lake	95-14
Lincoln Pond	95-15
Little Kennebago Lake	95-16
Madrid	95-17
Metallak Mtn.	95-18
Middle Dam	95-19
Old Speck Mtn.	95-20

Quadrangle Name	Open-File No.
Oquossoc	95-21
Parmachenee Lake	95-22
Puzzle Mtn.	95-23
Quill Hill	95-24
Redington	95-25
Richardson Pond	95-26
Roxbury	95-27
Rumford	95-28
Rump Mtn.	95-29
Saddleback Mtn.	95-30
Stratton	95-31
Tim Mountain	95-32
Umbagog Lake North	95-33
Umbagog Lake South	95-34
Weld	95-35
Wilsons Mills	95-36

ILLUSTRATIONS

TABLES

APPENDICES

CONVERSION FACTORS AND ABBREVIATIONS

For the convenience of readers who may prefer to use metric (International System) units rather than the inch-pound units used in this report, values may be converted by using the following factors:

Multiply inch-pound unit	By	To obtain metric unit
	Length	
inch (in)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
area(mi^2)	2.590	square kilometer (km^2)
	Velocity	
foot per second (ft/s)	0.3048	meter per second (m/s)
foot per day (ft/d)	0.3048	meter per day (m/d)
	Flow	
gallon per minute (gal/min)	0.06308	liter per second (L/s)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)
	Transmissivity	
foot squared per day (ft^2/d)	0.09290	meter squared per day (m^2/d)

OTHER ABBREVIATIONS USED IN THIS REPORT

S/cm, microsiemens per centimeter at 25 degrees Celsius
mg/L, milligrams per liter
g/L, micrograms per liter
Temperatures in degrees Celsius (°C) can be converted to degrees Fahrenheit (°F) as follows: °F = 1.8° C + 32

Chemical concentrations and water temperature are given in metric units. Chemical concentration is given in milligrams per liter or micrograms per liter. Milligrams per liter is a unit expressing the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) of water; 1,000 g/L (micrograms per liter) is equivalent to 1 mg/L (milligram per liter). For concentrations less than 7,000 mg/L, the numerical values are the same as concentrations in parts per million.

Specific-conductance data are reported in S/cm (microsiemens per centimeter at 25 degrees Celsius). Identical units are used for this analysis in the inch-pound and metric systems of measurement.

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

Maine Geological Survey
Open File 95-3

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ABSTRACT

A reconnaissance-level hydrogeologic study was made of 1717 square miles in Franklin, Oxford, and Somerset Counties in Maine to update maps 33, 34, 35, and 36 of the 1:50,000 scale Sand and Gravel Aquifer Map series previously published by the Maine Geological Survey. Those maps will be recompiled to include additional data and published as 1:24,000 scale maps of the Significant Sand and Gravel Aquifer Map series. Significant sand and gravel aquifers consist of glacial ice-contact, ice stagnation, outwash, and alluvial deposits found primarily in the valleys of the major river systems and their tributaries and near other surface-water bodies. Significant aquifers are those capable of a sustained yield of more than 10 gallons per minute to a properly constructed well. Significant aquifers comprise approximately 74.7 square miles (4.4 percent) of the study area, but yields estimated to exceed 50 gallons per minute are believed to be available from only 6.9 square miles (less than 1.0 percent) of this area. Typically, the water table is within 15 feet of land surface. On the basis of well records, the greatest known depth to bedrock is 191 feet in a domestic well in Andover. According to seismic-refraction data, the greatest depth to bedrock is approximately 297 feet. The greatest known well yield is approximately 670 gallons per minute from a gravel-packed industrial well in Coplin Plantation. The regional ground-water quality ranges from moderately acidic to moderately basic; the most abundant cations are calcium and sodium; bicarbonate is the most abundant anion, and the water generally is soft. In some locations, concentrations of iron and manganese are large enough to limit the suitability of untreated water for some uses.

INTRODUCTION

Significant sand and gravel aquifers are the primary ground-water source for satisfying the needs of municipalities and industry throughout Maine. They also are a major source of water for domestic wells and may provide recharge to the underlying fractured-bedrock aquifer. The term “aquifer” has varying connotations, but may best be defined as a “geologic deposit that yields useful quantities of ground water to wells and springs” (Caswell, 1987). The Maine State Legislature (38 MRSA Chapter 3, Section 403) defines a significant aquifer as one which is capable of producing 10 gal/min (gallons per minute) or more to a properly constructed well.

Recognizing the value of significant sand and gravel aquifers, the Maine State Legislature adopted a number of provisions that restrict the siting of activities that may discharge contaminants to the aquifers. Many local governments and planning boards have passed zoning ordinances to protect significant sand and gravel aquifers. To assist local and state governments in developing aquifer protection laws and ordinances, the Maine Geological Survey (MGS), in cooperation with the U.S. Geological Survey (USGS) and with financial cooperation from the Maine Department of Environmental Protection (MDEP), carried out preliminary investigations of sand and gravel aquifers throughout much of the state. These investigations, conducted from 1978 through 1980, resulted in the production of 59 maps at a scale of 1:50,000 that delineate approximate aquifer boundaries, potential well yields, and potential point sources of contamination.

The original Sand and Gravel Aquifer Maps provide a valuable source of information, but are limited in accuracy because of the large area mapped in a short period of time. Also, the maps contain little information on aquifer thickness and stratigraphy and no information on water quality. To correct these shortcomings, the Maine State Legislature directed the MDEP and MGS to update the sand and gravel aquifer maps to provide more information on depth to bedrock, depth to water table, stratigraphy, and water quality (38 MRSA Chapter 3, Section 403). In 1979, the Legislature instructed the MDEP and MGS to delineate all significant sand and gravel aquifers. These new maps are referred to as Significant Sand and Gravel Aquifer Maps.

A cooperative, reconnaissance aquifer-mapping project was initiated in June 1981 by the MGS, USGS, and the MDEP to satisfy the demand for more accurate, complete, and current hydrogeologic information concerning sand and gravel aquifers in Maine. The mapping first was conducted in densely populated and rapidly developing areas and subsequently has been extended to other areas of the state (Tolman and others, 1983; Tepper and others, 1985; Williams and others, 1987; Adamik and others, 1987; Weddle and others, 1988; Locke and others, 1989; Neil and others, 1992). The study area locations for the Significant Aquifers Project are shown in Figure 1. Significant Sand and Gravel Aquifer Maps for the 1981 through 1986 study areas were published at a scale of 1:50,000. Beginning with the 1987-88 study area and for subsequent years, Significant Sand and Gravel Aquifer Maps for the study areas designated on Figure 1 are published at a scale of 1:24,000.

This report presents the results from the ninth year of the mapping project (1989 field season) and updates the Sand and Gravel Aquifer Map Series for maps 33, 34, 35, and 36. These maps have been modified locally on the basis of new data, are compiled onto 1:24,000 scale topographic base maps, and are available separately (MGS Open File Nos. 95-4 through 95-36). The maps can be used as a base for detailed hydrogeological siting studies and planning. Furthermore, they provide a variety of information on aquifer favorability and vulnerability, as well as a preliminary estimate of well yield in certain areas.

Purpose and Scope

The purpose of this report is to describe the physical characteristics of sand and gravel aquifers in the area covered by Sand and Gravel Aquifer Maps 33, 34, 35, and 36 in parts of Franklin, Oxford, and Somerset Counties, Maine. A secondary objective is to describe the water quality in the aquifers and to compare it with water quality in other areas of the State.

The scope of the investigation included:

(1) surficial geologic mapping to define the boundaries of the glacial deposits

(2) presentation of supplemental information about the glacial geology of the area

(3) seismic-refraction investigations to determine the depth to water, depth to bedrock, and bedrock-surface topography

(4) a well inventory to supplement existing data on the stratigraphy, depth to water, depth to bedrock, and well yields

(5) observation-well and test-boring drilling to determine aquifer stratigraphy, thickness, and grain size (used to estimate transmissivity)

(6) water-quality sampling and analysis to characterize the regional ground-water chemistry

(7) identification of potential sources of ground-water contamination, and

(8) location of municipal-well fields.

Previous Investigations

Reconnaissance surficial and bedrock geologic mapping conducted in the study area provided information on bedrock outcrops and the areal extent of sand and gravel deposits (Boone, 1981; Borns, 1986; Caldwell, 1974, 1975 a, b, c, d, e, f, g, h, i; Guidotti, 1977; Pankiwskyj, 1978 a, b, 1981). General geologic relations are presented on the bedrock and surficial geologic maps of Maine (Osberg and others, 1985; Thompson and Borns, 1985). The maps associated with this report update information from earlier aquifer mapping efforts (Tolman and Lanctot, 1981 a, b, c, d).

METHODS OF STUDY

Approach

The methodology of this investigation included:

(1) recompilation of existing hydrogeologic data from each 1:50,000-scale map onto 1:24,000-scale maps

(2) collection of information on existing domestic, municipal, and monitoring wells, boring logs, and test pits

(3) identification of potential ground-water contamination sites

(4) verification of the original sand and gravel aquifer map boundaries by re-mapping surficial deposits

(6) seismic-refraction surveys

(7) test borings and observation-well installation

(8) well development and water-quality sampling

(9) monthly water-level measurements

(10) compilation of all data on 1:24,000-scale maps.

Details concerning several of these steps are given below.

Identification of Potential Ground-Water Contamination Sites

Potential ground-water contamination sites located on or near significant aquifers are shown on the associated maps[1]. These sites were identified primarily from files of the MDEP Bureaus of Land and Water Quality, and Hazardous Materials and Solid Waste Control. The locations of State-owned salt and

[1] The use of industrial firm or local town names in this report and on the maps is for location purposes only, and does not impute responsibility for any present or potential effects on natural resources.

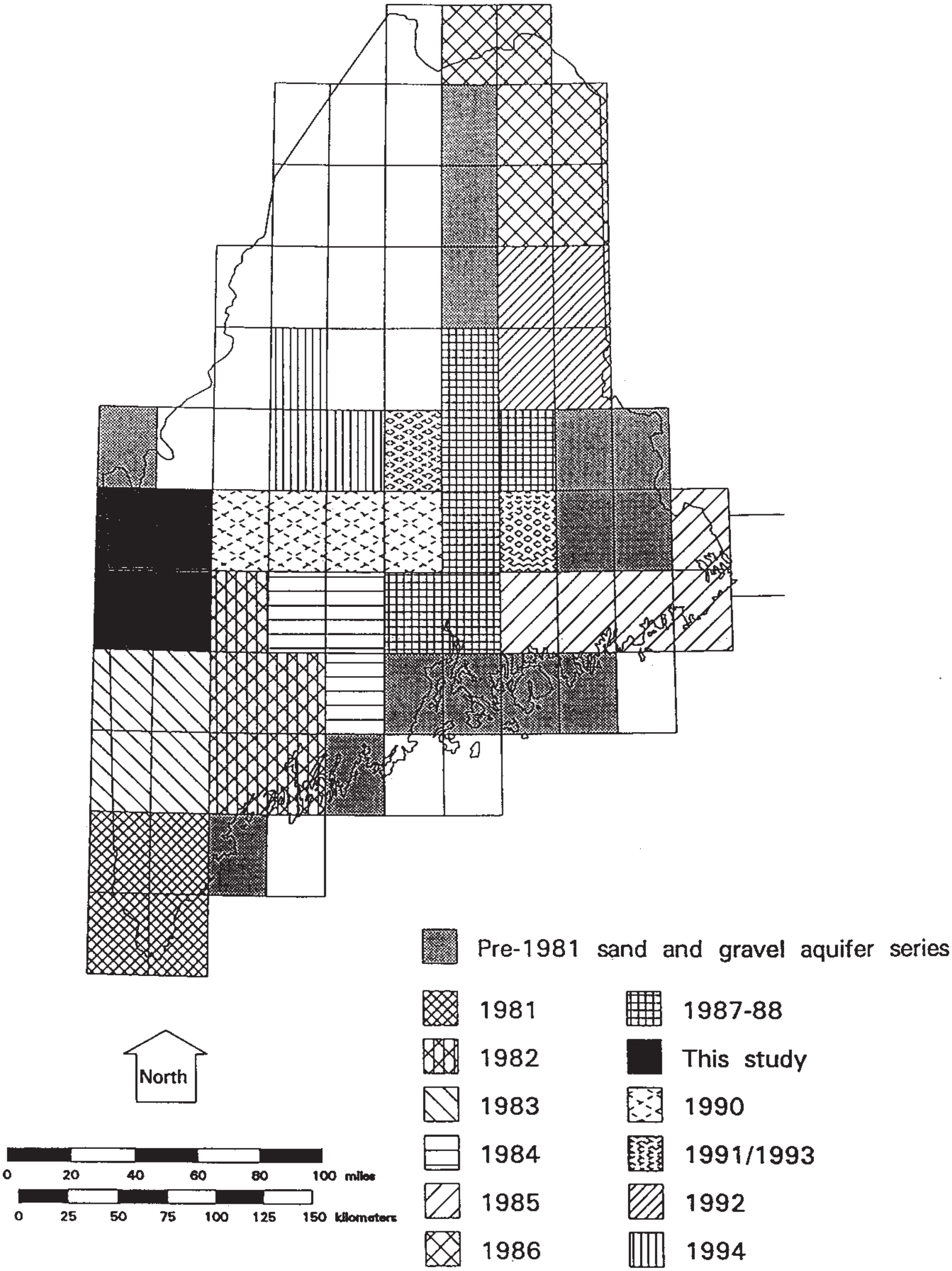


Figure 1. Location of study areas for the significant aquifers project.

salt-sand storage lots were determined from Maine Department of Transportation records.

The sites shown on the maps include waste-disposal areas and salt-sand storage piles. Sources of potential ground-water contamination not shown include septic systems, road de-icing activities, areas of fertilizer use, pesticides use, underground fuel storage tanks, small-quantity generators of hazardous wastes, and other agricultural, industrial, or commercial sites.

Surficial Mapping Techniques

The aquifers were mapped by field determination of boundaries between significant sand and gravel deposits and materials such as compact till or bedrock outcrops. All known borrow pits and other exposures of sand and gravel deposits were examined, with particular attention to the thickness and texture of the deposits and to any water in the pit. Shovel and auger holes were used to identify surficial materials in areas where exposures were lacking. Off-road areas were mapped by foot traverse and examination of aerial photographs.

Boundaries of the significant aquifers shown on the associated maps, were delineated on the basis of the known or inferred saturated thickness, and confirmed where possible by well, boring, or seismic data. In some cases, land-surface contacts between aquifers and surrounding materials were shifted slightly into the aquifers to indicate that the tapering margins of some aquifers are unlikely to yield 10 gal/min or more. The boundaries of the aquifer deposits are shown as dashed lines indicating the interpretive nature of the boundary delineation.

Seismic-Refraction Surveys

Seismic-refraction techniques, following field procedures described by Haeni (1988), were used to obtain profiles showing the depth to water table, depth to bedrock, and topography of the bedrock surface. In seismic exploration, seismic waves are generated at the surface by a small explosion or hammer blows. The waves travel at different velocities through different materials—the denser the material, the faster the wave velocity. In this study, seismic refraction was used to distinguish between dry sand and gravel, saturated sand and gravel, and bedrock. To permit these distinctions, the seismic velocity must increase with depth and there must be a significant velocity contrast between layers.

A twelve-channel, EG&G Geometrics Nimbus ES-1210F seismograph[2] was used to determine saturated thickness and bedrock surface topography in areas where the depth to bedrock was estimated to be more than 75 ft (feet). The seismic lines varied from 400 to 2,500 ft long. Elevations of the shot points and geophones were surveyed to determine their relative elevations. A computer program (Scott and others, 1972) was used to determine layer velocities and to generate a continuous profile of the water table and bedrock surface beneath each line. Wherever possible, data from any nearby private wells and project borings were used to verify seismic results. In total, fifty-two twelve-channel lines were run (37,343 ft). Forty-four of these lines (31,795 ft) provided reliable data for interpretation.

Single-channel Soiltest MD9A, MD11, or EG&G Geometrics ES 125 seismographs were used in areas where the depth to bedrock was estimated to be less than 75 ft. Information was obtained on depth to water table, depth to bedrock, and dip of the bedrock surface between the ends of each line. The single-channel seismic lines varied from 80 to 300 ft long. Data were analyzed and interpreted using a computer program created at MGS following methods developed by Mooney (1980) and Zohdy and others (1974). In total, 347 single-channel lines were run (56,310 ft), and 205 of these lines (37,650 ft) provided reliable data.

In several locations single-channel lines were run at sites where monitoring wells were subsequently installed or where twelve-channel seismic lines had previously been run. In most instances the single-channel interpretation closely matched the well log or twelve-channel profile, indicating that the single-channel procedure provides reliable data.

In the study area, the seismic velocity in unsaturated overburden materials ranges from 633 to 2,560 ft/s (feet per second), with an average velocity of 1,245 ft/s. Saturated overburden materials have velocities of 4,119 to 7,282 ft/s with an average velocity of 5,167 ft/s. Bedrock seismic velocities in the study area vary from 9,853 to 20,378 ft/s with an average velocity of 14,444 ft/s.

A summary of the information collected with the single-channel seismographs is presented in Appendix 1 (at end of report). Hydrogeologic sections from seismic-refraction surveys conducted with the twelve-channel seismograph are presented in Appendix 2 (at end of report). The locations of 205 single-channel and 44 twelve-channel seismic-refraction lines conducted throughout the study area are shown on the associated maps.

Drilling and Stratigraphic-Logging Methods

Twenty-four borings were made to determine the thickness of deposits, to collect sediment samples, and to verify depth to water table and bedrock as determined from seismic data. For the purpose of this report, the term "test boring" (TB) refers to a boring that was backfilled after test information was obtained. The term "observation well" (OW) refers to a boring where a monitoring well was installed. Borings are identified first by the appropriate TB or OW designation, followed by a number corresponding to the year in which it was drilled, and concluding with a sequential number in the order in which the borings were drilled. The observation wells were used to obtain water levels and water-quality samples during the period of investigation.

A 6-inch-diameter, hollow-stem auger rig was used for drilling. Overburden material penetrated above the water table was brought to the surface by the rotation of the augers. Where detailed stratigraphic information was needed below the water ta-

[2] Use of trade names in this report is for descriptive purposes only and does not constitute endorsement by the MGS or the USGS.

ble, a split-spoon sampler was used to collect undisturbed sediment samples ahead of the drill stem. Samples were collected according to guidelines established by the Federal Interagency Work Group (1977, Chap. 2). Twenty-one borings were drilled to refusal, which occurred when either bedrock, compact sediments, or sediments containing cobbles larger than 6-inches were encountered. Three borings were terminated before reaching refusal because the deposit was too deep or the material drilled was beyond the capabilities of the drill equipment. Stratigraphic logs and screened intervals of observation wells are presented in Appendix 3 (at end of report).

Observation-Well Installation and Development

Twenty-two borings were cased with 2-inch-diameter, schedule 40 PVC (polyvinyl chloride) pipe to allow collection of water samples and water level data. PVC screens with slot widths varying from 0.006 to 0.010 in. were used. Casing sections were connected either with couplings, fastened with 3/8-inch zinc-plated steel sheet metal screws, or, if flush threaded casing pipe was used, simply screwed together. The casing and screen were placed inside the hollow stem auger, and the boring was allowed to collapse around the casing as the drill stem was withdrawn. Bentonite pellets were backfilled from 1 ft below ground surface to the ground surface to prevent water from infiltrating directly around the casing.

At most sites, immediately after the casing was installed water was bailed from the observation well to aid well development. All observation wells were thoroughly developed 2 to 3 weeks after installation by surging and pumping with compressed air, using the well casing as an air-lift pump shaft, and removing at least 10 well volumes of water from each well. This procedure removed the fine materials from the screen and developed the hydraulic connection with the aquifer.

Procedures for Water-Quality Sampling and Analysis

Eighteen observation wells were sampled to determine water quality. To ensure that water samples were representative of the geochemical environment, the observation wells were pumped with an ISCO model 2600 bladder pump or Fultz model SP-202 positive displacement pump or bailed with a PVC bailer until the pH, temperature, and specific conductance measurements stabilized and at least three well volumes of water were removed. Field measurements of pH, alkalinity, dissolved oxygen, and specific conductance were made with portable meters (Leeds and Northrup model 7417 for pH and alkalinity, Fisher model 152 for specific conductance, YSI Model 54A for dissolved oxygen).

Unfiltered samples for nitrate, chloride, sulfate, and total organic carbon analyses were collected in plastic containers rinsed three times with sample water. Samples for dissolved metal analyses also were collected in rinsed plastic containers, but were filtered and then acidified with nitric acid. All samples were kept on ice and delivered to the USGS laboratory in Arvada, Colorado within 48 hours after collection.

Metals were analyzed by atomic-absorption spectrophotometry. Chloride was analyzed by the Argentometric Method (Standard Method 408A, American Public Health Association and others, 1976), nitrate-nitrite and sulfate by an automated Technicon method, and total organic carbon by a combustion-tube infrared technique (Standard Method 505, American Public Health Association and others, 1985).

SURFICIAL GEOLOGY

Glacial History

Maine was covered by continental glaciers several times during the Pleistocene Epoch, which occurred from approximately 2,000,000 to l0,000 years B.P. (before present). The last ice sheet, known as the Laurentide Ice Sheet, reached its maximum extent about 20,000 to 22,000 years B.P., in late Wisconsinan time. It flowed from Canada southeastward and eastward across Maine, beyond the present coastline, and into the Gulf of Maine.

After the peak of the late Wisconsinan glaciation, the margin of the Laurentide Ice Sheet began to retreat from its terminal position on the continental shelf. By about 14,000 years B.P., the ice margin was approximately at the present coast of Maine (Stuiver and Borns, 1975; Smith, 1985). The weight of the ice depressed the earth's crust enough to allow the sea to follow the retreating ice margin inland. The inland extent and elevation of the deposits laid down in the sea during this time mark what is known to geologists as the marine limit.

As deglaciation continued, glacial sediments were deposited, recording the style and pattern of glacial retreat in Maine. Glacial deltas in eastern Maine formed close to the inland marine limit elevation (Thompson and Borns, 1985), where the ice retreat became slow enough for large volumes of sediment to accumulate. At elevations below the marine limit, other glacial deposits are associated with an extensive silt and clay unit, the Presumpscot Formation (Bloom, 1960). Radiocarbon-age dates, determined largely from marine mollusks recovered from the Presumpscot Formation, bracket Maine's marine deglacial history to between 13,200 and 11,000 years B.P. (Stuiver and Borns, 1975; Smith, 1985). When the ice retreated beyond the reach of the sea, vast amounts of meltwater reworked the glacial sediment and laid down stream deposits and shoreline sediments over the Presumpscot Formation.

In the study area, which occurs well above the extent of the marine limit, the sand and gravel deposits consist primarily of glacial stream deposits laid down on or near the glacier, glacial lake deposits, and stream deposits laid down after the ice left the area (Thompson and Borns, 1985).

The mode of deglaciation in the study area has been a controversial topic. Recent workers (Borns and Calkin, 1977; Borns, 1985; Gerath and others, 1985; and Stone and Borns, 1986) suggest that regional stagnation and downwasting of the late Wisconsinan ice sheet occurred following thinning and separation of the ice mass along the Canada - U.S. international border (Boundary Mountains drainage divide). Others (Shilts, 1981; Caldwell and others 1985; Parent and Occhietti, 1988; Thompson and Fowler, 1989; Thompson, 1991) have argued for active-ice recession through the study area as well as directly north of it. The style of deglaciation determines the types of surficial deposits found in the area.

Glacial Deposits in the Study Area

As the glacier advanced, it eroded soil and rock debris and incorporated it into the ice. This material, when deposited directly from the ice as a discontinuous layer on the bedrock surface, is called "till". Till deposits in the State generally are not more than 10 ft thick. Till was deposited either at the base of the ice (lodgement or basal till) as the glacier advanced, or from melting ice (ablation till) as the glacier stagnated and retreated (Thompson, 1979). Till is a poorly sorted, usually nonstratified mixture of pebbles, cobbles, and boulders in a sandy silt or clayey silt matrix. It can be very compact to very loose, and usually is not a productive aquifer. Although till usually is a poor ground water producer, its hydraulic properties and areal extent affect the amount of natural recharge to the region. A poorly sorted, compact, clayey till with low permeability will not have as rapid an infiltration rate as a more well-sorted, less compact, sandy till. However, large amounts of runoff from upland till areas can recharge adjacent stratified-drift deposits (Morrissey and others, 1988; Randall and others, 1988).

In places, streamlined, till-covered hills are present in Maine. An example of streamlined hills is found on the Umbagog Lake South and B Pond (Figure 2) quadrangles, in the northeast and northwest corners of the quadrangles, respectively. (Open-File Nos. 95-36 and 95-5). The long axes of these hills trend northwest-southeast, parallel to the direction of flow of the last ice sheet that covered the region.

In places, linear ridges of sediment were deposited either in front of or beneath the ice at or near the terminus of the glacier. These ridges, termed moraines, are comprised predominantly of sand and gravel interbedded with till. Few moraines have been recognized in the study area; a discussion of these and others just beyond the limits of the study area can be found in Thompson and Fowler (1989).

As the ice margin retreated in Maine, meltwater streams transported and deposited large quantities of sand and gravel, mainly in the valleys. Coarse sediments transported by streams accumulated in channels within or beneath the ice, between the ice and adjacent valley walls, and in the sea at or near the glacier front. Typical "ice-contact" stratified-drift deposits include such features as eskers (long, sinuous ridges formed as tunnel fillings within the ice), crevasse fillings (ridges formed from sediments filling cracks on the ice surface), subaqueous fans (irregularly shaped hills formed by streams from ice tunnels entering a water body below the water surface), and deltas (flat-topped or irregularly shaped hills formed by streams entering a water body and building to the water surface). Sediments deposited by meltwater streams in valleys adjacent to or beyond the ice margin are termed fluvial outwash or outwash plain deposits, respectively, and commonly display pitted surfaces as a result of the burial and subsequent melting of blocks of ice.

The study area lies within the Kennebec River and Androscoggin River drainage basins. Prominent deposits representing glacial drainage systems are found on Figure 3. Figure 4 shows an example of an esker found in the northeast corner of the Black Nubble quadrangle (Open-File No. 95-6). Esker systems are comprised of segments of esker-fed deltas or fans, which were deposited at the ice marginal position at the time that the esker segment was forming (Clinch and Weddle, 1989; Ashley and others, 1991).

Deltas are formed where meltwater streams enter a body of water. If a delta forms at the ice margin it is termed an ice-contact delta. If a delta forms away from the ice margin it is termed an outwash delta. Well developed deltas with characteristic lobe-shaped form are not as common in the study area as they are in southwest and southeast Maine. Examples of deltas are the series of flat-topped landforms in Figure 5 (Quill Hill quadrangle, Open-File No. 95-24), and the ice-contact delta on the Kennebago quadrangle (Open-File No. 95-13) in Figure 6.

Associated with deltas are lake bottom deposits. The basin now occupied by Flagstaff Lake is the site of a glacial lake termed Glacial Lake Bigelow (Leavitt and Perkins, 1935; Borns and Calkin, 1977). Borings in this area (OW 89-10, -11, -12, -13) record as much as 100 feet of fine-grained glacial lake deposits (see Appendix 3).

Outwash deposits are primarily found in river valleys in the study area. Outwash deposits in the Parmachenee Lake, Lincoln Pond, and Kennebago quadrangles (Open-File Nos. 95-22, 95-15, and 95-13) in the Magalloway and Cupsuptic River valleys are aquifers in that area. Figure 7 shows an outwash plain in the Lincoln Pond quadrangle (Open-File No. 95-15). Some of these deposits are thin and directly overlie bedrock, so are not shown as significant aquifers.

Post-glacial sediments are also found in the study area. Wetland deposits, swamps and bogs, are typically underlain by till or fine-grained stratified deposits. Many of the wetlands are characterized by peat deposits. Though saturated, wetland deposits are not aquifers because of their low permeability. However, wetlands are often found adjacent to esker systems and may be hydrogeologically connected to the system.

Eolian deposits of fine-grained sand and silt occur in the study area, generally as a cap not more than a few feet thick over other glacial deposits. These wind-blown deposits are not permeable enough to be significant aquifers; however, they may overlie more coarse-grained, water-bearing strata.

Recent alluvial deposits, generally consisting of interbedded sand, gravel, silt, and cobble gravel, occupy much of the flood plain of the major rivers in the study area. Alluvial deposits of late glacial and early post-glacial age may be difficult to

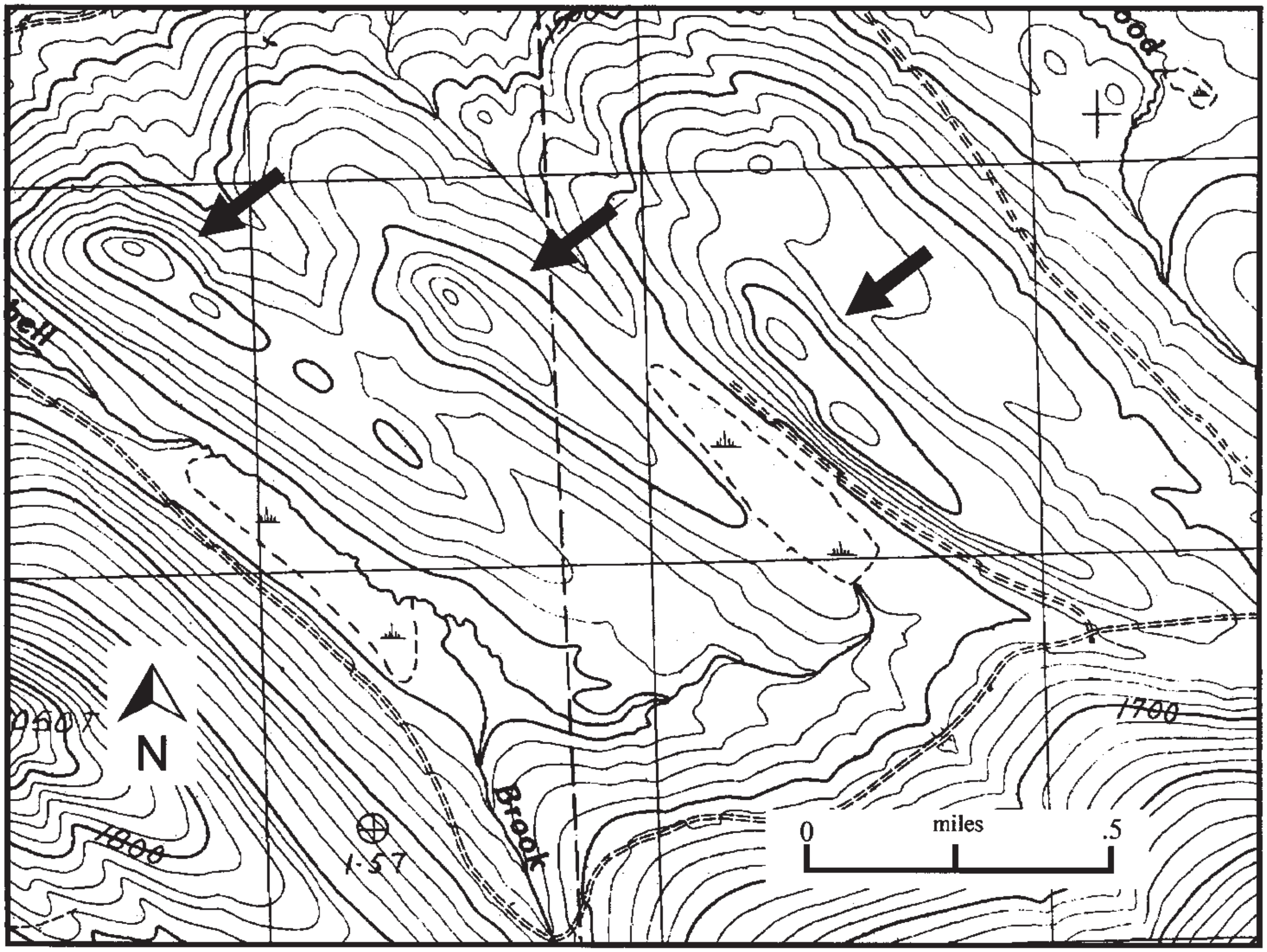


Figure 2. Example of streamlined hills, B Pond quadrangle.

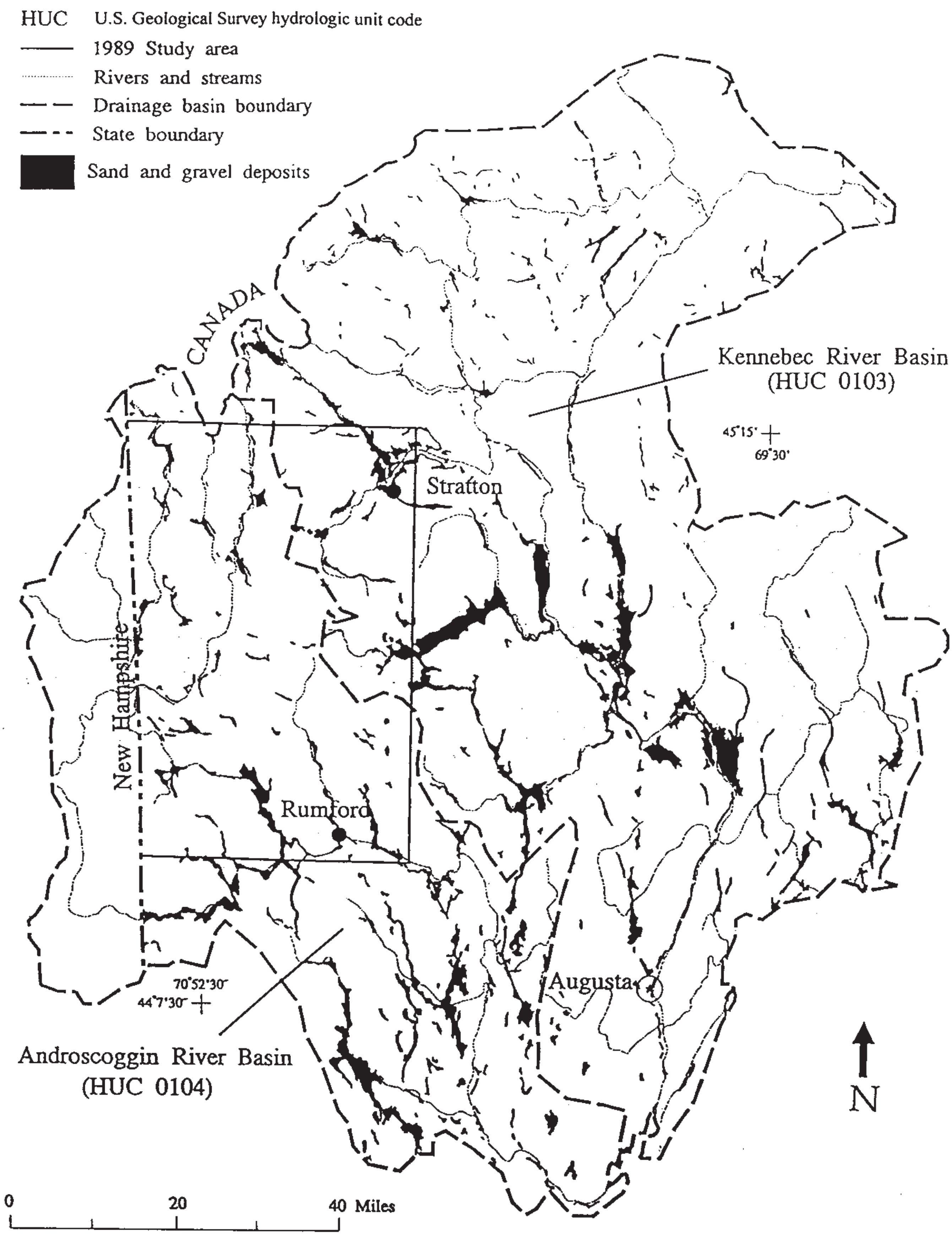


Figure 3. Glacial sand and gravel deposits of the Kennebec and Androscoggin River basins (modified from Borns and others, 1985).

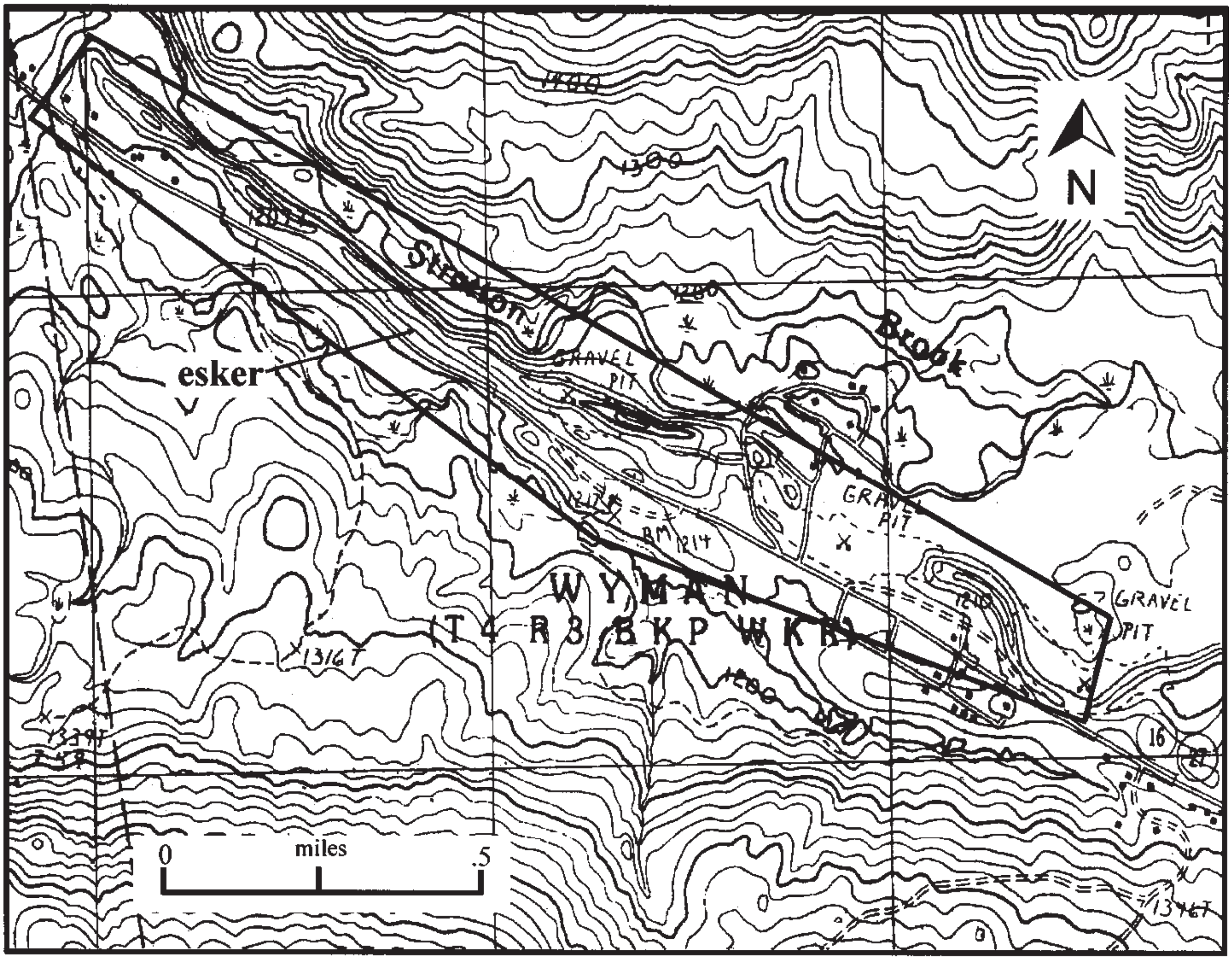


Figure 4. Example of an esker, Black Nubble quadrangle.

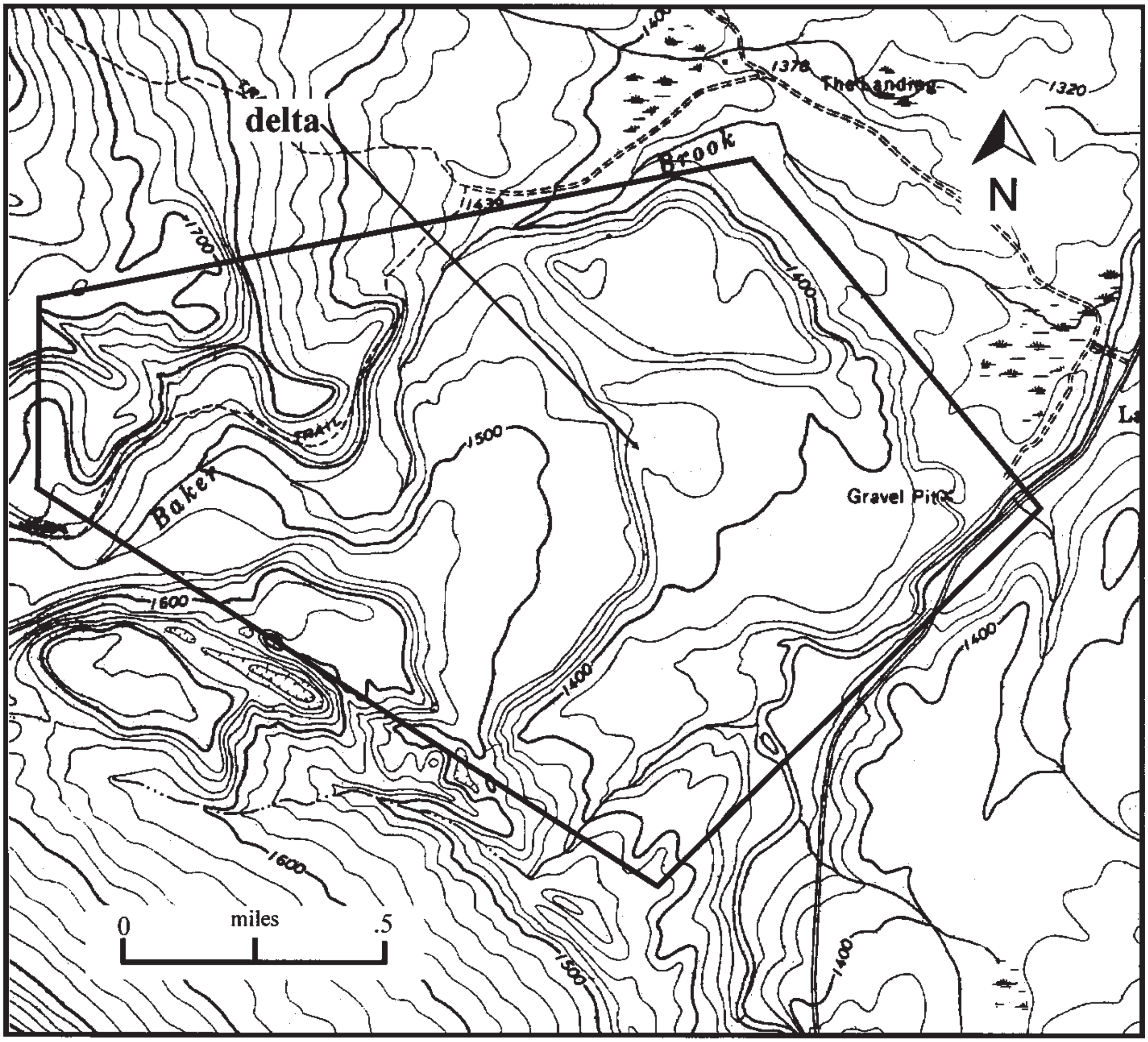


Figure 5. Example of a delta, Quill Hill quadrangle.

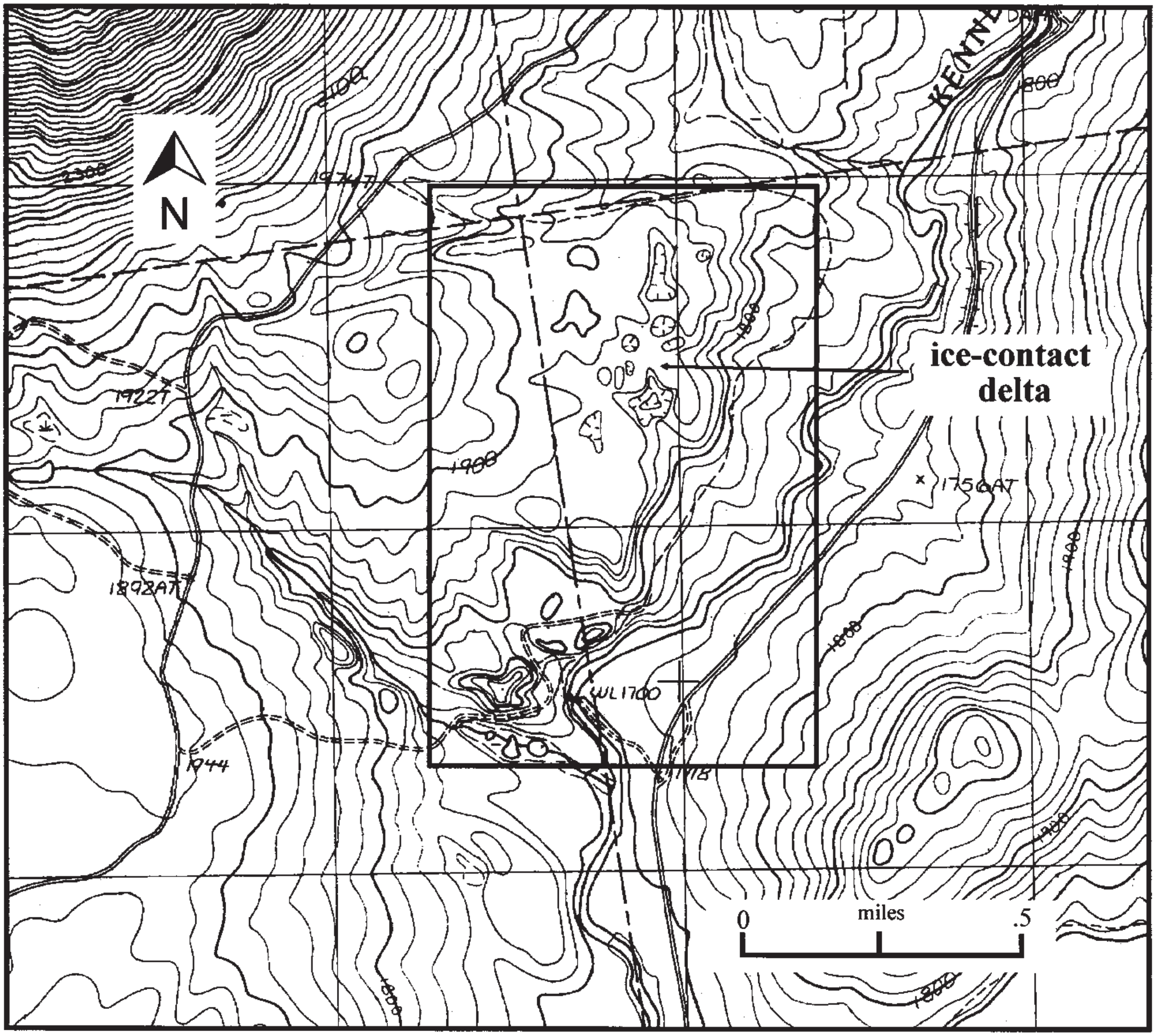


Figure 6. Example of an ice-contact delta, Kennebago quadrangle.

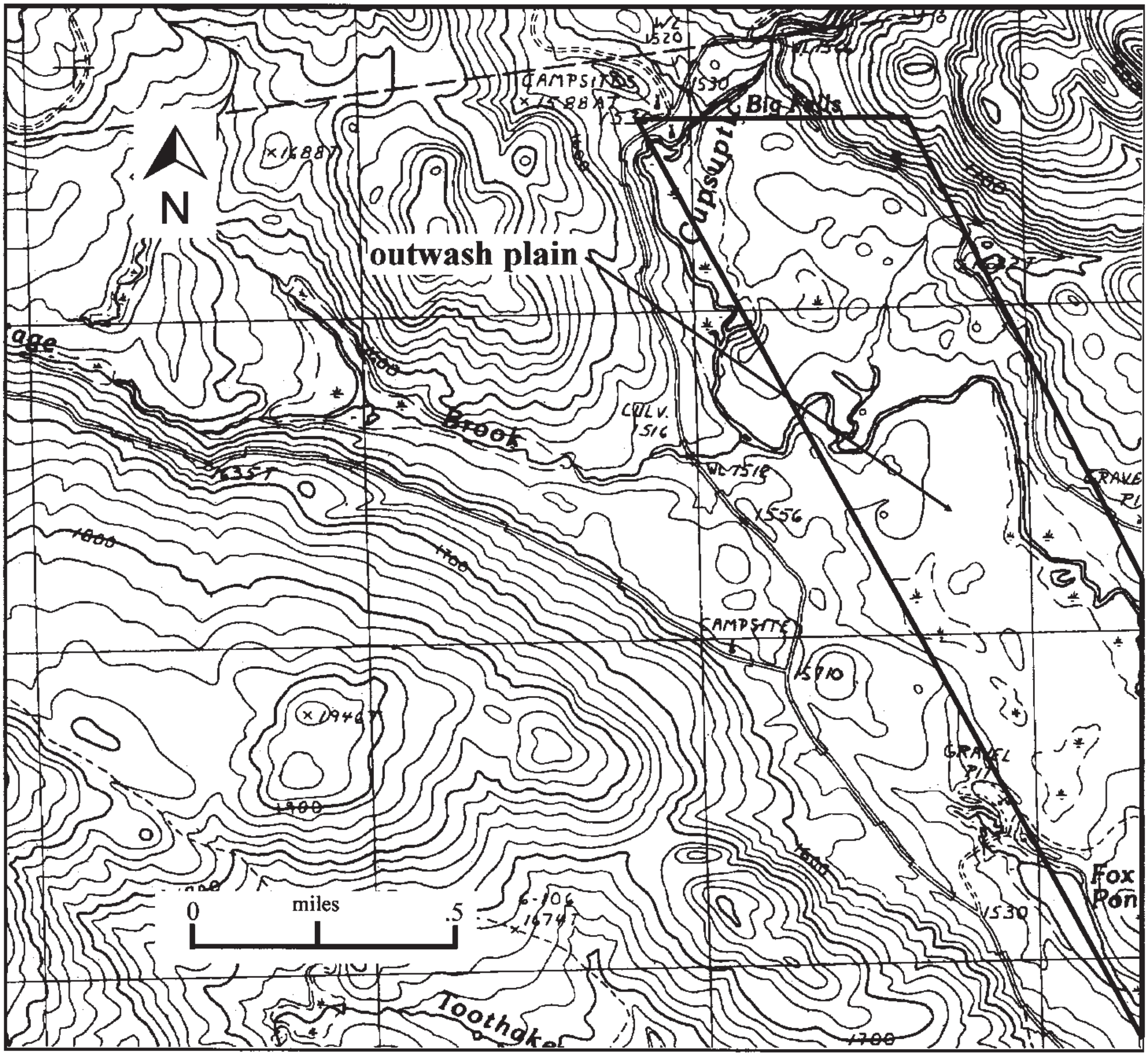


Figure 7. Example of an outwash plain, Lincoln Pond quadrangle.

differentiate from glacial outwash, however, post-glacial alluvium is generally deposited at lower elevations than outwash.

Stratigraphy of Glacial Deposits

Figure 8 is a schematic diagram that shows the generalized regional stratigraphic relations of glacial deposits in Maine. In general, the surficial stratigraphy in the study area is best represented by the left and central parts of the schematic figure. Not all of the units shown on this figure will necessarily be found in any one place.

Figure 8 indicates the relative positions of the deposits. Bedrock is overlain by till, which is overlain in places by clay, silt, sand and gravel in the form of ice-contact stratified drift, glacial outwash and glacial-lake sediments. The youngest surficial deposit, a thin veneer of sand and gravel overlying the glacial deposits, may represent late outwash deposits or alluvium.

HYDROLOGY OF THE SIGNIFICANT SAND AND GRAVEL AQUIFERS

The significant sand and gravel aquifers in the study area consist of coarse-grained glaciolacustrine, ice-contact, ice-stagnation, and glaciofluvial-outwash deposits, and Holocene stream alluvium. The largest yields available are from wells in coarse-grained ice-contact stratified-drift or alluvial deposits near surface-water bodies that may serve as sources of induced recharge.

The most productive and highly-developed aquifer is located in ice-contact and outwash deposits in Rumford (Rumford quadrangle). Several wells in this aquifer report yields of greater than 300 gal/min. The largest reported single well yield, 670 gal/min, is from a gravel-packed industrial well in Coplin Plantation in an esker system along Stratton Brook (Black Nubble quadrangle).

Significant sand and gravel aquifers are shown on the associated maps as areas with moderate to good potential water yield (greater than 10 gal/min to a properly constructed well), and areas with good to excellent potential water yield (greater than 50 gal/min to a properly constructed well). Areas with moderate to low or no potential water yield (generally less than 10 gal/min to a properly constructed well) are shown as surficial deposits with less favorable aquifer characteristics. These less favorable areas include regions underlain by surficial deposits such as till, alluvium, peat, and thin glacial sand and gravel deposits. Bedrock wells shown on these maps record only the depth to bedrock in the well. Aquifer boundaries and estimated yield zones shown on the associated maps are based on available information and are subject to modification as additional data become available.

Major surface-water drainage-basin boundaries are also identified on the maps. In general, ground-water divides coincide with surface-water divides. The general direction of ground-water flow is away from surface-water divides and toward surface-water bodies.

Hydraulic Properties

Hydraulic Conductivity

Hydraulic conductivity is a measure of the rate at which water will flow through aquifer materials. It is dependent on a variety of physical factors, including porosity, particle size and distribution, shape of particles, and arrangement of particles (Todd, 1980). Hydraulic conductivity is usually the most important hydraulic property of sediments for assessing ground-water flow and well yield (Caswell, 1987).

Hydraulic conductivity is best measured directly in the field on an undisturbed section of aquifer. When field measurements are impractical, the hydraulic conductivity of the aquifer material can be estimated in the laboratory. For this study, the median particle diameter (in millimeters) and the degree of sorting of representative sediment samples were determined by grain-size analyses. These analyses were performed at the USGS laboratory in Harrisburg, Pennsylvania, using a dry sieve method (Folk, 1974). The results of these analyses, converted to phi units, were used to estimate hydraulic conductivity, using nomographs published by Masch and Denny (1966) that relate median grain size and degree of sorting to hydraulic conductivity (Table 1). A typical range of hydraulic conductivities suggested by Freeze and Cherry (1979), expressed in ft/d (feet per day), is 0.0000001 to 0.01 for till, 0.001 to 10 for silt, 0.1 to 100 for silty sand, and 1 to 1,000 for clean sand. The hydraulic conductivities estimated for selected aquifer materials sampled in this study have much less variation, from 5 ft/d to 33 ft/d (Table 1).

Transmissivity

Transmissivity is a measure of the rate at which water or another liquid is transmitted through an aquifer or confining bed. It is a function of properties of the liquid and the porous media, along with the thickness of the porous media (Fetter, 1988). The transmissivity is equal to the average hydraulic conductivity multiplied by the saturated thickness. Driscoll (1986) suggests that aquifers with transmissivities less than 130 ft^2/d (feet squared per day) can only supply enough water for domestic wells or other low-yield uses. Aquifers with transmissivities of 1,700 ft^2/d or greater are capable of transmitting adequate quantities of water for industrial, municipal, or irrigation purposes.

Approximate transmissivity values were calculated at 22 sites from the complete stratigraphic logs of observation wells. Sediment from each interval in the saturated part of the exploration boring (Appendix 3, at end of report) was assigned a hydraulic conductivity, based on sample descriptions, grain size, and sorting (Table 1). This hydraulic conductivity was multiplied by the interval thickness to obtain an interval transmissivity. The interval transmissivity values were then summed to give a total transmissivity for that part of the aquifer penetrated by the exploration boring. The transmissivities estimated by this method range from 32 to 1,684 ft^2/d and are presented in Table 2.

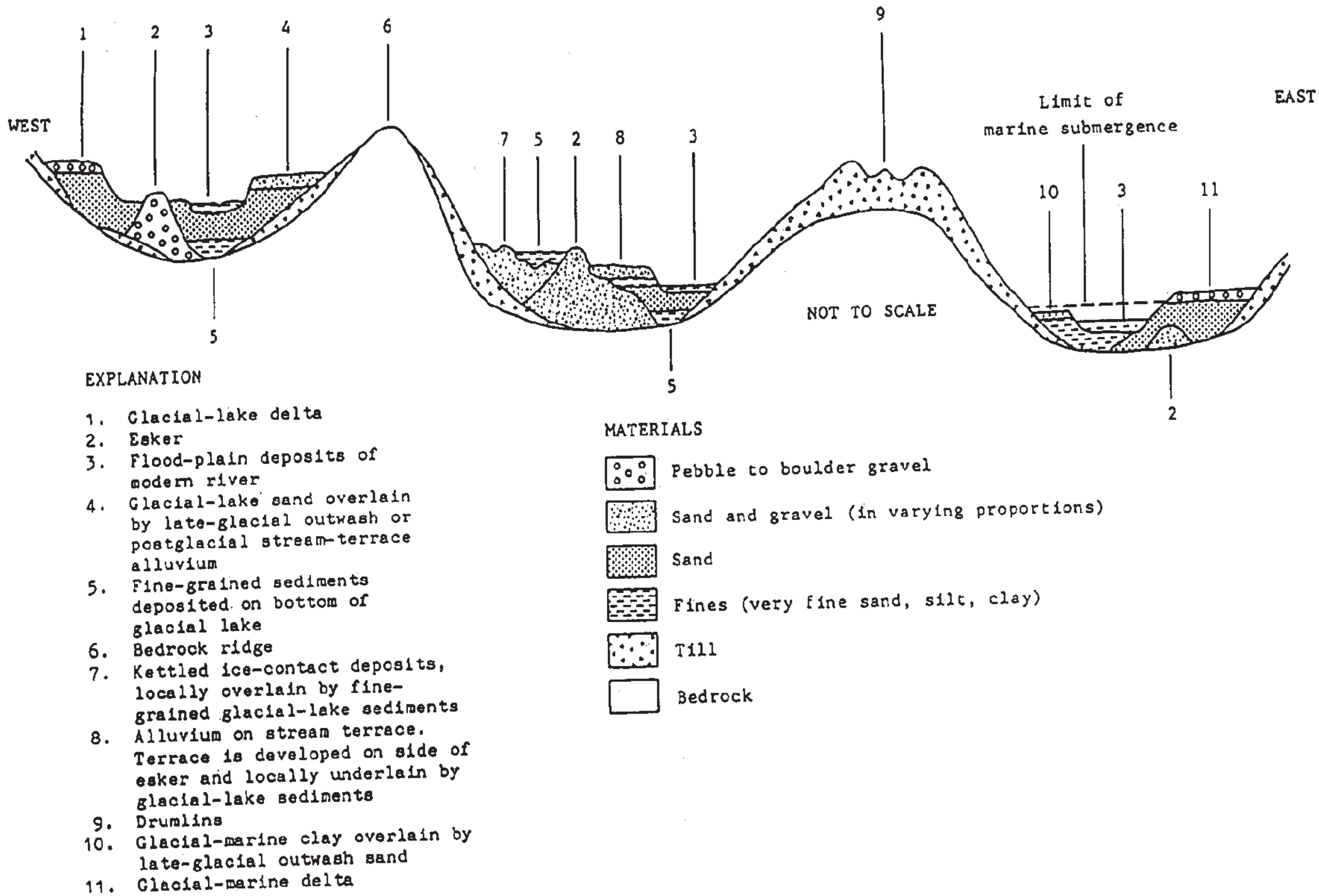


Figure 8. Generalized regional stratigraphic relation of glacial deposits.

Table 1.—Grain-size analysis, sorting, and estimated hydraulic conductivity of aquifer material.

Sample description	Observation well or test boring number	Depth of interval sampled (feet)	Median diameter (phi) [1]	Degree of sorting [2]	Estimated hydraulic conductivity (feet per day) [3]
Silt to very fine sand					
Silt to very fine sand	OW 89 - 21	47 - 49	—	—	10
Silt to very fine sand	OW 89 - 3	38 - 39	5.32	Poor	12
Silt to very fine sand	OW 89 - 6	23.1 - 24	4.10	Poor	24
Silt to very fine sand	OW 89 - 5	38.1 - 39	5.40	Poor	11
Silt to very fine sand	OW 89 - 9	87 - 89.5	4.40	Poor	17
Silt to very fine sand	OW 89 - 17	27.85 - 29	—	—	32
Silt to very fine sand	OW 89 - 10	38.3 - 39	5.00	Poor	12
Silt to very fine sand	OW 89 - 11	38 - 38.5	4.42	Poor	11
Very fine sand to silt					
Very fine sand to silt	TB 89 - 1	38 - 39	—	—	15
Very fine sand to silt	OW 89 - 14	12.8 - 14	—	—	12
Very fine sand to silt	OW 89 - 16	12.7 - 14	3.64	Poor	16
Very fine sand to silt	OW 89 - 13	27.8 - 28.2	3.22	Poor	24
Very fine sand to silt	TB 89 - 2	8.7 - 9	3.62	Poor	12
Very fine sand to silt	OW 89 - 8	12.6 - 13.4	3.40	Poor	17

[1] Phi is the negative log (base 2) of the particle diameter in millimeters
[2] Sorting classified by Inclusive Graphic Standard Deviation
greater than 1.0 - poor
0.75 - 1.00 - moderate
0.51 - 0.74 - moderately well
less than or equal to 0.50 - well
[3] Masch and Denny (1966)
— ; value not reported

Table 1.—Grain-size analysis, sorting, and estimated hydraulic conductivity of aquifer material (cont.).

Sample description	Observation well or test boring number	Depth of interval sampled (feet)	Median diameter (phi) [1]	Degree of sorting [2]	Estimated hydraulic conductivity (feet per day) [3]
Very fine; fine to very coarse sand					
Very fine to fine sand	OW 89 - 3	7.8 - 9	3.86	Poor	17
Very fine to fine sand	OW 89 - 7	37 - 38.2	3.27	Poor	24
Very fine to fine sand	OW 89 - 10	27.3 - 27.85	3.00	Poor	24
Fine to very fine sand	OW 89 - 10	28 - 29	2.85	Poor	30
Very fine to medium sand	OW 89 - 21	17 - 19	2.92	Poor	24
Very fine to medium sand	OW 89 - 22	47 - 49	2.32	Poor	21
Very fine to coarse sand	OW 89 - 4	13.5 - 13.9	2.25	Poor	33
Very fine to coarse sand	OW 89 - 5	48.15 - 48.4	2.08	Poor	24
Very fine to coarse sand	OW 89 - 16	37.75 - 37.9	3.12	Poor	12
Very fine to coarse sand	OW 89 - 18	43.45 - 44	1.90	Poor	33
Very fine to very coarse sand	OW 89 - 4	98 - 99	2.02	Poor	7
Very fine to very coarse sand	OW 89 - 7	107 - 107.8	-1.32	Poor	5
Very fine to very coarse sand	OW 89 - 5	28.1 - 28.4	0.84	Moderate	11
Very fine to very coarse sand	OW 89 - 16	28.85 - 29	1.80	Poor	11
Very fine; very coarse sand to granules					
Very fine to very coarse sand, granules	OW 89 - 1	68.9 - 69	1.36	Poor	30
Medium sand to pebbles	OW 89 - 2	22.8 - 24	-1.90	Poor	12
Medium sand to pebbles	TB 89 - 2	48.6 - 49	0.70	Moderately Well	10

1 Phi is the negative log (base 2) of the particle diameter in millimeters

2 Sorting classified by Inclusive Graphic Standard Deviation

greater than 1.0 - poor

0.75 - 1.00 - moderate

0.51 - 0.74 - moderately well

less than or equal to 0.50 - well

3 Masch and Denny (1966)

Table 2.—Estimated transmissivity values of aquifers based on stratigraphic logs of observation wells.

Aquifer quadrangle	Observation well number	Estimated transmissivity, in feet squared per day
East Andover	OW 89 - 1	705
Roxbury	OW 89 - 2	852
East Andover	OW 89 - 3	1123
East Andover	OW 89 - 4	1136
East Andover	OW 89 - 5	359
East Andover	OW 89 - 6	1128
East Andover	OW 89 - 7	1536
Weld	OW 89 - 8	484
Madrid	OW 89 - 9	1684
Stratton	OW 89 - 10	1356
Stratton	OW 89 - 11	1013
Stratton	OW 89 - 12	>800
Stratton	OW 89 - 13	1072
Quill Hill	OW 89 - 14	228
Kennebago	OW 89 - 15	458
Richardson Pond	OW 89 - 16	250
Redington	OW 89 - 17	32
Rumford	OW 89 - 18	1295
Quill Hill	OW 89 - 19	>615
Quill Hill	OW 89 - 20	>200
Kennebago	OW 89 - 21	373
Parmachenee Lake	OW 89 - 22	1084

Estimated Well Yields

Significant sand and gravel aquifers consist of deposits that have sufficient areal extent, hydraulic conductivity, and saturated thickness to sustain a yield of 10 gal/min or more to a properly installed well. Yields available from wells constructed in the aquifers were obtained from yields reported by well drillers, well owners, and previously published studies, and from estimates based on saturated thickness, transmissivity, and areal extent of the aquifers. Sustained yield values determined through aquifer tests were not within the scope of this study. Therefore, a method developed by Mazzaferro (1980) was used to estimate well yields in a water-table aquifer. This method is based on transmissivity (T), in ft^2/d, and saturated thickness (B), in ft, where $(T \times B)/750 =$ well yield in gallons per minute. Yields calculated for observation wells range from <1 to 193 gal/min (Table 3). Areas where wells are estimated to yield more than 10 gal/min and more than 50 gal/min are shown in separate shading patterns on the maps. Areas where wells may yield less than 10 gal/min constitute the remaining unshaded portion of the map.

Although the total study area covers 1717 mi^2 (square miles), areas mapped as significant sand and gravel aquifers include only about 74.7 mi^2 (4.4 percent) of this area. Yields exceeding 50 gal/min are estimated to be obtainable in only 6.9 mi^2 (less than 1.0 percent) of the study area.

The greatest yields are obtainable in areas where the deposits are coarse grained, have a thick saturated zone, or are hydraulically connected to an adjacent body of surface water that is a source of induced recharge. The largest reported well yield in the sand and gravel deposits is 670 gal/min from a gravel-packed well in Coplin Plantation (Black Nubble quadrangle). Other large well yields in the area include municipal wells in Rumford, 500 gal/min, (East Andover quadrangle), and 300 gal/min (Rumford quadrangle), and in Stratton, 125 gal/min (Stratton quadrangle).

Depths to the Water Table and Bedrock Surface

Depths to the water table and bedrock surface in the significant sand and gravel aquifers were determined from seismic-refraction surveys, water-level measurements, well inventory, test drilling, mapping of bedrock outcrops, and previous investigations. In the significant sand and gravel aquifers, the depth to the water table differs considerably areally, but typically is within 15 ft of the land surface. The greatest depth to bedrock determined by seismic-refraction is approximately 297 ft, along seismic line ETA -13, (East Andover quadrangle). Well records indicate that bedrock is at a depth of 191 feet in a domestic well drilled in Andover (East Andover quadrangle).

Determinations of depths to the water table and bedrock surface are necessary to provide a three-dimensional picture of aquifer geometry. Saturated thickness at selected points can be determined by subtracting the depth to water table from the depth to bedrock. Depth to bedrock data and bedrock surface profiles can be used to estimate the amount of casing required in overburden for bedrock well construction and to locate buried valleys, which may contain water-bearing sediments.

The computer program used to interpret single-channel seismic data provides a depth to water table and bedrock at the ends of the line only. Therefore, on the associated maps and in Appendix 1 depths are shown at each end of the line. Twelve-channel seismic interpretation generates a profile of the subsurface with depths at twelve locations along the line. The most reliable segment of the profile is the center where the most data went into the interpretation. Therefore, the depths to water table and bedrock are reported only for the center of twelve-channel seismic lines.

Water-Level Fluctuations

Monthly water-level measurements at 22 observation wells in the study area are shown in Table 4. Water-level measurements were made once a month from November 1989 to November 1990. Water levels over a 12-month period in all observation wells fluctuated within a range of approximately 1 to 6 ft (Table 5). The mean depth to the water table in the 22 wells ranged from 1.40 to 46.11 ft below land surface over a 12-month period. In the majority of the wells the water table is less than 15 ft from the surface. This thin unsaturated zone renders the ground water vulnerable to potential contamination originating at the land surface.

Hydrographs from selected observation wells are shown in Figure 9. Combined average monthly precipitation data from National Oceanic and Atmospheric Administration Stations at Eustis, Middle Dam, Rangeley, and Rumford are presented for comparison. Regional recharge generally occurs in the late fall and early spring months, when the ground is not frozen and there is little plant growth to intercept precipitation as it infiltrates the aquifer. Most water levels decline slowly but steadily between these recharge events.

GROUND-WATER QUALITY

Factors Influencing Water Quality

The chemical quality of water in sand and gravel aquifers is determined by a number of factors. The primary control is the mineralogy of the sand and gravel. Most sand and gravel in the study area is derived from granitic rocks and medium to high grade metamorphic rocks (slates, quartzites, gneisses, and schists). The metamorphic grade of the bedrock from which stratified drift is derived has a strong influence on the chemical quality of water from that aquifer (Weddle and Loiselle, in press). Chemical reactions that occur as water passes through the soil zone can also affect ground-water chemistry. Where the flow path of water from the recharge zone to the discharge zone is long, more time is available for the dissolution of soluble material in the aquifer (Hem, 1985). Residence time also depends on hydraulic conductivity, hydraulic gradient, and the porosity of the unconsolidated deposits. For a given flow path, the higher the hydraulic conduc-

Table 3.—Estimated well yields for observation wells.

Aquifer quadrangle	Observation well number	Estimated well yield (gallons per minute)[1]
East Andover	OW 89 - 1	44
Roxbury	OW 89 - 2	81
East Andover	OW 89 - 3	126
East Andover	OW 89 - 4	150
East Andover	OW 89 - 5	11
East Andover	OW 89 - 6	71
East Andover	OW 89 - 7	174
Weld	OW 89 - 8	19
Madrid	OW 89 - 9	193
Stratton	OW 89 - 1	181
Stratton	OW 89 - 1	134
Stratton	OW 89 - 12	>85
Stratton	OW 89 - 13	106
Quill Hill	OW 89 - 14	>6
Kennebago	OW 89 - 15	>11
Richardson Pond	OW 89 - 16	7
Redington	OW 89 - 17	<1
Rumford	OW 89 - 18	69
Quill Hill	OW 89 - 19	>22
Quill Hill	OW 89 - 20	>8
Kennebago	OW 89 - 21	9
Parmachenee Lake	OW 89 - 22	74

[1] Yields calculated from the methodology of Mazzaferro (1980), where yield (gallons per minute) = transmissivity (T) x saturated thickness (B) / 750.

Table 4.—Water-level data for observation wells in the study area, November 1989 through November 1990.
[Depth to water in feet below land surface; —, no water level measured during this period]

Observation Well Number	Town	Nov. 29 - 30	Dec. 28 - 29	Jan. 29 - 30	Feb. 27 - 28	Mar. 27 - 28	May 1 - 2	Jun. 11	Jul. 11 - 13	Aug. 7 - 8	Sep. 4 - 5	Oct. 1 - 2	Nov. 5 - 6
OW 89-1	Rumford	16.30	17.43	16.35	15.97	14.15	14.86	—	16.21	16.25	16.57	16.52	14.59
OW 89-2	Byron	2.80	3.51	2.46	2.19	1.80	2.22	—	2.97	2.51	3.27	2.84	2.11
OW 89-3	Rumford	8.53	9.78	10.86	8.89	3.30	6.32	—	8.19	9.24	8.97	9.62	7.29
OW 89-4	Andover	3.68	5.19	7.02	3.15	2.70	3.35	—	5.01	5.17	5.73	5.47	2.94
OW 89-5	Andover	23.15	23.78	23.91	24.23	23.15	19.61	—	22.44	23.35	23.49	23.77	23.56
OW 89-6	Rumford	4.19	4.93	3.68	2.83	1.55	2.83	—	4.88	5.21	5.04	5.36	2.17
OW 89-7	Andover	9.48	8.98	—	10.95	7.90	6.08	—	7.44	9.64	8.80	9.68	8.36
OW 89-8	Carthage	1.25	2.27	1.15	0.82	—	0.30	—	1.78	2.34	1.96	1.85	0.26
OW 89-9	Phillips	5.65	6.72	6.23	5.66	3.35	3.09	—	5.07	6.12	6.37	6.80	3.81
OW 89-10	Eustis	14.54	15.27	14.85	15.66	15.00	13.69	12.95	13.16	13.38	13.62	13.87	13.42
OW 89-11	Eustis	11.08	11.69	11.24	11.90	11.00	9.38	9.10	9.47	9.83	10.11	10.39	9.34
OW 89-12	Eustis	6.47	7.34	6.88	7.28	6.35	5.24	5.08	5.45	5.87	6.04	6.11	5.02
OW 89-13	Eustis	4.50	6.26	6.01	5.78	3.10	3.24	1.10	2.92	3.86	4.89	4.93	2.88
OW 89-14	Coplin Plt.	3.32	3.99	2.92	2.91	2.05	1.99	1.83[1]	2.74[1]	4.19[1]	4.27[1]	4.67[1]	2.18[1]
OW 89-15	Lower Cupsuptic Twp.	16.36	16.15	15.90	15.32	13.88	11.50	15.50	16.75	17.10	17.27	16.44	15.17
OW 89-16	Magalloway Plt.	12.58	—	12.64	12.43	11.86	11.52	11.70	11.80	12.01	12.15	12.10	11.43
OW 89-17	Madrid	12.38	13.61	13.12	12.97	12.05	10.28	—	11.78	12.74	12.87	12.99	10.52
OW 89-18	Roxbury	8.85	9.87	8.65	7.93	6.65	7.24	—	9.30	9.81	9.17	9.80	6.93
OW 89-19	Lang Twp.	27.79	28.44	27.73	28.35	27.05	25.93	25.75	26.08	25.56	26.98	27.22	26.43
OW 89-20	Lang Twp.	26.24	27.15	26.78	26.86	25.43	23.72	24.45	—	25.15	24.62	25.41	23.52
OW 89-21	Stetsontown Twp.	3.99	—	4.94	4.64	2.98	1.29	1.65	2.82	3.67	3.73	4.55	1.24
OW 89-22	Parmachenee Twp.	46.41	47.36	48.26	46.38	—	—	44.70	45.23	45.66	45.85	46.17	45.05

[1] These readings collected by an automatic datalogger installed by U.S.G.S.

Table 5.—Statistical analysis of water-level data for observation wells in the study area, November 1989 through November 1990.

Well Number	Town	Number of Measurements	Mean depth to water (in feet below land surface)	Standard Deviation	Maximum depth to water (in feet below land surface)	Minimum depth to water (in feet below land surface)	Range of values (feet)
OW 89-1	Rumford	11	15.93	0.98	17.43	14.15	3.28
OW 89-2	Byron	11	2.61	0.52	3.51	1.80	1.71
OW 89-3	Rumford	11	8.27	2.05	10.86	3.30	7.56
OW 89-4	Andover	11	4.49	1.39	7.02	2.70	4.32
OW 89-5	Andover	11	23.13	1.26	24.23	19.61	4.62
OW 89-6	Rumford	11	3.88	1.35	5.36	1.55	3.81
OW 89-7	Andover	10	8.73	1.37	10.95	6.08	4.87
OW 89-8	Carthage	10	1.40	0.76	2.27	0.26	2.01
OW 89-9	Phillips	11	5.35	1.35	6.80	3.09	3.71
OW 89-10	Eustis	12	14.12	0.90	15.66	12.95	2.71
OW 89-11	Eustis	12	10.38	0.98	11.90	9.10	2.80
OW 89-12	Eustis	12	6.09	0.81	7.34	5.02	2.32
OW 89-13	Eustis	12	4.12	1.55	6.26	1.10	5.16
OW 89-14	Coplin Plt.	12	3.09	0.99	4.67	1.83	2.84
OW 89-15	Lower Cupsuptic Twp.	12	15.61	1.60	17.27	11.50	5.77
OW 89-16	Magalloway Plt.	11	12.02	0.41	12.64	11.43	1.21
OW 89-17	Madrid	11	12.30	1.07	13.61	10.28	3.33
OW 89-18	Roxbury	11	8.56	1.19	9.87	6.65	3.22
OW 89-19	Lang Twp.	12	27.03	0.91	28.44	25.75	2.69
OW 89-20	Lang Twp.	11	25.39	1.25	27.15	23.52	3.63
OW 89-21	Stetsontown Twp.	11	3.23	1.35	4.94	1.24	3.70
OW 89-22	Parmachenee Twp.	10	46.11	1.08	48.26	44.70	3.56

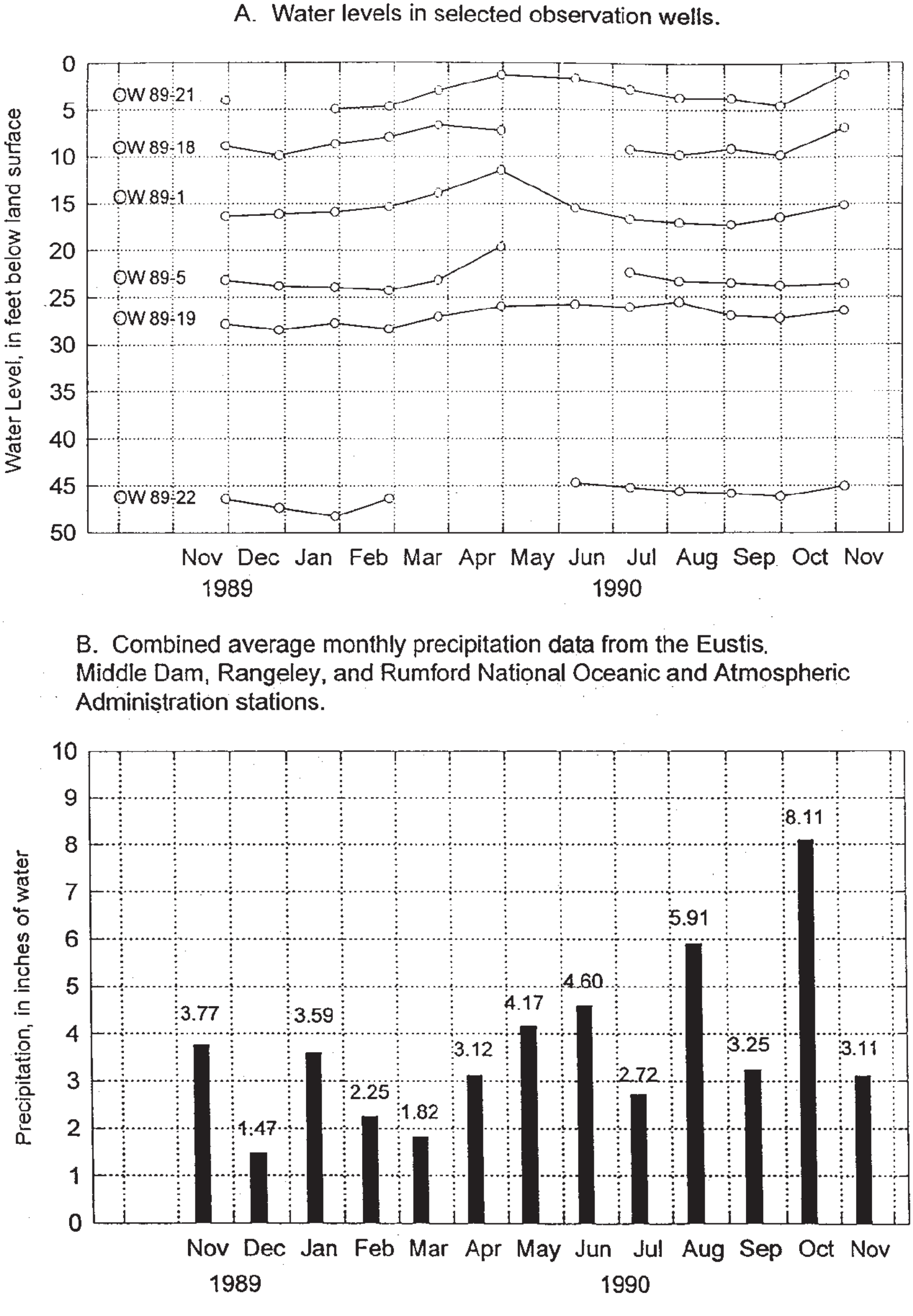


Figure 9. Ground-water levels in selected observation wells and average monthly precipitation, November 1989 through November 1990.

tivity, hydraulic gradient, and porosity of the deposit, the shorter the residence time of the ground water.

Contamination by human activities may introduce elevated concentrations of many compounds into ground water. Activities that may significantly alter the quality of ground water include the following:

(1) Landfill disposal of household and industrial wastes, which may include petroleum derivatives and other hazardous material

(2) Road salt application and storage. An investigation conducted in the Province of New Brunswick, Canada, indicated that as much as 57 percent of the salt in an uncovered salt-sand storage pile may leach in a year (Environment New Brunswick, 1978)

(3) Human wastes introduced into ground water through septic tanks, disposal of septic wastes, or by spreading or landfilling of sludge from municipal sewage treatment systems. Studies indicate the density of housing using individual septic disposal systems to be a controlling factor in the likelihood of nitrate contamination of ground water (Wehrmann,1983, Pinette and others, in prep).

(4) Agricultural activities, which include stockpiling and spreading of manure, applying commercial fertilizers, and spraying pesticides. From 1985 to 1988, the Maine Geological Survey collected samples from 47 overburden wells within agricultural areas underlain by sand and gravel; eight of these wells had detectable concentrations of pesticides. Furthermore, seven of these wells had nitrate concentrations exceeding the State drinking water standard of 10 mg/L (milligrams per liter) (Neil and others, 1989). More than 100 wells in Aroostook County contaminated by aldicarb (Temik), an agricultural chemical used extensively for potato farming, have also been documented (unpublished data, Rhone-Poulenc Agricultural Products Company)

(5) Leaking waste-storage or disposal lagoons

(6) Leaking fuel- or chemical-storage tanks. The MDEP Bureau of Hazardous Materials and Solid Waste Control has documented concentrations of gasoline as high as 600,000 parts per billion in a well installed in a sand and gravel aquifer (Garrett and others, 1986). Underground petroleum tank leaks were documented at 158 locations in Maine from 1979-83. In total, 76 wells were found to be contaminated, most commonly by gasoline that leaked from buried tanks and connecting pipes at retail and nonretail commercial establishments (Caswell, 1987)

(7) Toxic or hazardous materials spills along transportation routes

(8) Contaminants in precipitation. In the northeastern United States "acid rain" has been reported to cause a lowering of pH and subsequent increase in aluminum and trace metal concentrations in ground water in New Hampshire and New York (Bridge and Fairchild, 1981). Continued research has failed to conclusively document this finding (Steve Kahl, University of Maine, personal communication, April 26, 1990).

A USGS study (Goolsby and others,1991) has documented quantifiable levels of several herbicides in rainwater samples from a 23 state area mostly in the midwest and northeast.

Common indicators of ground-water contamination are elevated levels of nitrate, a contaminant derived from sewage, animal waste, fertilizer, and landfill waste; chloride, a contaminant introduced by road salt, saltwater intrusion, fertilizer, and landfill wastes; and specific conductance, which indicates the presence of dissolved ionic compounds.

Background Water Quality

The six major drainage basins in Maine, as mapped by the U.S. Geological Survey (1974), are the St. John/Aroostook River, the Penobscot River, the Kennebec River, the Androscoggin River, Eastern and Central Coastal Maine, and the Saco River. The Eastern and Central Coastal basins are a number of medium to small drainage basins that discharge directly into the Gulf of Maine. These six major drainage basins with their corresponding Hydrologic Unit Code (HUC) number are shown in Figure 10. Also shown on Figure 10 is an outline of the study area and the location of all sand and gravel observation wells from this and previous study areas.

The wells installed for this study are within the drainage basins of the Kennebec and Androscoggin Rivers. Characteristics of these wells are given in Table 6. Water-quality analyses of samples from 18 of the 22 wells are provided in Table 7 and are summarized for the study area as a whole and by the individual drainage basins in which they lie. Table 8 presents the background water-quality data from the statewide Significant Sand and Gravel Aquifer Mapping Program to date grouped by drainage basin. Data for all properties are reported in standard metric units used for these analyses.

Comparison of water quality constituents or parameters between drainage basins are made using median concentrations rather than mean concentrations. Water quality values do not represent a normal distribution. Therefore, the median concentration for a constituent or parameter is a more representative indicator of the water quality in a drainage basin.

The study area contains headwaters of both the Kennebec and Androscoggin Rivers in the mountainous uplands of west-central Maine. Both basins are underlain by high grade metamorphic and intrusive rocks, and have been subjected to the same glacial action leaving behind similar surficial deposits.

This similarity in geologic setting between the Kennebec and Androscoggin basins within the field area is reflected in the ground-water chemistry. The mean, median and range of values for all parameters are very similar. Where significant differences in statistical values for a parameter do occur, for instance with iron, it can usually be attributed to an anomalous value from one well. Comparisons of water quality between drainage basins within the study area and between the various drainage basins around the state can be reviewed in Tables 7 and 8.

The wells installed for the Significant Sand and Gravel Aquifer Mapping Project were sited to minimize any influence by human-induced contamination. Variations in water quality are attributed to natural geologic and geochemical factors and to the in-

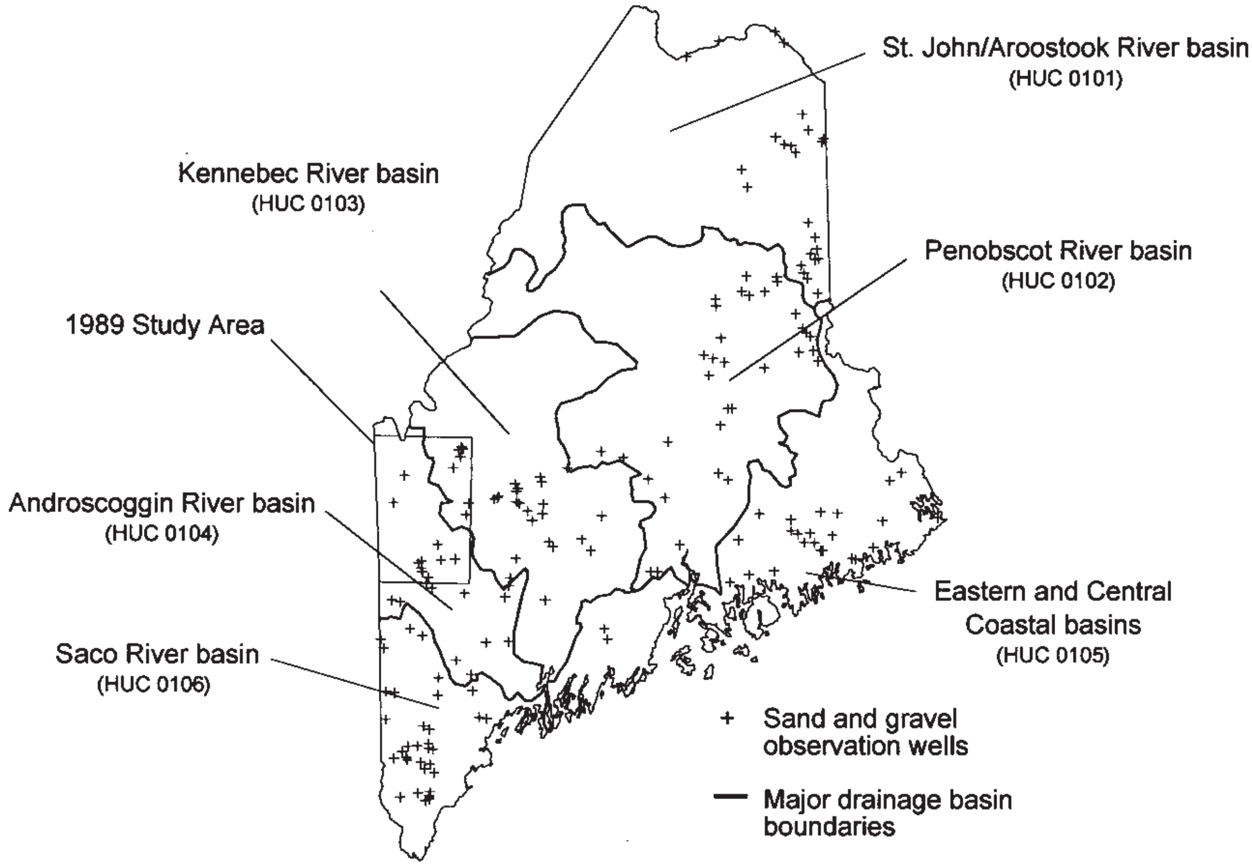


Figure 10. Major drainage basins, the study area, and sand and gravel observation wells.

Table 6.—Characteristics of observation wells in the study area.

Well Number	Town	Drainage Basin (HUC)	Latitude	Longitude	Altitude[1]	Depth[2]	Predominant Land Type Around Well
OW 89-1	Rumford	0104	44°31'47''N	70°40'08''W	620	67	Field
OW 89-2	Byron	0104	44°41'58''N	70°36'28''W	760	42	Field
OW 89-3	Rumford	0104	44°33'26''N	70°42'43''W	640	32	Sand Pit
OW 89-4	Andover	0104	44°34'31''N	70°43'16''W	625	12	Field
OW 89-5	Andover	0104	44°36'48''N	70°43'04''W	670	32	Field
OW 89-6	Rumford	0104	44°30'07''N	70°40'58''W	605	37	Field
OW 89-7	Andover	0104	44°36'11''N	70°44'32''W	665	47	Field
OW 89-8	Carthage	0104	44°37'37''N	70°28'36''W	460	31	Field
OW 89-9	Phillips	0103	44°51'17''N	70°24'18''W	710	27	Field
OW 89-10	Eustis	0103	45°12'02''N	70°36'28''W	1180	32	Forest
OW 89-11	Eustis	0103	45°11'25''N	70°26'18''W	1170	30	Forest
OW 89-12	Eustis	0103	45°11'08''N	70°28'03''W	1170	27	Forest
OW 89-13	Eustis	0103	45°09'00''N	70°27'16''W	1150	17	Forest
OW 89-14	Coplin Plt.	0103	45°05'39''N	70°30'13''W	1330	22	Forest
OW 89-15	Lower Cupsuptic Twp.	0104	45°02'55''N	70°51'52''W	1500	31	Field
OW 89-16	Magalloway Plt.	0104	44°54'34''N	70°55'57''W	1460	37	Forest
OW 89-17	Madrid	0103	44°54'51''N	70°23'21''W	1290	22	Forest
OW 89-18	Roxbury	0104	44°37'10''N	70°51'32''W	570	41	Field
OW 89-19[3]	Lang Twp.	0103	45°06'24''N	70°32'51''W	1370	42	Forest
OW 89-20[3]	Lang Twp.	0103	45°03'54''N	70°35'39''W	1430	40	Gravel Pit
OW 89-21[3]	Stetsontown Twp.	0104	45°07'16''N	70°45'19''W	1780	15	Forest
OW 89-22[3]	Parmachenee Twp.	0104	45°11'22''N	70°58'25''W	1680	58	Forest

[1] Altitude of observation well at land-surface datum, in feet.
[2] Depth of observation well in feet below land-surface datum.
[3] These wells were not sampled for water quality.

Table 7.—Background water quality in sand and gravel aquifers in the study area.
All values in milligrams per liter (mg/L) except as noted; uS/cm, microsiemens per centimeter at 25° Celsius;
—, value not determined.

OBSERVATION WELL NUMBER	HUC	DATE	SPECIFIC CONDUCTANCE (uS/cm)	pH (STANDARD UNITS)	TEMPERATURE WATER (DEG C)	OXYGEN DISSOLVED (mg/L)	HARDNESS TOTAL (mg/L AS $CaCO_3$)	CALCIUM DISSOLVED (mg/L AS Ca)	MAGNESIUM DISSOLVED (mg/L AS Mg)	SODIUM DISSOLVED (mg/L AS Na)
89-1	0104	10-26-89	111	7.8	8.0	7.0	44	12.0	3.4	2.7
89-2	0104	10-27-89	55	6.3	8.0	8.2	17	4.9	1.2	2.9
89-3	0104	10-27-89	191	7.3	8.0	11.2	77	16.0	8.9	4.3
89-4	0104	10-26-89	68	6.0	10.5	4.8	21	5.5	1.7	3.1
89-5	0104	10-27-89	100	6.6	8.5	14.6	27	7.0	2.2	4.6
89-6	0104	10-26-89	64	7.0	8.5	9.5	21	5.9	1.4	3.2
89-7	0104	10-27-89	34	6.3	7.0	15.0	11	3.1	0.8	1.5
89-8	0104	11-01-89	145	7.6	8.0	9.2	18	5.8	0.9	2.0
89-9	0103	10-30-89	54	6.2	7.5	11.7	45	13.0	3.1	13.0
89-10	0103	10-31-89	55	8.6	7.0	13.3	24	7.1	1.4	1.2
89-11	0103	10-31-89	64	8.2	7.0	11.8	26	7.9	1.6	1.4
89-12	0103	11-01-89	137	7.7	6.0	9.8	50	13.0	4.3	3.1
89-13	0103	10-31-89	103	6.7	9.5	12.0	34	8.5	3.1	4.3
89-14	0103	11-03-89	90	7.0	9.0	11.2	29	6.2	3.2	6.3
89-15	0104	11-01-89	47	6.3	6.0	11.8	18	4.9	1.5	2.0
89-16	0104	11-01-89	60	6.6	8.0	9.6	8	2.2	0.5	8.8
89-17	0103	10-30-89	59	6.6	8.5	11.5	19	5.4	1.4	3.3
89-18	0104	10-30-89	88	5.9	8.0	9.5	13	3.7	0.9	11.0
		MINIMUM	34	5.9	6.0	4.8	8	2.2	0.5	1.2
		MAXIMUM	191	8.6	10.5	15.0	77	16.0	8.9	13.0
		MEDIAN	66	6.6	8.0	11.2	23	6.1	1.6	3.2
		MEAN	85	—	7.9	10.7	28	7.3	2.3	4.4
		STD. DEVIATION	41	—	1.1	2.5	17	3.8	2.0	3.4

HUC 0104

NUMBER	11	11	11	11	11	11	11	11
MINIMUM	34	5.9	6.0	4.8	8	2.2	0.5	1.5
MAXIMUM	191	7.8	10.5	15.0	77	16.0	8.9	11.0
MEDIAN	68	6.6	8.0	9.5	18	5.5	1.4	3.1
MEAN	88	—	8.0	10.0	25	6.5	2.1	4.2
STD. DEVIATION	47	—	1.1	3.0	20	4.1	2.4	3.0

HUC 0104

NUMBER	7	7	7	7	7	7	7	7
MINIMUM	54	6.2	6.0	9.8	19	5.4	1.4	1.2
MAXIMUM	137	8.6	9.5	13.3	50	13.0	4.3	13.0
MEDIAN	64	7.0	7.5	11.7	29	7.9	3.1	3.3
MEAN	80	—	7.8	11.6	32	8.7	2.6	4.7
STD. DEVIATION	31	—	1.3	1.0	11	3.1	1.1	4.1

Table 7.—Background water quality in sand and gravel aquifers in the study area.
All values in milligrams per liter (mg/L) except as noted; uS/cm, microsiemens per centimeter at 25^{o} Celsius;
—, value not determined.

OBSERVATION WELL NUMBER	POTASSIUM DISSOLVED (mg/L AS K)	CARBONATE WATER DIS IT FIELD (mg/L AS $CACO_3$)	BICARBONATE WATER DIS IT FIELD (mg/L AS HCO_3)	ALKALINITY WAT WH TOT FET FIELD (mg/L AS $CaCO_3$)	ALKALINITY WAT DIS TOT IT FIELD (mg/L AS $CaCO_3$)	SULFATE DISSOLVED (mg/L AS SO_4)	CHLORIDE DISSOLVED (mg/L AS Cl)	FLUORIDE DISSOLVED (mg/L AS F)	SILICA DISSOLVED (mg/L AS SiO_2)
89-1	3.1	0	44	37	36	14.0	0.6	0.1	13.0
89-2	1.1	0	17	16	14	8.0	0.8	0.1	15.0
89-3	2.9	0	64	53	52	11.0	16.0	0.1	15.0
89-4	0.5	0	27	23	22	4.0	5.6	0.1	17.0
89-5	7.1	0	41	34	34	4.0	5.0	0.1	7.7
89-6	2.3	0	23	23	19	9.0	0.9	0.1	18.0
89-7	1.0	0	9	8	8	7.0	0.5	<0.1	9.2
89-8	1.1	0	86	71	70	7.0	1.4	<0.1	12.0
89-9	2.4	0	20	17	16	3.0	0.9	0.1	15.0
89-10	1.5	0	33	28	27	<1.0	0.2	<0.1	9.5
89-11	1.8	0	38	34	31	<1.0	0.3	<0.1	12.0
89-12	1.8	0	64	55	52	5.0	6.7	<0.1	15.0
89-13	1.9	0	38	33	31	5.0	9.1	<0.1	9.3
89-14	1.6	0	43	39	35	6.0	6.6	0.2	12.0
89-15	0.4	0	18	16	15	5.0	0.3	0.1	11.0
89-16	0.9	0	20	18	16	8.0	1.0	0.1	13.0
89-17	1.4	0	19	17	16	10.0	0.6	<0.1	16.0
89-18	1.4	0	15	13	13	10.0	7.8	<0.1	10.0
MINIMUM	0.4	0	9	8	8	<1.0	0.2	<0.1	7.7
MAXIMUM	7.1	0	86	71	70	14.0	16.0	0.2	18.0
MEDIAN	1.6	0	30	26	25	7.0	1.0	0.1	12.5
MEAN	1.9	0	34	30	28	7.0	3.6	0.1	12.8
STD.DEVIATION	1.5	0	20	17	16	4.0	4.3	0.0	3.0

HUC 0104

NUMBER	11	11	11	11	11	11	11	11	11
MINIMUM	0.4	0	9	8	8	4.0	0.3	<0.1	7.7
MAXIMUM	7.1	0	86	71	70	14.0	16.0	0.1	18.0
MEDIAN	1.1	0	23	23	19	8.0	1.0	0.1	13.0
MEAN	2.0	0	33	28	27	7.9	3.6	0.1	12.8
STD. DEVIATION	2.0	0	24	19	19	3.0	4.8	0.0	3.2

HUC 0103

NUMBER	7	7	7	7	7	7	7	7	7
MINIMUM	1.4	0	19	17	16	<1.0	0.2	<0.1	9.3
MAXIMUM	2.4	0	64	55	52	10.0	9.1	0.2	16.0
MEDIAN	1.8	0	38	33	31	5.0	0.9	0.1	12.0
MEAN	1.8	0	36	32	30	4.3	3.5	0.1	12.7
STD. DEVIATION	.3	0	15	13	12	3.3	3.8	0.1	2.7

Table 7.—Background water quality in sand and gravel aquifers in the study area.
All values in milligrams per liter (mg/L) except as noted; uS/cm, microsiemens per centimeter at 25^{o} Celsius;
—, value not determined.

OBSERVATION WELL NUMBER	SOLIDS, RESIDUE AT 180^{0}C DISSOLVED (MG/L)	SOLIDS, SUM OF CONSTITUENTS DISSOLVED (MG/L)	NITROGEN, $NO_2 + NO_3$ TOTAL (MG/L AS N)	PHOSPHOROUS TOTAL (MG/L AS P)	IRON, TOTAL RECOVERABLE (MG/L AS FE)	IRON DISSOLVED (MG/L AS FE)	MANGANESE TOTAL RECOVERABLE (MG/L AS MN)	MANGANESE DISSOLVED (MG/L AS MN)	CARBON, ORGANIC TOTAL (MG/L AS C)
89-1	49	72	0.1	0.06	1.20	0.030	0.120	0.130	1.2
89-2	35	43	0.2	0.80	49.00	0.006	3.100	0.100	2.2
89-3	94	108	<0.1	0.12	1.60	0.120	1.200	1.200	1.2
89-4	36	51	<0.1	0.51	12.00	3.200	0.400	0.330	8.5
89-5	45	57	0.4	6.20	74.00	0.012	1.400	0.049	3.5
89-6	29	53	0.1	1.00	31.00	0.160	0.600	0.280	1.5
89-7	28	37	<0.1	0.06	0.53	0.016	0.070	0.055	1.5
89-8	31	40	0.1	0.82	18.00	0.006	0.950	0.320	1.9
89-9	71	93	<0.1	1.10	26.00	0.033	0.640	0.270	5.3
89-10	24	38	<0.1	0.58	18.00	0.014	0.390	0.011	—
89-11	21	46	<0.1	0.94	24.00	0.018	0.660	0.210	2.1
89-12	62	81	0.4	0.06	1.70	0.012	0.050	0.012	1.1
89-13	50	62	0.2	1.40	56.00	1.000	2.900	2.100	7.5
89-14	59	83	0.1	17.00	470.00	0.590	8.500	0.200	7.0
89-15	21	35	0.2	1.00	51.00	0.110	0.990	0.130	2.1
89-16	28	45	0.2	0.59	17.00	0.051	0.340	0.040	1.4
89-17	34	48	0.3	0.05	1.20	0.007	0.190	0.160	1.8
89-18	44	53	0.7	0.13	<0.01	0.008	0.030	0.022	1.4
MINIMUM	21	35	<0.1	0.05	<0.01	0.006	0.030	0.011	1.1
MAXIMUM	94	108	0.7	17.00	470.00	3.200	8.500	2.100	8.5
MEDIAN	36	52	0.1	0.70	18.00	0.024	0.620	0.145	1.9
MEAN	42	58	0.2	1.80	48.20	0.325	1.254	0.312	3.0
STD. DEVIATION	19	21	0.2	4.04	107.50	0.767	2.014	0.521	2.5

HUC 0104

NUMBER	11	11	11	11	11	11	11	11	11
MINIMUM	21	35	<0.1	0.06	<0.01	0.006	0.030	0.022	1.2
MAXIMUM	94	108	0.7	6.20	74.00	3.200	3.100	1.200	8.5
MEDIAN	35	51	0.1	0.59	17.00	0.030	0.600	0.130	1.5
MEAN	40	54	0.2	1.03	23.20	0.380	0.841	0.241	2.4
STD. DEVIATION	20	21	0.2	1.76	25.00	0.947	0.882	0.338	2.1

HUC 0103

NUMBER	7	7	7	7	7	7	7	7	6
MINIMUM	21	38	<0.1	0.05	1.20	0.007	0.050	0.011	1.1
MAXIMUM	71	93	0.4	17.00	470.00	1.000	8.500	2.100	7.5
MEDIAN	50	62	0.1	0.94	24.00	0.018	0.640	0.200	3.7
MEAN	46	64	0.2	3.02	87.46	0.239	1.904	0.423	4.1
STD. DEVIATION	20	21	0.1	6.19	169.49	0.398	3.064	0.746	2.8

Table 8.—Background water quality in sand and gravel aquifers in previous and ongoing study areas, by drainage basin.
(All values in milligrams per liter except as noted)

HUC 0101: St. John / Aroostook River Basin

	Conductivity (microsiemens / cm)	pH	Temperature (°C)	Hardness as $CaCO_3$	Calcium dissolved	Magnesium dissolved	Sodium dissolved	Potassium dissolved	Alkalinity as $CaCO_3$	Sulfate dissolved	Chloride dissolved	Nitrate + Nitrite as N	Iron dissolved	Manganese dissolved	Total Organic Carbon
Number	25	25	25	25	25	25	25	25	21	25	25	15	25	25	25
Minimum	110	5.8	6.0	38.0	10.0	1.30	1.4	0.4	41	5.0	<0.5	0.02	0.004	0.003	0.4
Maximum	530	8.1	13.5	260.0	85.0	18.00	29.0	3.2	202	54.0	20.0	5.30	42.000	3.100	62.0
Median	250	7.2	7.5	120.0	42.0	3.60	3.9	1.0	112	12.0	5.6	1.50	0.050	0.170	3.4
Mean	273	NC	8.2	137.6	46.8	5.13	5.7	1.1	123	17.5	7.1	1.95	2.194	0.504	8.1
Standard Deviation	98	NC	1.9	60.5	20.0	3.96	5.7	0.7	49	13.5	5.5	2.00	8.363	0.800	14.0

HUC 0102: Penobscot River Basin

	Conductivity (microsiemens / cm)	pH	Temperature (°C)	Hardness as $CaCO_3$	Calcium dissolved	Magnesium dissolved	Sodium dissolved	Potassium dissolved	Alkalinity as $CaCO_3$	Sulfate dissolved	Chloride dissolved	Nitrate + Nitrite as N	Iron dissolved	Manganese dissolved	Total Organic Carbon
Number	34	35	35	35	35	35	35	35	34	35	35	22	35	35	33
Minimum	25	6.1	6.0	10.0	2.8	0.07	1.4	0.3	11	<0.1	0.4	<0.10	0.007	<0.001	0.5
Maximum	310	9.2	16.5	150.0	44.0	10.00	32.0	3.0	150	27.0	67.0	7.30	13.000	9.800	6.1
Median	134	7.1	7.5	56.0	18.0	2.30	2.6	0.8	56	6.2	1.7	0.10	0.060	0.059	1.6
Mean	147	NC	8.0	61.9	19.8	2.95	4.6	1.0	64	7.2	5.2	0.54	1.301	0.829	1.9
Standard Deviation	74	NC	2.1	35.2	11.4	2.13	5.3	0.6	35	4.8	11.5	1.54	3.104	1.847	1.4

Table 8.—Background water quality in sand and gravel aquifers in previous and ongoing study areas, by drainage basin. (All values in milligrams per liter except as noted)

HUC 0103: Kennebec River Basin

	Conductivity (microsiemens / cm)	pH	Temperature (°C)	Hardness as $CaCO_3$	Calcium dissolved	Magnesium dissolved	Sodium dissolved	Potassium dissolved	Alkalinity as $CaCO_3$	Sulfate dissolved	Chloride dissolved	Nitrate + Nitrite as N	Iron dissolved	Manganese dissolved	Total Organic Carbon
Number	26	26	26	26	26	26	26	26	26	26	26	25	26	26	24
Minimum	28	6.0	7.4	8.3	2.2	0.60	1.3	0.5	5	<3.0	0.4	<0.01	<0.020	<0.005	<1.0
Maximum	347	8.8	12.1	158.0	45.0	14.00	15.0	3.2	150	49.0	24.0	5.00	3.700	1.400	5.0
Median	110	7.3	8.5	43.0	13.5	2.80	3.4	2.1	43	6.6	3.0	0.10	0.052	0.130	1.0
Mean	138	NC	8.8	57.4	16.4	3.95	4.6	1.9	47	9.7	6.1	0.61	0.449	0.231	1.6
Standard Deviation	83	NC	1.2	39.7	10.8	3.51	3.2	0.8	35	11.6	6.5	1.16	0.877	0.292	1.3

HUC 0104: Androscoggin River Basin

	Conductivity (microsiemens / cm)	pH	Temperature (°C)	Hardness as $CaCO_3$	Calcium dissolved	Magnesium dissolved	Sodium dissolved	Potassium dissolved	Alkalinity as $CaCO_3$	Sulfate dissolved	Chloride dissolved	Nitrate + Nitrite as N	Iron dissolved	Manganese dissolved	Total Organic Carbon
Number	11	11	11	11	11	11	11	11	11	11	11	11	11	10	9
Minimum	52	5.6	7.0	13.0	4.0	0.80	1.9	0.5	4	<3.0	<0.5	<0.01	<0.030	<0.005	<1.0
Maximum	131	8.5	9.5	53.3	17.0	3.20	9.2	4.5	52	10.0	7.4	0.80	0.150	0.490	30.0
Median	98	6.6	9.0	34.0	11.0	1.60	5.8	1.5	17	6.0	4.5	0.14	0.070	0.057	2.0
Mean	90	NC	8.8	33.6	10.5	1.76	5.4	2.0	20	5.9	3.6	0.26	0.073	0.136	6.7
Standard Deviation	28	NC	0.7	15.4	5.4	0.74	2.2	1.3	13	3.3	2.7	0.27	0.043	0.164	10.5

Table 8.—Background water quality in sand and gravel aquifers in previous and ongoing study areas, by drainage basin.
(All values in milligrams per liter except as noted)

HUC 0105: Eastern and Central Coastal Basins

	Conductivity (microsiemens / cm)	pH	Temperature (°C)	Hardness as $CaCO_3$	Calcium dissolved	Magnesium dissolved	Sodium dissolved	Potassium dissolved	Alkalinity as $CaCO_3$	Sulfate dissolved	Chloride dissolved	Nitrate + Nitrite as N	Iron dissolved	Manganese dissolved	Total Organic Carbon
Number	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
Minimum	25	5.7	7.0	1.0	0.2	0.08	2.2	0.3	5	<5.0	0.5	<0.01	<0.030	0.005	<1.0
Maximum	460	8.5	12.0	200.0	63.0	11.00	39.0	4.4	450	28.0	63.0	0.51	4.700	0.820	83.0
Median	46	6.7	9.2	13.5	3.8	0.96	4.6	1.0	15	2.5	2.0	0.07	0.070	0.034	0.5
Mean	83	NC	9.7	26.8	8.0	1.68	7.5	1.3	39	4.8	4.9	0.13	0.420	0.111	9.2
Standard Deviation	90	NC	1.5	38.6	12.3	2.09	7.9	1.0	83	5.1	11.7	0.14	0.927	0.196	20.7

HUC 0106: Saco River Basin

	Conductivity (microsiemens / cm)	pH	Temperature (°C)	Hardness as $CaCO_3$	Calcium dissolved	Magnesium dissolved	Sodium dissolved	Potassium dissolved	Alkalinity as $CaCO_3$	Sulfate dissolved	Chloride dissolved	Nitrate + Nitrite as N	Iron dissolved	Manganese dissolved	Total Organic Carbon
Number	36	35	36	36	36	36	36	36	35	35	35	35	36	36	13
Minimum	17	5.3	6.5	3.9	1.2	0.21	1.4	0.4	3	<3.0	<0.5	<0.01	<0.030	<0.005	<1.0
Maximum	214	7.3	15.0	92.0	29.0	4.80	52.0	4.8	82	18.0	42.0	8.00	10.000	1.500	17.0
Median	58	6.3	8.5	20.5	5.3	1.10	4.8	1.4	13	5.0	3.0	0.05	0.115	0.135	2.0
Mean	70	NC	8.9	25.7	6.7	1.51	7.0	1.7	18	6.5	5.6	0.52	0.850	0.294	5.0
Standard Deviation	42	NC	1.8	19.0	5.2	1.11	8.5	1.1	16	4.5	7.6	1.46	2.173	0.381	5.5

fluence of agricultural practices on ground water. Volatile organic compounds were analyzed in earlier project field seasons (1981-84), but they were not analyzed for the 1985-1992 seasons because previously collected samples did not yield positive results.

Graphic summaries of selected water-quality properties and constituents are presented as box plots in Figures 11 and 12. The summaries are based on analyses of water samples collected from all study areas of the statewide Significant Sand and Gravel Aquifer Mapping Program. Percentiles of some of the constituents are compared to the U.S. Environmental Protection Agency (USEPA) (1986) and Maine Department of Human Services (MDHS) drinking-water standards (1983) in Figure 12. The maximum contaminant levels (MCL) are health-related and are legally enforceable. The secondary maximum contaminant levels (SMCL) apply to aesthetic qualities and are recommended guidelines. The minimum reporting level shown on Figure 12 is the value presently in use at the USGS laboratory in Arvada, Colorado. That value has changed with time and with the particular laboratory used for the analyses. Data points on Figure 12 shown below the minimum reporting level are from earlier study areas when the minimum reporting level was lower or from a laboratory that claimed a lower reporting level.

Specific Conductance

The specific conductance (conductivity) of water is a measure of its capacity to conduct an electrical current. The presence of charged ions makes water conductive; as the ion concentration increases, so does the specific conductance. Dissolved inorganic salts are the source of most ionic species and make up a large part of the total dissolved solids in most natural waters.

Although there is no drinking-water standard for specific conductance, the U.S. Department of Health, Education and Welfare (1962) has recommended a maximum concentration of 500 mg/L for dissolved solids in drinking water. The concentration of dissolved solids, in milligrams per liter, can be estimated by multiplying the specific conductance value, in S/cm (microsiemens per centimeter at 25 degrees Celsius), by a factor dependent on water chemistry, usually from 0.55 to 0.75 (Hem, 1985).

Specific conductance of the water-quality samples from the study area range from 34 to 191 S/cm, with a median of 66 S/cm (Table 7, Figure 11). Converting to dissolved solids (using the high-end factor of 0.75 for a worst-case estimate), a range of 26 to 143 mg/L and median of 50 mg/L is estimated for dissolved-solids concentration. The estimated dissolved-solid concentrations in the study area are therefore below the recommended maximum concentration of 500 mg/L.

pH

The pH of water is a measure of hydrogen-ion activity (concentration). Each unit increase in the pH scale represents a tenfold decrease in hydrogen-ion activity. A pH of 7 is considered neutral, less than 7 is acidic, and greater than 7 is alkaline. In Tables 7 and 8 mean and standard deviation values are not given for pH because those statistics are not valid for values from an exponential scale. The primary control on pH in ground water involves interaction of soil and rocks with gaseous carbon dioxide, bicarbonate, and carbonate ions. The pH in the background water-quality samples from the study area ranges from 5.9 to 8.6, with a median of 6.6 (Table 7, Figure 11). USEPA (1986) has set a recommended pH range for drinking water of from 5 to 9.

Temperature

The temperature of ground water normally has a small seasonal fluctuation and remains within a few degrees of the mean annual air temperature in a given area. In Maine, ground-water temperatures are typically between 4.4° C and 10.0° C (Caswell, 1987). The temperature of ground water in the study area varies from 6.0° C to 10.5° C, with a median of 8.0° C (Table 7, Figure 11).

Calcium, Magnesium, and Hardness

Because calcium is widely distributed in the common minerals of rocks and soil, it is the principal cation in most freshwater (Hem, 1985). Magnesium is also a common cation in ground water. The Maine Department of Human Services (1983) has not recommended any maximum limits for calcium, magnesium, or hardness in drinking water.

Concentrations of calcium, the principal cation in the background water-quality samples, range from 2.2 to 16.0 mg/L in the study area, with a median of 6.1 mg/L (Table 7, Figure 12).

Magnesium concentrations in the study area range from 0.5 to 8.9 mg/L, with a median of 1.6 mg/L (Table 7, Figure 12).

Hardness is a measure of the abundance of cations, mainly calcium and magnesium, that react with soap to form insoluble compounds or precipitate from heated water to form encrustations (Hem, 1985). Other divalent cations, including strontium, iron, and manganese, also can contribute to hardness. Hard water requires considerable amounts of soap to produce a foam or lather and is the cause of scale in hot-water pipes, heaters, boilers, and other units that use hot water.

Hardness in study-area samples was calculated by Standard Method 314A (American Public Health Association, 1985) and is expressed in terms of an equivalent concentration of calcium carbonate. Water is considered soft if it contains 0 to 60 mg/L of hardness, moderately hard if it contains 61 to 120 mg/L, hard if it contains 121 to 180 mg/L and very hard if it contains more than 180 mg/L (Hem, 1985). Ground-water samples from the study area have hardness ranging from 8 to 77 mg/L with a median of 23 mg/L (Table 7, Figure 11). This indicates that water in the region is soft, with the exception of one sample which was moderately hard.

Sodium and Potassium

Sodium and potassium are among the major cations in ground water in Maine. For sodium, a drinking water standard of 20 mg/L has been set by the Maine Department of Human Ser-

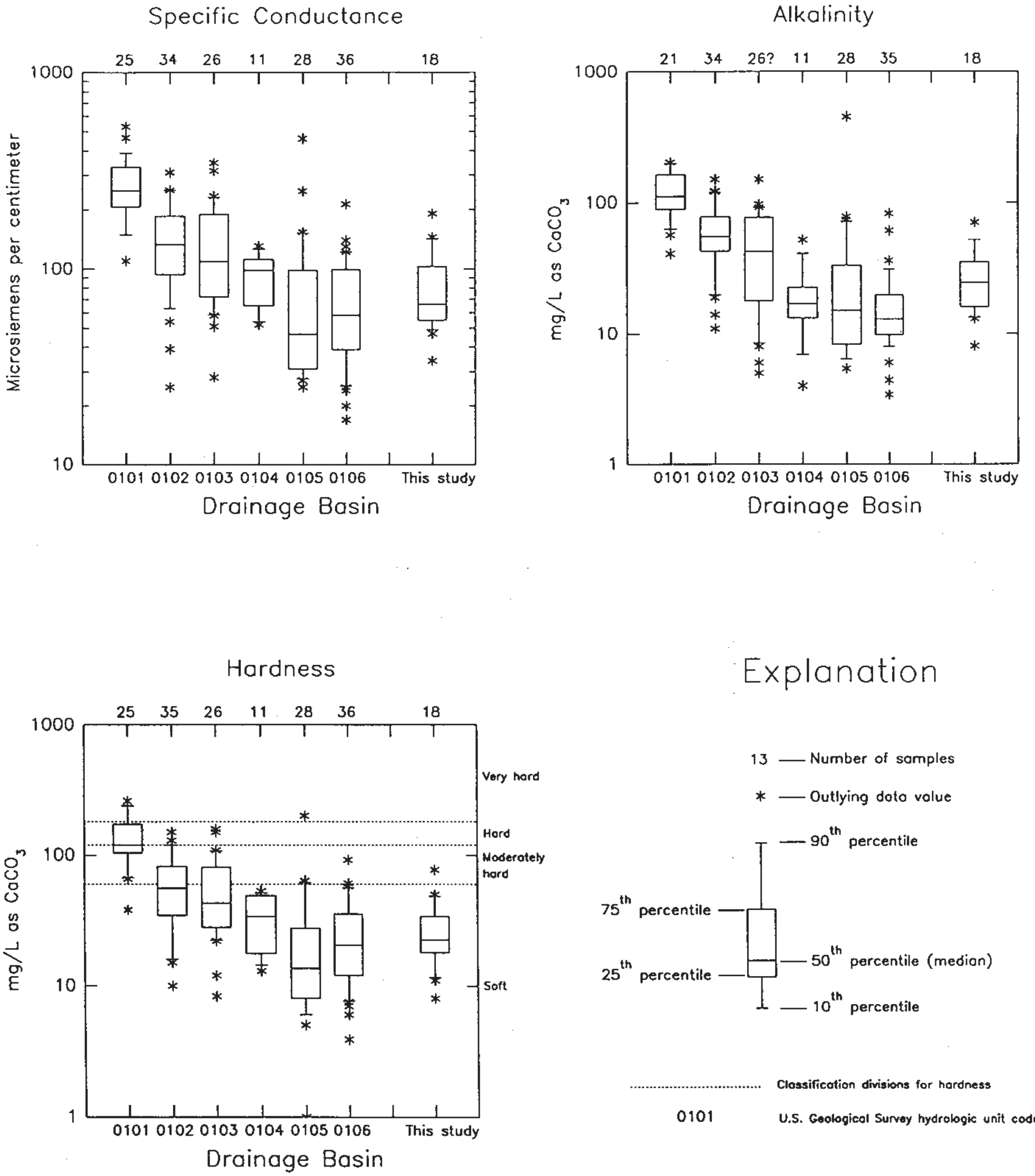


Figure 11. Boxplots of selected water-quality properties, by drainage basin.

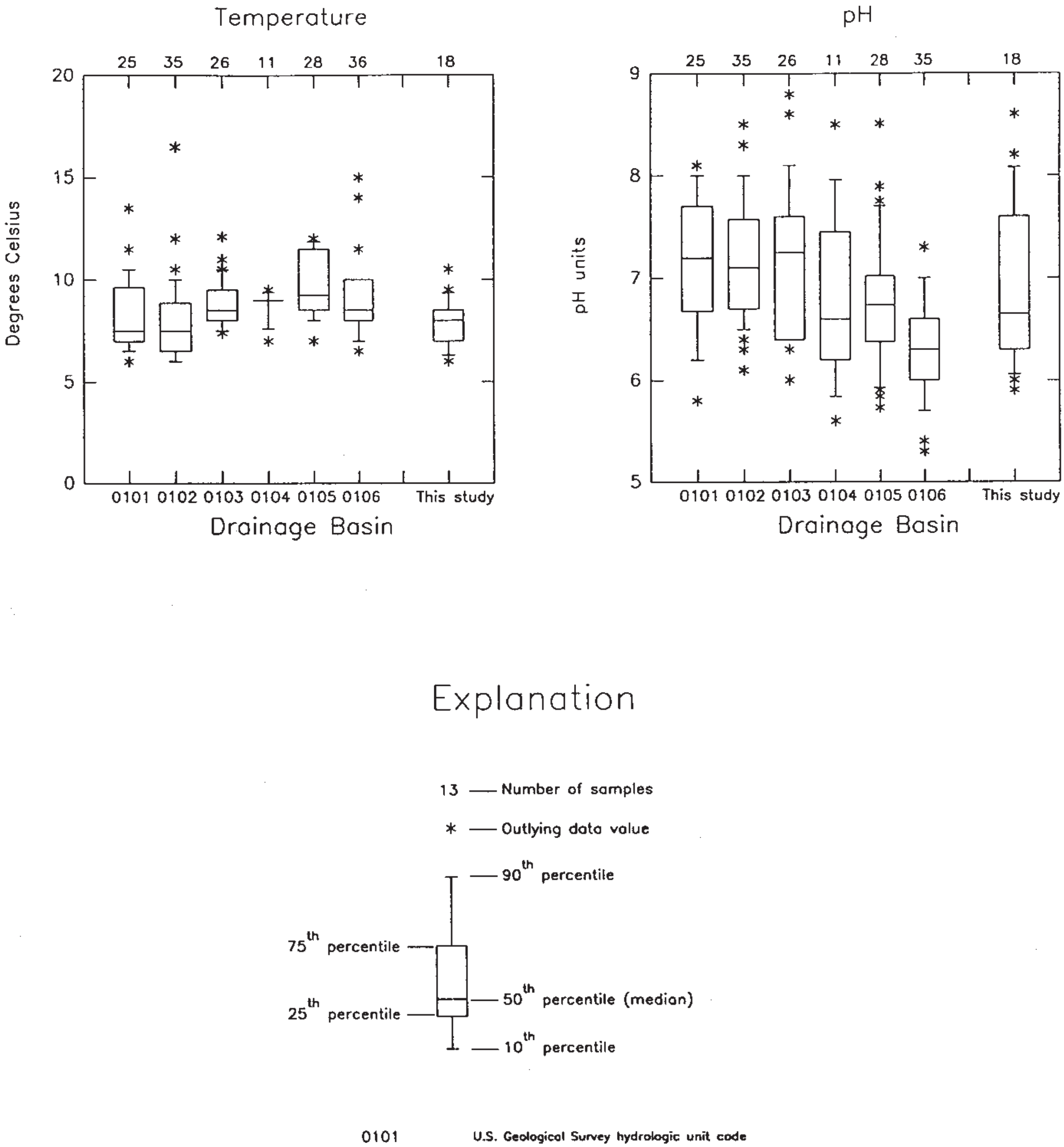


Figure 11. Boxplots of selected water-quality properties, by drainage basin.

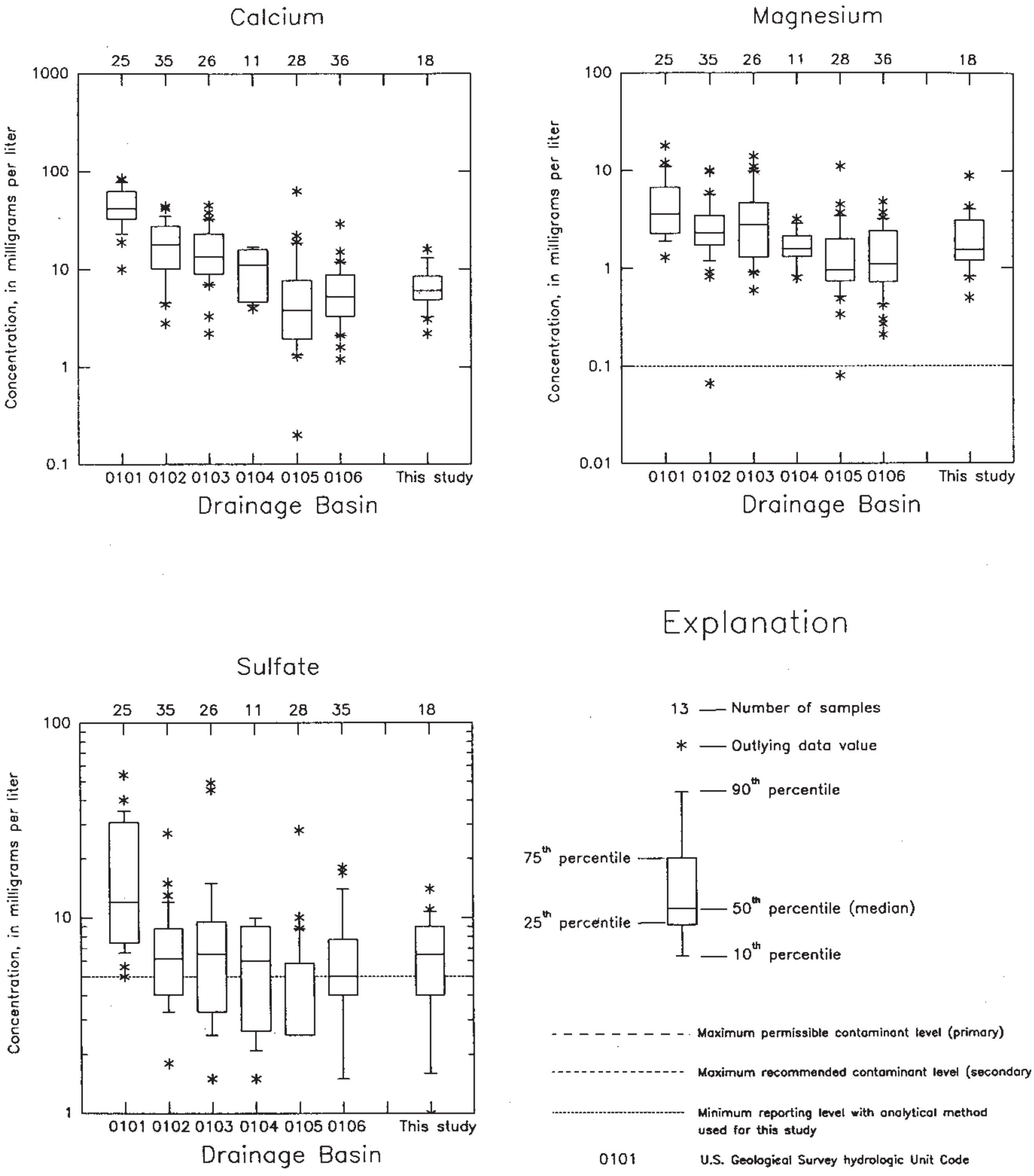


Figure 12. Boxplots of selected water-quality constituents by drainage basin with the U.S. Environmental Protection Agency and Maine Department of Human Services drinking water standards.

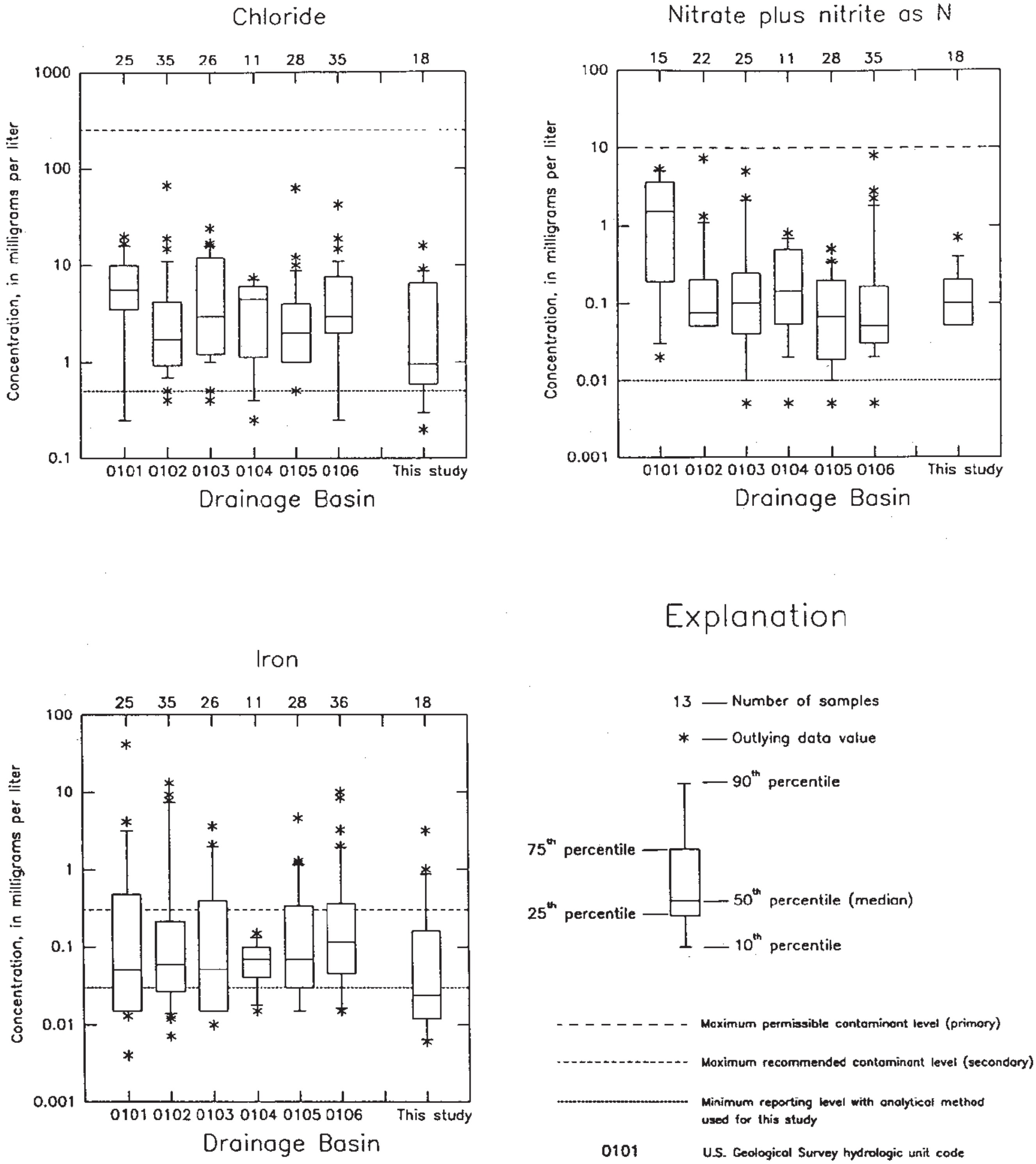


Figure 12. Boxplots of selected water-quality constituents by drainage basin with the U.S. Environmental Protection Agency and Maine Department of Human Services drinking water standards.

vices (1983) to protect individuals on sodium restricted diets. These diets are usually recommended for people with heart, hypertension, or kidney problems. The U.S. Environmental Protection Agency (1989) has not set a maximum limit for potassium in drinking water. Concentrations of sodium in the background water-quality samples from the study area range from 1.2 to 13.0 mg/L, with a median of 3.2 mg/L (Table 7). Concentrations of potassium in the study area range from 0.4 to 7.1 mg/L, with a median of 1.6 mg/L (Table 7).

Alkalinity

Alkalinity is a measure of the capacity of a solution to neutralize acid. This capacity depends on the concentrations of carbonate (CO_3^{2-}), bicarbonate (HCO_3^-), and hydroxyl (OH^-). Under equilibrium conditions, pH can be used to indicate the distribution of the different carbonate species (Hem, 1985). Bicarbonate is the dominant anion in ground water in the study area. Alkalinity is reported in terms of equivalent calcium carbonate ($CaCO_3$) concentration. Alkalinity concentrations within the study area range from 8 to 71 mg/L, with a median of 26 mg/L (Table 7, Figure 11).

Sulfate

Sulfate is one of the major anions in natural waters. Sulfate can be reduced under anaerobic conditions to hydrogen-sulfide gas (H_2S). The rotten-egg odor of this gas can be detected in water at levels as low as a few tenths of a milligram per liter. The USEPA (1989) has set a SMCL for sulfate of 250 mg/L in drinking water; at levels above this, sulfate can have a laxative effect. Sulfate concentrations in the background water-quality samples from the study area range from less than 1.0 to 14.0 mg/L, with a median of 7.0 mg/L (Table 7, Figure 12).

Chloride

Because chloride is a highly mobile ion and is not readily sorbed, it can be used to trace contamination from road salt, salt-sand storage piles, landfills, and septic tanks. The USEPA (1989) has set a SMCL of 250 mg/L for chloride. High chloride concentrations in water will contribute to the deterioration of plumbing, water heaters, and water works equipment. High chloride concentrations in water may also be associated with sodium concentrations. Chloride concentrations in the background water-quality samples from the study area range from 0.2 to 16.0 mg/L, with a median concentration of 1.0 mg/L (Table 7, Figure12).

Nitrate Plus Nitrite

Nitrate and nitrite commonly are derived from plant and animal materials, but can also be contributed by fertilizers. Nitrate is the most common nitrogen compound in ground water. Because nitrate is weakly adsorbed by soil, it is a good indicator of contamination from septic systems and waste-disposal sites. Nitrate can be converted to nitrite in the stomach; this may lead to the onset of methemoglobinemia in infants, a potentially lethal disease (National Research Council, 1977). Because of this, the USEPA (1986) established a MCL of 10 mg/L nitrate-nitrogen (NO_3-N) in drinking water. High nitrate levels are also potentially lethal to cattle and other ruminants.

Nitrate plus nitrite concentrations in the background water-quality samples from the study area range from less than 0.1 to 0.7 mg/L, with a median of 0.1 mg/L (Table 7, Figure 12). Values below the detection limit of 0.1 mg/L were reported as less than 0.1 mg/L.

Iron and Manganese

Elevated iron and manganese concentrations may cause some problems for municipal water systems and individual well owners in the study area. Humans are not known to suffer any harmful effects from drinking water that contains excessive iron; however, concentrations of only a few tenths of a milligram per liter of iron and a few hundredths of a milligram per liter of manganese can make water unsuitable for some uses. Both iron and manganese may stain clothes and plumbing fixtures and iron can cause problems in distribution systems by supporting growth of iron bacteria. Even at very low concentrations, iron in water can impart an objectionable taste, which is often described as rusty or metallic. When exposed to the air, water that contains dissolved iron and manganese may become turbid because of the formation of colloidal precipitates.

Dissolved iron concentrations in the study area samples vary from 0.006 mg/L to 3.200 mg/L, with a median of 0.024 mg/L (Table 7). The median value for iron is below the recommended limit of 0.3 mg/L for drinking water set by the USEPA (1989).

Dissolved manganese concentrations in the project area range from 0.011 mg/L to 2.100 mg/L, with a median of 0.145 mg/L (Table 7). The median dissolved manganese concentration exceeds the recommended drinking limit of 0.050 mg/L set by the USEPA (1989).

Filtration units can be installed by individual well owners to remove objectionable levels of iron and manganese. Treatment might be necessary to remove iron and manganese from public ground-water supplies in some localities in the study area.

Total Organic Carbon

TOC (total organic carbon) is a bulk indicator of all organic chemicals present in water. The TOC-measurement technique does not distinguish between toxic and nontoxic organic species. Natural organic species derived from soils can cause anomalously high TOC concentrations. The TOC concentrations in the background water-quality samples from the study area range from 1.1 mg/L to 8.5 mg/L, with a median of 1.9 mg/L (Table 7).

Discussion

Several studies have indicated that the composition of stratified drift in an area mirrors the local bedrock lithology (Trefethen and Trefethen, 1944; Flint, 1971; Van Beever, 1971; Legget, 1976; Bolduc and others, 1987; Evenson and Clinch, 1987). This is reflected in the water quality from wells installed in the stratified drift when compared by drainage basin.

The median values of selected chemical and physical parameters in Figures 11 and 12 and Table 8 show a consistent trend between major drainage basins. Median values for conductivity, alkalinity, sulfate, calcium, magnesium and hardness consistently decrease from north to south. The highest parameter values are found in the St. John/Aroostook River basin (HUC 0101), with progressively decreasing values found in the Penobscot River basin (HUC 0102), the Kennebec River basin (HUC 0103), the Androscoggin River basin (HUC 0104), the eastern and central coastal basins (HUC 0105) and the Saco River basin (HUC 0106) respectively. While there may be a wide range of values for a particular parameter within each drainage basin, the consistent trend of the median values is noteworthy.

A geologic feature which varies from north to south in Maine is metamorphic grade (Figure 13). Using all ground-water quality data collected for the Significant Sand and Gravel Aquifer Mapping Program through the 1992 study area, Figure 14 shows, both graphically and in tabular form, median values of conductivity, alkalinity and hardness for each major drainage basin versus the percent of each basin underlain by "weakly metamorphosed" bedrock. Weakly metamorphosed in this case is taken from the Generalized Map of Metamorphic Facies in Osberg and others (1985), and corresponds roughly to sub-greenschist grade. A best fit regression line for each parameter is also shown on Figure 14. The correlations between conductivity, alkalinity, and hardness and percent weakly metamorphosed bedrock in each basin is good, with r^2 values greater than .92 in all cases.

The evidence suggests that the variation in water quality, and the inferred variation in total dissolved solids, is primarily a function of the solubility of the stratified drift in each basin. Water quality is a function of several factors, including the mineralogy of the aquifer material, the pH of the recharge to the aquifer, temperature and residence time. However, drainage basins underlain by predominantly low-grade metamorphic rocks have higher values of many chemical and physical parameters as measured in background water quality than do basins underlain by abundant high-grade metamorphic rocks and felsic plutons (Weddle and Loiselle, in press).

SUMMARY

The significant sand and gravel aquifers in the study area consist of glacial ice-contact, ice-stagnation, outwash, and stream-alluvium deposits. These primarily occur in the valleys of the major river systems and their tributaries, or associated with other surface-water bodies.

Although the study area includes 1717 mi^2, areas mapped as significant aquifers cover only 74.7 mi^2. Yields exceeding 50 gal/min are estimated to be available in only 6.9 mi^2 of these significant aquifers. The highest yields are obtainable in areas of thick, coarse-grained, saturated deposits that are hydraulically connected to an adjacent body of surface water as a source of induced recharge. The largest reported well yield is 670 gal/min. from a gravel-packed, industrial well in Coplin Plantation.

The water table in the significant sand and gravel aquifers typically is within 15 ft of the land surface. Based on well-record data, the greatest known depth to bedrock is 191 ft in a domestic well in Andover.

On the basis of field relations, logs of observation wells, and interpretation of the geologic history, the following generalized stratigraphic relations have been determined: bedrock is overlain by till, which locally is overlain by ice-contact and outwash deposits, which may be overlain by and locally interbedded with glaciolacustrine deposits. These deposits in turn, may be overlain by sand and gravel deposits of mixed origin. The thickness of the deposits and stratigraphic units varies considerably, depending on landform and local depositional controls during deglaciation and postglaciation.

The background water quality in sand and gravel aquifers in the study area has the following characteristics: the median pH is 6.6; calcium and sodium are the most abundant cations, bicarbonate is the dominant anion and the water is generally soft. According to water-quality data for the study area and the prescribed drinking water standards, the regional water quality generally is suitable for drinking and most other uses. However, in some localities, concentrations of iron and manganese may limit the use of untreated water.

Solid-waste facilities and salt-sand storage areas are the most common potential sources of ground-water contamination identified on or near sand and gravel aquifers in the study area. No municipal water-supply wells are known to have been contaminated by these sources.

Comparison of background water quality between the major drainage basins of the state reveals a consistent decrease in median values of selected parameters from north to south. This decrease correlates well with the percentage of the basin that is underlain by "weakly metamorphosed" bedrock. Numerous other factors (pH, temperature, residence time) may influence water quality but the evidence suggests these factors are minor relative to the composition of the aquifer material which is controlled primarily by the basin bedrock geology and metamorphic grade.

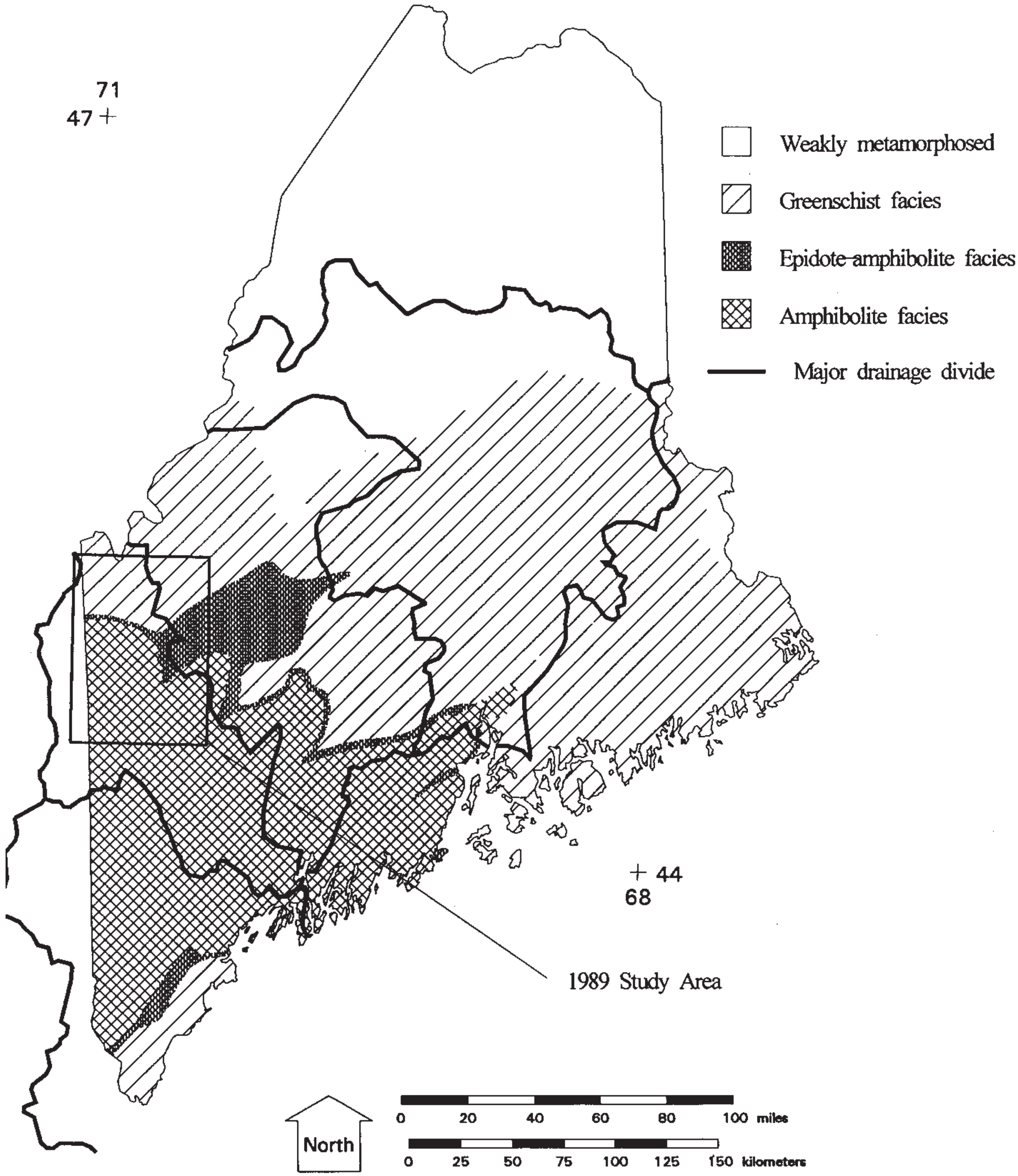
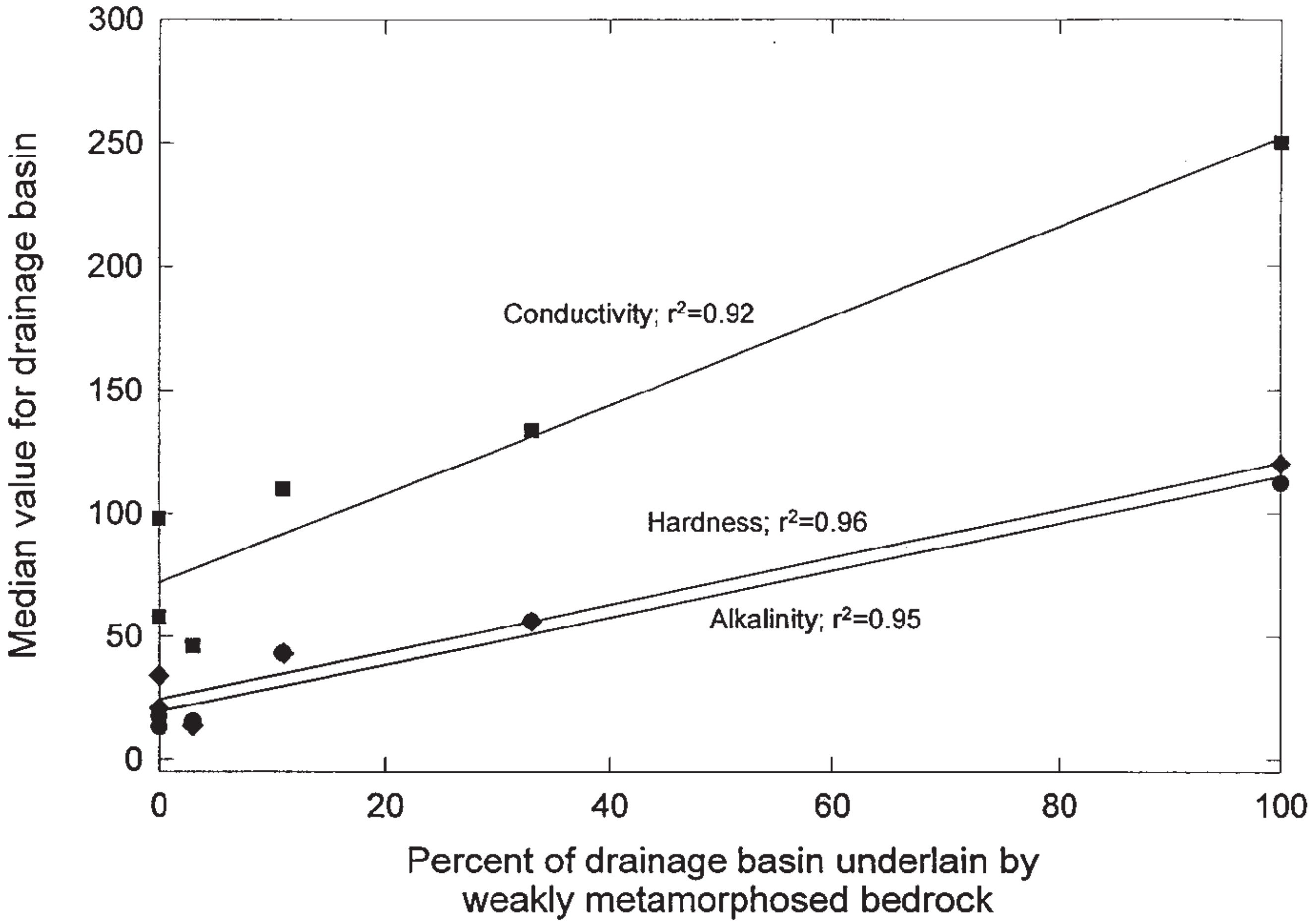


Figure 13. Major drainage basins, the study area, and metamorphic zones, (modified from Osberg and others, 1985).



	PERCENT AREA	COND ■	ALK ●	HARD ♦
HUC 0101	100	250.0	112.0	120.0
HUC 0102	33	134.0	56.0	56.0
HUC 0103	11	110.0	43.0	43.0
HUC 0104	0	98.0	17.0	34.0
HUC 0105	3	46.0	15.0	13.5
HUC 0106	0	58.0	13.0	20.5

HUC - U.S. Geological Survey hydrologic unit code
PERCENT AREA - percentage of HUC underlain by weakly metamorphosed bedrock.
COND - conductivity, in microsiemens/cm.
ALK - alkalinity, in mg/L, as $CaCO_3$.
HARD - hardness, in mg/L, as $CaCO_3$.

Figure 14. Median conductivity, alkalinity, and hardness for major drainage basins vs. percent of each basin underlain by weakly metamorphosed bedrock.

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Appendix 1

Single-Channel Seismic-Refraction Data

The following is a compilation of data interpreted from single-channel seismic-refraction surveys conducted by the Maine Geological Survey during 1989. Data were interpreted using a computer program developed at the Maine Geological Survey following the methods of Mooney (1980) and Zohdy and others (1974). Depths are measured from land surface. If the line was run in a gravel pit the amount of material that had been removed is noted under "Comments". Location of individual seismic lines are shown on the quadrangle indicated by the three letter quadrangle code identifying the seismic line. A list of these quadrangle codes is given below.

CODE	QUADRANGLE	CODE	QUADRANGLE
AND	Andover	PUZ	Puzzle Mountain
BLM	Black Mountain	QUI	Quill Hill
BPD	B Pond	RED	Redington
DXF	Dixfield	RHP	Richardson Pond
ETA	East Andover	ROX	Roxbury
HOU	Houghton	RPM	Rump Mountain
KBG	Kennebago	RUM	Rumford
LCP	Lincoln Pond	STR	Stratton
LKL	Little Kennebago Lake	TMT	Tim Mountain
MAD	Madrid	UBN	Umbagog Lake North
MMT	Metallak Mountain	UBS	Umbagog Lake South
OQS	Oquossoc	WLD	Weld
OSM	Old Speck Mountain	WMS	Wilsons Mills
PAR	Parmachenee Lake		

All single-channel seismic-refraction surveys presented in Appendix 2 were reversed, or run from both directions, to allow apparent velocity corrections. The end of the line on which readings were taken first was designated the "A" end. The line was then reversed and readings were taken on the "B" end. The orientation of the line, shown in Appendix 2, was measured from the "A" end. Depths to water table and bedrock are reported for both the "A" end and the "B" end of single-channel seimic lines.

Depth to water table and depth to bedrock based on single-channel seismic data

Seismic-line identifier [1]	Quadrangle	Town	Orientation from A (° T)	Length of line (feet)	Depth to water table (feet) A	Depth to water table (feet) B	Depth to bedrock, (feet) A	Depth to bedrock, (feet) B	Comments
AND-B	Andover	Andover	202	170	7	5	58	>58	10-20 ft. removed from pit
AND-J	Andover	Andover	99	210	13	14	80	87	6 ft removed from pit
AND-L	Andover	Andover West Surplus	182	200	5	3	60	61	5-10 ft removed from pit
AND-N	Andover	Andover North Surplus	135	140	5	8	35	38	
AND-O	Andover	Township C	8	270	10	8	85	87	brook 10 ft below line
AND-S	Andover	Township C	131	220	6	7	76	75	35-45 ft removed from east side of road
AND-T	Andover	Township C	136	180	9	6	58	61	
AND-U	Andover	Township C	344	140	9	7	44	41	
BLM-A	Black Mountain	Stetsontown	82	270	6	6	>96	>95	
BLM-C	Black Mountain	Stetsontown	189	150	12	13	43	44	10-50 ft removed from pit
BPD-AA	B Pond	C Surplus	238	170	9	9	44	42	
BPD-B	B Pond	Grafton	270	190	2	2	68	>65	
BPD-D	B Pond	Grafton	87	280	7	6	101	105	
BPD-E	B Pond	Grafton	215	170	14	17	52	50	
BPD-F	B Pond	Grafton	1	140	9	9	48	49	
BPD-FF	B Pond	Upton	204	120	9	8	37	36	river 4 ft below line
BPD-G	B Pond	Grafton	102	120	10	13	42	29	
BPD-GG	B Pond	C Surplus	294	100	4	4	16	16	
BPD-H	B Pond	Upton	68	170	9	11	26	30	
BPD-I	B Pond	Upton	343	200	12	16	59	60	about 20 ft removed from back of pit
BPD-N	B Pond	Upton	120	150	10	4	31	35	10-30 ft removed from pit
BPD-O	B Pond	C Surplus	122	210	6	6	51	50	

[1] - Location of all seismic lines are shown on associated maps.

Depth to water table and depth to bedrock based on single-channel seismic data, (cont.)

Seismic-line identifier [1]	Quadrangle	Town	Orientation from A (°T)	Length of line (feet)	Depth to water table (in feet)		Depth to bedrock (feet)		Comments
					A	B	A	B	
BPD-P	B Pond	C Surplus	121	130	4	3	31	35	
BPD-S	B Pond	Upton	269	130	5	6	42	42	
BPD-W	B Pond	Upton	304	200	7	10	43	45	
BPD-X	B Pond	Upton	134	220	4	5	64	62	
BPD-Y	B Pond	C Surplus	264	150	6	7	28	28	
DXF-A	Dixfield	Dixfield	122	150	25	28	67	68	
DXF-D	Dixfield	Dixfield	200	150	15	17	59	54	
DXF-F	Dixfield	Dixfield	50	160	29	32	86	73	
DXF-H	Dixfield	Dixfield	190	130	11	12	48	40	20 ft removed from pit
DXF-I	Dixfield	Peru	286	170	5	5	37	51	
DXF-J	Dixfield	Peru	346	150	7	8	36	38	10-15 ft removed from pit
DXF-L	Dixfield	Dixfield	113	100	12	12	36	32	river 10 ft below line
DXF-O	Dixfield	Dixfield	291	220	28	26	>92	>99	
DXF-P	Dixfield	Dixfield	47	150	7	6	>58	>62	river 10 ft below line
DXF-R	Dixfield	Carthage	242	220	4	5	65	68	
DXF-S	Dixfield	Carthage	147	130	4	7	38	25	
DXF-U	Dixfield	Carthage	253	90	6	4	26	27	
DXF-V	Dixfield	Carthage	334	110	12	12	41	38	
ETA-A	East Andover	Andover	24	240	14	18	87	>82	pond surface 12 ft below line
ETA-AA	East Andover	Rumford	239	300	8	15	91	79	
ETA-B	East Andover	Andover	60	290	26	29	95	98	
ETA-BB	East Andover	Rumford	271	230	6	4	76	77	

[1] - Location of all seismic lines are shown on associated maps.

Depth to water table and depth to bedrock based on single-channel seismic data, (cont.)

Seismic-line identifier[1]	Quadrangle	Town	Orientation from A (°T)	Length of line (feet)	Depth to water table (feet)		Depth to bedrock (feet)		Comments
					A	B	A	B	
ETA-CC	East Andover	Rumford	240	210	18	22	66	67	
ETA-D	East Andover	Andover	200	160	8	9	54	48	water 15 ft below line
ETA-DD	East Andover	Rumford	1	170	12	14	>55	57	river 8 ft below line
ETA-F	East Andover	Andover	283	140	18	17	43	35	
ETA-FF	East Andover	Rumford	176	240	18	14	93	91	15-30 ft removed
ETA-GG	East Andover	Andover	62	210	21	21	>57	78	
ETA-H	East Andover	Andover	102	300	18	18	>110	>108	
ETA-HH	East Andover	Andover	237	120	16	17	40	45	
ETA-J	East Andover	Andover	308	170	10	12	47	48	
ETA-JJ	East Andover	Rumford	79	220	8	7	56	58	
ETA-K	East Andover	Andover	249	150	13	12	53	>61	
ETA-N	East Andover	Rumford	181	290	9	11	>86	>92	
ETA-T	East Andover	Rumford	220	120	19	17	36	50	
ETA-Y	East Andover	Rumford	265	190	12	13	63	>66	
ETA-Z	East Andover	Rumford	240	300	12	23	111	85	
HOU-A	Houghton	Rangley Plt.	180	230	2	7	48	54	
HOU-E	Houghton	Byron	352	220	10	10	55	53	stream 8-10 ft below line
KBG-AAA	Kennebago	Lower Cupsuptic	66	150	6	6	37	40	10 ft removed from pit
KBG-B	Kennebago	Rangley	77	220	12	10	64	63	
KBG-C	Kennebago	Rangley	308	240	14	13	62	64	
KBG-E	Kennebago	Lower Cupsuptic	100	230	11	14	84	89	
KBG-OO	Kennebago	Lower Cupsuptic	74	180	6	7	53	50	

[1] - Location of all seismic lines is shown on plates.

Depth to water table and depth to bedrock based on single-channel seismic data, (cont.)

Seismic-line identifier [1]	Quadrangle	Town	Orientation from A (°T)	Length of line (feet)	Depth to water table (feet)		Depth to bedrock, (feet)		Comments
					A	B	A	B	
KBG-QQ	Kennebago	Lower Cupsuptic	111	140	4	4	44	36	river 15 ft below line
KBG-SS	Kennebago	Lower Cupsuptic	200	220	9	10	57	59	
KBG-UU	Kennebago	Stetsontown	12	210	7	8	>82	>80	river 1-3 ft below line
KBG-VV	Kennebago	Stetsontown	74	220	8	9	73	67	
KBG-WW	Kennebago	Stetsontown	310	290	12	14	101	100	
KBG-XX	Kennebago	Stetsontown	95	300	4	1	>104	122	10 ft removed from pit
KBG-YY	Kennebago	Stetsontown	180	230	12	12	78	75	
KBG-ZZ	Kennebago	Stetsontown	152	240	12	16	81	81	
LCP-F	Lincoln Pond	Lower Cupsuptic	95	90	11	10	28	27	20-30 ft removed from pit
LCP-G	Lincoln Pond	Lower Cupsuptic	140	180	3	6	49	52	
LCP-W	Lincoln Pond	Lynchtown	345	300	5	4	83	83	
LCP-X	Lincoln Pond	Lynchtown	131	160	13	12	44	39	
LKL-J	Little Kennebago Lake	Stetsontown	222	220	7	9	57	59	water in base of pit
LKL-K	Little Kennebago Lake	Stetsontown	14	270	14	13	79	76	
LKL-M	Little Kennebago Lake	Stetsontown	106	200	15	13	59	53	
LKL-N	Little Kennebago Lake	Stetsontown	101	90	10	10	27	26	
LKL-O	Little Kennebago Lake	Stetsontown	342	250	5	8	54	50	
LKL-P	Little Kennebago Lake	Stetsontown	341	140	5	5	38	36	
LKL-R	Little Kennebago Lake	Stetsontown	271	150	12	12	53	56	
LKL-S	Little Kennebago Lake	Seven Ponds	87	180	12	7	57	57	brook 5-7 ft below line
LKL-T	Little Kennebago Lake	Seven Ponds	135	230	9	12	61	62	10 ft removed from pit
LKL-U	Little Kennebago Lake	Seven Ponds	127	240	11	11	84	89	

[1] - Location of all seismic lines are shown on associated maps.

Depth to water table and depth to bedrock based on single-channel seismic data, (cont.)

Seismic-line identifier [1]	Quadrangle	Town	Orientation from A (°T)	Length of line (feet)	Depth to water table (in feet) A	Depth to water table (in feet) B	Depth to bedrock (feet) A	Depth to bedrock (feet) B	Comments
PAR-NN	Parmachenee	Parmachenee	353	220	8	4	73	68	creek 4 ft below line
PAR-Z	Parmachenee	Lynchtown	117	110	15	11	35	42	
PUZ-A	Puzzle Mtn.	Newry	188	180	8	9	54	54	
PUZ-B	Puzzle Mtn.	Newry	31	240	12	11	89	88	
PUZ-D	Puzzle Mtn.	Newry	58	150	4	6	44	44	10-15 ft removed from pit
PUZ-F	Puzzle Mtn.	Newry	164	150	7	6	57	55	
PUZ-M	Puzzle Mtn.	Newry	300	220	35	37	86	90	
PUZ-N	Puzzle Mtn.	Newry	325	110	9	10	32	28	
QUI-A	Quill Hill	Lang	245	180	10	7	48	50	30 ft removed from pit
QUI-B	Quill Hill	Lang	328	120	26	27	56	54	
QUI-C	Quill Hill	Lang	300	110	12	14	48	>49	
QUI-D	Quill Hill	Lang	68	110	15	16	35	38	
QUI-F	Quill Hill	Coplin Plt.	290	130	10	8	54	>51	
QUI-K	Quill Hill	Dallas Plt.	163	140	4	4	18	18	
QUI-L	Quill Hill	Dallas Plt.	330	170	21	24	46	50	
QUI-M	Quill Hill	Dallas Plt.	159	140	8	6	50	52	river 10-15 ft below line
QUI-O	Quill Hill	Dallas Plt.	153	80	20	19	38	36	road is 5 ft above natural land surface
QUI-P	Quill Hill	Lang	327	150	20	22	52	54	
QUI-Q	Quill Hill	Coplin Plt.	145	90	8	7	25	26	
QUI-R	Quill Hill	Coplin Plt.	128	120	6	6	26	24	
QUI-S	Quill Hill	Coplin Plt.	55	160	6	8	52	56	
RED-A	Redington	Madrid	300	260	51	48	110	105	

[1] - Location of all seismic lines are shown on associated maps.

Depth to water table and depth to bedrock based on single-channel seismic data, (cont.)

Seismic-line identifier [1]	Quadrangle	Town	Orientation from A (°T)	Length of line (feet)	Depth to water table (feet)		Depth to bedrock (feet)		Comments
					A	B	A	B	
MAD-A	Madrid	Phillips	293	170	4	7	51	>54	river is about 10 ft below line
MAD-B	Madrid	Phillips	322	100	4	5	28	35	
MAD-D	Madrid	Phillips	330	200	8	9	55	56	
MMT-B	Metallak Mtn.	Rangley Plt.	120	110	5	5	24	25	
OQS-B	Oquossoc	Rangley	2	130	10	10	37	36	
OQS-C	Oquossoc	Rangley	193	140	10	7	38	36	5-8 ft removed from pit
OQS-D	Oquossoc	Rangley	80	140	4	6	44	45	stream 5 ft below line
OQS-E	Oquossoc	Rangley	324	170	15	14	57	59	river 15 ft below line
OSM-B	Old Speck Mtn.	Grafton	4	150	6	8	49	47	
OSM-C	Old Speck Mtn.	Grafton	73	80	6	7	24	24	stream 5 ft below line
OSM-D	Old Speck Mtn.	Grafton	2	160	6	6	60	63	
PAR-AA	Parmachenee	Lynchtown	310	220	22	16	78	73	
PAR-B	Parmachenee	Parmachenee	142	210	9	4	56	53	river 10 ft below line
PAR-C	Parmachenee	Parmachenee	165	230	10	13	61	64	
PAR-DD	Parmachenee	Parmachenee	101	240	50	44	98	100	
PAR-EE	Parmachenee	Parmachenee	318	130	10	10	25	21	river 10 ft below line
PAR-FF	Parmachenee	Parmachenee	204	150	10	14	23	27	
PAR-HH	Parmachenee	Parmachenee	210	180	13	16	46	47	12 ft removed from pit at ‘A’ end
PAR-II	Parmachenee	Parmachenee	222	170	5	5	38	38	
PAR-KK	Parmachenee	Lynchtown	101	190	40	45	87	88	
PAR-LL	Parmachenee	Lynchtown	326	210	20	19	67	62	
PAR-MM	Parmachenee	Lynchtown	66	270	10	10	91	95	

[1] - Location of all seismic lines is shown on plates.

Depth to water table and depth to bedrock based on single-channel seismic data, (cont.)

Seismic-line identifier [1]	Quadrangle	Town	Orientation from A (°T)	Length of line (feet)	Depth to water table (feet)		Depth to bedrock, (feet)		Comments
					A	B	A	B	
RED-C	Redington	Madrid	124	130	14	12	43	42	
RED-E	Redington	Madric	352	150	28	27	67	68	
RED-F	Redington	Madrid	190	180	34	38	91	81	
RED-J	Redington	Madrid	316	200	21	19	55	54	
RHP-A	Richardson Pond	Magalloway Plt.	184	120	12	11	43	42	5-10 ft removed from pit
RHP-B	Richardson Pond	Magalloway Plt.	172	100	10	8	28	26	6 ft removed from pit; stream 5 ft below line
RHP-D	Richardson Pond	Lincoln Plt.	176	110	13	14	42	37	
RHP-G	Richardson Pond	Lincoln Plt.	117	100	9	11	29	30	
RHP-H	Richardson Pond	Lincoln Plt.	87	120	10	8	22	20	
RHP-J	Richardson Pond	Lincoln Plt.	310	110	13	9	28	32	6-30 ft removed from pit
RHP-K	Richardson Pond	Magalloway Plt.	170	260	8	10	55	54	10-12 ft removed from pit
ROX-D	Roxbury	Byron	48	170	4	4	46	32	
ROX-E	Roxbury	Byron	229	130	4	4	20	29	
ROX-F	Roxbury	Byron	52	120	7	5	18	25	
ROX-G	Roxbury	Byron	231	130	6	7	32	31	10-15 ft removed from pit
ROX-Q	Roxbury	Roxbury	352	110	4	6	31	30	
RPM-A	Rump Mtn.	Parmachenee	217	130	16	16	45	47	
RPM-E	Rump Mtn.	Parmachenee	302	210	16	17	70	64	
RPM-G	Rump Mtn.	Parmachenee	175	160	12	14	55	47	
RPM-H	Rump Mtn.	Parmachenee	75	100	15	12	32	35	20 ft removed from pit
RUM-B	Rumford.	Rumford	41	110	7	7	30	36	
RUM-D	Rumford	Mexico	234	120	9	4	29	37	40-50 ft removcd from pit

[1] - Location of all seismic lines are shown on associated maps.

Depth to water table and depth to bedrock based on single-channel seismic data, (cont.)

Seismic-line identifier [1]	Quadrangle	Town	Orientation from A (°T)	Length of line (feet)	Depth to water table (in feet)		Depth to bedrock (feet)		Comments
					A	B	A	B	
RUM-E	Rumford	Mexico	126	90	11	12	33	30	
RUM-H	Rumford	Rumford	342	210	13	16	70	66	river 8-10 ft below line
RUM-K	Rumford	Roxbury	76	80	16	16	32	25	river 15 ft below line
RUM-L	Rumford	Roxbury	228	100	10	11	30	25	
RUM-M	Rumford	Mexico	232	130	14	16	42	38	
STR-C	Stratton	Coplin Plt.	18	270	15	18	102	95	
STR-E	Stratton	Eustis	217	290	9	10	94	91	lake 7 ft below line
STR-F	Stratton	Eustis	106	300	7	6	96	92	
STR-G	Stratton	Eustis	159	300	11	11	>115	>118	river 7-10 ft below lie
STR-H	Stratton	Eustis	121	300	6	7	108	111	river 10 ft below line
STR-I	Stratton	Eustis	65	280	6	8	89	88	
STR-J	Stratton	Eustis	24	300	9	10	>115	>117	
STR-K	Stratton	Eustis	280	300	21	23	113	>116	
STR-L	Stratton	Eustis	36	300	14	13	98	>104	
STR-M	Stratton	Eustis	267	300	17	14	65	107	
STR-N	Stratton	Eustis	201	120	17	19	45	42	
STR-O	Stratton	Eustis	45	300	10	16	102	107	river 8-10 ft below line
STR-P	Stratton	Eustis	229	120	18	16	50	>47	
STR-R	Stratton	Eustis	231	140	16	16	46	42	
STR-S	Stratton	Eustis	245	180	12	10	65	56	
STR-T	Stratton	Eustis	145	280	19	21	110	>110	20 ft removed form pit
STR-U	Stratton	Eustis	141	210	15	16	57	60	very sandy

[1] - Location of all seismic lines are shown on associated maps.

Depth to water table and depth to bedrock based on single-channel seismic data, (cont.)

Seismic-line identifier[1]	Quadrangle	Town	Orientation from A (°T)	Length of line (feet)	Depth to water table (feet)		Depth to bedrock (feet)		Comments
					A	B	A	B	
STR-V	Stratton	Flagstaff	111	190	7	7	62	63	
TMT-B	Tim Mtn.	Jim Pond	91	300	45	45	131	>131	
UBN-A	Umbagog Lake North	Magalloway Plt.	224	180	8	10	54	56	river 15-20 ft below line
UBN-B	Umbagog Lake North	MagallowayPlt.	301	130	6	5	33	33	lake 5 ft below line
UBN-C	Umbagog Lake North	MagallowayPlt.	179	150	14	10	65	>66	
UBN-D	Umbagog Lake North	Magalloway Plt.	10	230	14	15	>91	>90	
UBN-E	Umbagog Lake North	Magalloway Plt.	220	120	15	15	38	41	
UBN-F	Umbagog Lake North	Magalloway Plt.	123	230	9	5	>65	>86	25 ft removed from pit
UBN-G	Umbagog Lake North	Magalloway Plt.	69	180	9	9	59	58	
UBS-D	Umbagog Lake South	Upton	306	110	7	7	36	36	
UBS-F	Umbagog Lake South	Upton	343	90	6	6	22	22	water level in swamp 2 ft belowline
WLD-A	Weld	Carthage	83	300	7	6	>96	>98	creek 10 ft below line ; 7 ft to H_2O ; clay at 11 ft
WLD-B	Weld	Carthage	57	160	17	16	66	57	
WLD-C	Weld	Carthage	102	300	8	8	>90	>96	
WLD-D	Weld	Carthage	177	300	8	7	>85	>99	
WLD-E	Weld	Carthage	0	180	4	4	34	35	
WLD-F	Weld	Carthage	132	160	4	6	26	27	
WLD-H	Weld	Weld	268	250	4	5	80	80	
WLD-J	Weld	Weld	40	190	7	11	71	67	stream 5-10 ft below line
WLD-K	Weld	Weld	184	140	5	6	29	34	
WLD-L	Weld	Weld	319	280	11	12	88	>90	
WLD-M	Weld	Weld	317	220	6	6	60	47	

[1] - Location of all seismic lines is shown on plates.

Depth to water table and depth to bedrock based on single-channel seismic data, (cont.)

Seismic-line identifier[1]	Quadrangle	Town	Orientation from A (°T)	Length of line (feet)	Depth to water table (in feet)		Depth to bedrock (feet)		Comments
					A	B	A	B	
WLD-N	Weld	Weld	322	240	5	3	44	47	
WLD-O	Weld	Carthage	157	200	13	18	36	49	
WMS-A	Wilsons Mills	Lincoln Plt.	102	220	8	8	71	71	river 15 ft below line
WMS-B	Wilsons Mills	Lincoln Plt.	129	140	16	18	38	38	
WMS-C	Wilsons Mills	Lincoln Plt.	36	150	8	8	>50	50	river 10-15 ft below line
WMS-D	Wilsons Mills	Lincoln Plt.	9	300	14	16	114	112	
WMS-E	Wilsons Mills	Magalloway Plt.	299	150	7	6	45	42	water 15 ft below line

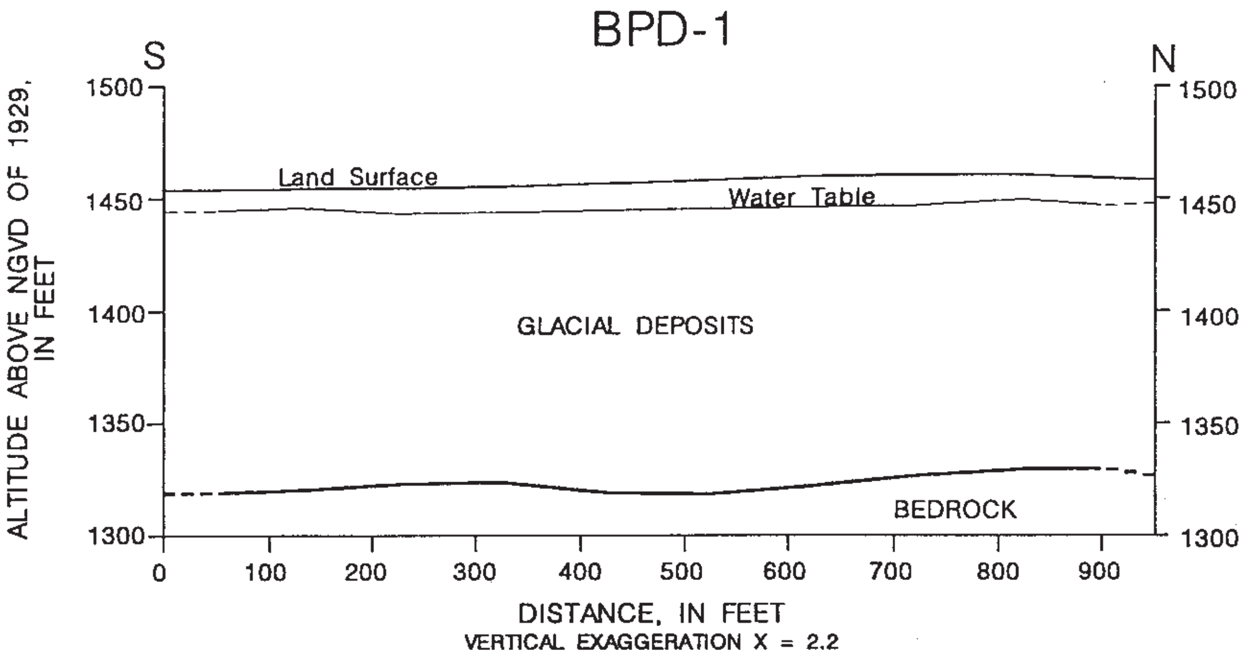
[1] - Location of all seismic lines are shown on associated maps.

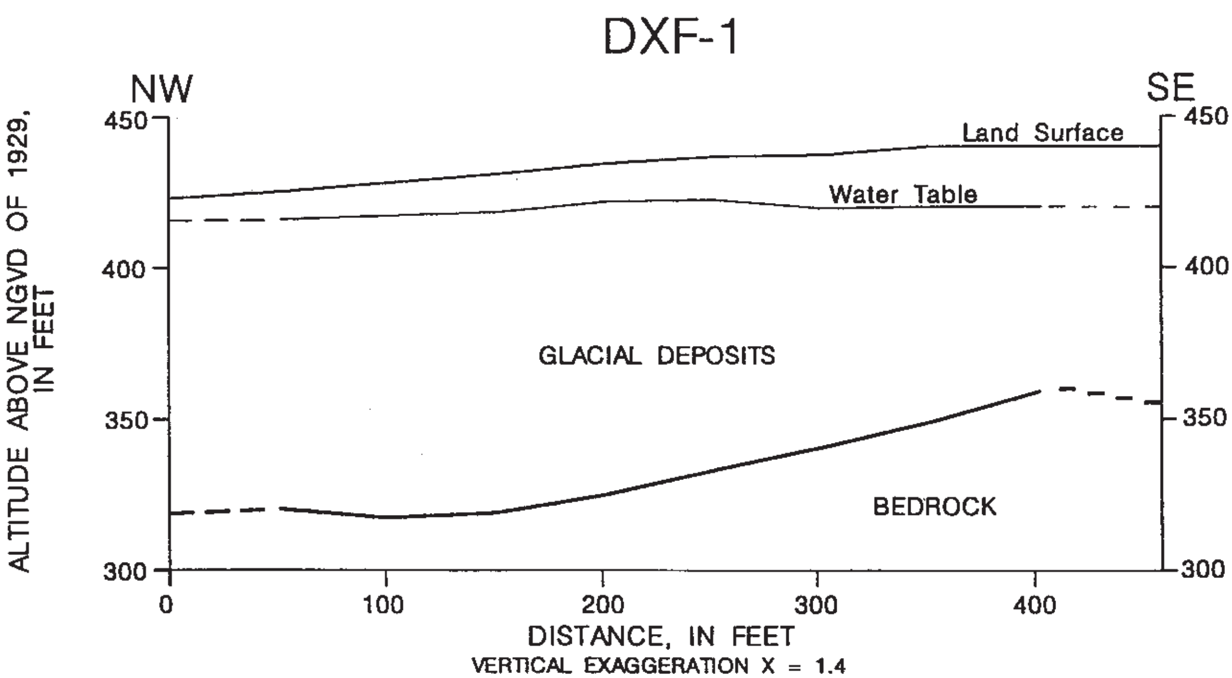
Appendix 2

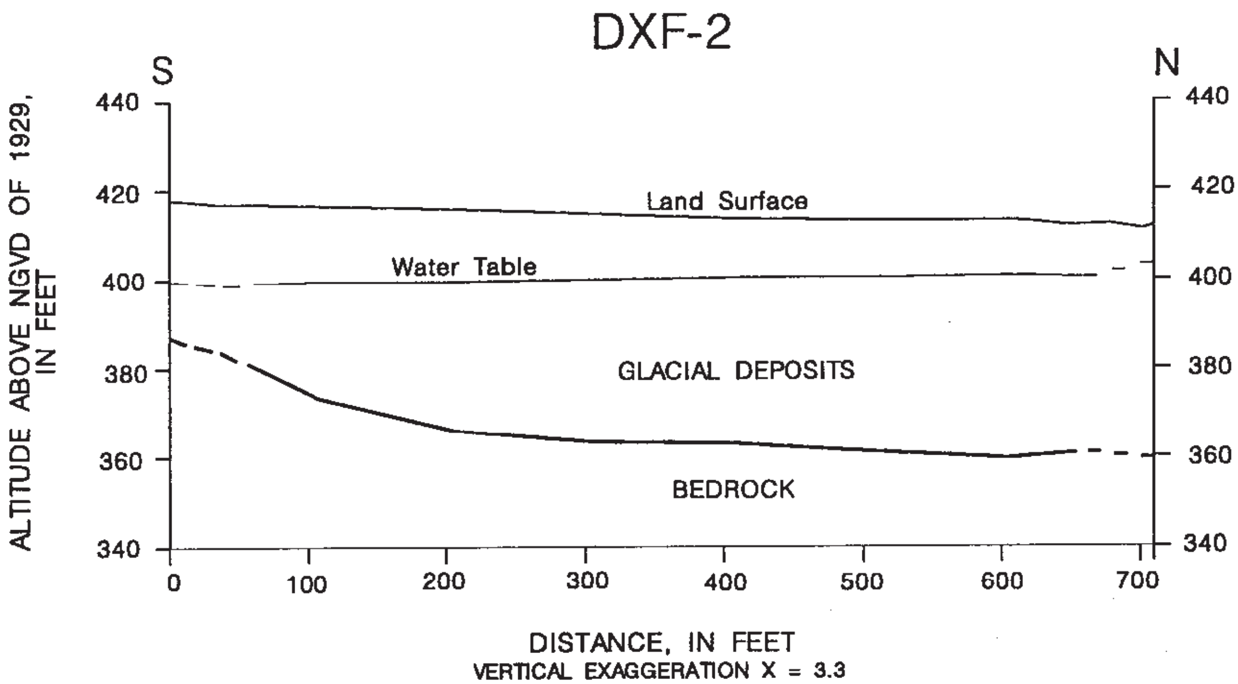
Twelve-Channel Seismic-Refraction Profiles

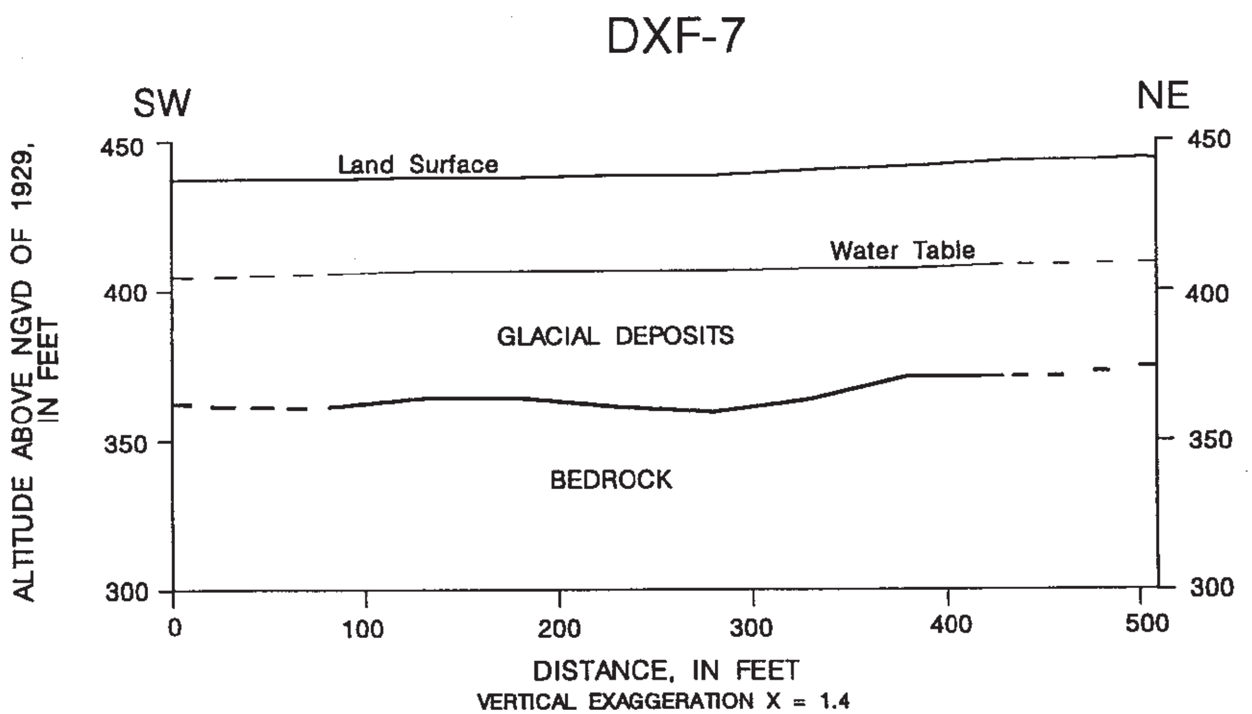
The following are hydrogeologic cross sections interpreted from twelve-channel seismic-refraction surveys conducted by the Maine Geological Survey and the U.S. Geological Survey during 1989. Data interpretation is based on a computer modeling program described by Scott and others (1972). Distances shown on the x-axes are measured from geophone number 1. In places, the altitude of the water table and bedrock surfaces have been shown with dashed lines to emphasize the relative unreliability of the interpretation at the extreme ends of the line. Not all seismic lines shown on the associated maps have corresponding profiles in this appendix. Locations of individual profiles are shown on the quadrangle indicated by the three letter quadrangle code identifying the seismic line. A list of these quadrangle codes is given below.

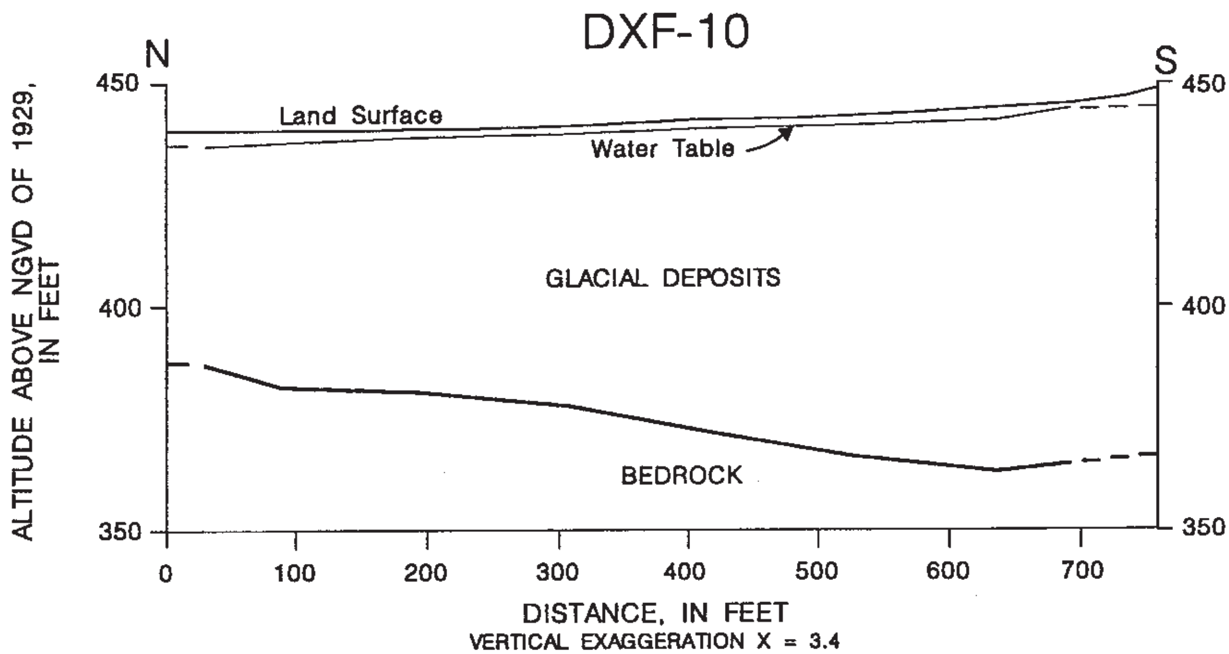
CODE	QUADRANGLE	CODE	QUADRANGLE
BDP	B Pond	RED	Redington
DXF	Dixfield	RHP	Richardson Pond
ELP	Ellis Pond	ROX	Roxbury
ETA	East Andover	RUM	Rumford
LKL	Little Kennebago Lake	STR	Stratton
MAD	Madrid	UBN	Umbagog Lake North
OQS	Oquossoc	WLD	Weld
QUI	Quill Hill	WMS	Wilsons Mills

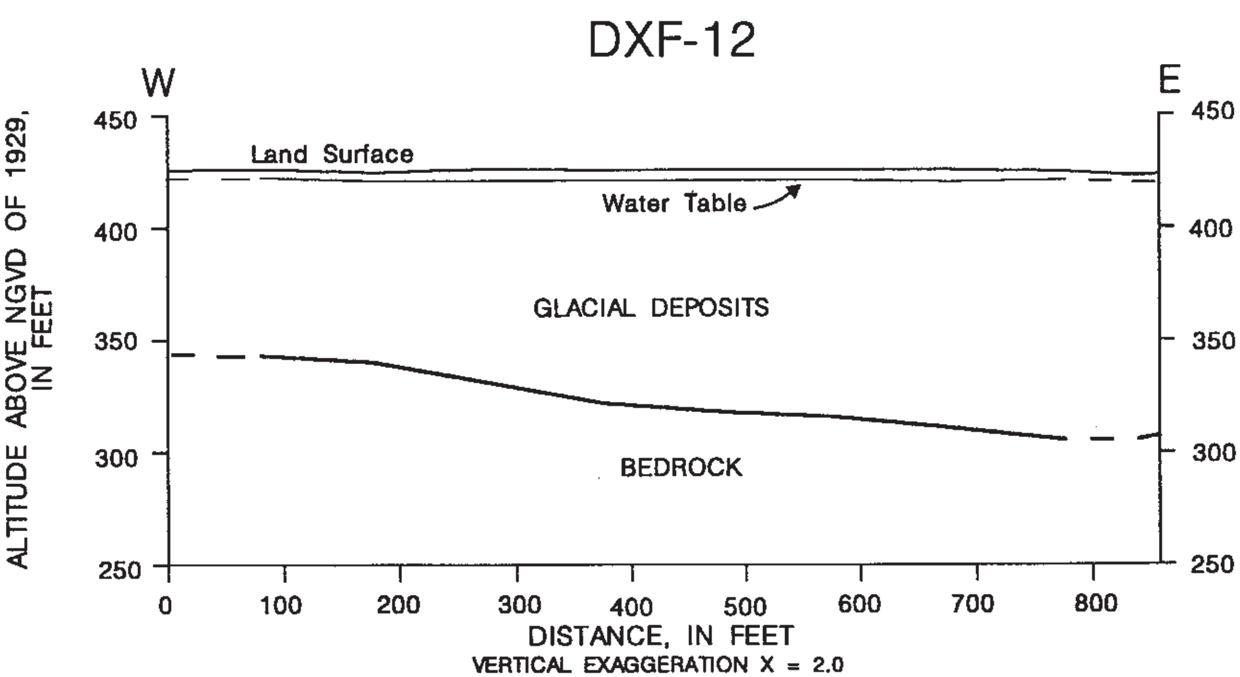

BPD-1
S
N
ALTITUDE ABOVE NGVD OF 1929, IN FEET
1500
1450
1400
1350
1300
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
0
100
200
300
400
500
600
700
800
900
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 2.2

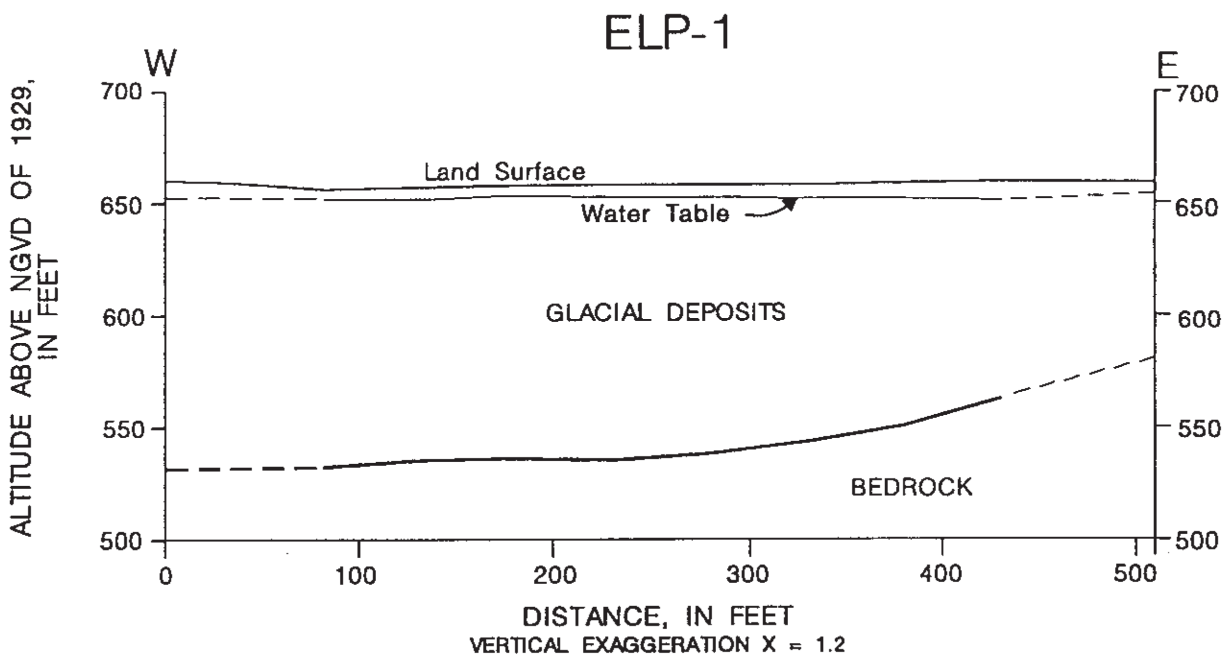

DXF-1
NW
SE
ALTITUDE ABOVE NGVD OF 1929, IN FEET
450
400
350
300
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
0
100
200
300
400
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 1.4


DXF-2
S
N
ALTITUDE ABOVE NGVD OF 1929, IN FEET
440
420
400
380
360
340
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
0
100
200
300
400
500
600
700
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 3.3

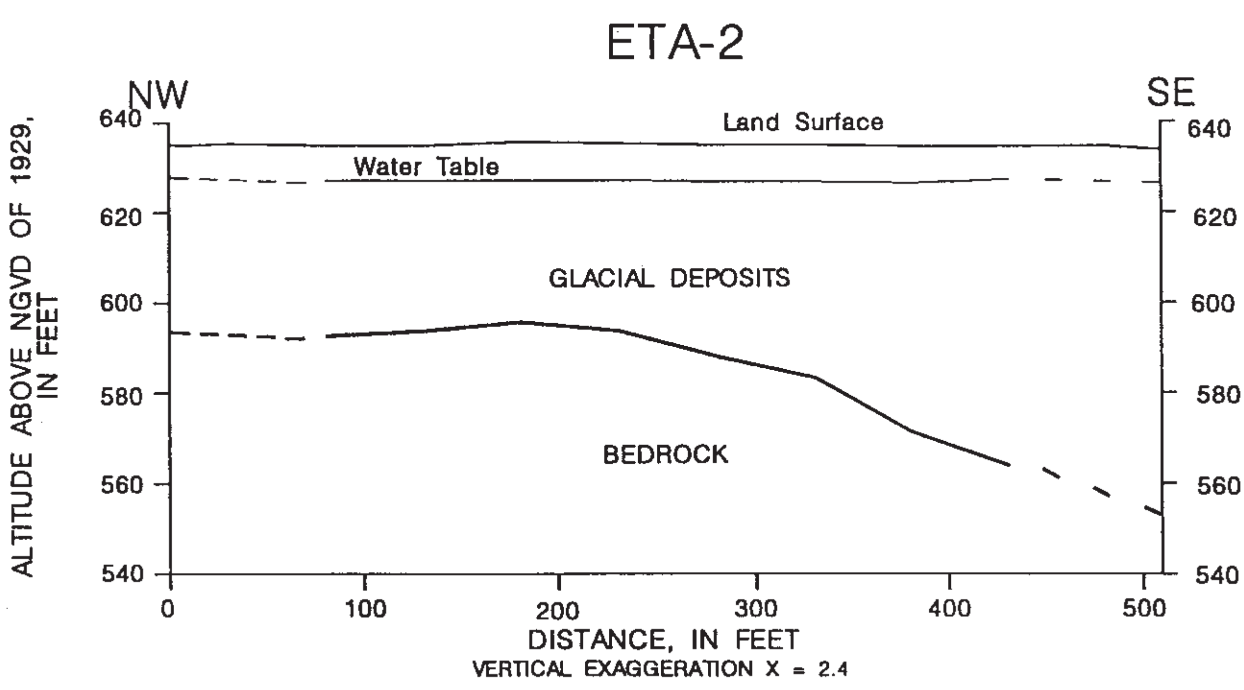

DXF-7
SW
NE
ALTITUDE ABOVE NGVD OF 1929, IN FEET
450
400
350
300
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
0
100
200
300
400
500
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 1.4


DXF-10
N
S
450
400
350
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
ALTITUDE ABOVE NGVD OF 1929, IN FEET
0
100
200
300
400
500
600
700
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 3.4

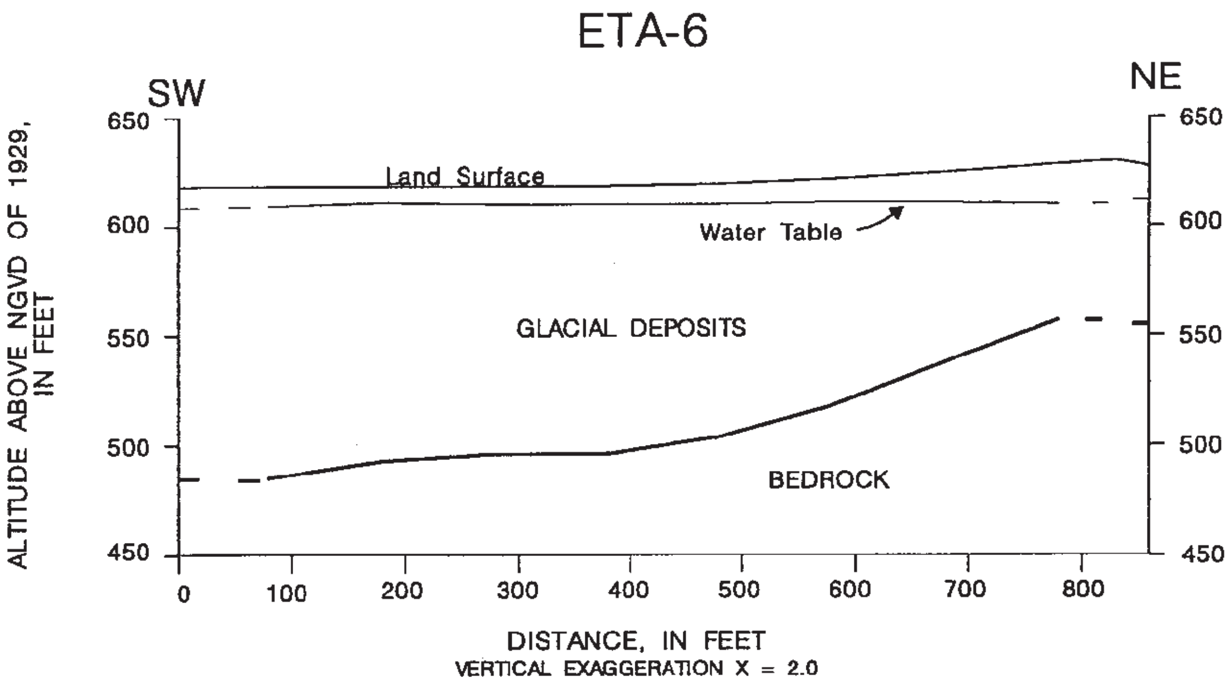

DXF-12
W
E
450
400
350
300
250
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
ALTITUDE ABOVE NGVD OF 1929, IN FEET
0
100
200
300
400
500
600
700
800
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 2.0

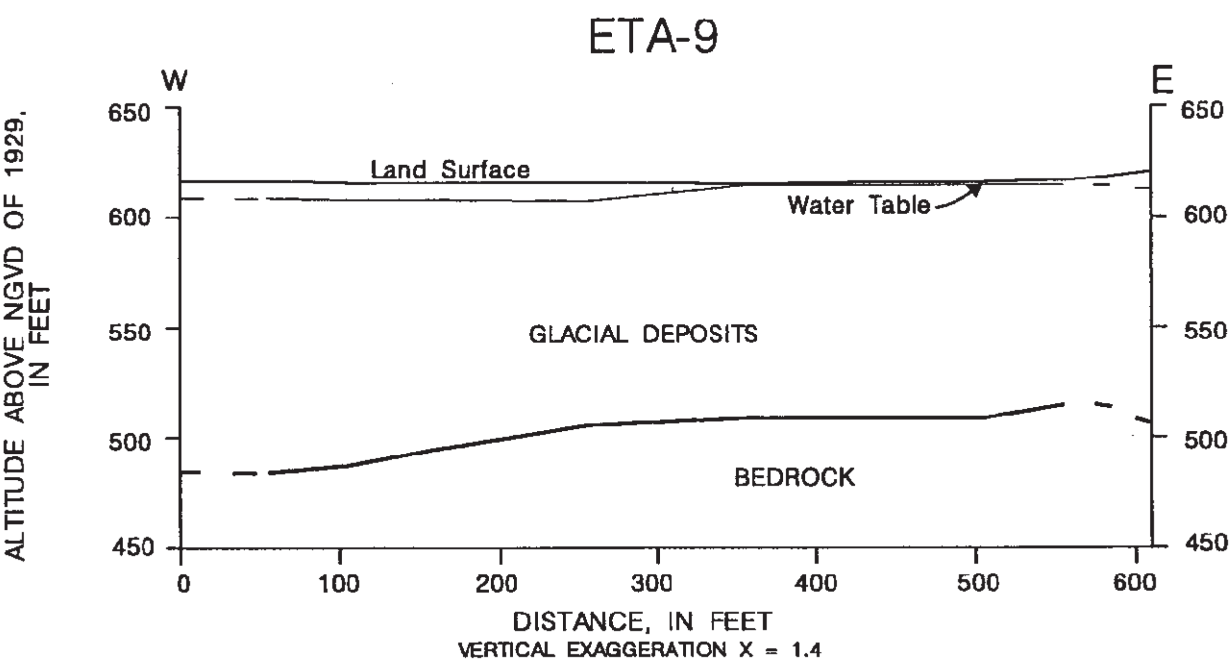


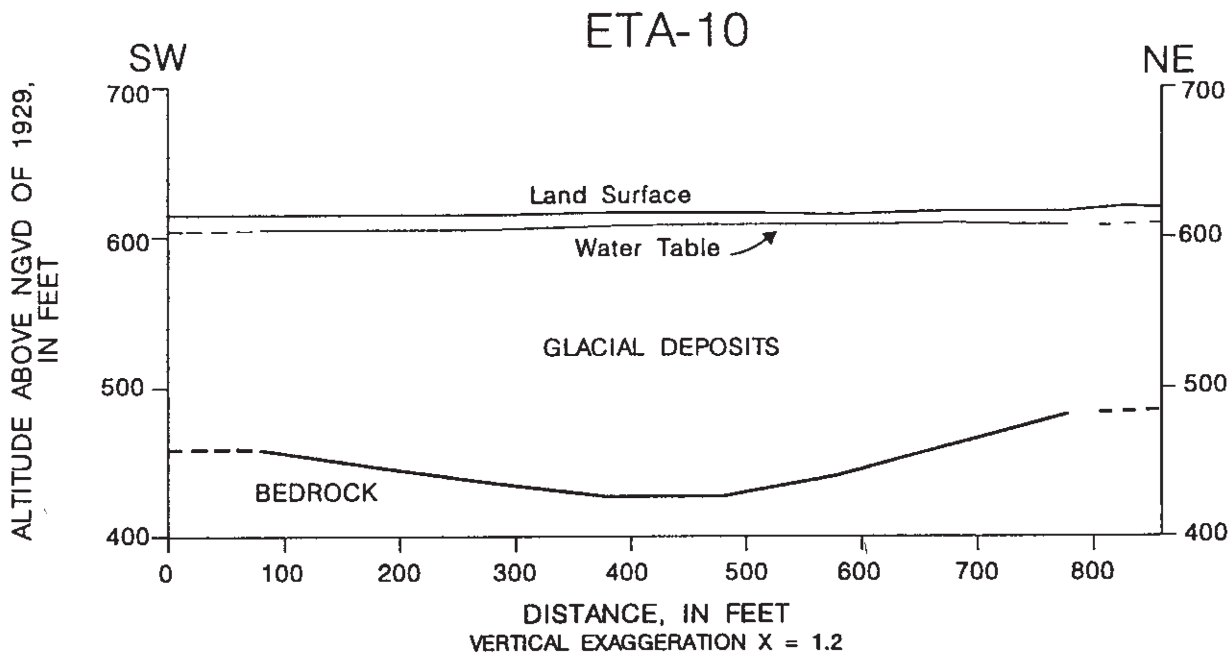
ELP-1
W
E
700
650
600
550
500
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
ALTITUDE ABOVE NGVD OF 1929, IN FEET
0
100
200
300
400
500
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 1.2

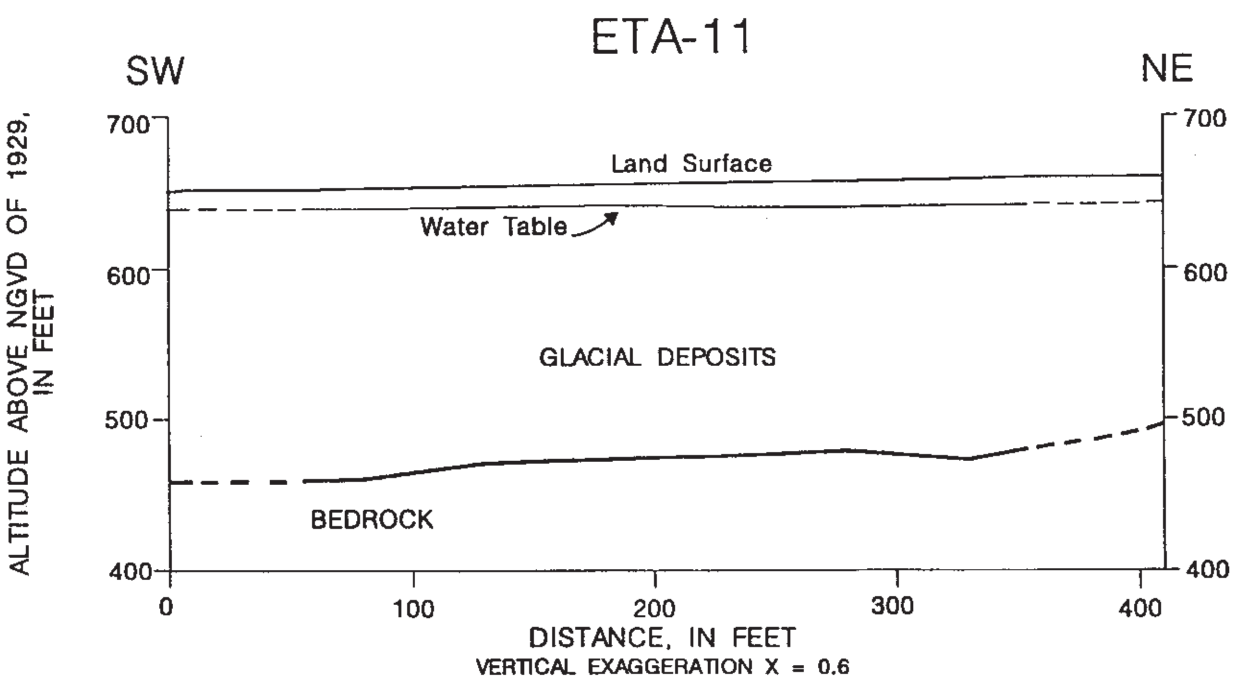


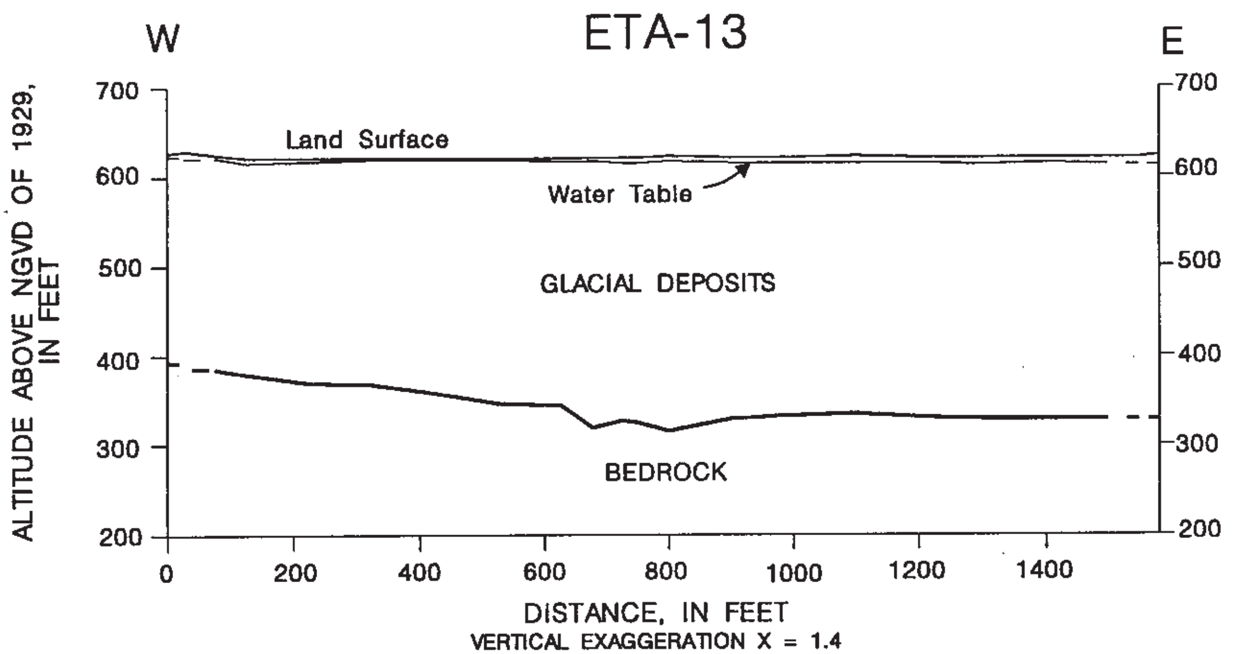
ETA-2
NW
SE
640
620
600
580
560
540
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
ALTITUDE ABOVE NGVD OF 1929, IN FEET
0
100
200
300
400
500
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 2.4


ETA-6
SW
NE
650
600
550
500
450
ALTITUDE ABOVE NGVD OF 1929, IN FEET
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
0
100
200
300
400
500
600
700
800
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 2.0

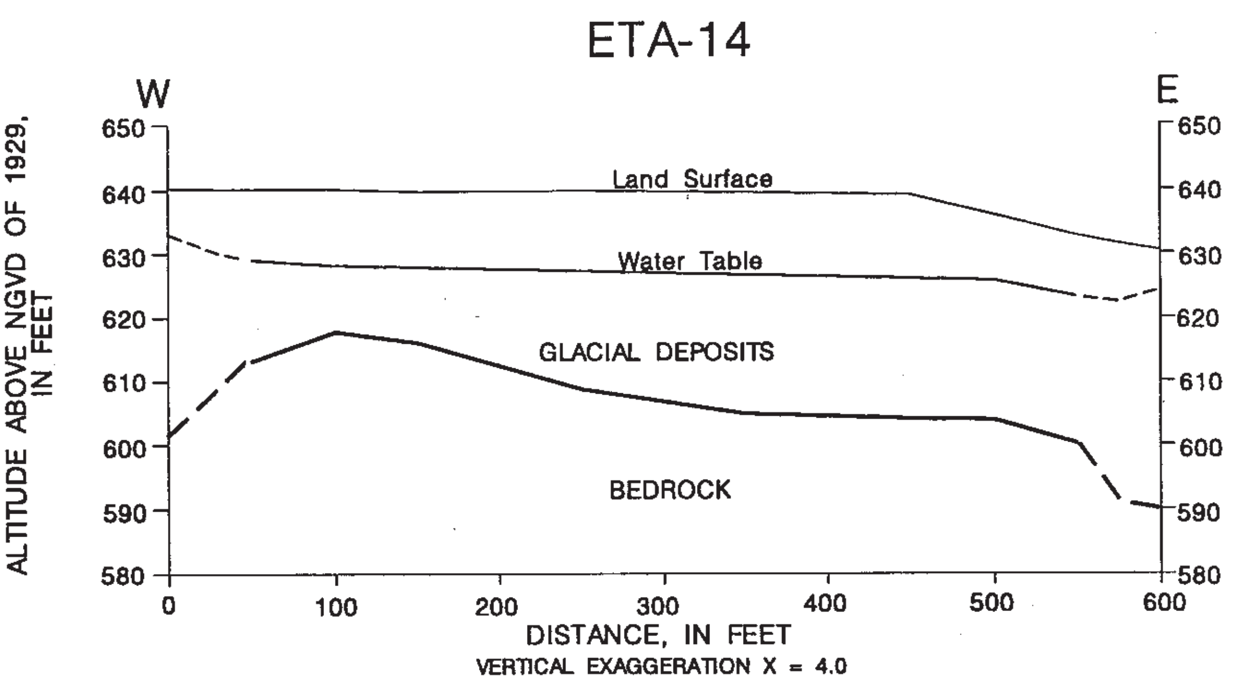

ETA-9
W
E
650
600
550
500
450
ALTITUDE ABOVE NGVD OF 1929, IN FEET
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
0
100
200
300
400
500
600
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 1.4


ETA-10
SW
NE
ALTITUDE ABOVE NGVD OF 1929, IN FEET
700
600
500
400
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
0
100
200
300
400
500
600
700
800
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 1.2

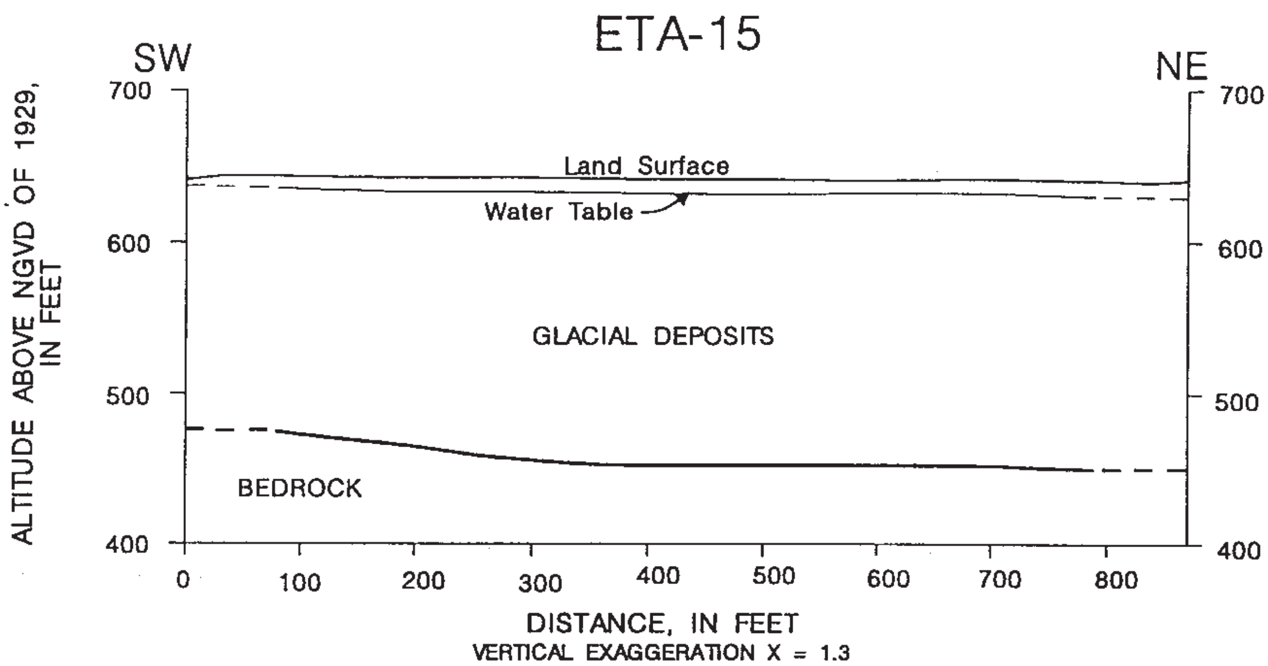

ETA-11
SW
NE
ALTITUDE ABOVE NGVD OF 1929, IN FEET
700
600
500
400
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
0
100
200
300
400
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 0.6

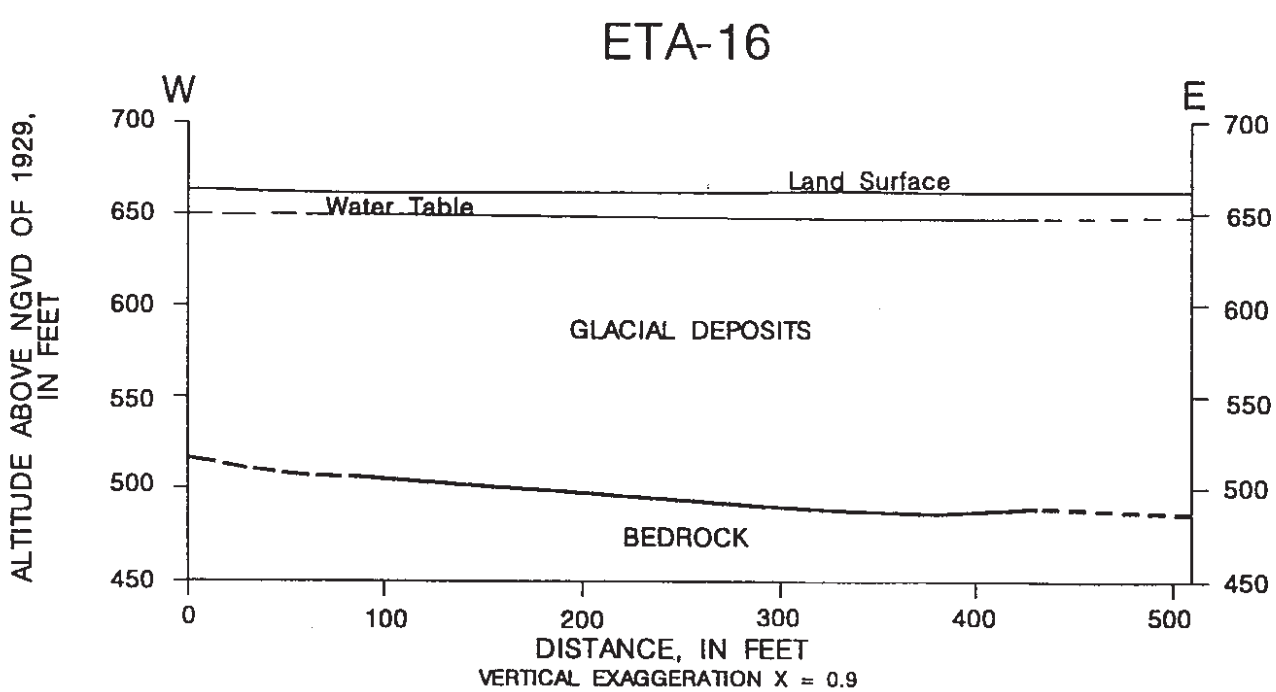


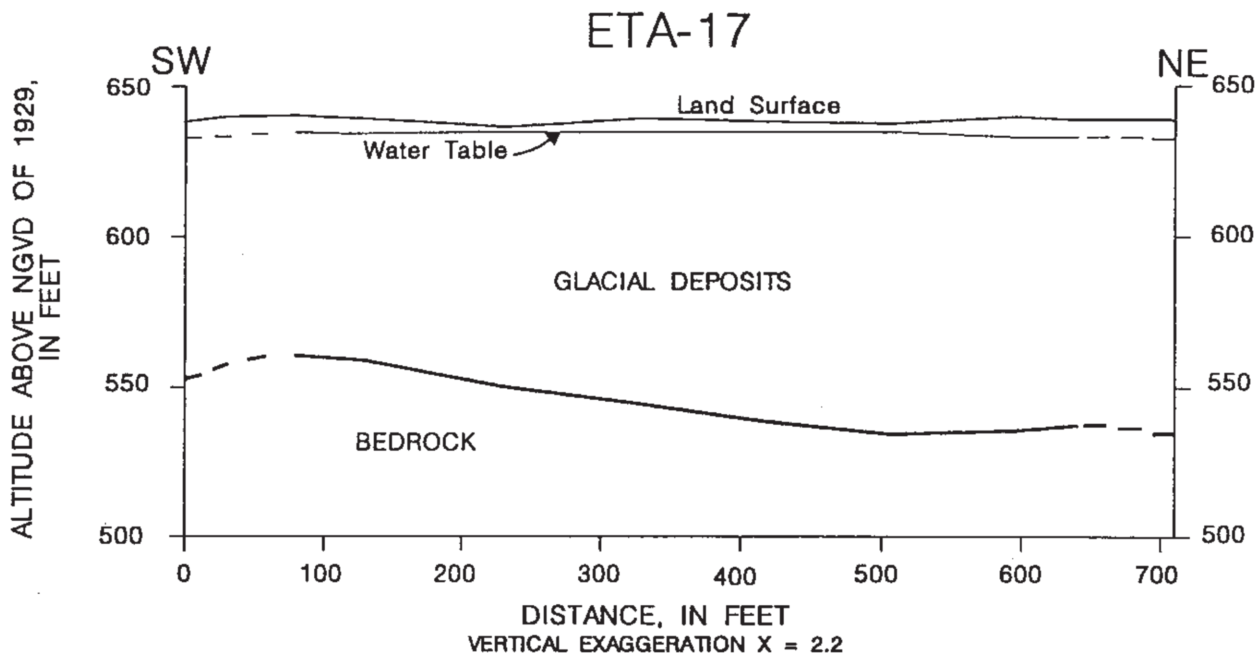
ETA-13
W
E
ALTITUDE ABOVE NGVD OF 1929, IN FEET
700
600
500
400
300
200
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
0
200
400
600
800
1000
1200
1400
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 1.4

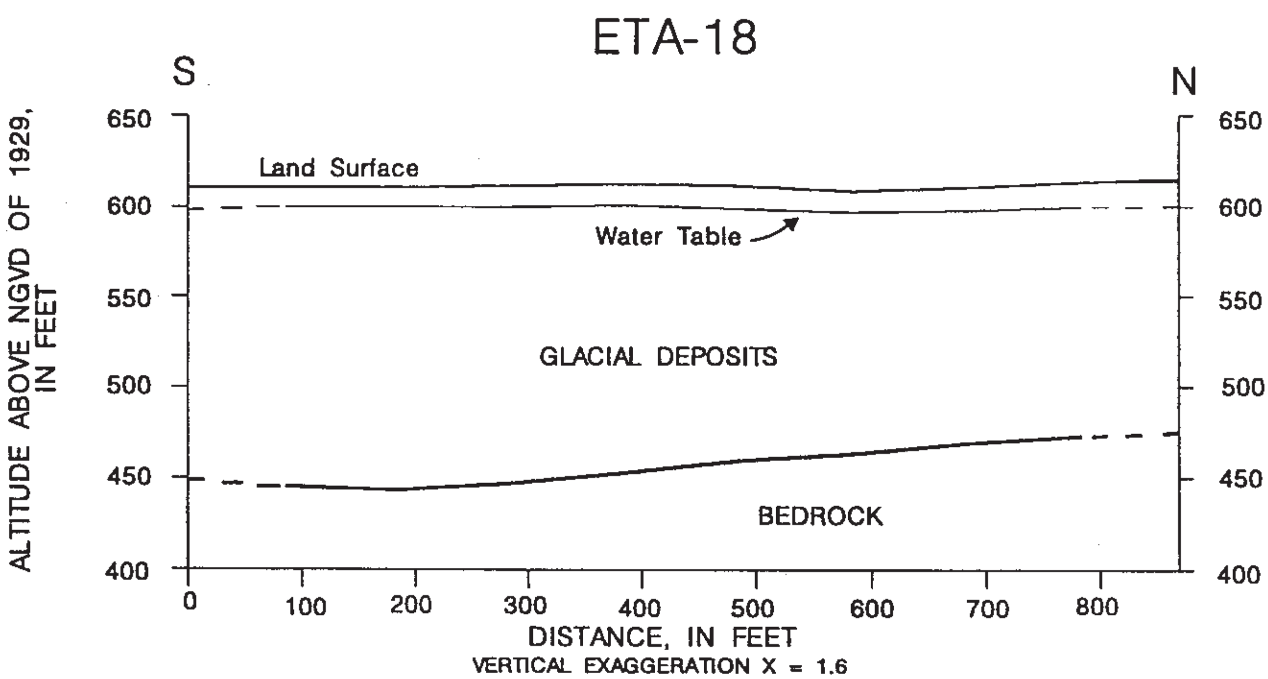


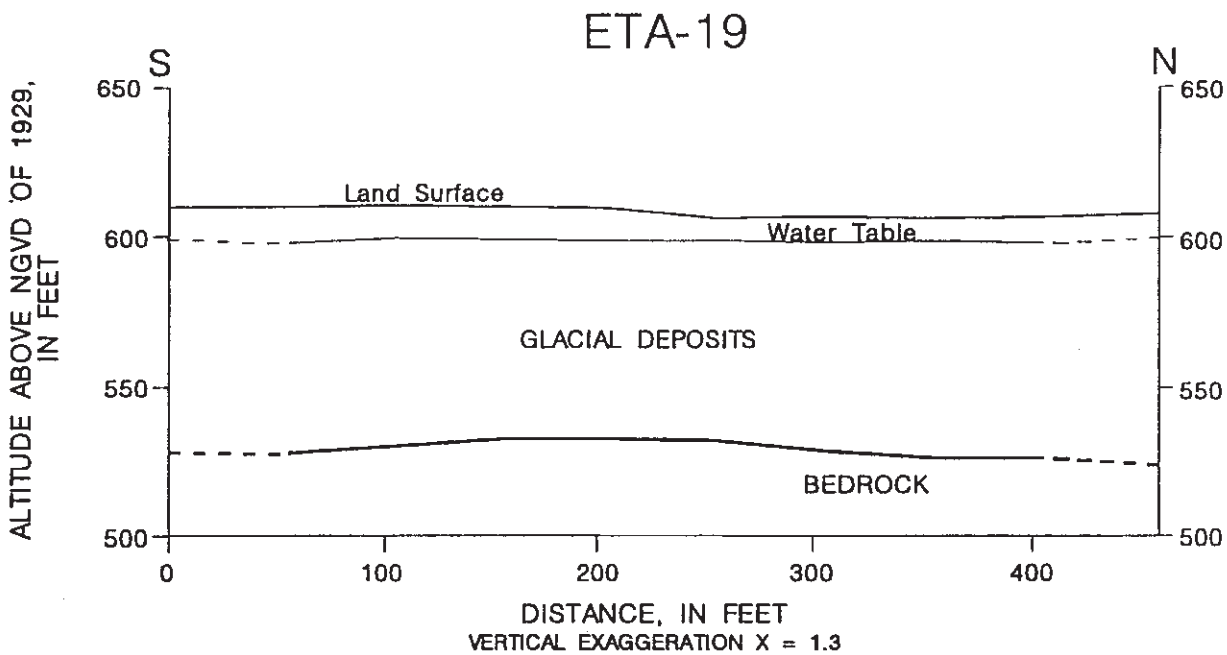
ETA-14
W
E
ALTITUDE ABOVE NGVD OF 1929, IN FEET
650
640
630
620
610
600
590
580
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
0
100
200
300
400
500
600
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 4.0

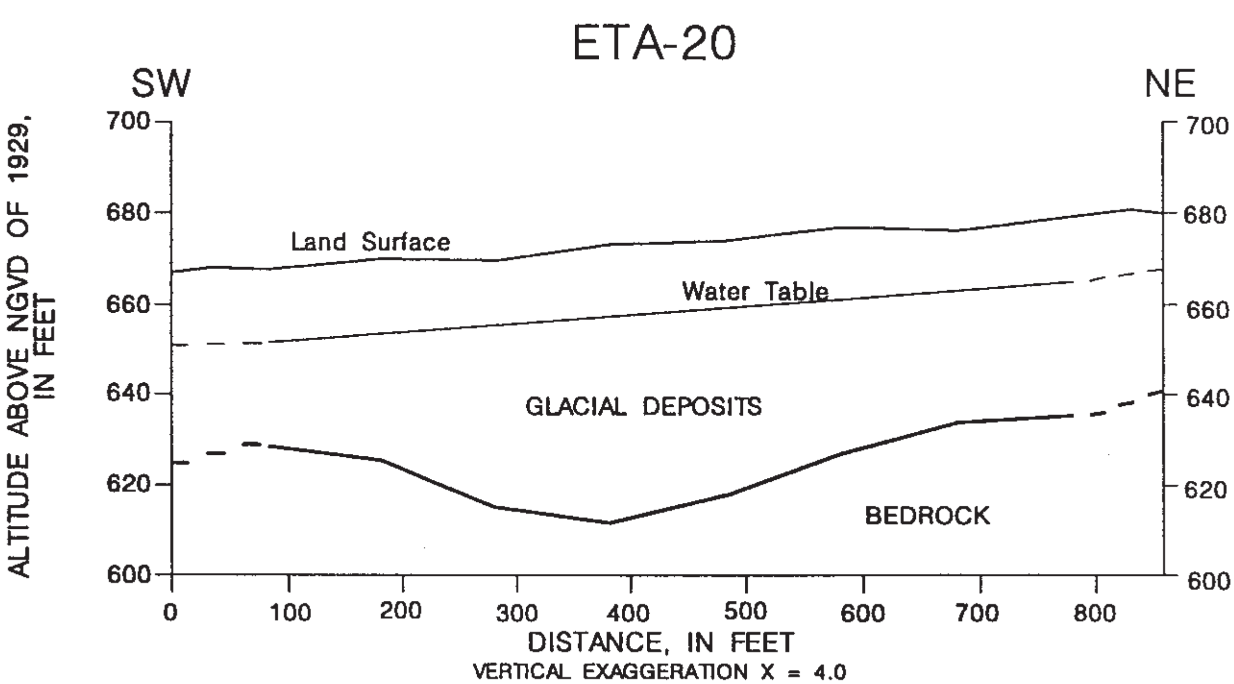

ETA-15
SW
NE
700
600
500
400
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
ALTITUDE ABOVE NGVD OF 1929, IN FEET
0
100
200
300
400
500
600
700
800
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 1.3

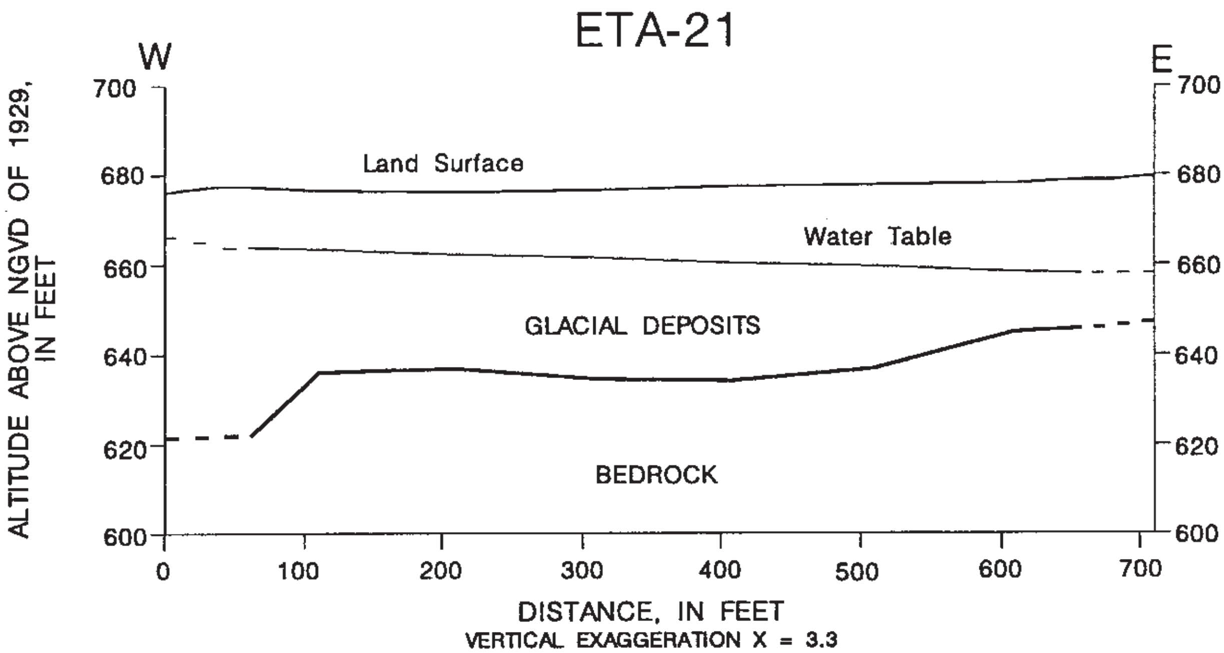

ETA-16
W
E
700
650
600
550
500
450
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
ALTITUDE ABOVE NGVD OF 1929, IN FEET
0
100
200
300
400
500
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 0.9

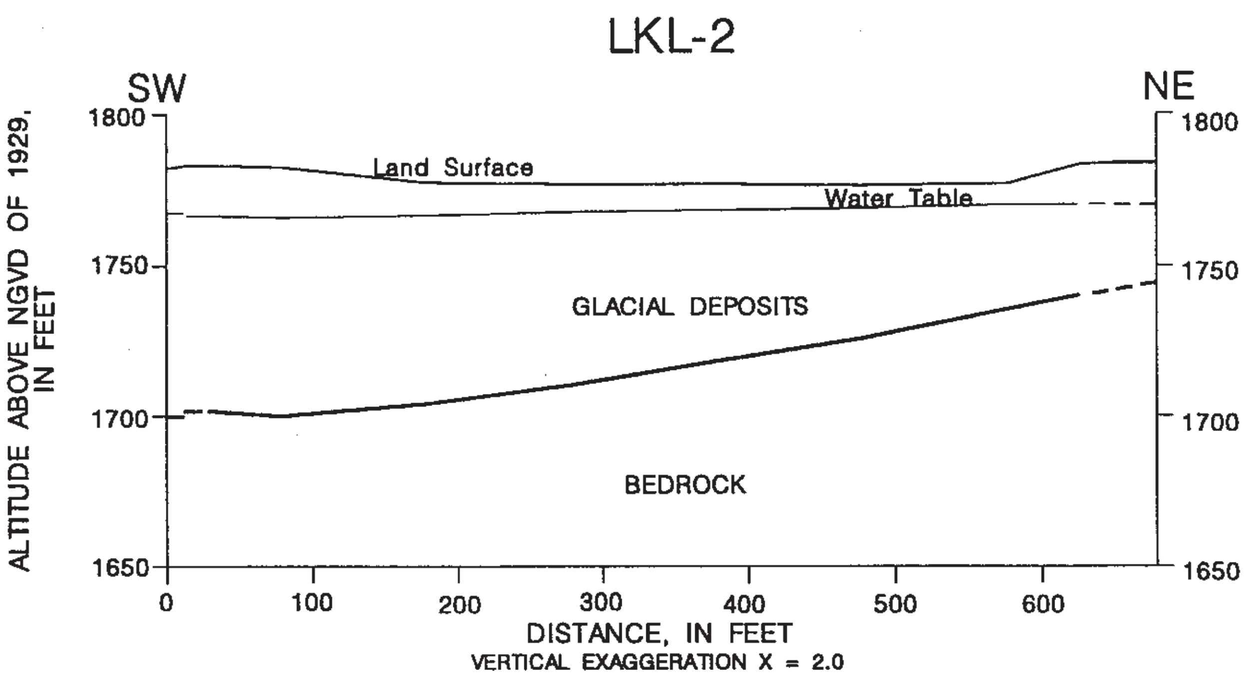

ETA-17
SW
NE
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
ALTITUDE ABOVE NGVD OF 1929, IN FEET
650
600
550
500
0
100
200
300
400
500
600
700
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 2.2

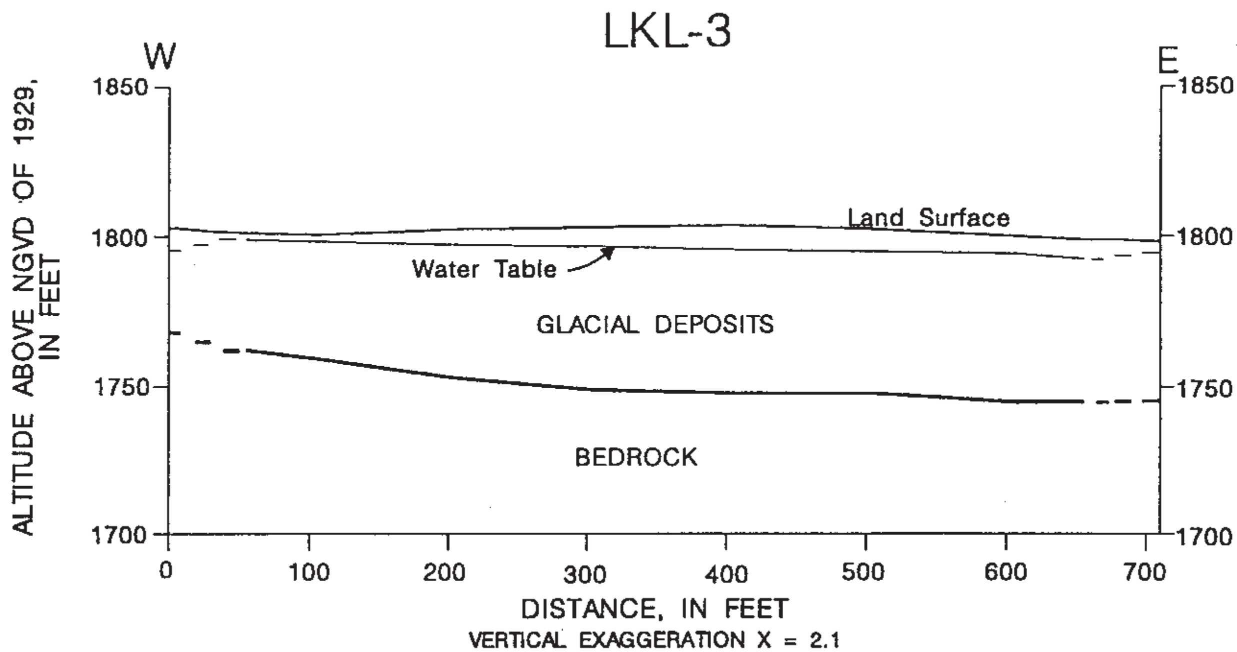

ETA-18
S
N
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
ALTITUDE ABOVE NGVD OF 1929, IN FEET
650
600
550
500
450
400
0
100
200
300
400
500
600
700
800
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 1.6

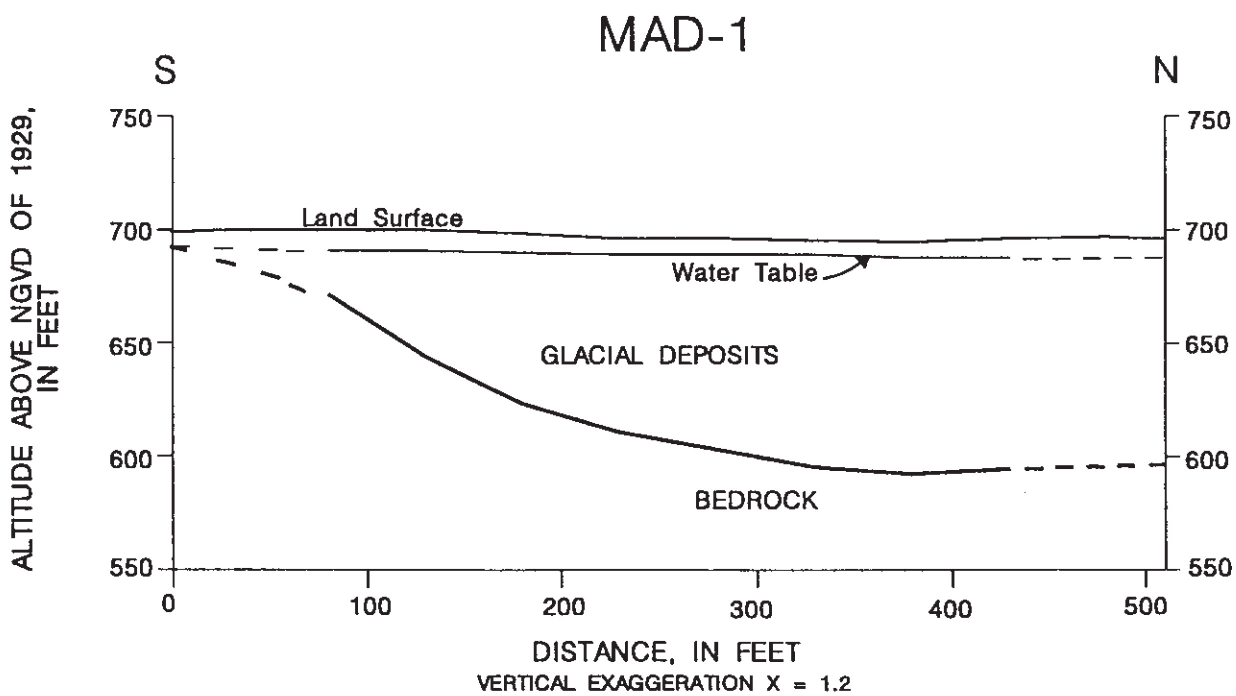

ETA-19
S
N
650
600
550
500
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
ALTITUDE ABOVE NGVD OF 1929, IN FEET
0
100
200
300
400
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 1.3

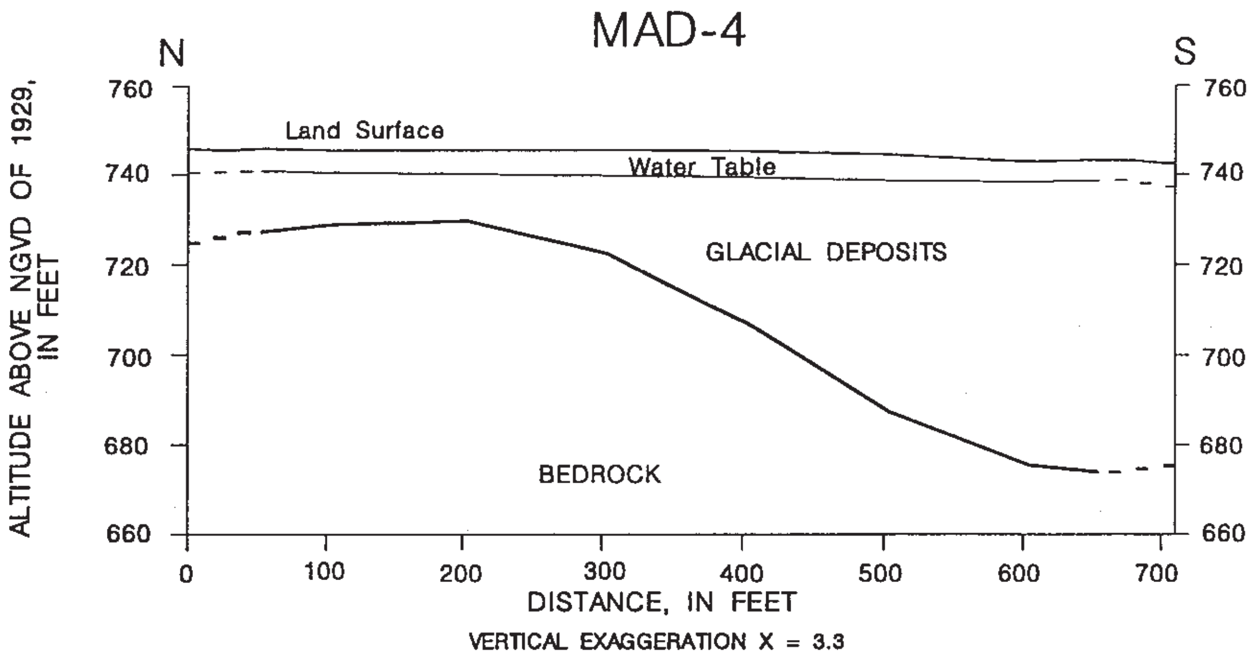

ETA-20
SW
NE
700
680
660
640
620
600
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
ALTITUDE ABOVE NGVD OF 1929, IN FEET
0
100
200
300
400
500
600
700
800
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 4.0

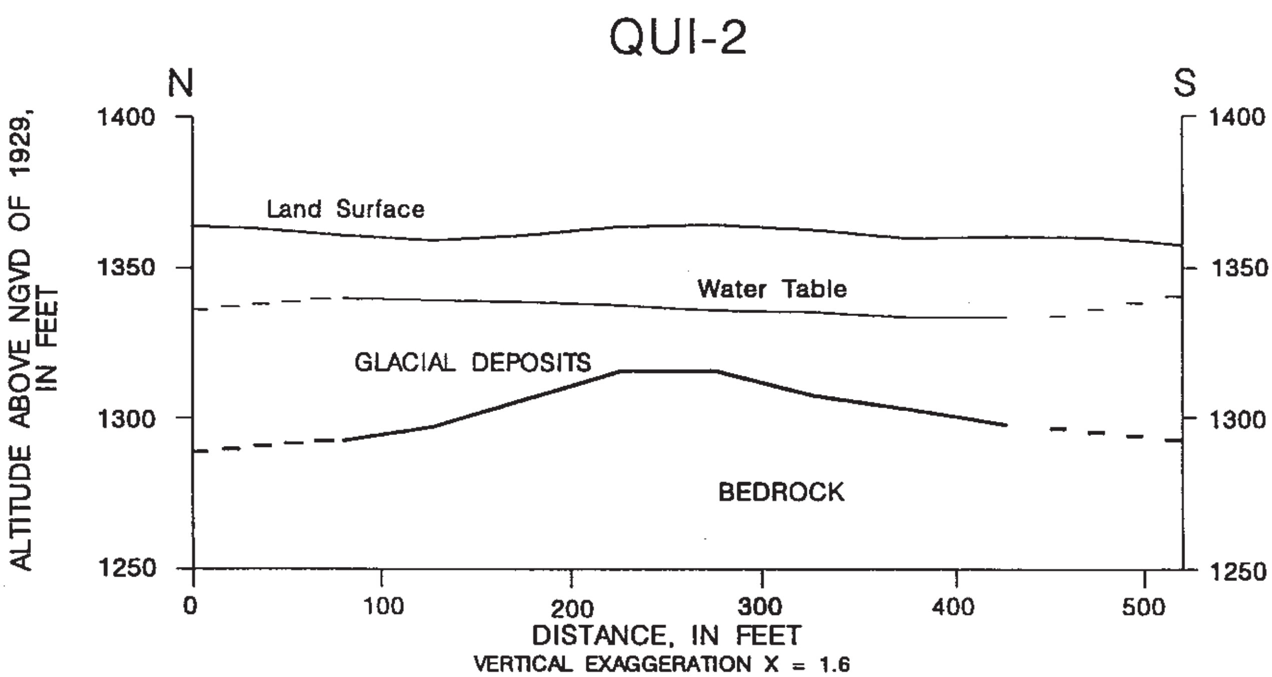

ETA-21
W
E
ALTITUDE ABOVE NGVD OF 1929, IN FEET
700
680
660
640
620
600
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
0
100
200
300
400
500
600
700
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 3.3

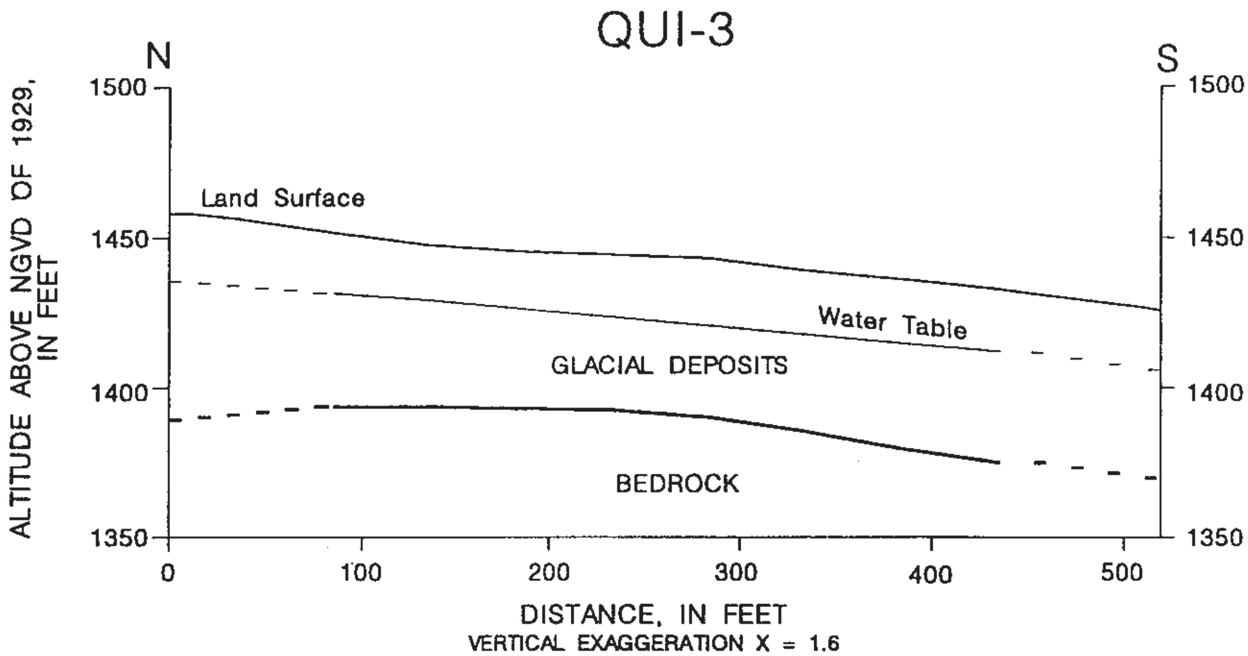

LKL-2
SW
NE
ALTITUDE ABOVE NGVD OF 1929, IN FEET
1800
1750
1700
1650
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
0
100
200
300
400
500
600
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 2.0

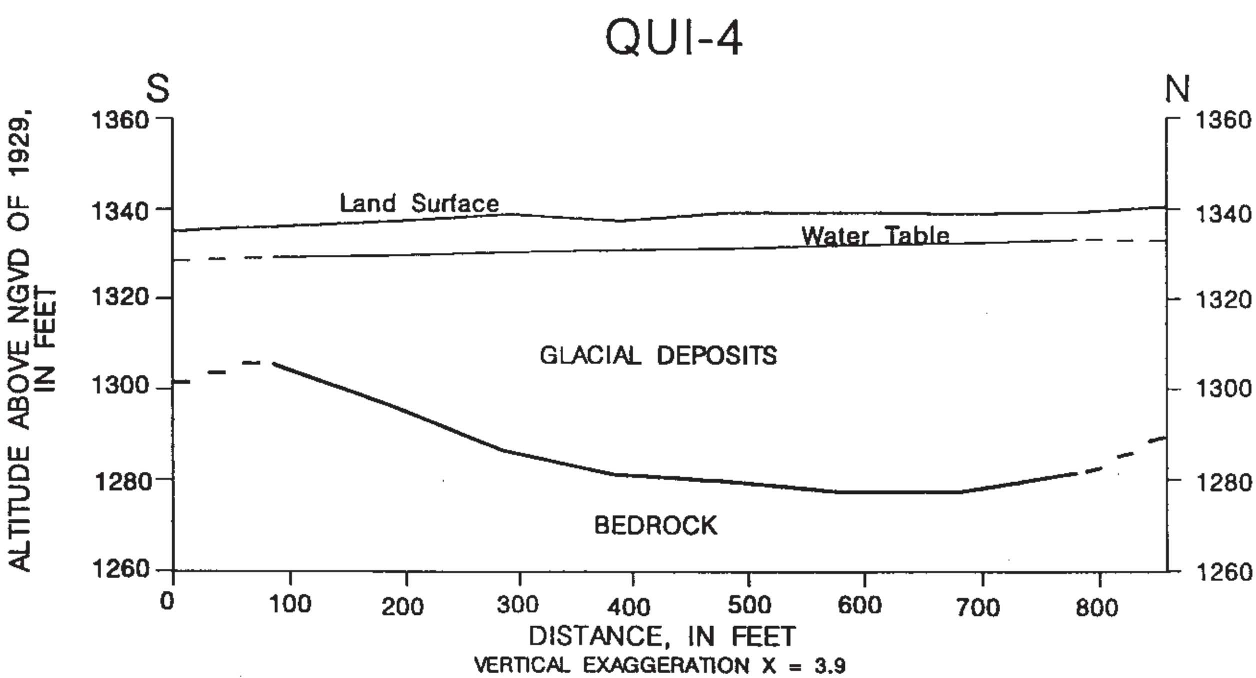

LKL-3
W
E
1850
1800
1750
1700
ALTITUDE ABOVE NGVD OF 1929, IN FEET
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
0
100
200
300
400
500
600
700
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 2.1

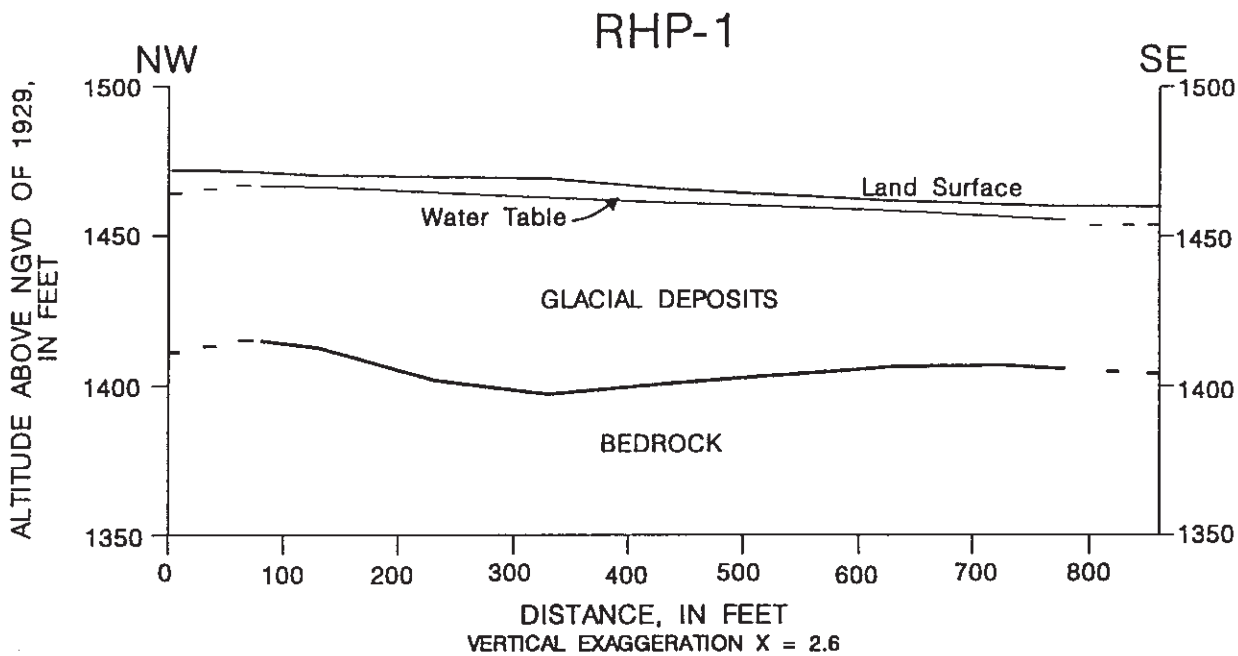

MAD-1
S
N
750
700
650
600
550
ALTITUDE ABOVE NGVD OF 1929, IN FEET
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
0
100
200
300
400
500
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 1.2

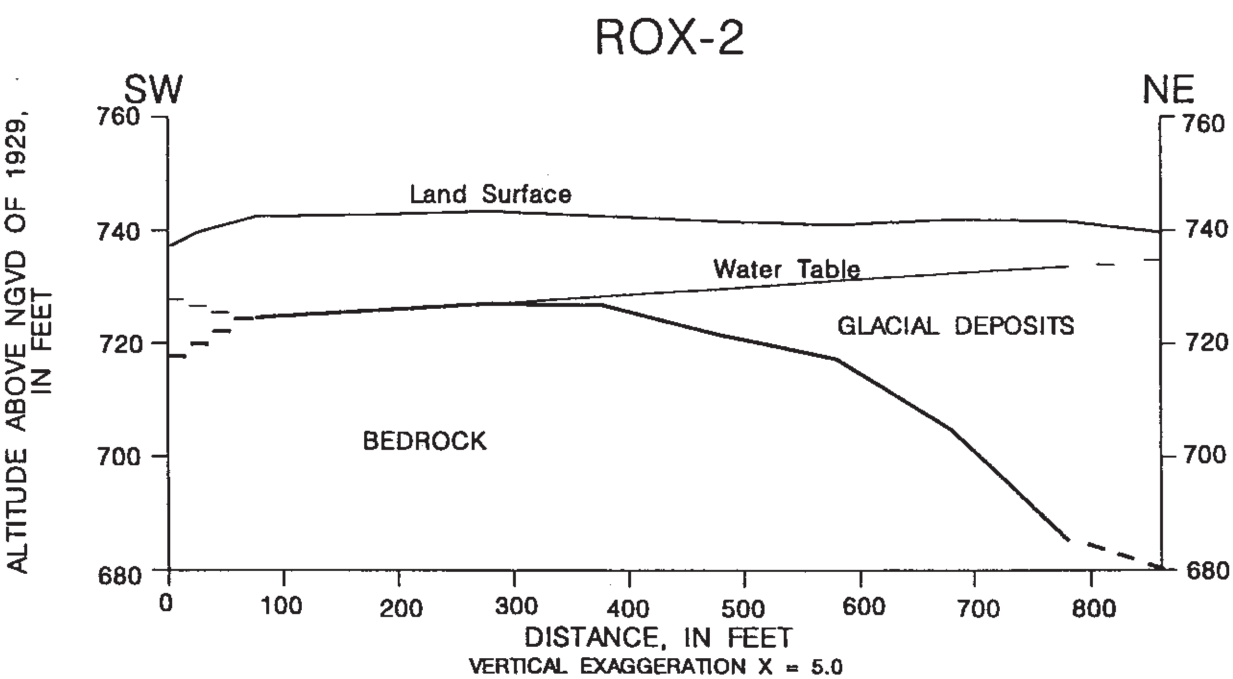

MAD-4
N
S
ALTITUDE ABOVE NGVD OF 1929, IN FEET
760
740
720
700
680
660
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
0
100
200
300
400
500
600
700
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 3.3

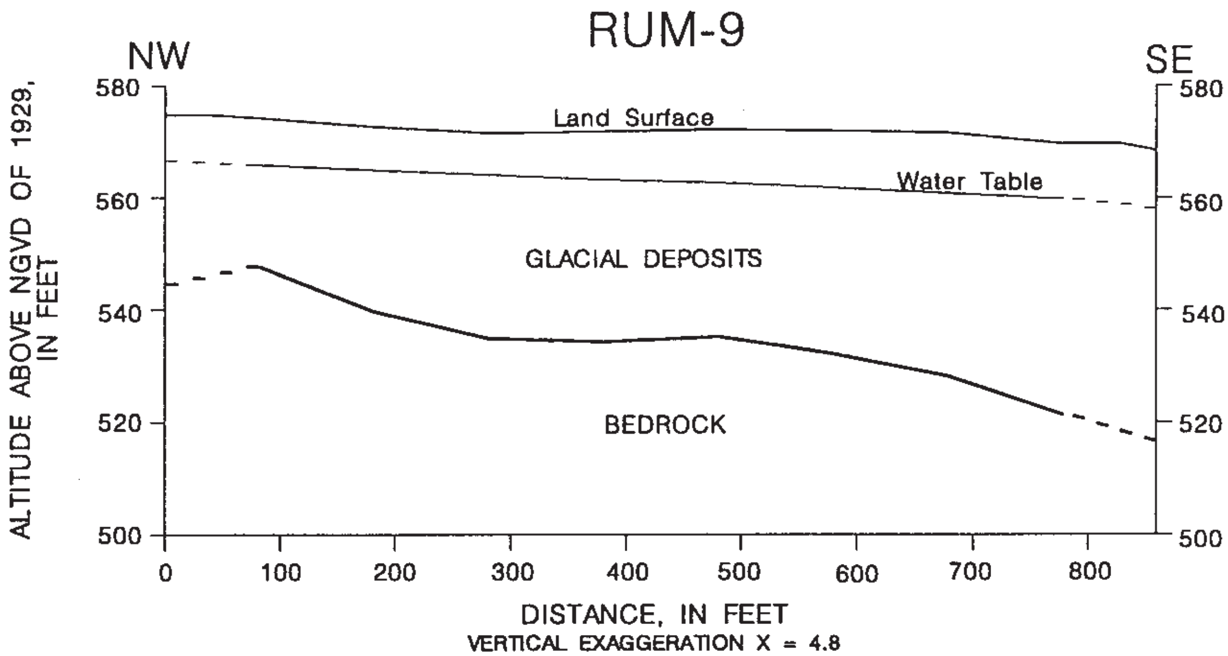

QUI-2
N
S
ALTITUDE ABOVE NGVD OF 1929, IN FEET
1400
1350
1300
1250
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
0
100
200
300
400
500
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 1.6


QUI-3
N
S
1500
1450
1400
1350
ALTITUDE ABOVE NGVD OF 1929, IN FEET
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
0
100
200
300
400
500
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 1.6

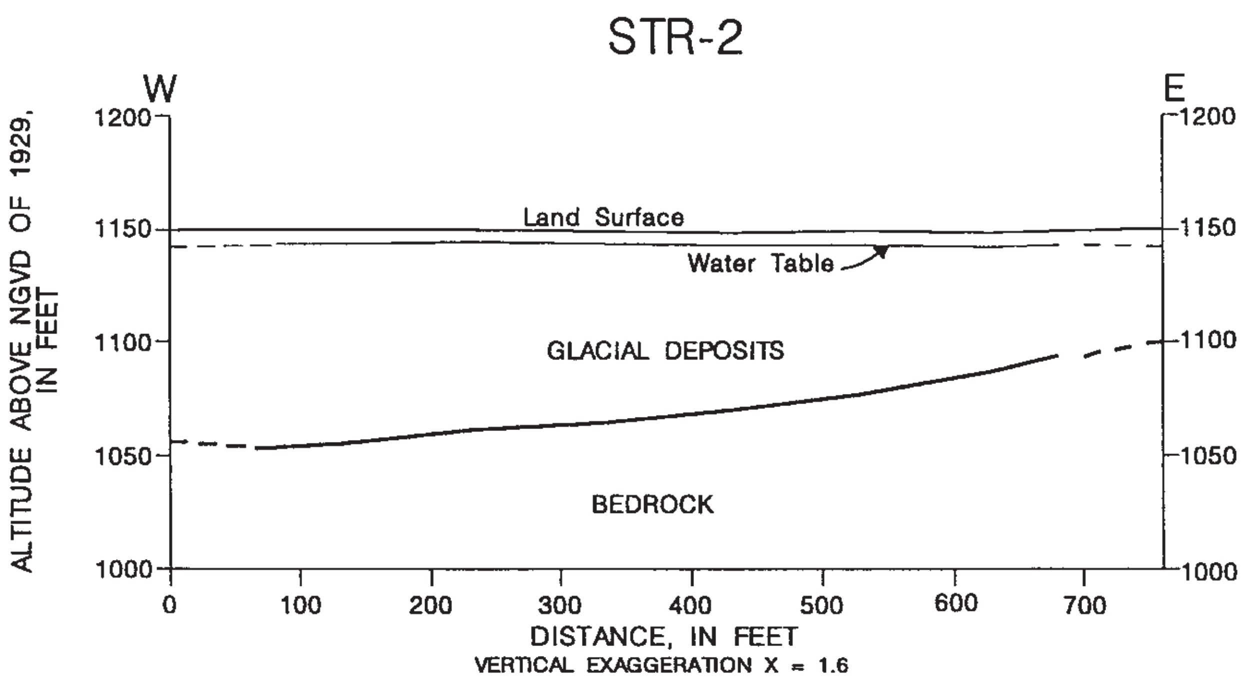

QUI-4
S
N
1360
1340
1320
1300
1280
1260
ALTITUDE ABOVE NGVD OF 1929, IN FEET
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
0
100
200
300
400
500
600
700
800
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 3.9


RHP-1
NW
SE
ALTITUDE ABOVE NGVD OF 1929, IN FEET
1500
1450
1400
1350
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
0
100
200
300
400
500
600
700
800
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 2.6

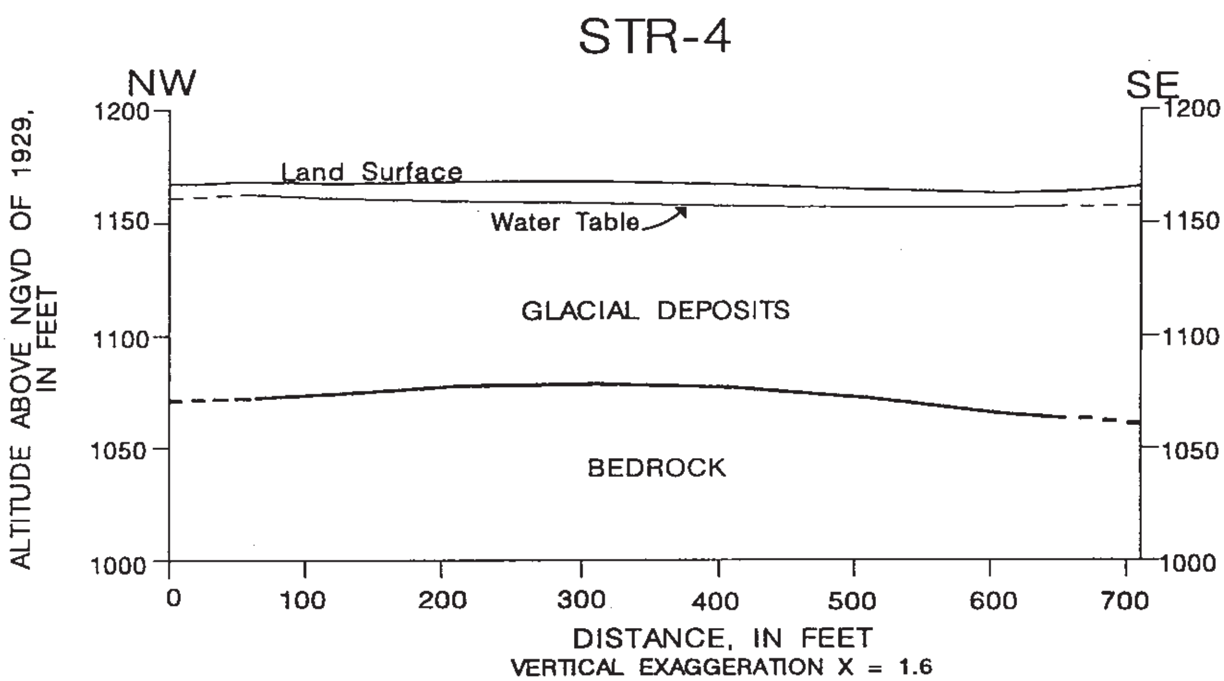

ROX-2
SW
NE
ALTITUDE ABOVE NGVD OF 1929, IN FEET
760
740
720
700
680
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
0
100
200
300
400
500
600
700
800
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 5.0



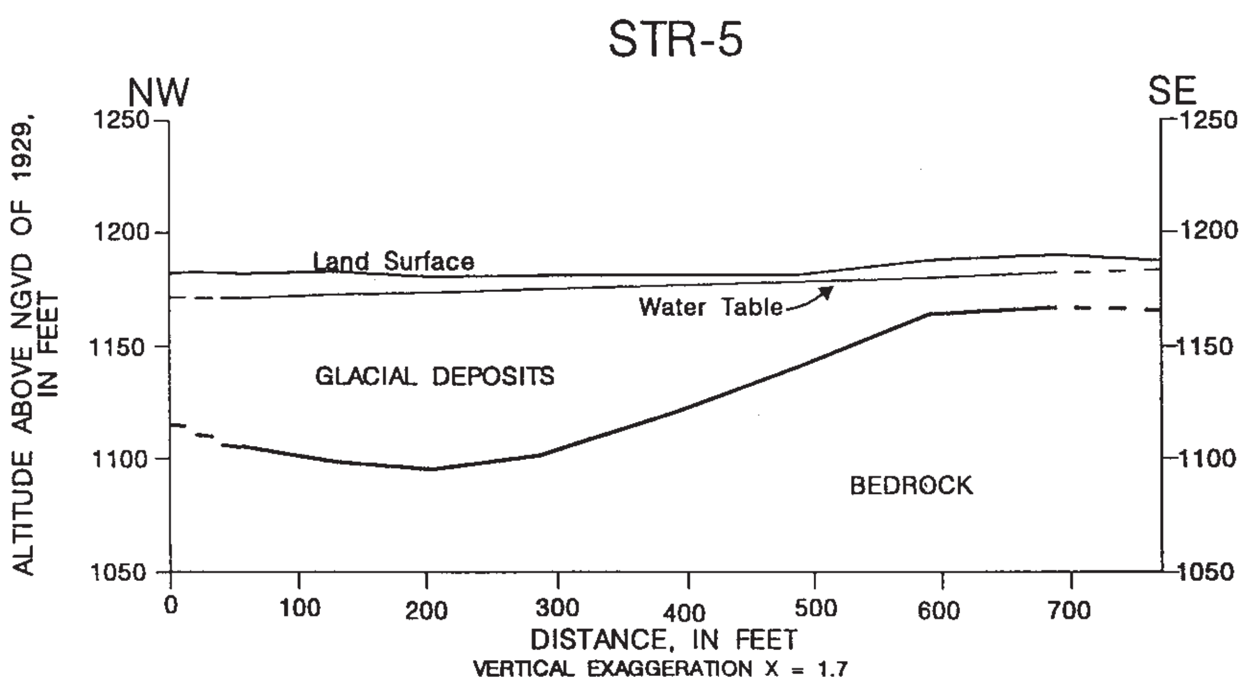
RUM-9
NW
SE
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
ALTITUDE ABOVE NGVD OF 1929, IN FEET
580
560
540
520
500
0
100
200
300
400
500
600
700
800
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 4.8



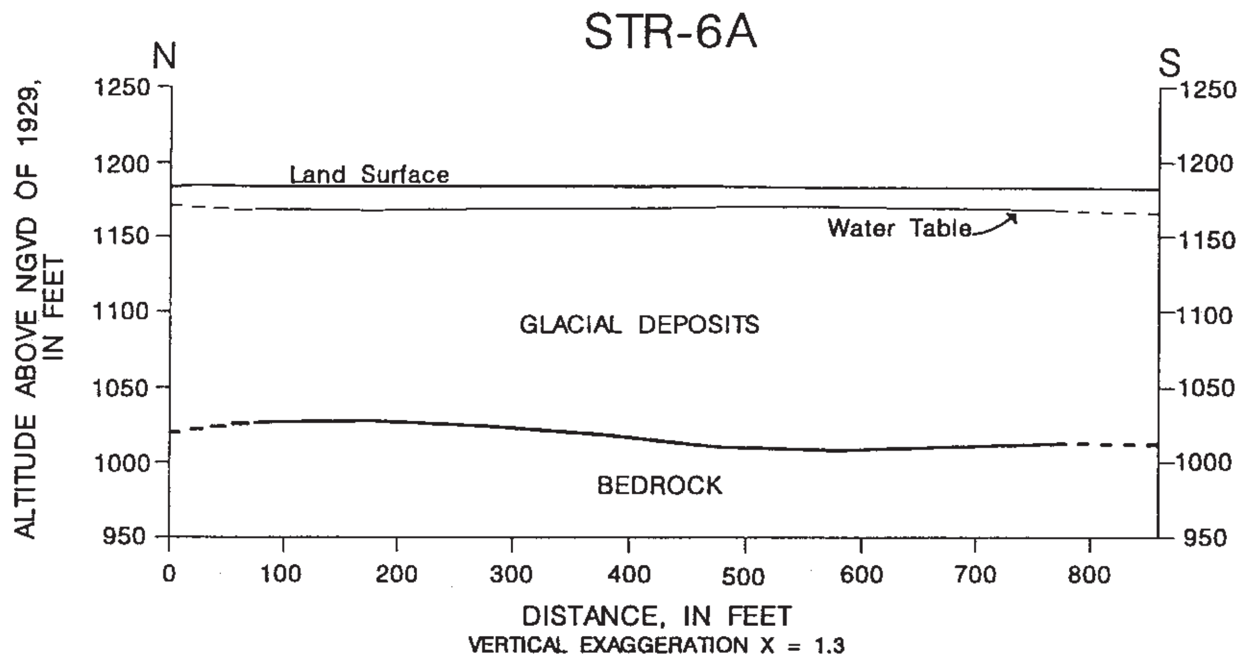
STR-2
W
E
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
ALTITUDE ABOVE NGVD OF 1929, IN FEET
1200
1150
1100
1050
1000
0
100
200
300
400
500
600
700
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 1.6

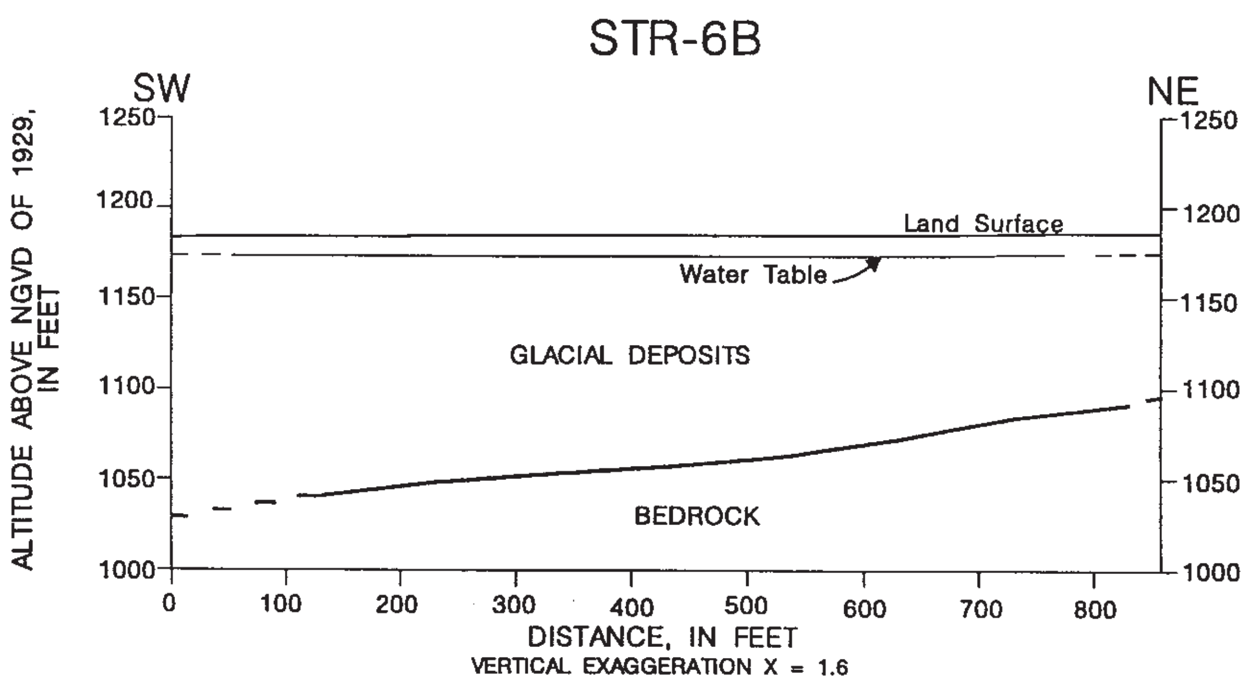


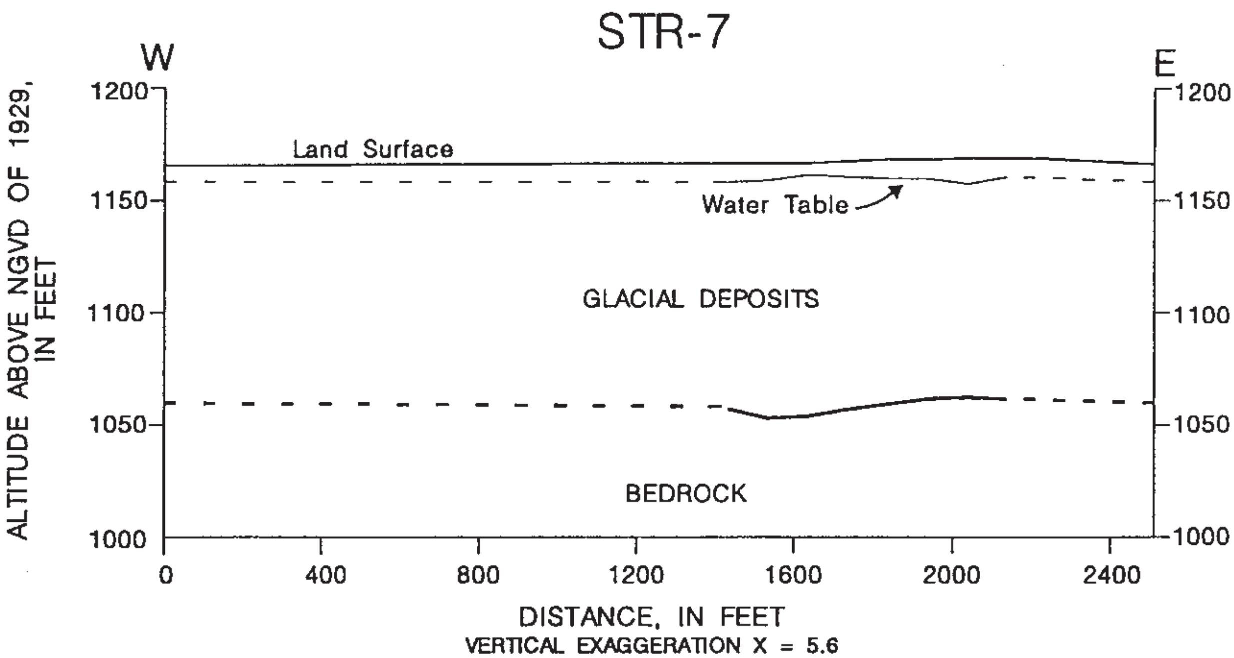
STR-4
NW
SE
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
ALTITUDE ABOVE NGVD OF 1929, IN FEET
1200
1150
1100
1050
1000
0
100
200
300
400
500
600
700
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 1.6



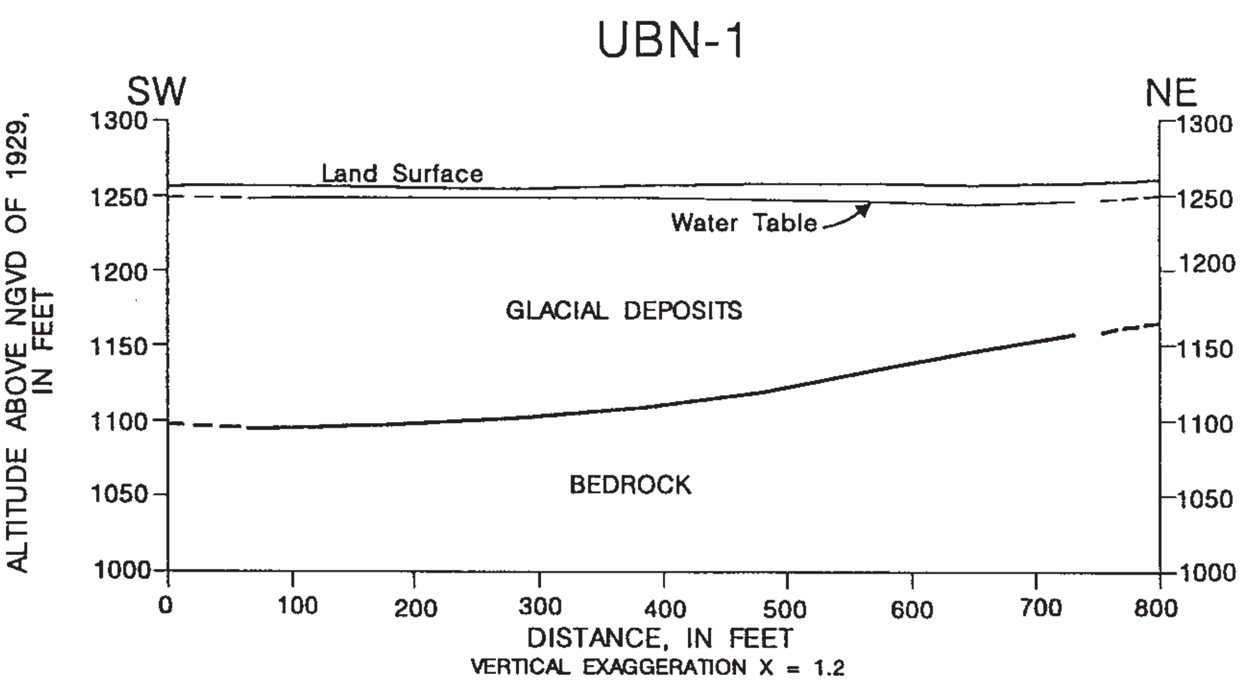
STR-5
NW
SE
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
ALTITUDE ABOVE NGVD OF 1929, IN FEET
1250
1200
1150
1100
1050
0
100
200
300
400
500
600
700
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 1.7


STR-6A
N
S
1250
1200
1150
1100
1050
1000
950
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
ALTITUDE ABOVE NGVD OF 1929, IN FEET
0
100
200
300
400
500
600
700
800
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 1.3

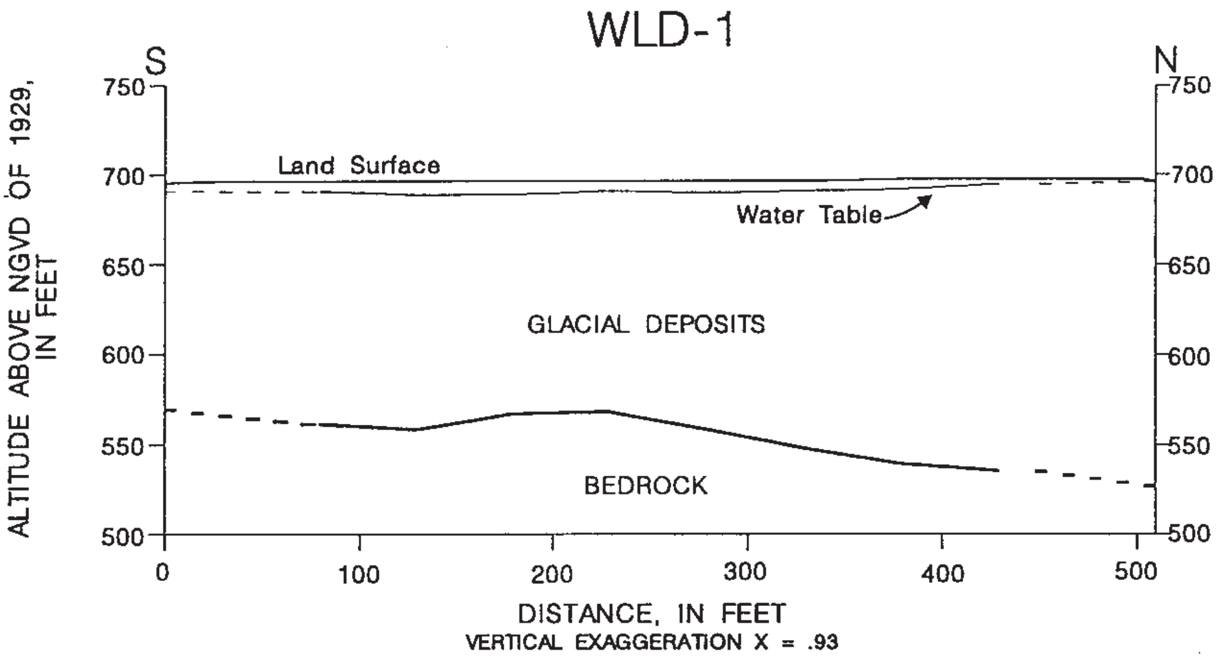

STR-6B
SW
NE
1250
1200
1150
1100
1050
1000
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
ALTITUDE ABOVE NGVD OF 1929, IN FEET
0
100
200
300
400
500
600
700
800
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 1.6

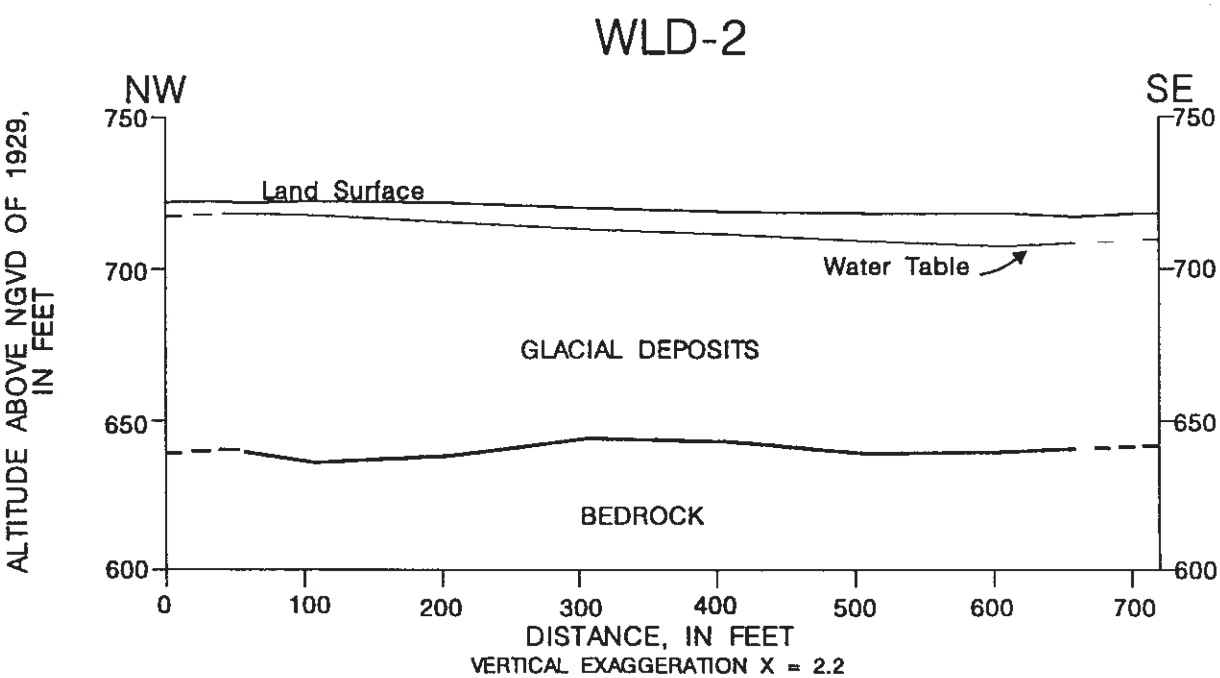


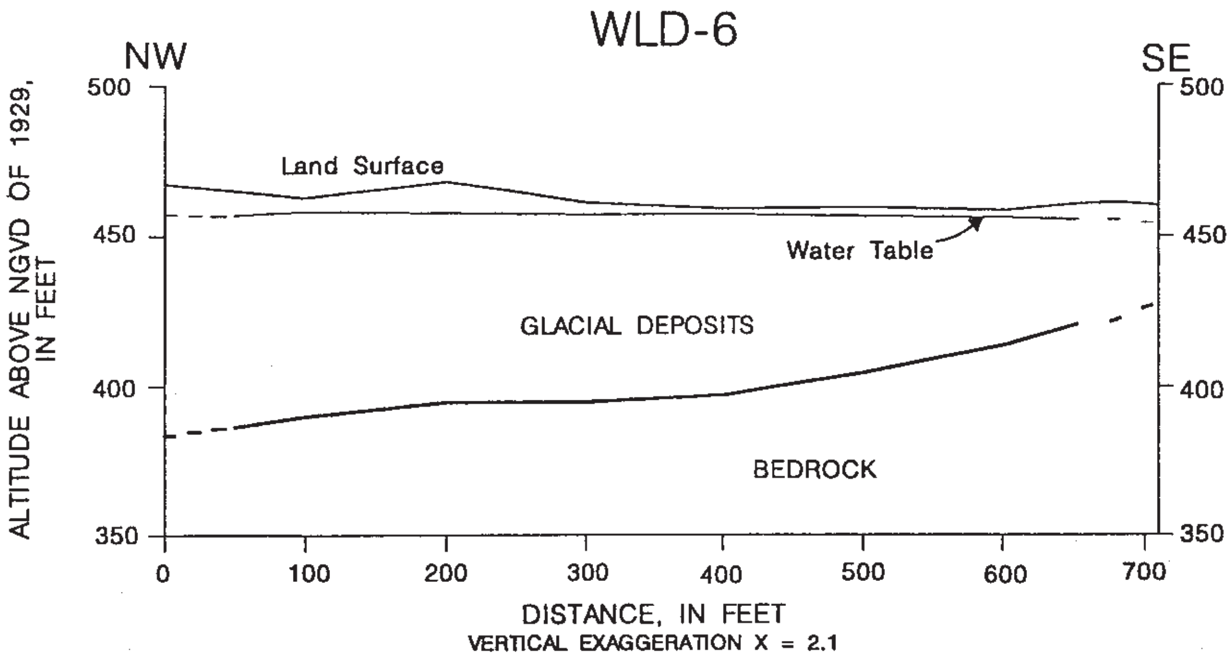
STR-7
W
E
ALTITUDE ABOVE NGVD OF 1929, IN FEET
1200
1150
1100
1050
1000
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
0
400
800
1200
1600
2000
2400
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 5.6

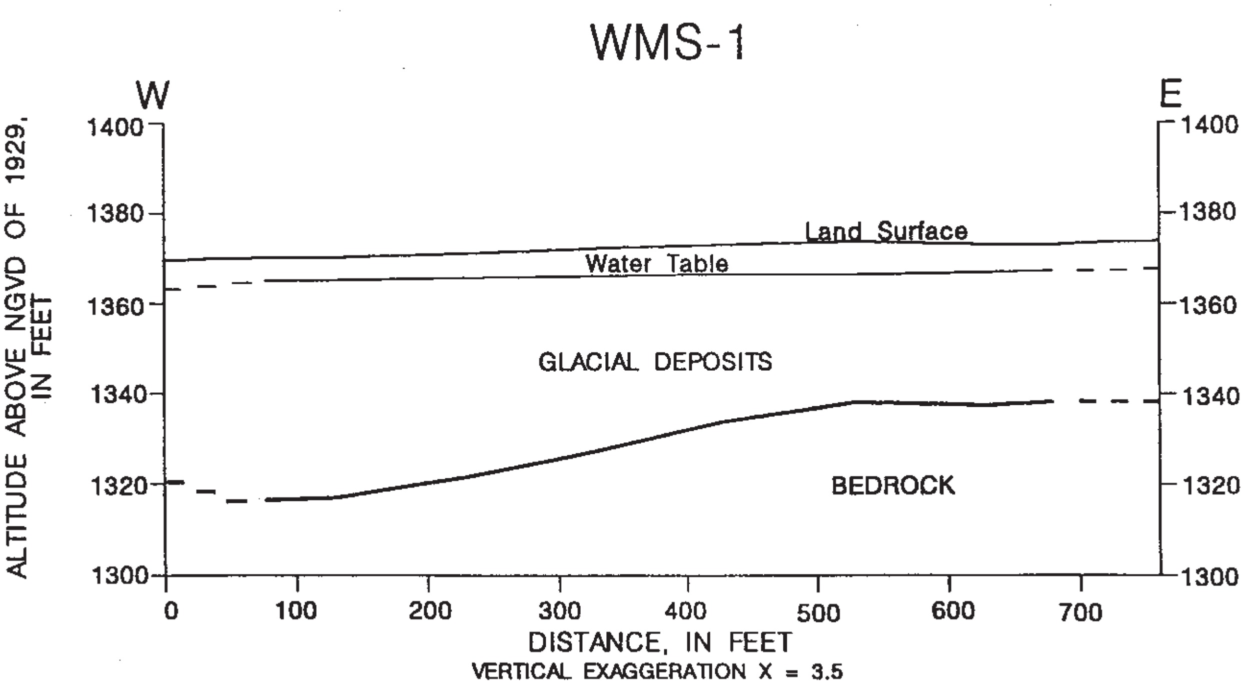


UBN-1
SW
NE
ALTITUDE ABOVE NGVD OF 1929, IN FEET
1300
1250
1200
1150
1100
1050
1000
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
0
100
200
300
400
500
600
700
800
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 1.2


WLD-1
S
N
750
700
650
600
550
500
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
ALTITUDE ABOVE NGVD OF 1929, IN FEET
0
100
200
300
400
500
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = .93


WLD-2
NW
SE
750
700
650
600
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
ALTITUDE ABOVE NGVD OF 1929, IN FEET
0
100
200
300
400
500
600
700
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 2.2


WLD-6
NW
SE
500
450
400
350
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
ALTITUDE ABOVE NGVD OF 1929, IN FEET
0
100
200
300
400
500
600
700
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 2.1


WMS-1
W
E
1400
1380
1360
1340
1320
1300
Land Surface
Water Table
GLACIAL DEPOSITS
BEDROCK
ALTITUDE ABOVE NGVD OF 1929, IN FEET
0
100
200
300
400
500
600
700
DISTANCE, IN FEET
VERTICAL EXAGGERATION X = 3.5

Appendix 3

Observation-Well and Test-Boring Logs [1]

Identification number: composed of three elements:

OW (Observation Well installed for collection of water-level and water-quality data) or TB (test boring drilled but no observation well installed); year well was drilled in; and a sequential number in the order the exploration borings were drilled.

Location: Latitude and longitude are specified; observation wells and test borings are located on the associated maps.

Site description: A brief site description is given.

Description of materials: Logs of observation wells and test borings, based on the Wentworth scale, in Pettijohn (1975).

Terms used in logs of exploration borings:

Sand and Gravel—Sorted sediment varying in size from boulders to very fine sand.

Silt—sediment particles ranging in size from 1/16 mm to 1/256 mm.

Clay—Sediment particles 1/256 mm and smaller in size.

Till—A predominantly nonsorted, nonstratified sediment deposited directly by a glacier and composed of boulders, gravel, sand, silt, and clay.

Loam—A mixture of sand, silt and clay particles which exhibits light and heavy properties in roughly equal proportions.

End of Boring—Depth of bottom of exploration boring in which bedrock or refusal was not reached.

Refusal—Depth at which drill equipment could not penetrate further. If it is fairly certain that a boulder was encountered, the word “boulder” is shown in parentheses after the word “refusal”. If it is fairly certain that the bedrock surface was encountered, the word “bedrock” is shown in parentheses after the word “refusal”.

PVC — Polyvinyl chloride

[1] See tables 1, 2, and 3 for information on grain-size analyses and estimated transmissivities and well yields.

OW 89-1. Latitude: 44°31'47" N., Longitude: 70°40'08" W.

Located on the East Andover quadrangle near Rumford Point in a field on the northwest side of Whippoorwill Road, approximately 0.2 miles west of the junction with the East Andover Road. Water level is approximately 16 feet below land surface.

MATERIAL	DEPTH (feet)	THICKNESS (feet)	SAMPLE INTERVAL (feet)
Loam, very fine silty sand	0 - 7	7	
Sand, medium, some fine to very coarse, some pebbles	7 - 12	5	
Sand, fine to very fine	12 - 38	26	27 - 29, 32 - 34, 37 - 39
Sand, very fine to fine, silt, blue grey	38 - 68	30	47 - 49, 57 - 59, 67 - 69
Sand, medium to coarse, few pebbles 1/4 - 1/2 " diameter	68 - 72	4	
Refusal (bedrock?)	72	—	

OW 89-1 is screened from 62 to 67 feet below land surface with a .006 inch slotted, schedule 40, PVC screen.

OW 89-2. Latitude: 44°41'58" N., Longitude: 70°36'28" W.

Located on the Roxbury quadrangle near Roxbury in a field on the west side of Route 17, approximately 0.4 miles north of the Roxbury - Byron townline. Water level is approximately 3 feet below land surface.

MATERIAL	DEPTH (feet)	THICKNESS (feet)	SAMPLE INTERVAL (feet)
Loam, silt, sandy	0 - 5	5	
Sand, medium to very coarse, silt, pebbles, cobbles	5 - 19	14	17 - 19
Sand, medium to very coarse, pebbles	19 - 24	5	22 - 24
Sand, fine to very coarse, pebbles	24 - 29	5	27 - 29
Sand, fine to very coarse, pebbles, some silt	29 - 39	10	37 - 39
Sand, fine to very coarse, pebbles gravel, silt	39 - 59	20	47 - 49, 57 - 59
Sand, very fine to very coarse, pebbles	59 - 69	10	67 - 69
Sand, very fine to very coarse, blue-gray, pebbles, silt	69 - 78	9	77 - 78
Refusal (bedrock)	78	—	

OW 89-2 is screened from 36.5 to 41.5 feet below land surface with a .010 inch slotted , schedule 40, PVC screen.

OW 89-3. Latitude: 44°33'26" N., Longitude: 70°42'43" W.

Located on the East Andover quadrangle near South Andover in field on east side of Route 5, approximately 1.6 miles north of bridge over the Ellis River. Water level is approximately 8 feet below land surface.

MATERIAL	DEPTH (feet)	THICKNESS (feet)	SAMPLE INTERVAL (feet)
Sand, very fine to coarse, some silt layers	0 - 9	9	7 - 9
Sand, very fine to very coarse, some silt	9 - 29	20	17 - 19, 22 - 24, 27 - 29
Sand, very fine to coarse, some silt	29 - 38	9	37 - 39
Silt, sandy, blue-gray	38 - 69	31	47 - 49, 57 - 59, 67 - 69
Silt, sandy, very fine, blue-gray	69 - 99	30	77 - 79, 97 - 99
End of boring	99	—	

OW 89-3 is screened from 27.3 to 32.3 feet below land surface with a .006 inch slotted, schedule 40, PVC screen.

OW 89-4. Latitude: 44°34'31" N., Longitude: 70°43'16" W.

Located on the East Andover quadrangle near South Andover at end of dirt road on the east side of Route 5, 2.1 miles north of the junction of Route 5 and Andover Road. Water level is approximately 4 feet below land surface.

MATERIAL	DEPTH (feet)	THICKNESS (feet)	SAMPLE INTERVAL (feet)
Silt, very fine sand, brown	0 - 4	4	
Silt, very fine sand, blue-gray	4 - 7	3	
Sand, very fine to coarse, some silt	7 - 14	7	7 - 9, 12 - 14
Silt, very fine sand, blue-gray	14 - 97	83	17 - 19, 27 - 29, 37 - 39, 57 - 59, 77 - 79
Sand, coarse to very coarse, silt, pebbles	97 - 103	6	97 - 99
Refusal (bedrock)	103	—	

OW 89-4 is screened from 6.65 to 11.65 feet below land surface with a .010 inch slotted, schedule 40, PVC screen.

OW 89-5. Latitude: 44°36'48" N., Longitude: 70°43'04" W.

Located on the East Andover quadrangle in East Andover in a field just north of the East Andover post office. Water level is approximately 23 feet below land surface.

MATERIAL	DEPTH (feet)	THICKNESS (feet)	SAMPLE INTERVAL (feet)
Sand, very fine to fine	0 - 12	12	
Silt, very fine sand	12 - 18	6	12 - 14, 17 - 19
Sand, very coarse to fine, pebbles	18 - 28	10	22 - 24, 27 - 29
Silt, sand,very fine to coarse	28 - 49	21	37 - 39, 47 - 49
Refusal (bedrock)	49	—	

OW 89-5 is screened from 27 to 32 feet below land surface with a .010 inch slotted, schedule 40, PVC screen.

OW 89-6. Latitude: 44°30'07" N., Longitude: 70°40'58" W.

Located on the East Andover quadrangle near Rumford Point in a field on the south side of Route 2, approximately 0.3 miles west of the intersection of Routes 2 and 5. Water level is approximately 4 feet below land surface.

MATERIAL	DEPTH (feet)	THICKNESS (feet)	SAMPLE INTERVAL (feet)
Silt, sand, very fine	0 - 3	3	
Sand, fine to very coarse, pebbles	3 - 14	11	7 - 9, 12 - 14
Sand, very fine to coarse, some layering	14 - 29	15	17 - 19, 22 - 24, 27 - 29
Sand, very fine to medium, some layering, red-brown	29 - 38	9	37 - 39
Sand, very fine to medium, some layering, blue-gray	38 - 49	11	47 - 49
Sand, very fine to fine, silt, some layering	49 - 58	9	57 - 59
Sand, very fine, silt	58 - 65	7	
Refusal (bedrock?)	65	—	

OW 89-6 is screened from 31.9 to 36.9 feet below land surface with a .010 inch slotted, schedule 40, PVC screen.

OW 89-7. Latitude: 44°36'11" N., Longitude: 70°44'32" W.

Located on the East Andover quadrangle near Andover in recreational field on the west side of old Route 5, approximately 0.2 miles south of the northerly junction of old Route 5 and Route 5. Water level is approximately 9 feet below land surface.

MATERIAL	DEPTH (feet)	THICKNESS (feet)	SAMPLE INTERVAL (feet)
Sand, fine to coarse	0 - 4	4	
Sand, fine to very fine	4 - 23	19	17 - 19, 22 - 24
Sand, fine to very fine, silt, some layering, red-brown	23 - 39	16	27 - 29, 37 - 39
Sand, fine to very fine, some layering, red	39 - 58	19	47 - 49, 57 - 59
Sand, fine to very fine, silt, red	58 - 67	9	
Sand, very fine, silt, some layering, red-brown	67 - 87	20	67 - 69, 77 - 79
Silt, very fine sand, clay, layered, blue-gray	87 - 94	7	87 - 89
Sand, very fine to coarse, pebbles, silt	94 - 108	14	98 - 100, 107 - 109
Silt, very fine to medium sand, rock fragments	108 - 110	2	
Refusal (difficult drilling)	110	—	

OW 89-7 is screened from 41.8 to 46.8 feet below land surface with a .006 inch slotted, schedule 40, PVC screen

OW 89-8. Latitude: 44°37'37" N., Longitude: 70°28'36" W.

Located on the Weld quadrangle in Carthage in a field on the west side of Route 142, approximately 300 feet north of the bridge over the Webb River. Water level is approximately 1 foot below land surface.

MATERIAL	DEPTH (feet)	THICKNESS (feet)	SAMPLE INTERVAL (feet)
Sand, very fine to fine, silt	0 - 12	12	
Sand, very fine to fine, some layering, red	12 - 19	7	12 - 14, 17 - 19
Sand, very fine to fine, silt, blue-gray	19 - 37	18	27 - 29
Clay, very tight, dry	37 - 39	2	37 - 39
Refusal (difficult drilling)	39	—	

OW 89-8 is screened from 26 to 31 feet below land surface with a .006 inch slotted, schedule 40, PVC screen.

OW 89-9. Latitude: 44°51'17" N., Longitude: 70°24'18" W.

Located on the Madrid quadrangle in a field on the south side of Echo Valley Road, approximately 1.0 mile southwest of Madrid Junction. Water level is approximately 5 feet below land surface.

MATERIAL	DEPTH (feet)	THICKNESS (feet)	SAMPLE INTERVAL (feet)
Loam, some gravel	0 - 5	5	
Cobbles, sandy gravel	5 - 17	12	
Sand, medium to coarse	17 - 25	8	17 - 19
Till, silt, granite fragments, angular stones	25 - 47	22	27 - 29, 37 - 39
Till, sandy	47 - 83	36	47 - 49, 57 - 59, 67 - 69
Silt, gray	83 - 90	7	87 - 89
Till	90 - 94	4	
Refusal (bedrock?)	94	—	

OW 89-9 is screened from 22.2 to 27.2 feet below land surface with a .010 inch slotted, schedule 40, PVC screen.

OW 89-10. Latitude: 45°12'02" N., Longitude: 70°26’49" W.

Located on the Stratton quadrangle between Stratton village and Eustis village. Proceed east 0.4 miles on gravel road from intersection with Route 27 just north of the Flagstaff Memorial Church. Bear left for approximately 0.35 miles to the well. Water level is approximately 14 feet below land surface.

MATERIAL	DEPTH (feet)	THICKNESS (feet)	SAMPLE INTERVAL (feet)
Sand, medium	0 - 7	7	
Sand, fine to medium	7 - 18	11	17 - 19
Sand, fine to very fine	18 - 38	20	27 - 29, 37 - 39
Sand, very fine, silt, clay, layered	38 - 117	79	47 - 49, 57 - 59, 67 - 69 77 - 79, 87 - 89, 97 - 99 107 - 109, 117 - 119
Refusal (difficult drilling)	117	—	

OW 89-10 is screened from 27.3 to 32.2 feet below land surface with a .008 inch slotted, schedule 40, PVC screen.

OW 89-11. Latitude: 45°11'25" N., Longitude: 70°26'18" W.

Located on the Stratton quadrangle between Stratton village and Eustis village. Proceed east on gravel road from intersection with Route 27 just north of the Flagstaff Memorial Church for 0.4 miles. Bear right and continue for 0.9 miles. Well is in woods on left. Water level is approximately 10 feet below land surface.

MATERIAL	DEPTH (feet)	THICKNESS (feet)	SAMPLE INTERVAL (feet)
Sand, medium	0 - 13	13	12 - 14
Sand, very fine to medium, silt, layered	13 - 38	25	17 - 19, 27 - 29, 37 - 39
Sand, very fine to fine, silt, clay, layered	38 - 90	52	47 - 49, 57 - 59, 67 - 69 77 - 79
Till, very silty, some rock fragments 1/4 to 1 1/2 inch	90 - 109	19	97 - 109
Refusal (bedrock)	109	—	

OW 89-11 is screened from 24.7 to 29.7 feet below land surface with a .006 inch slotted, schedule 40, PVC screen.

OW 89-12. Latitude: 45°11'08" N., Longitude: 70°28'03" W.

Located on the Stratton quadrangle between Stratton village and Eustis village. Turn left onto Eustis Ridge Road from Route 27, go 0.5 miles and turn left onto woods road, proceed 0.3 miles to well site. Water level is approximately 6 feet below land surface.

MATERIAL	DEPTH (feet)	THICKNESS (feet)	SAMPLE INTERVAL (feet)
Sand, fine to medium	0 - 12	12	
Sand, very fine to medium, silt, clay, layered, red	12 - 19	7	12 - 14, 17 - 19
Sand, very fine, silt, clay, layered, blue-gray	19 - 29	10	27 - 29
Sand, very fine to fine	29 - 37	8	
Sand, very fine to fine, silt, clay, layered	37 - 87	50	37 - 39, 47 - 49, 57 - 59 77 - 79
Till	87 - 91	4	
Refusal (difficult drilling)	91	—	

OW 89-12 is screened from 21.8 to 26.8 feet below land surface with a .006 inch slotted, schedule 40, PVC screen.

OW 89-13. Latitude: 45°09′00″ N., Longitude: 70°27′16″ W.

Located on the Stratton quadrangle in Stratton on Vaughn Road approximately 0.25 miles west of Route 27. Water level is approximately 4 feet below land surface.

MATERIAL	DEPTH (feet)	THICKNESS (feet)	SAMPLE INTERVAL (feet)
Silt	0 - 2	2	
Sand, fine to medium, few pebbles	2 - 7	5	
Sand, coarse to very fine	7 - 18	11	7 - 9, 17 - 19
Sand, very fine, silt, layered	18 - 47	29	27 - 29, 37 - 39
Silt, very fine sand, layered	47 - 82	35	47 - 49, 67 - 69
Till	82 - 89	7	87 - 89
Refusal (difficult drilling)	89	—	

OW 89-13 is screened from 11.6 to 16.6 feet below land surface with a .006 inch slotted, schedule 40, PVC screen.

OW 89-14. Latitude: 45°05′39″ N., Longitude: 70°30′13″ W.

Located on the Quill Hill quadrangle in Coplin Plantation in a field on the north side of Route 16, 4.9 miles west of Stratton village. Water level is approximately 3 feet below land surface.

MATERIAL	DEPTH (feet)	THICKNESS (feet)	SAMPLE INTERVAL (feet)
Sand, very fine, silt	0 - 4	4	
Sand, very coarse to fine, silt, pebbles	4 - 14	10	12 - 14
Silt, very fine sand, layered	14 - 22	8	17 - 19
Silt, very fine to fine sand, pebbles	22 - 26	4	22 - 24
Sand, very fine to coarse, silt, pebbles	26 - 31	5	27 - 29
Refusal (bedrock?)	31	—	

OW 89-14 is screened from 11.8 to 21.8 feet below land surface with a .006 inch slotted, schedule 40, PVC screen.

OW 89-15. Latitude: 45°02'55" N., Longitude: 70°51'32" W.

Located on the Kennebago quadrangle in Lower Cupsuptic township on the north side of Kennebago Road 0.25 miles east of the bridge over the Cupsuptic River. Water level is approximately 16 feet below land surface.

MATERIAL	DEPTH (feet)	THICKNESS (feet)	SAMPLE INTERVAL (feet)
Sand, fine to very coarse, silt, pebbles, brown	0 - 28	28	22 - 24, 27 - 29
Sand, very fine to very coarse, pebbles, gray-brown	28 - 36	8	
Till	36 - 38	2	37 - 38
Refusal (bedrock)	38	—	

OW 89-15 is screened from 26.4 to 31.4 feet below land surface with a .010 inch slotted, schedule 40, PVC screen.

OW 89-16. Latitude: 44°54'34" N., Longitude: 70°55'57" W.

Located on the Richardson Pond quadrangle in Magalloway Plantation in a gravel pit south of Route 16, approximately 0.2 miles west on Route 16 from the Adamstown-Lincoln Plantation town line. Water level is approximately 12 feet below land surface.

MATERIAL	DEPTH (feet)	THICKNESS (feet)	SAMPLE INTERVAL (feet)
Sand, very fine, silt, layered	0 - 12	12	
Sand, very fine to very coarse, brown-red	12 - 38	26	12 - 14, 17 - 19, 27 - 29
Sand, very fine to very coarse, silt, pebbles, layered, red	38 - 46	8	37 - 39
Refusal (bedrock)	46	—	

OW 89-16 is screened from 31.7 to 36.7 feet below land surface with a .006 inch slotted, schedule 40, PVC screen.

OW 89-17. Latitude: 44°54'51" N., Longitude: 70°23'21" W.

Located on the Redington quadrangle in Madrid at East Madrid village in a field along road 0.2 miles north of the bridge over Perham Stream. Water level is approximately 12 feet below land surface.

MATERIAL	DEPTH (feet)	THICKNESS (feet)	SAMPLE INTERVAL (feet)
Sand, medium to very coarse, pebbles	0 - 12	12	
Sand fine to very fine, silt, brown	12 - 28	16	12 - 14, 17 - 19, 27 - 29
Silt, blue-gray	28 - 37	9	
Silt, till, blue-gray	37 - 39	2	37 - 39
Refusal (till)	39	—	

OW 89-17 is screened from 16.9 to 21.9 feet below land surface with a .006 inch slotted, schedule 40, PVC screen.

OW 89-18. Latitude: 44°37'10" N., Longitude: 70°34'49" W.

Located on the Rumford quadrangle at Frye in a field on the west side of Route 17 just south of the Frye bridge over the Swift River. Water level is approximately 9 feet below land surface.

MATERIAL	DEPTH (feet)	THICKNESS (feet)	SAMPLE INTERVAL (feet)
Loam, very fine to fine sand	0 - 5	5	
Sand, silt, pebbles 1 to 3 inch diam.	5 - 12	7	
Sand, coarse to very fine, pebbles	12 - 16	4	
Gravel	16 - 18	2	17 - 19
Sand, very coarse to very fine, pebbles	18 - 38	20	22 - 24, 27 - 29, 32 - 34 37 - 39
Sand, very coarse to fine, pebbles, red-brown	38 - 50	12	42 - 44, 47 - 49
Till	50 - 51	1	
Refusal (bedrock)	51	—	

OW 89-18 is screened from 31.2 to 41.2 feet below land surface with a .010 inch slotted, schedule 40, PVC screen.

OW 89-19. Latitude: 45°06'24" N., Longitude: 70°32'51" W.

Located on the Quill Hill quadrangle near Kennebago Settlement in Lang township. From the bridge over the South Branch Dead River on the Kennebago Settlement Road continue nortwest for 1.25 miles. Turn right onto dirt road and go approximately 0.15 miles to well site on right. Water level is approximately 27 feet below land surface.

MATERIAL	DEPTH (feet)	THICKNESS (feet)	SAMPLE INTERVAL (feet)
Sand, fine to medium, some gravel	0 - 40	40	37 - 39
Sand, fine to coarse, silt, layered	40 - 50	10	47 - 49
Till, sandy, coarse	50 - 52.5	2.5	52 - 54
Refusal (till)	52.5	—	

OW 89-19 is screened from 37 to 42 feet below land surface with a .008 inch slotted, schedule 40, PVC screen.

OW 89-20. Latitude: 45°03'54" N., Longitude: 70°35'39" W.

Located on the Quill Hill quadrangle in Lang township at Langtown Mill. At Langtown Mill turn right off Route 16 onto dirt road. Cross South Branch Dead River and bear left, continue for 1.0 miles and turn right onto gravel road. Well site is at end of road. Water level is approximately 25 feet below land surface.

MATERIAL	DEPTH (feet)	THICKNESS (feet)	SAMPLE INTERVAL (feet)
Gravel, cobbly, bouldery	0 - 13	13	
Sand, very fine to medium, pebbles	13 - 20	7	
Sand, very fine to medium	20 - 35	15	
Till	35 - 44	9	37 - 39, 39 - 41
Refusal (till)	44	—	

OW 89-20 is screened from 30 to 40 feet below land surface with a .008 inch slotted, schedule 40, PVC screen.

OW 89-21. Latitude: 45°07'16" N., Longitude: 70°45'19" W.

Located on the Kennebago quadrangle in Stetsontown township on the east side of road that runs down the east side of the Kennebago River from Little Kennebago Lake to Kennebago Lake. Well site is 0.5 miles in on road that runs through closed landfill. Water level is approximately 3 feet below land surface.

MATERIAL	DEPTH (feet)	THICKNESS (feet)	SAMPLE INTERVAL (feet)
Sand, fine to medium, some gravel	0 - 17	17	
Sand, very fine to fine	17 - 27	10	
Sand, very fine, silt	27 - 37	10	
Sand, very fine, silt, layered	37 - 47	10	
Silt, lacustrine, layered	47 - 51	4	47 - 49
Till, gravelly	51 - 57	6	57 - 59
Refusal (bedrock?)	57	—	

OW 89-21 is screened from 10 to 15 feet below land surface with a .006 inch slotted, schedule 40, PVC screen.

OW 89-22. Latitude: 45°11'22" N., Longitude: 70°58'25" W.

Located on the Parmachenee Lake quadrangle in Parmachenee township at the 4-way intersection of dirt roads north of Parmachenee Lake approximately 0.25 miles east of Little Boy Falls on the Magalloway River. Water level is approximately 46 feet below land surface.

MATERIAL	DEPTH (feet)	THICKNESS (feet)	SAMPLE INTERVAL (feet)
Sand, gravel, cobbles	0 - 10	10	
Gravel	10 - 15	5	
Sand, fine to very fine, powdery, pebbles	15 - 47	32	17 - 19, 27 - 29, 37 - 39
Sand, very fine to medium	47 - 57	10	47 - 49
Till	57 - 59	2	57 - 59
Refusal (till)	59	—	

OW 89-22 is screened from 48 to 53 feet below land surface with a .008 inch and from 53 to 58 feet below land surface with a .006 inch slotted, schedule 40, PVC screen.

TB 89-1. Latitude: 44°33'33" N., Longitude: 70°27'18" W.

Located on the Dixfield quadrangle in Dixfield in a field on the west side of Route 142 approximately 2.1 miles north of the junction of Route 2 and 142 in Dixfield. Water level is approximately 7 feet below land surface.

MATERIAL	DEPTH (feet)	THICKNESS (feet)	SAMPLE INTERVAL (feet)
Sand, fine to medium, silt, blue-gray	0 - 9	9	7 - 9
Sand, fine to very fine, silt, blue-gray	9 - 19	10	17 - 19
Sand, very fine to fine, brown, silt, blue, interbedded	19 - 49	30	27 - 29, 37 - 39, 47 - 49
Sand, fine to very fine	49 - 59	10	57 - 59
Sand, very fine to coarse, silt	59 - 69	10	67 - 69
Sand, medium to very coarse	69 - 71	2	71 - 72
Refusal (till)	71	—	

No well installed.

TB 89-2. Latitude: 44°42'27" N., Longitude: 70°28'42" W.

Located on the Weld quadrangle near Weld Corner approximately 0.1 miles north of the bridge over West Brook, next to cemetery. Water level is approximately 23 feet below land surface.

MATERIAL	DEPTH (feet)	THICKNESS (feet)	SAMPLE INTERVAL (feet)
Sand, veryfine to very coarse, silt	0 - 9	9	7 - 9
Silt, gray, layers of very fine sand	9 - 19	10	17 - 19
Silt, very fine sand, blue-gray	19 - 29	10	27 - 29
Silt, very fine to very coarse sand, pebbles	29 - 55	26	47 - 49
Refusal (bedrock)	55	—	

No well installed.