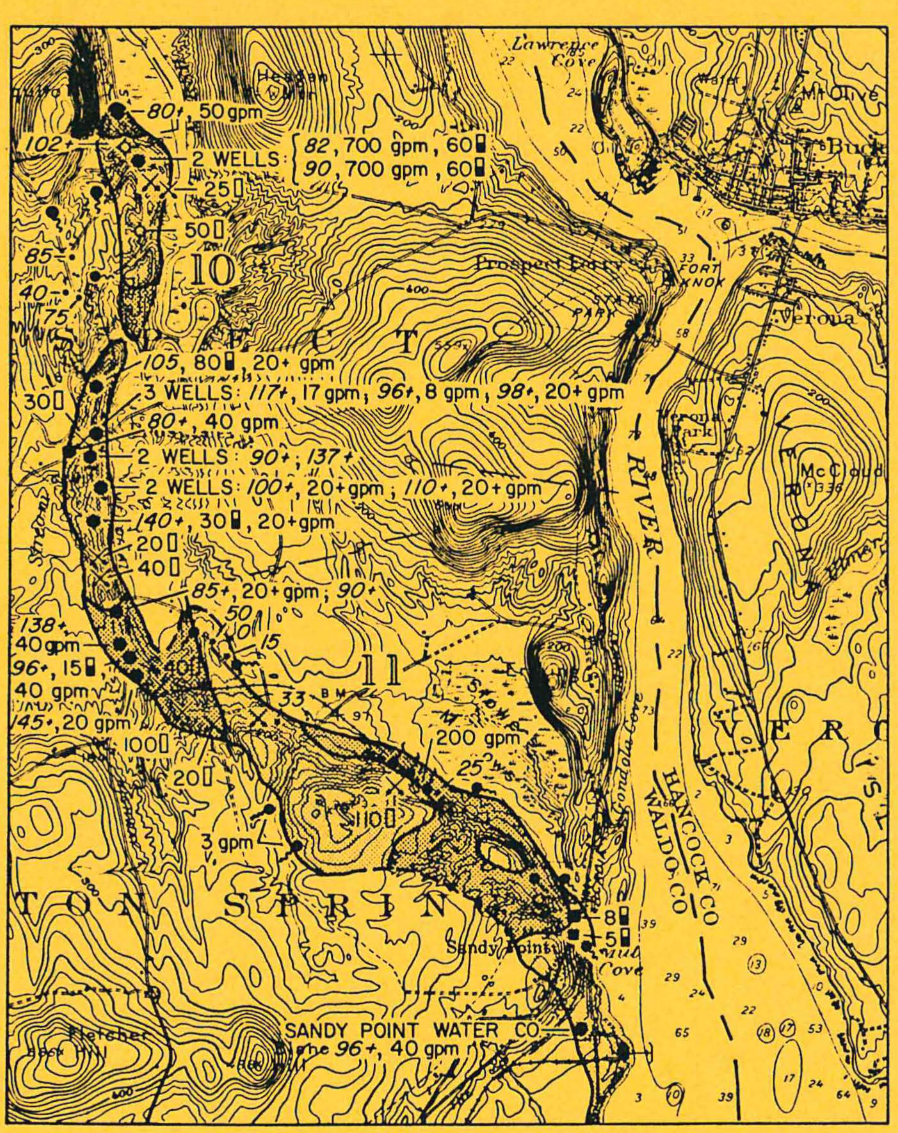
SAND AND GRAVEL AQUIFER MAPPING

FIELD TRIP

June 8, 1988



Maine Geological Survey

DEPARTMENT OF CONSERVATION

Hydrogeology Division

SAND AND GRAVEL AQUIFER MAPPING FIELD TRIP

WINTERPORT, HAMPDEN, AND PITTSFIELD, MAINE

June 8, 1988

Led by: THOMAS K. WEDDLE and JOHN S. WILLIAMS

MAINE GEOLOGICAL SURVEY

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PART ONE:

AN OVERVIEW OF RECENT AQUIFER MAPPING IN MAINE

Introduction

Sand and gravel aquifers are an extremely valuable resource in the State of Maine. They are used for the development of public water supplies in many cities, including Sanford, Brunswick, Topsham, and Machias. Sand and gravel aquifers are also used for many industrial water supplies, and provide recharge for underlying bedrock aquifers, which are used most frequently as domestic water supplies. The deposits forming the aquifers are valuable in their own right as sand and gravel supplies, which are becoming increasingly scarce as development pressures increase the need for their use and diminish the availability of locations for sand and gravel extraction.

The high permeability of sand and gravel aquifers allows relatively rapid transmission of water and contaminants. This causes sand and gravel aquifers to be highly vulnerable to water quality degradation from human activities. To protect these aquifers, the Maine Legislature, the Maine Department of Environmental Protection, and local planning boards have passed and adopted a number of laws and regulations restricting development of certain activities over sand and gravel aquifers. This has led to increased pressure to identify and understand the aquifers, and provided the initiative to fund aquifer mapping projects over the past decade.

During the 1960's the first efforts to specifically identify ground water resources began with the publication of hydrologic atlases by the U. S. Geological Survey. These atlases describe the geologic and hydrologic conditions governing the occurrence of ground water in Maine, both in surficial and bedrock aquifers.

The Hydrologic Atlas series has not been used by the general public as extensively as the later sand and gravel aquifer map series, but has been an invaluable resource in the production of the later maps.

The Sand and Gravel Aquifer Mapping Program

In 1978, the Hydrogeology Division of the Maine Geological Survey undertook a new program to map sand and gravel aquifers in all of the populated regions of Maine. The aquifers are defined as those capable of providing well yields in excess of 10 gallons per minute. The program was conducted in cooperation with the U.S. Geological Survey, and with funding from the U. S. Environmental Protection Agency and the Maine Department of Environmental Protection.

The sand and gravel maps for this program are shown on 1:50,000 scale base maps, compiled by photo-reducing nine 7.5-minute topographic maps or parts of several 15-minute maps, covering an area 22.5 by 22.5 minutes in size. Betweeen 1978 and 1980, 58 aquifer maps were produced, covering all of the organized towns in the State.

Where Hydrologic Atlases were available, the aquifer maps were compiled largely by adjusting the scale of the aquifer favorability maps, and overlaying the favorable areas onto the new map base. New mapping or well information was obtained in some of these areas, and aquifer boundaries were adjusted where warranted by the new information.

In areas of the State where no Hydrologic Atlas information was available other types of existing data, if any, were compiled. These data include existing surficial geologic maps, well driller logs, boring logs from the State Department of Transportation and the Maine Turnpike Authority, and well information from water utilities and private well owners. The existing information was supplemented with reconnaissance-level surficial mapping. In many areas only the surficial geologic maps were available for the delineation of aquifer boundaries.

The Sand and Gravel Aquifer Map Series was published during the initial stages of implementation of new environmental laws designed to protect ground water. The Site Location of Development Law discourages the siting of many new activities over sand and gravel aquifers, as do the Waste Discharge Regulations and the Underground Tank Rules. With such an emphasis on accurately defining the boundaries of sand and gravel aquifers, it became apparent that in many areas the reconnaissance nature of mapping for the sand and gravel aquifer maps was not sufficient. Thus, despite being one of the Maine Geological Survey's most widely used map series, by the time the last of the aquifer maps were published in 1981, the maps were being updated through the Significant Sand and Gravel Aquifer Mapping Project.

The Significant Sand and Gravel Aquifer Mapping Project

The Significant Sand and Gravel Aquifer Mapping Project is an ongoing program which was initiated in 1981 as a cooperative undertaking of the Maine Geological Survey, the Maine Department of Environmental Protection, and the U.S. Geological Survey. The purpose of this study is to accurately define the aquifers in three dimensions, and to assess water quality within the aquifers.

Many of the same techniques used in the Sand and Gravel Aquifer Mapping Project have been repeated for the preparation of the Significant Aquifer Maps. More detailed surficial mapping enables further refinement of aquifer boundaries, and the identification of areas of sand and gravel which may have been overlooked in the initial mapping program. Aquifer depth information is obtained by collecting new well and boring log data, and by seismic profiling. Single channel seismic lines are run, using a sledge hammer and willing field help, over portions of all possible aquifers which are accessible. Where depth to bedrock requires a stronger energy source, 12-channel seismic lines are run using explosives.

Several monitoring wells are installed in each 1:50,000 scale quadrangle. These wells are used to confirm seismic interpretations, to describe the aquifer medium, and to collect water samples for an analysis of regional water quality.

From 1981 to 1984 reconnaissance-level investigations of potential contamination sites located over or near the aquifers were conducted. These investigations consisted of resistivity and terrain conductivity surveys, limited water quality sampling, seismic surveys, and compilation of existing information. After the 1984 field season, these investigations were abandoned due to insufficient funding and staffing levels.

To date the Significant Aquifer Mapping Program has completed 21 new aquifer maps and 5 accompanying reports. An additional 6 maps and 1 report are in review, and field work is being completed for another 6 maps. The project is expected to continue until the early 1990's, with regions of central and west-central Maine planned as field areas.

The Sand and Gravel/Significant Sand and Gravel Aquifer Maps have been used extensively for many purposes, related to both water supply development and ground water quality protection. In 1986 alone, the Maine Geological Survey sold over 1800 aquifer maps. Completion of this project is considered to be a top priority for the Survey.

Summary

Until recently, reliable water resources were taken for granted in Maine. Prior to 1962, ground water resource assessments were limited to surficial materials surveys. From 1962 to 1979, the U.S. Geological Survey initiated regional ground water studies in Maine with the publication of hydrogeological maps of several river basins (Hydrologic Atlas Series). To improve the understanding of Maine's hydrogeological resources, the statewide sand and gravel aquifer mapping program was established in 1978. Consequently, the Maine Geological Survey, in cooperation with the Maine Department of Environmental Protection and the U.S. Geological Survey, has been accurately defining the hydrogeological characteristics of sand and gravel deposits in the state. To date, the mapping study has covered approximately 10,000 mi^2 in southern, eastern, and northern Maine.

Maps and reports produced through this program delineate sand and gravel aquifers capable of >10gpm yield, present geologic- and seismic-cross sections, provide well inventory information and well logs, discuss ground water-quality data, and identify potential sources of ground water contamination. Other programs in conjunction with the project include well inventory database collection, pesticide screening, fractured aquifer characterization, and surficial geologic mapping. The aquifer maps and texts contain information on aquifer favorability and vulnerability, and are widely used by local and state officials in making environmentally sound siting decisions, and by well drillers, developers, and geological consultants as a base for detailed hydrogeological studies.

PART TWO:

FIELD TRIP OVERVIEW

The purpose of this field trip is to provide a general presentation of the Significant Sand and Gravel Aquifer Mapping Project to state officials. To facilitate comprehension of the data collecting methods used by the staff of the Maine Geological Survey in its field work, a general understanding of geologic and hydrogeologic characteristics of the aquifer-bearing deposits is necessary. A general description of the basics of seismic profiling will also be provided, as will a description of water quality investigations.

Glacial Geology
(Figures 1 and 2)

Most of the deposits that are mapped as significant sand and gravel aquifers are of glacial origin, either formed by glacial streams or laid down in lakes or the ocean during the latter part of the Pleistocene Epoch (what we informally term the "Ice Age"). After the last great ice sheet reached its maximum position as far south as Long Island, New York, and Cape Cod, Massachusetts, it began to melt and recede. At this time, Maine was still covered by ice which extended eastward in the present-day Gulf of Maine to George's Bank.

An important effect of the mass of ice on the surface of the earth was that the ice mass caused the earth's crust to be depressed. It is recognized in the deposits of the coastal area of Maine and up the major river valleys that the ocean was in contact with the ice margin. As the ice melted, it appears the depressed crust of the earth did not rebound, so the depressed area became flooded by the ocean. In fact, the crust did rebound but not quite as fast as the ocean could occupy the region. With time the crustal rebound caught up with and overtook the flooding, so that an apparent fall of sea level is also recorded in the glacial deposits. During this time of marine flooding, the ubiquitous "blue clay" common to coastal Maine was deposited. This deposit is formally named the Presumpscot Formation, after exposures found along the Presumpscot River in southern Maine.

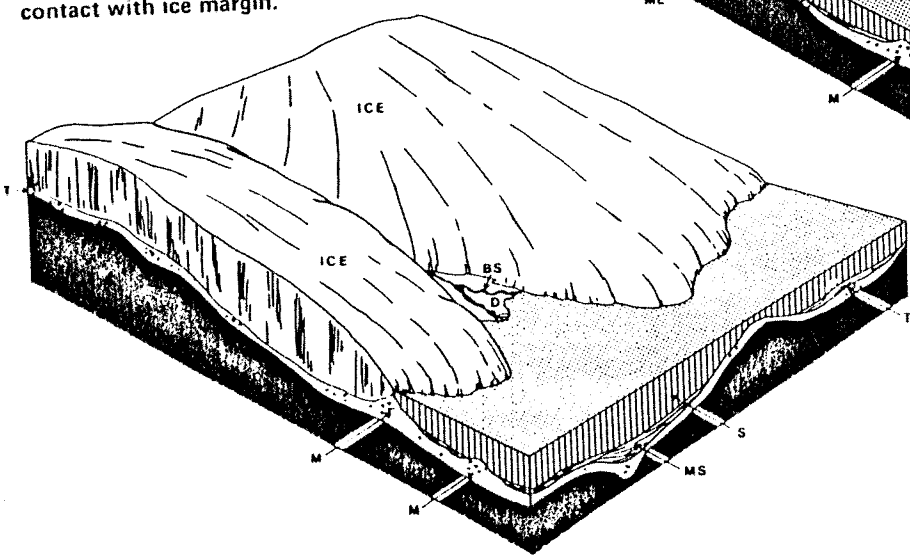
Also during the time when the ocean and ice margin were in contact, large bodies of sand and gravel were deposited in the ocean. These features are called glacial deltas if they breached the water surface, and subaqueous fans if they did not. We will visit examples of these deposits during the day. Usually, these deltas or fans are associated with another glacial deposit, known locally as a "horseback", like the Enfield Horseback. Geologically speaking the horseback is called an esker, a Gaelic word meaning "ridge." It is a long sinuous ridge of sand and gravel, derived from glacial streams which flowed in tunnels in the ice. Where one of these streams entered either the ocean or a glacial lake, a delta or fan would be deposited. The deltas, fans, and eskers are the principal significant sand and gravel aquifer deposits. One other sand and gravel deposit should be included as a significant aquifer deposit, that being outwash plains. Where glacial streams emanated from the part of the ice front not in contact with a water body, extensive deposits of sand and gravel were laid down. Examples of this type of deposit can be found inland from the marine limit, especially in southwestern and eastern Maine.

SEQUENCE OF GLACIAL RECESSION

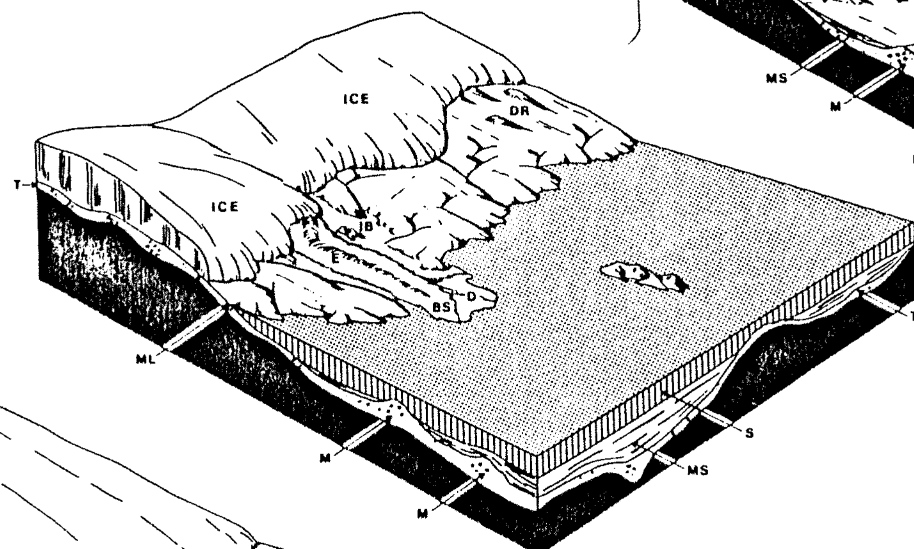
AND

DEPOSITION OF GLACIAL MATERIALS

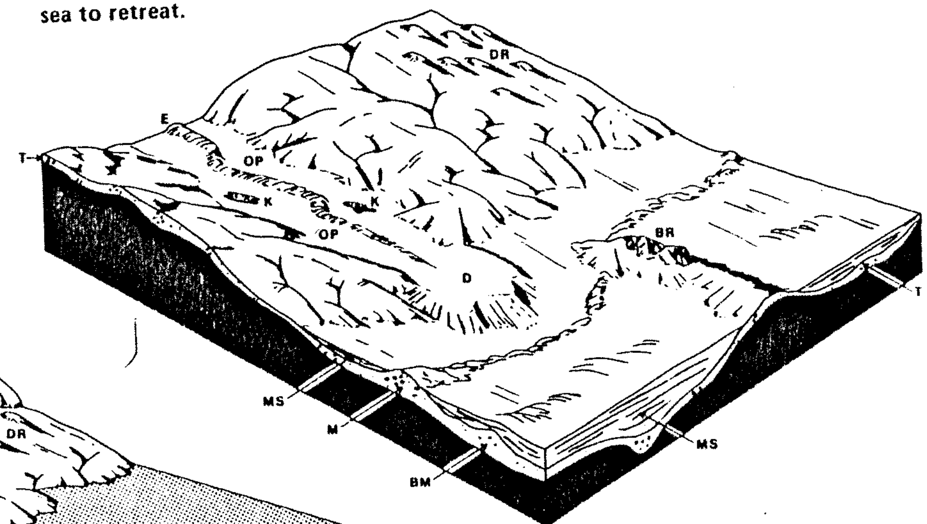
13,000 years ago: Continental glacier covered most of Maine, but was beginning to disappear from what is now the coast. Sea was in contact with ice margin.



12,800 years ago: Glacier was receding rapidly and much of southern Maine was ice-free. Land was still depressed from weight of ice, allowing sea to cover coastal lowland.



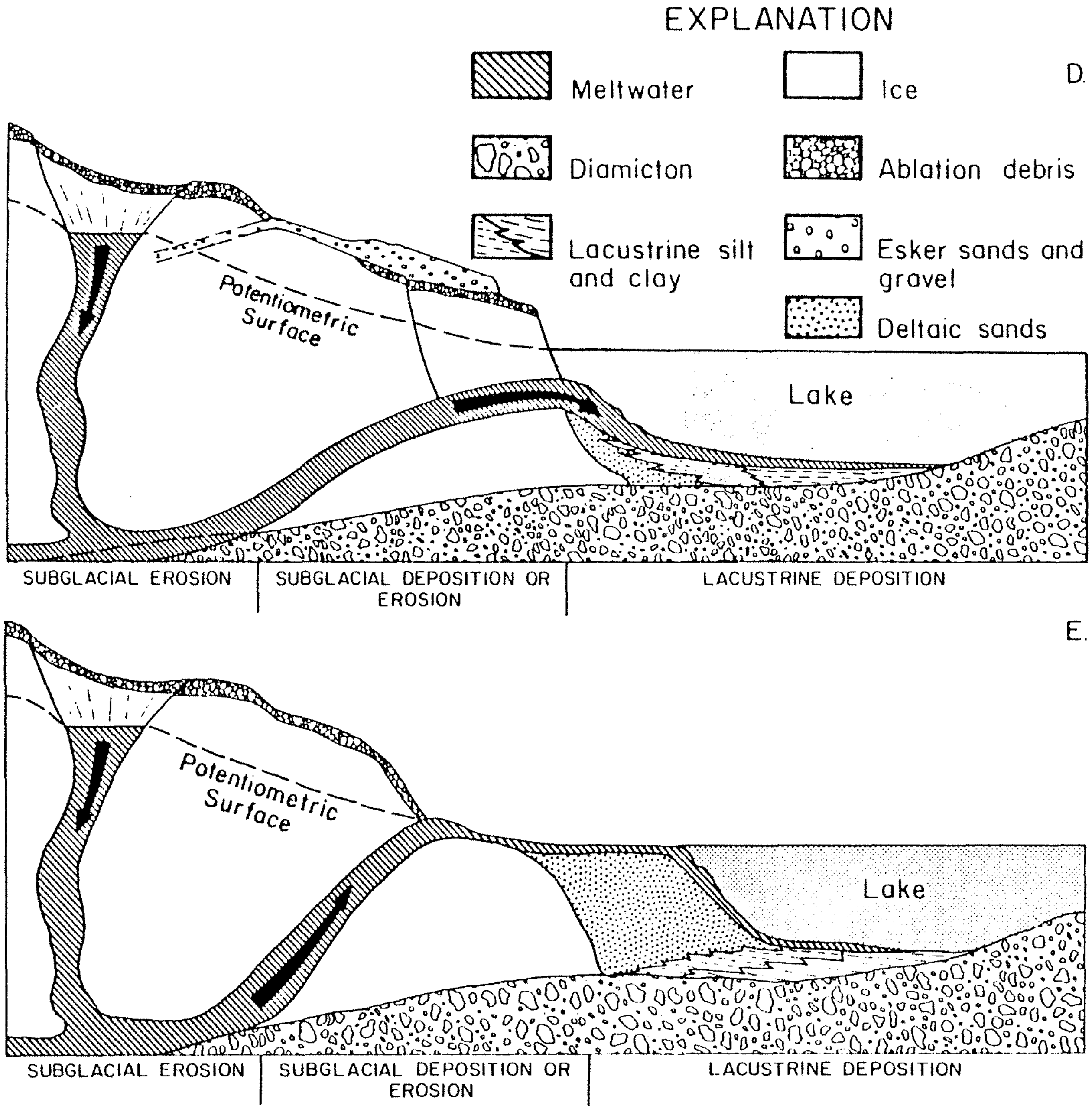
12,000 years ago: Glacier had disappeared from central and southern Maine. Uplift of land had caused sea to retreat.



BM - Buried moraine
BR - Bedrock ridge
BS - Braided stream
D - Delta
DR - Drumlins
E - Esker
IB - Ice block
K - Kettle
M - Moraine
ML - Marine limit
MS - Marine sediments
OP - Outwash plain
S - Seawater
T - Till

Block diagrams by R. D. Tucker

FIGURE 1



Models for fan and delta deposition

(D) A lacustrine fan being constructed by density underflows derived from meltwater issuing from an englacial stream. Model also shows the position of an englacial sediment-filled tunnel and its exposure to become a superglacial esker and outwash. An example of the superglacial esker and outwash is given in Figure 3. (E) A lacustrine delta is being deposited by a meltwater stream issuing from an englacial tunnel. An example of deltaic sedimentation is given in Figure 6.

FIGURE 2

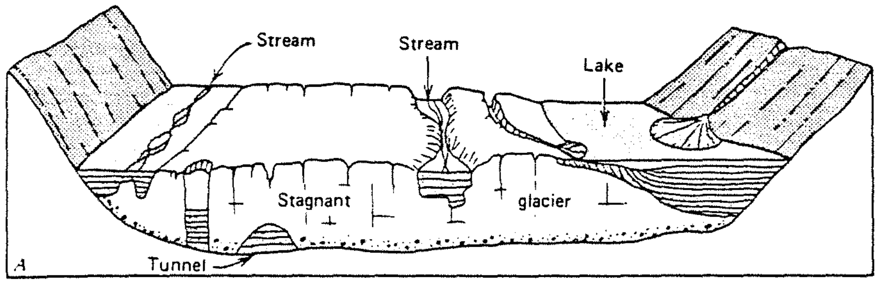
Hydrogeology
(Figure 3)

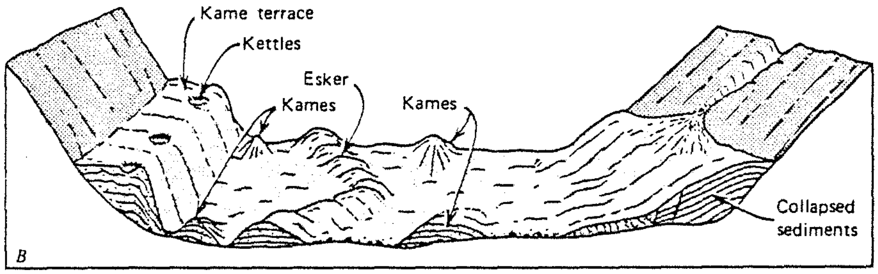
The glacial deposits mapped as significant sand and gravel aquifers are deemed significant when they can yield greater than 10 gallons per minute to a properly constructed well. Furthermore, as a rule of thumb they should have more than 10 feet of saturated thickness of material to continue a sustained yield to the well. Saturated material is that sand and gravel in which the open spaces between the sand and gravel grains are completely filled with water. The greatest yielding aquifers include the glacial deposits already mentioned and alluvial deposits associated with modern rivers. Under favorable conditions, yields of 100 to 1000 gallons per minute or more are not uncommon in sand and gravel aquifers.

The water table is the boundary between material which is completely saturated and that which is not. The water table reflects the topographic surface of the earth, with ground water divides generally corresponding to surface water divides. Horizontal ground water flow will be away from the ground water divides and toward the nearest body of surface water. In general, topographically high regions will be ground water recharge areas, whereas topographically low areas are commonly regions of ground water discharge. A more precise understanding of ground water flow is procured with the installation of monitoring wells in which water levels can be measured and gradient determined. The thickness of the saturated and unsaturated materials also must be determined. This can be accomplished through test borings, however a geophysical method known as seismic refraction profiling is much less expensive and less time-consuming.

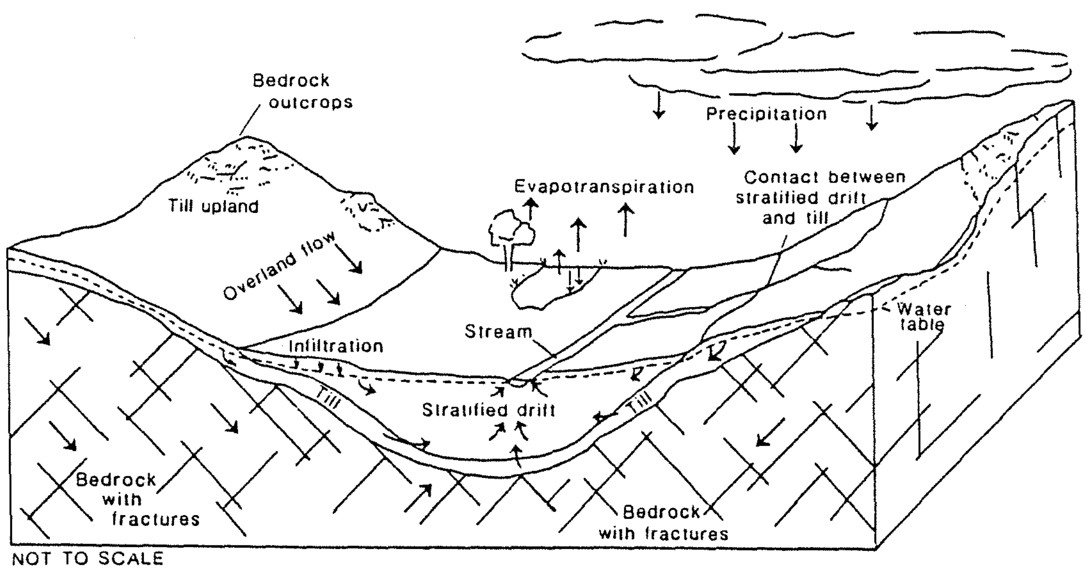
Seismic Profiling
(Figure 4)

In seismic refraction profiling, sound waves are generated at the earth's surface by a small explosion or a hammer. The waves travel at different velocities through different materials; the denser the material, the faster the wave velocity. The waves are refracted through the different materials and are sensed by an apparatus coupled to the earth's surface known as a geophone, basically a listening device. The time of wave arrival to the geophone is recorded by a device similar to an oscilloscope. The velocity of the waves through a material and time of wave arrival can be used to identify whether it is dry sand and gravel, saturated sand and gravel, or solid rock, and the depth to the boundaries between the different materials also can be determined.





Origin of bodies of ice-contact stratified drift. *A*. Stagnant glacier ice affords temporary retaining walls for bodies of sediment built by streams and in lakes. *B*. As ice melts, bodies of sediment are let down and in the process are deformed.

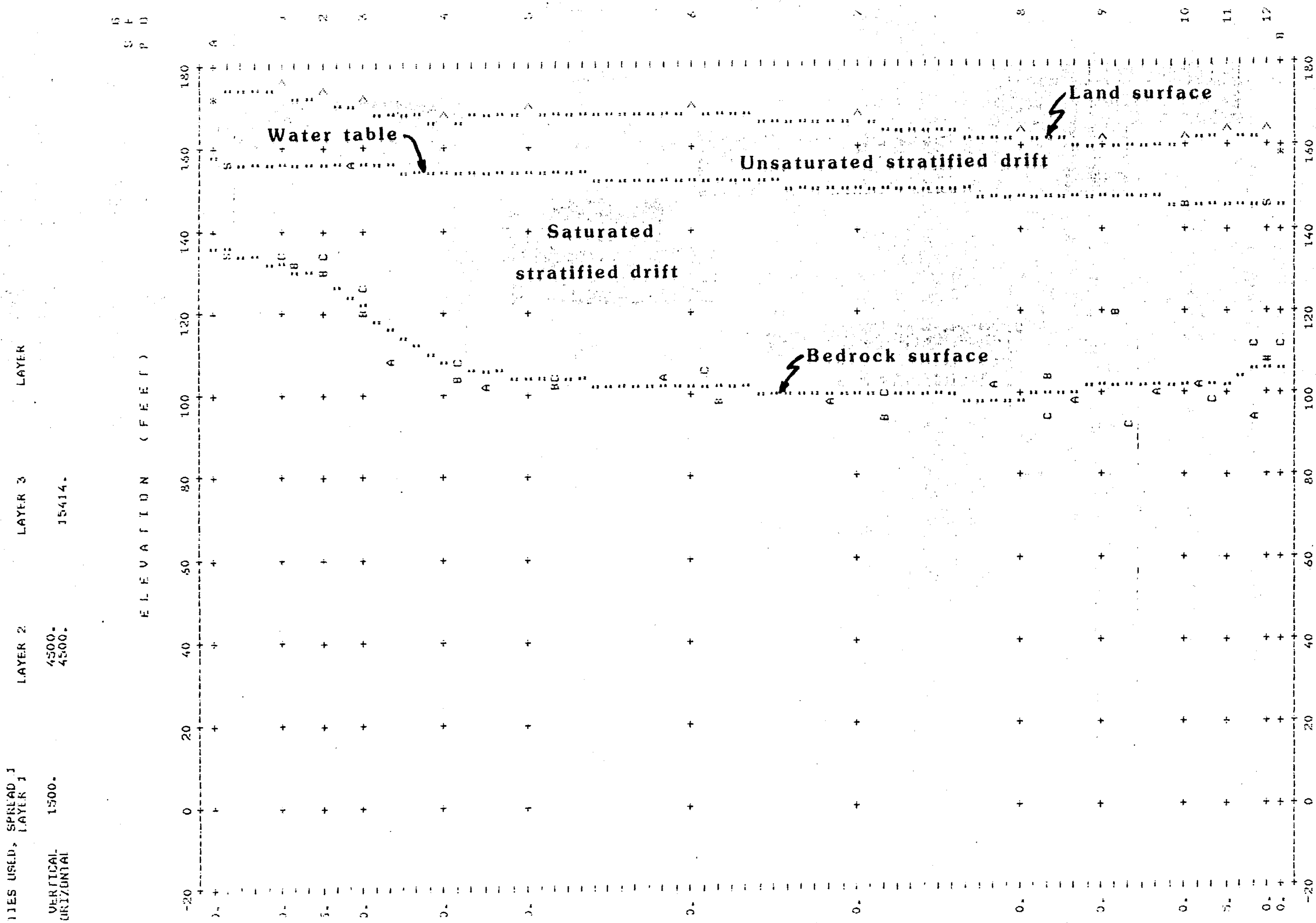


–Recharge/discharge relations and generalized flow patterns in glacial-drift, river-valley aquifers.

Origin of sand and gravel aquifer deposits and hydrogeologic regime in river valleys

FIGURE 3

FIGURE 4



Hydrogeologic cross-section (12-channel seismic data)

Well Installation
(Figures 5 and 6)

Since 1981 approximately 150 monitoring wells have been installed across the State through the Sand and Gravel Aquifer Aquifer Mapping Project. These wells are used for a variety of reasons, as discussed below.

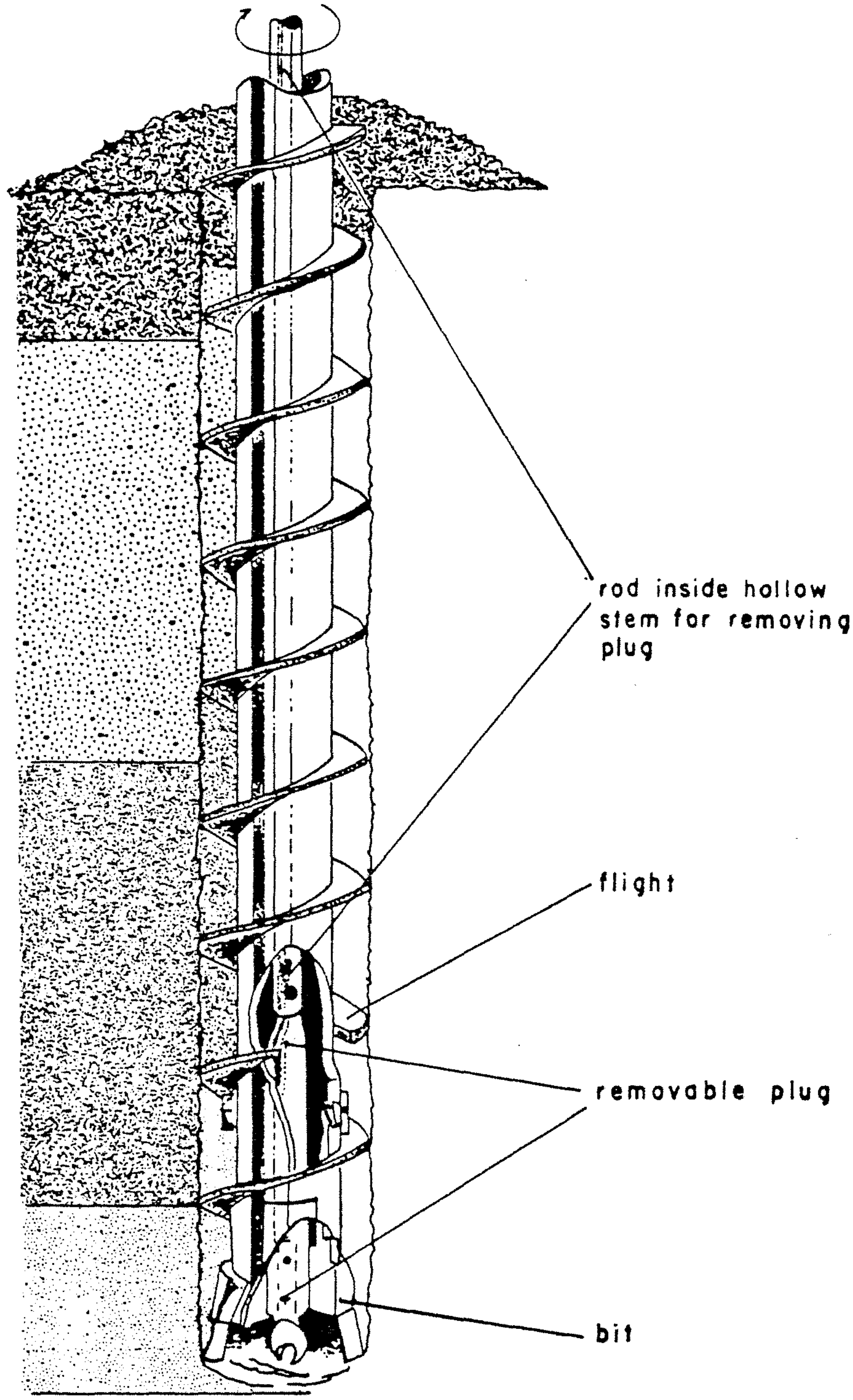
The wells are drilled with a 6-inch diameter hollow-stem drill rig which is owned by the U.S. Geological Survey. Sediment samples are collected as drilling progresses. Above the water table the sediment is brought to the ground surface by the rotation of the augers; below the water table cores of undisturbed sediment are collected by a split-spoon sampler. The split-spoon sampler is a 2 foot long metal tube, made of two half tubes divided lengthwise and screwed together by metal heads. The split-spoon sampler is inserted through the hollow center of the augers, and driven into the sediment ahead of the auger drill bit. The split-spoon sampler is then brought to the land surface, unscrewed, and divided in half so an undisturbed core can be observed and collected.

If time permits, the wells are drilled until refusal, which is the point at which the augers can no longer penetrate the subsurface materials. This usually occurs when bedrock is encountered, but can also occur when a boulder or large cobbles are struck. The hole is then backfilled with augered sediment to the desired well depth, usually 10 feet below the water table. A well is constucted out of 2-inch diameter PVC pipe, which is slotted along the bottom 5 feet to allow water to enter. The well is inserted through the center of the augers, the augers are removed, and the hole around the well is backfilled with augered sediment. Near ground surface the hole is plugged with bentonite, to prohibit surface water from running down the side of the well.

Well drilling reveals the nature and depth of the sediments in much greater detail than can be obtained from seismic exploration, but at a much greater cost. Well drilling is often used in combination with seismic data to confirm the depths obtained by seismic interpretation, and to construct geologic cross sections such as that shown in figure 6.

Water Quality

Perhaps the most important use of the monitoring wells is to determine water quality of the aquifers. The majority of the wells installed for the sand and gravel aquifer mapping project are in locations where no contamination of ground water is believed to have occurred. By analysing the water from these "background water quality wells" we have gained a great insight into the chemistry of water in sand and gravel aquifers across the State. For example, the water in eastern and southwestern Maine was found to be the least mineralized, with a purity approaching that of distilled water.



The hollow-stem, continuous-flight auger bores into soft soils carrying the cuttings upward along the flights. When the desired depth is reached, the plug is removed from the bit and withdrawn from inside the hollow stem. A well point (1¼-in. or 2-in.) can then be inserted to the bottom of the hollow stem and the auger pulled out leaving the small-diameter monitoring well in place.

Figure 5. Hollow Stem Auger Drilling

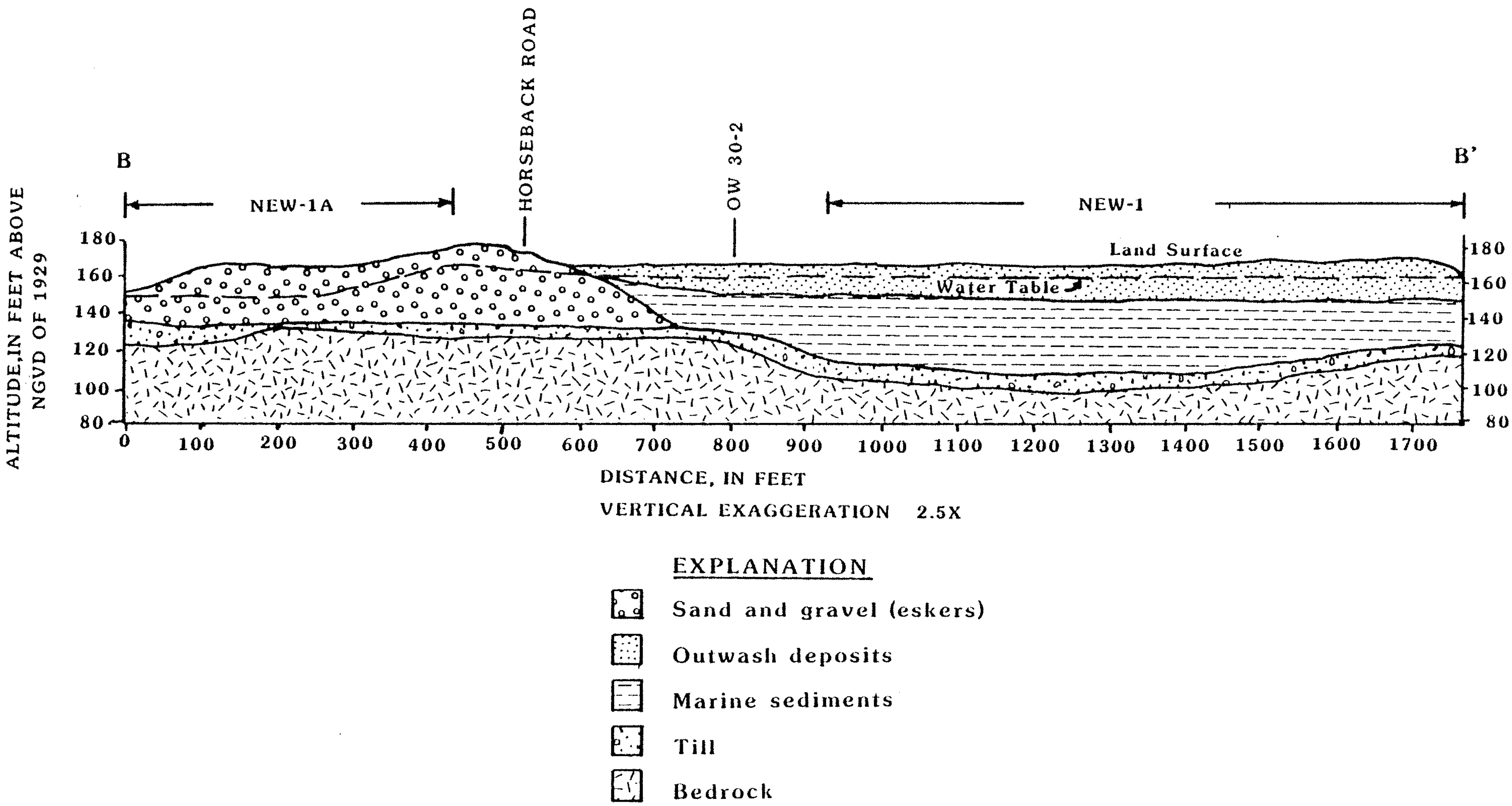


Figure 6.- - Cross section through esker along Horseback Road at former Pittsfield landfill site (Significant Sand and Gravel Aquifer Map 30).

The water in central and northern Maine was found to be hard, with relatively high levels of calcium, and magnesium. High levels of iron and manganese were found in many wells in all areas of the State, and are probably the constituents of most frequent concern in successfully developing new public water supply wells in sand and gravel aquifers. Nitrate levels were above drinking water standards in a few wells near heavily fertilized agricultural fields, but were usually very low. No organic pollutants were found in any of the background water quality wells. This work has shown that in general, water quality of Maine's sand and gravel aquifers remains excellent, and that despite the widespread publicity of ground water contamination incidents, the contamination has been limited to isolated areas to date.

PART THREE:

STOP DESCRIPTIONS
(Refer to Figure 7 for Stops 1 and 2)

Stop 1a - Maine DOT Gravel Pit, Twining Road, Winterport: Aquifer Maps 28+29.

This pit is located in a near-ice (proximal) part of a submarine fan. We will only briefly stop here to note the coarse texture of the deposits, and if the pit is not being worked, to generally discuss its origin.

Stop 1b - City of Bangor Gravel Pit, Twining Road, Winterport: Aquifer Maps 28+29.

We are just south of Stop 1a on the opposite side of the road. This pit is located in distal deposits of the same submarine fan of Stop 1a, that is, these sediments were deposited further away from the ice source than the coarse sediments we just saw. Note the finer-grained texture of the sediment in this pit. We know this fan was deposited in the sea because there are fossil marine shells in the sediments here. This is an inactive pit, so at this stop, we can discuss the general glacial history of Maine, and general hydrogeologic concepts helpful to understanding what a significant sand and gravel aquifer is. We also will be given a presentation of seismic methods used in the project.

From this pit we will drive south along Winterport Road, part of which follows the trend of the aquifer-bearing sand and gravel deposit, outlined by the heavy dashed line on the map (Figure 7). From Coles Corner southward, the morphology of the deposit to the west can easily be seen from the road. Coles Corner is on a bedrock controlled hill, whereas the low area just south of it is underlain by the blue clay of the Presumpscot Formation. The hills to the west (to our right as we drive south) are continuations of the sand and gravel deposit, visible in pit exposures. At approximately the 230 foot elevation mark along the Winterport Road we ride onto the sand and gravel deposit and follow the crest of this ridge to where the road drops off the ridge west of Punchbowl Hill. Along this part of the road are small excavations exposing the core of the ridge. House wells (both dug and drilled) are located along this stretch. It isn't known if all the homeowners are using ground water from the sand and gravel deposit, or the bedrock ground water system, or both. However, the old Sand and Gravel Aquifer maps show several gravel-pack wells along the ridge with yields up to 100 gallons per minute. Further south, the Winterport Water District has two well points driven into the sand and gravel system, both with yields of 75 gallons per minute. From here we will trace our route back north along the Winterport Road, and if time allows make an optional stop in one of the gravel pits to the west of the road.

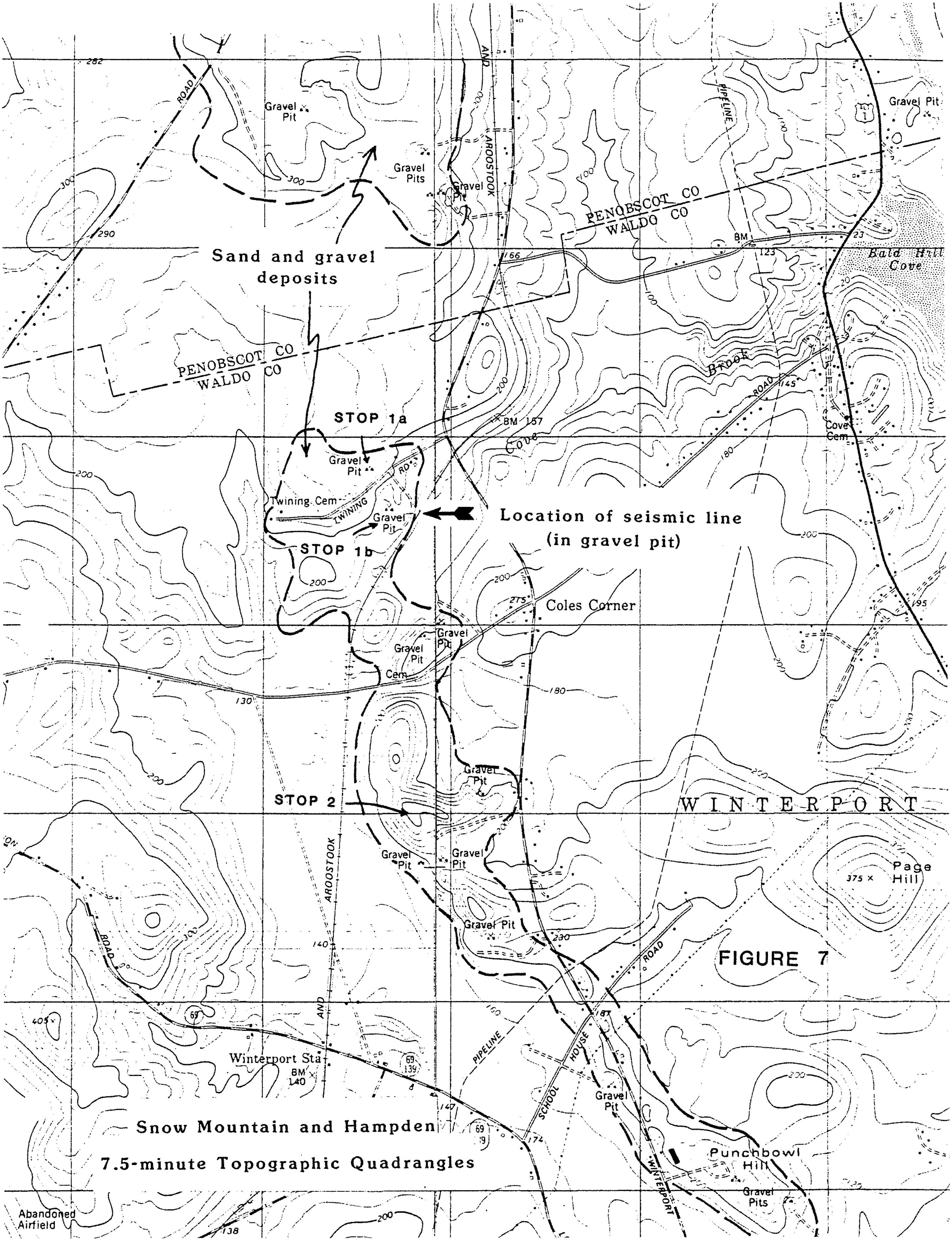

Sand and gravel deposits
STOP 1a
STOP 1b
Location of seismic line (in gravel pit)
STOP 2
Gravel Pit
Gravel Pits
Twining Cem
TWINING RD
Coles Corner
PENOBSCOT CO
WALDO CO
AROOSTOOK
PIPELINE
ROAD
Bald Hill Cove
Brook
Cove
Cove Cem
BM 157
BM 123
WINTERPORT
Page Hill
Winterport Sta
BM 140
SCHOOL HOUSE
Punchbowl Hill
Abandoned Airfield
Cem
Snow Mountain and Hampden
7.5-minute Topographic Quadrangles

FIGURE 7

Stop 2 (optional) - Hughes Brothers Pit, Winterport Road, Winterport.

This pit exposure is an impressive example of a section into the front of a submarine fan. Although the elevation of the top of this landform is very close to what the ocean surface was when the ice margin was here, at last visit no features were exposed which would indicate the landform is a delta. A good sense of the ocean water depth can be estimated here. The elevation at the top of the fan is approximately 310 feet (the marine limit in the area is about 315 feet). The elevation in the low wetland to the west, which was ocean bottom when the fan was being deposited is about 135 feet. The difference in elevation gives about a 175-180 feet water column here.

Lunch Stop - Dorothea Dix Park, Hampden.

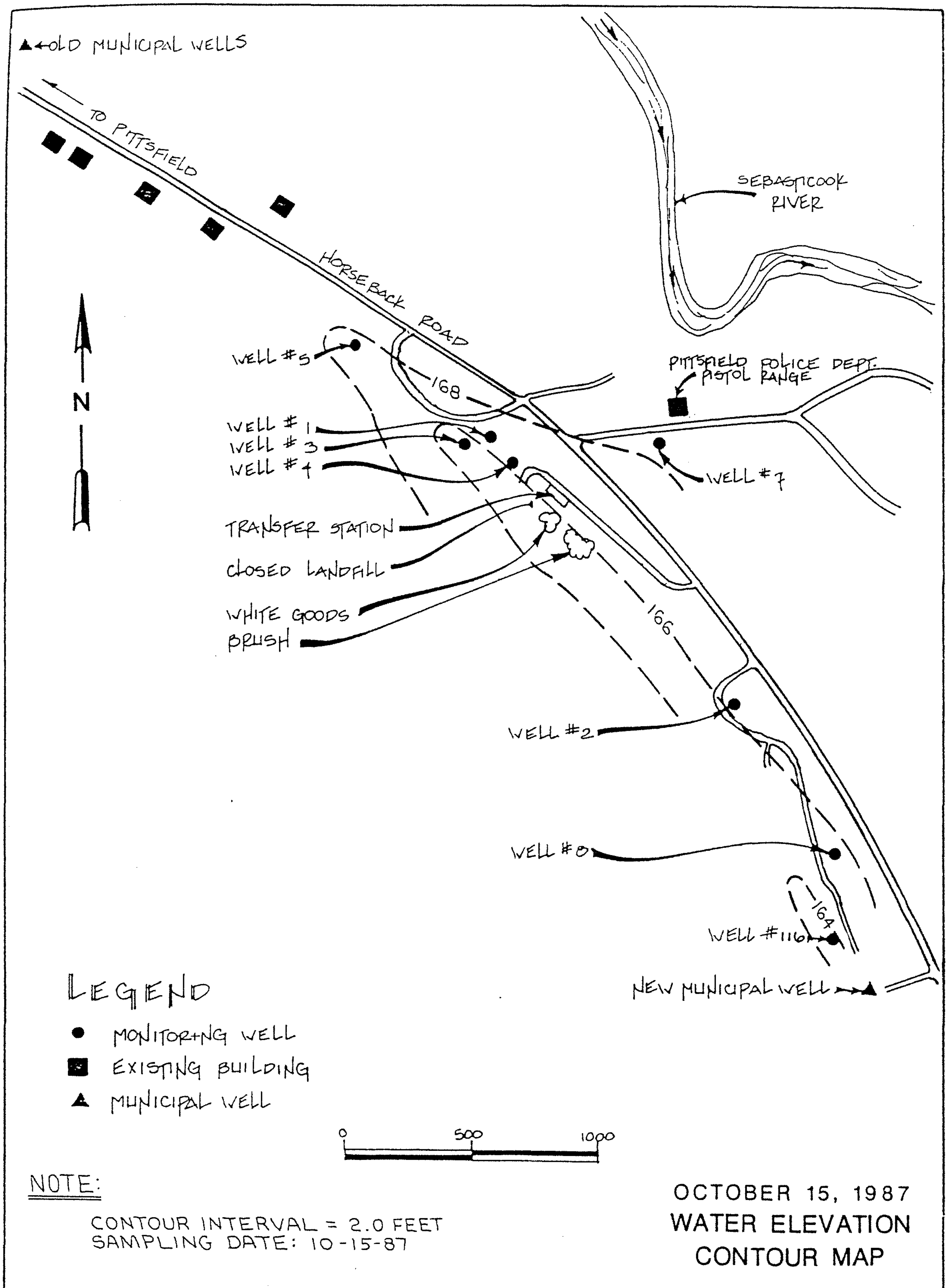
Stop 3 - Monitoring Well 7, Pittsfield Landfill: Significant Sand and Gravel Aquifer Map 30. (Refer to Figures 8-10)

This stop is located at monitoring well (MW) 7 which was installed during the 1984 field season for the Aquifer Mapping Project. The Town of Pittsfield now uses this well as part of their ground water quality monitoring network around the closed Pittsfield Landfill, which is located 400 feet west of this well, under the present transfer station (Figure 8).

In the 1950's the Pittsfield Water District installed two municipal wells approximately one mile north of the Pittsfield Landfill. In 1980 trace levels of chloroform and several other organic chemicals were discovered in the water from these wells. The landfill was considered to be a possible source of these chemicals. Morrison Geotechnical Engineering Company was hired to conduct a study of ground water at the landfill, and installed five monitoring wells in the landfill area. They found some ground water contamination near the site, and determined that ground water was moving to the north, in the direction of the municipal wells. However, there was no indication that the landfill was responsible for diminishing the water quality in the muncipal wells.

In 1983 the Pittsfield Landfill was closed, capped, and covered. Later that year the Pittsfield Water District decided to seek a new water supply source, and hired another engineering firm to locate a new water supply well. A location approximately 2000 feet south of the landfill was selected, and in 1984 a new water supply well was drilled, despite concern that the new well might become contaminated by leachate from the closed landfill.

Figure 8


OLD MUNICIPAL WELLS
TO PITTSFIELD
HORSEBACK ROAD
SEBASTICOOK RIVER
PITTSFIELD POLICE DEPT. PISTOL RANGE
N
WELL #5
168
WELL #1
WELL #3
WELL #4
WELL #7
TRANSFER STATION
CLOSED LANDFILL
WHITE GOODS
BRUSH
166
WELL #2
WELL #8
164
WELL #116
NEW MUNICIPAL WELL
LEGEND
MONITORING WELL
EXISTING BUILDING
MUNICIPAL WELL
0
500
1000
NOTE:
CONTOUR INTERVAL = 2.0 FEET
SAMPLING DATE: 10-15-87
OCTOBER 15, 1987
WATER ELEVATION
CONTOUR MAP

The aquifer mapping project's study of ground water contamination from the closed Pittsfield Landfill began in 1984, before the new municipal well was placed in operation. We first conducted a terrain conductivity study of the site. Terrain conductivity is a geophysical field method in which an electrical current is generated in the ground, and the ease with which the current is transmitted (the conductivity) is measured. Currents are transmitted more easily in saturated sediments than in dry sand or rock, and are transmitted even more easily where ground water is contaminated with inorganic chemicals such as salt. By measuring and plotting the conductivity at many locations around a contamination source, a "plume", or zone of contamination can be defined. At the Pittsfield Landfill terrain conductivity showed that most of the ground water contamination was restricted to the immediate landfill area, but suggested that some contaminants might be moving as much as 1000 feet north of the landfill, toward the north municipal wells (figure 9).

Two monitoring wells were then installed; MW 7 east of the landfill, and MW 8 south of the landfill. Water levels in these two wells and in the five wells installed previously by Morrison Geotechnical were measured, and the elevations of the wells were surveyed in. From this information a water table map was constructed. However, the water table gradient was so low that flow directions could not be determined.

Water quality in the monitoring wells was also determined. Trace levels of trichloroethane were found in well 1, which is located approximately 200 feet north of the landfill. Levels of sodium, chloride, iron and manganese were slightly elevated in MW 7 and in several wells north of the site, but were at background levels in the two wells south of the site.

From this study it was concluded that ground water was moving north from the landfill in the direction of the municipal wells, but that the landfill was an unlikely to be the source of any contamination of the municipal wells, since contaminant concentrations were low in wells adjacent to the landfill, and would be expected to be further diluted as the contamination plume moved away from the site.

Subsequent work by the DEP and the Department of Human Services has shown that the dumping and burning of hazardous waste at the Cianbro Storage Facility, located several hundred feet north of the northern municipal wells, was another possible source of the organic constituents found in the municipal wells in 1980. The chemicals also could have been associated with the chlorination process used to disinfect the water. In any case, recent sampling of these wells has not shown any contaminants to be present in the north wells.

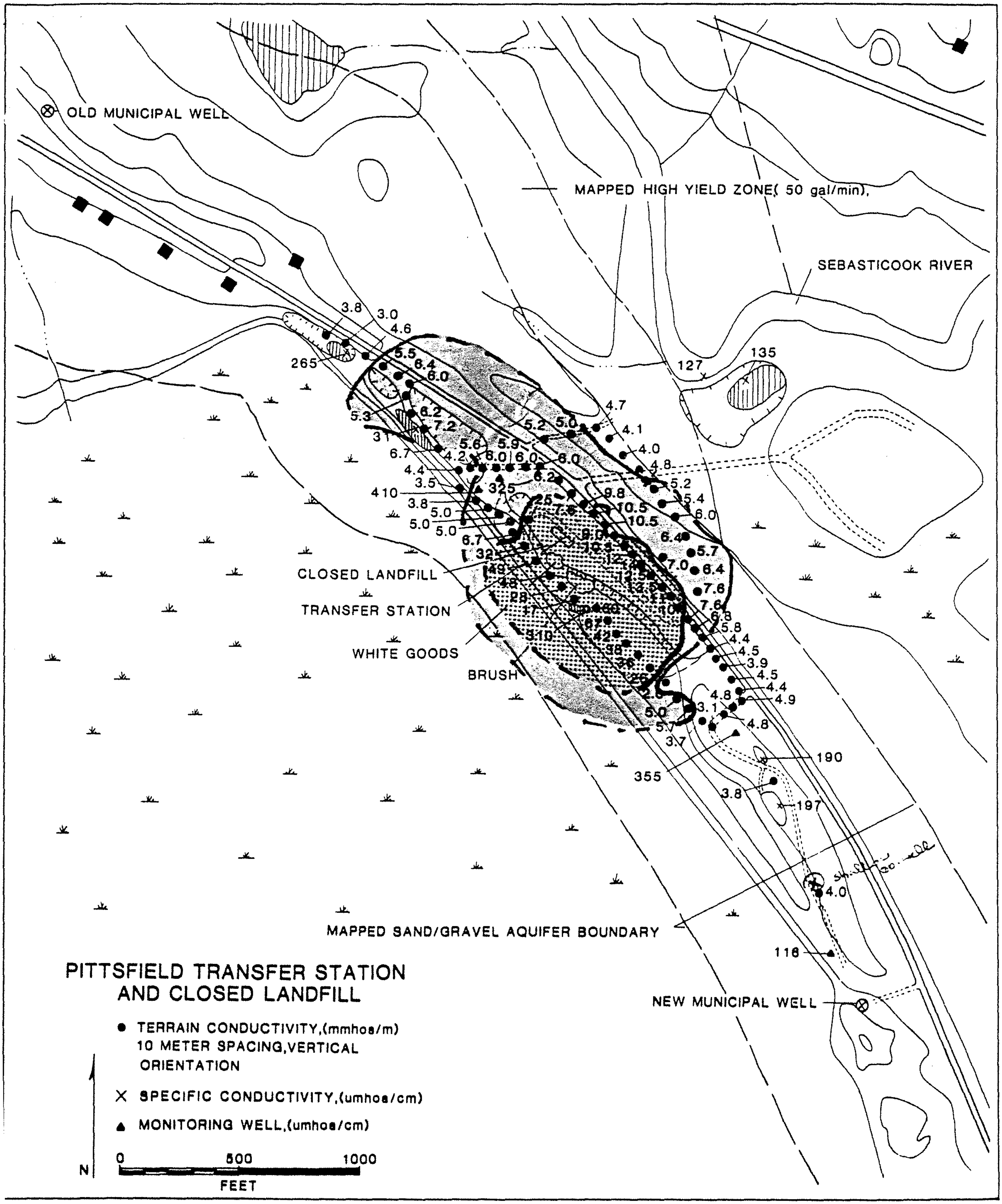


Figure 9. Apparent contamination plume from Pittsfield Landfill as determined by terrain conductivity profiling, July, 1984.

Recent monitoring of the ground water at the landfill site by Morrison Geotechnical Company shows that a contamination plume is now moving south from the closed landfill toward the south municipal well, which presumably has reversed ground water flow directions since it began operating in 1984. The specific conductance of the ground water has increased steadily since 1984 in monitoring wells south of the landfill, and appears to be increasing in the municipal well itself (figure 6). Testing of the water from the south well shows that the water is still safe to drink, but the trend of increasing specific conductance is alarming. The Pittsfield Water District is currently looking for a new, safer water supply source.

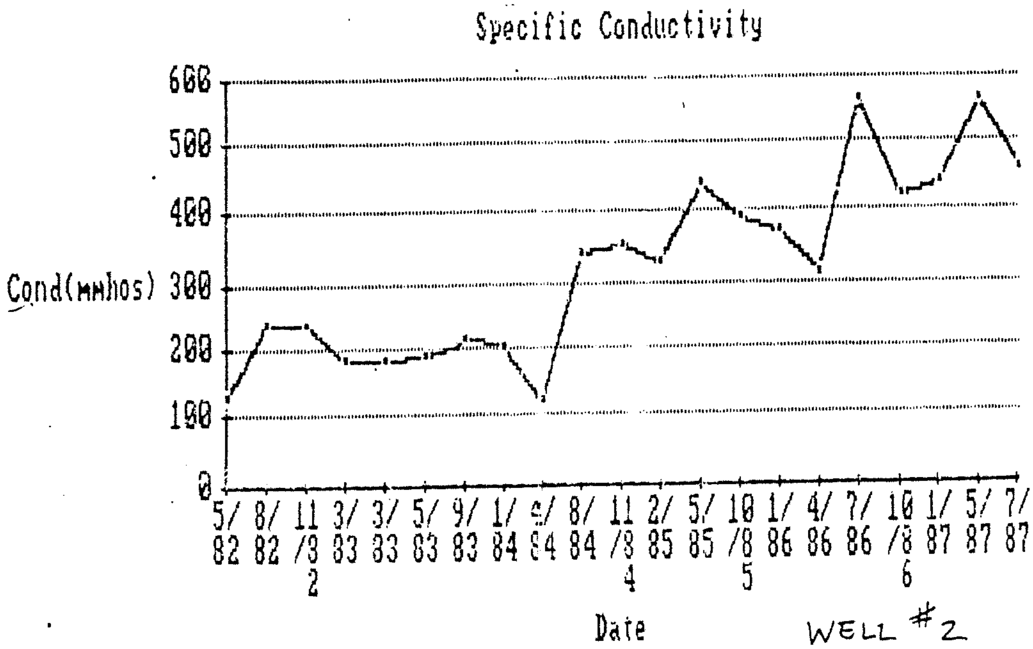
Site contamination studies are no longer being performed through the Sand and Gravel Aquifer Mapping Project, due to funding and staffing restraints. Most of this type of work is now performed by private geologic consulting firms.

Stop 4: Bedrock outcrop on Weeks Road, Pittsfield. The stop is between the Pittsfield Exit of I-95 and Spring Street.

At the previous three stops we have discussed sand and gravel aquifers. Ground water is also found in a completely different geologic setting; within fractures in consolidated rock. These fractured bedrock aquifers are used extensively in Maine for domestic drilled, or artesian, wells. Fractured bedrock aquifers are being increasingly relied upon for municipal and industrial water supplies. Contamination studies are also demonstrating that bedrock aquifers are highly vulnerable to contamination: approximately 90 percent of the wells in Maine known to be contaminated with salt, gasoline, and pesticides are bedrock wells.

Ground water in Maine's bedrock aquifers cannot flow through the rock itself, as the crystalline nature of our rocks make them impermeable to water movement. However, most of our rocks contain joints, or fractures, which allow ground water movement. The potential yield of a bedrock aquifer is dependent on the abundance, size, and inter-connectiveness of the fractures. In nearly all of Maine the rocks are sufficiently fractured to provide a useable quantity of water for domestic use. For example, the two homes across the street from this stop are served by wells drilled into bedrock with yields of 1 and 3 gallons/minute. Neither homeowner reported any water supply problems despite the relatively low yields.

In some locations in Maine the rocks are sufficiently fractured to produce yields in excess of 100 gallons per minute. These high yield bedrock zones can be valuable ground water resources, especially in northern Maine and in the mid-coast region, where sand and gravel aquifers are not extensive. Identifying these high yield zones is much more difficult than mapping sand and gravel aquifers, but in the past few years we have had increasing success using air photo interpretation, geologic mapping, and geophysical techniques to delineate potential high yield zones. Later this year we will publish the results of our work in Northern Maine, and will begin a limited bedrock aquifer mapping program in the Bath-Brunswick area.



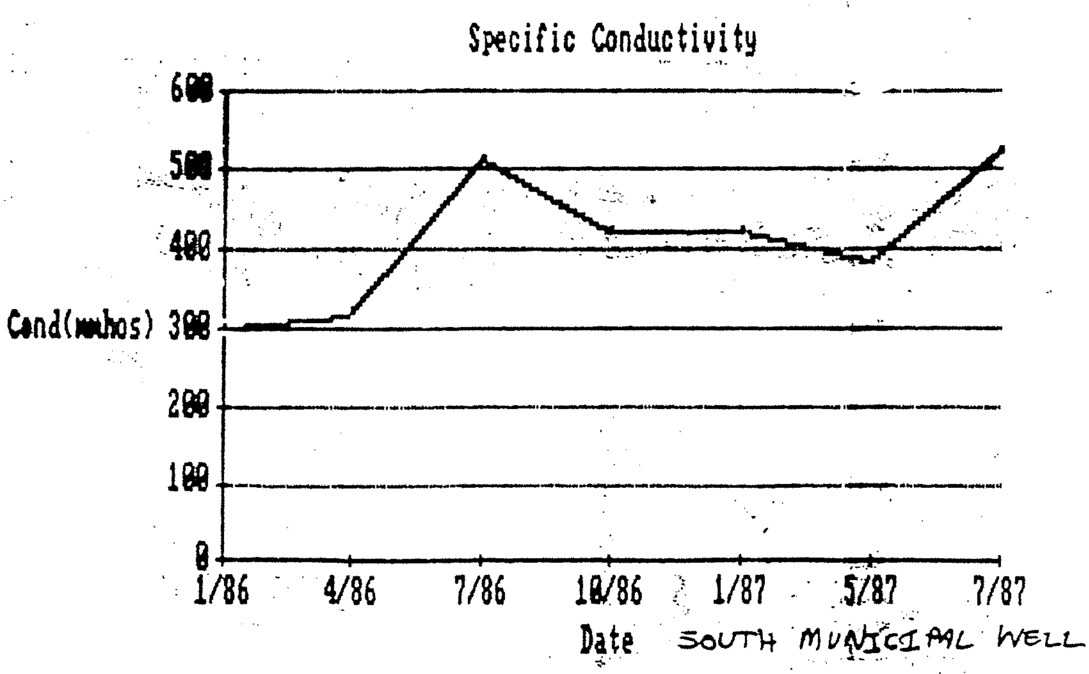
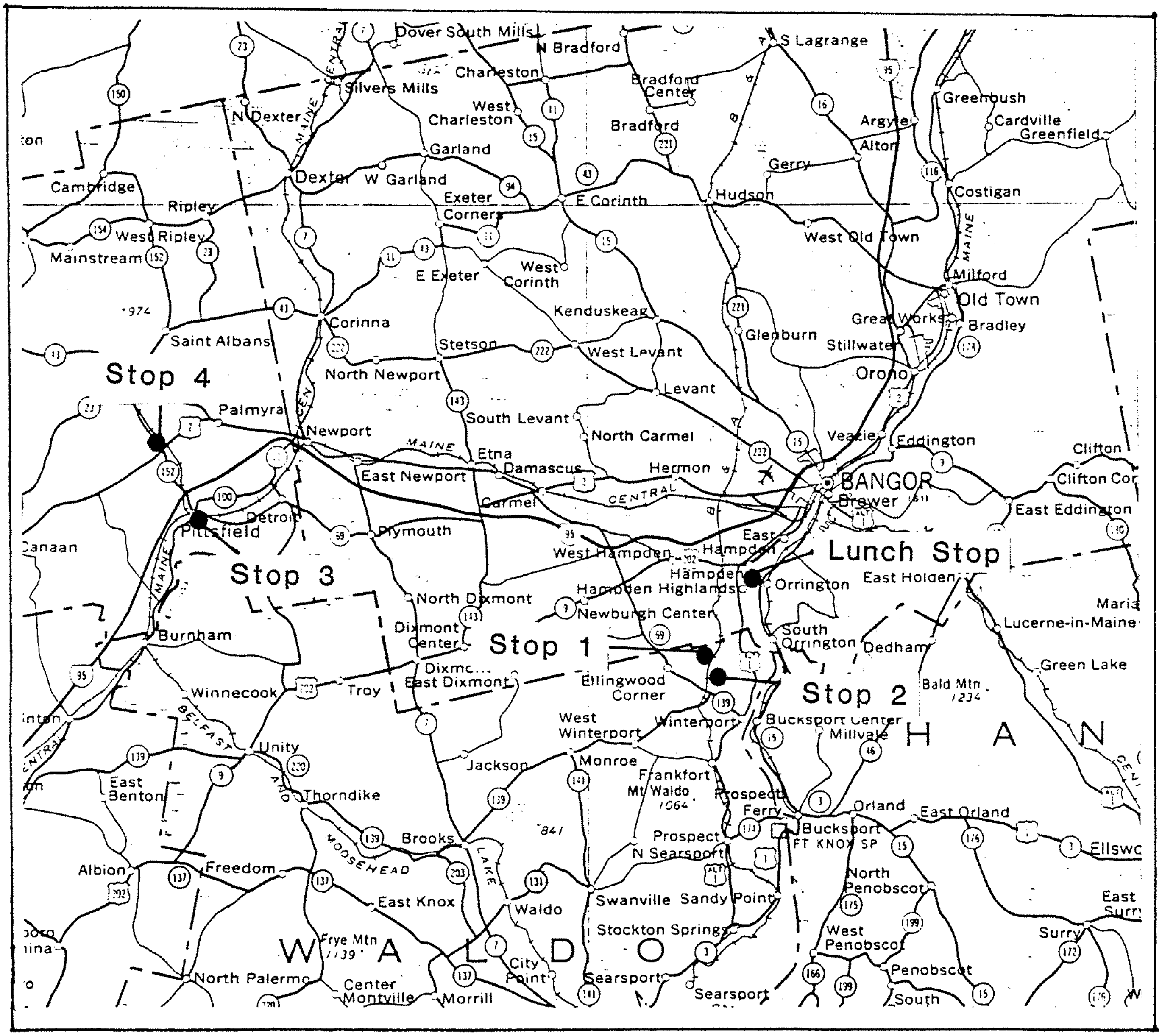


Figure 10. Specific Conductance vs. Time; Monitoring well 2 and south municipal well: Pittsfield. Figure from Morrison Geotechnical Engineering Company report to DEP.



Scale 1:500,000

1 inch equals approximately 8 miles

10 0 10 Miles

10 0 10 Kilometers

Base map by U.S. Geological Survey, 1973

Lambert conformal conic projection based on standard parallels 33° and 45°

STOP LOCATIONS MAP