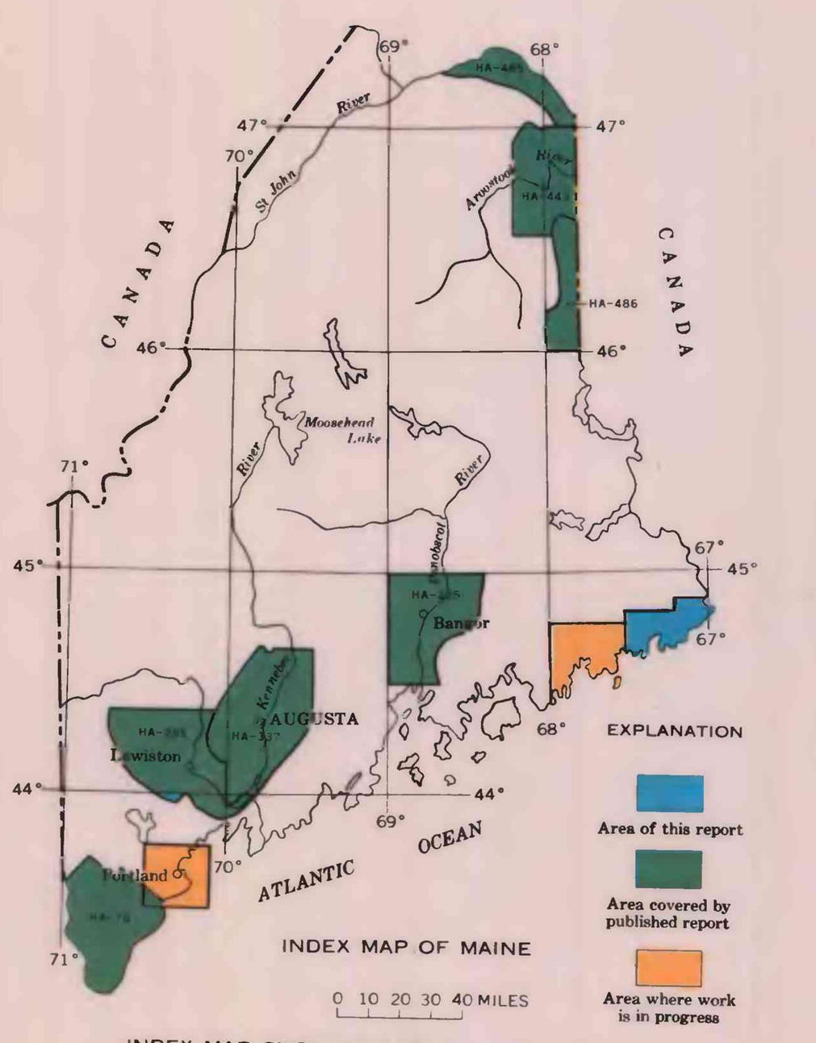
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
STATE OF MAINE, PUBLIC UTILITIES COMMISSION

HYDROLOGIC INVESTIGATIONS
ATLAS HA-535

INTRODUCTION

The Machias-Lubec area includes about 330 square miles in Washington County on the eastern border of Maine (index map). Included are parts or all of the following towns or townships: Cutler, Dennysville, East Machias, Eastport, Edmunds, Lubec, Machias, Machiasport, Marion, Marshfield, Pembroke, Perry, Roque Bluffs, T. 18 E.D., Trescott, Whiting, and Whitneyville.



INDEX MAP SHOWING AREAS OF GROUND-WATER INVESTIGATIONS

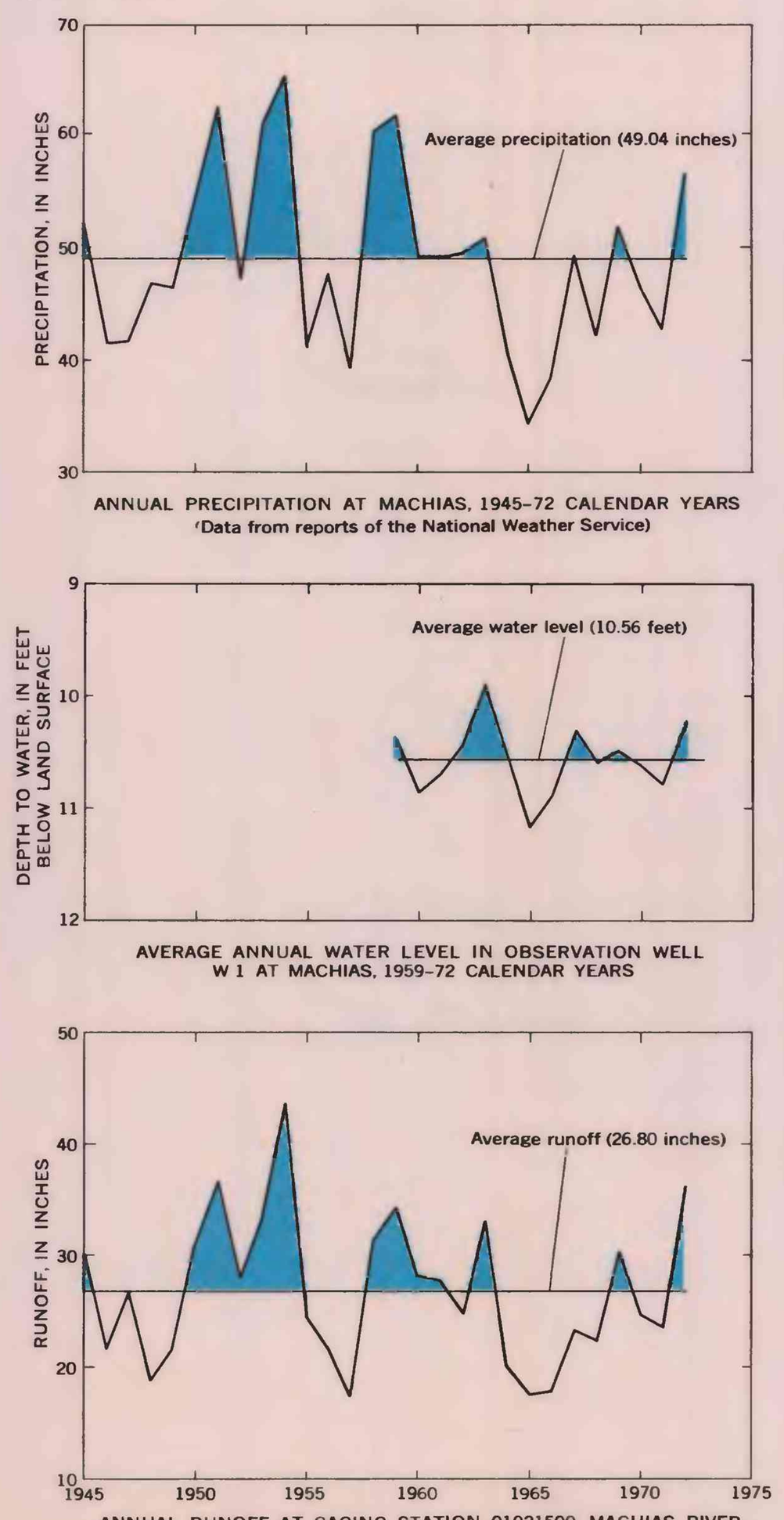
This report is one of a series describing the geologic and hydrologic conditions governing the occurrence of ground water in Maine. These reports are intended to provide information of use to those doing resource planning, or to those wishing to develop water supplies, particularly supplies large enough for public, industrial, or commercial use, from ground-water sources. The magnitude of yields that might be obtained from properly located and constructed wells or from springs is indicated by the map showing surficial geology and ground-water favorability. This map gives a generalized interpretation of observed geologic and hydrologic data and provides a basis for directing detailed exploration for ground water but does not eliminate the need for such exploration.

RELATION OF CLIMATE TO AVAILABILITY OF WATER

All fresh water available for use in the Machias-Lubec area comes from precipitation within the drainage basins of streams flowing in or through the area. According to records of the National Weather Service, annual precipitation at Machias during 1945-72 ranged from 34.42 inches in 1965 to 65.52 inches in 1954 and averaged 49 inches (annual precipitation graph). This is 2 inches more than the average annual precipitation for the same period at Jonesboro, which is a few miles west of Machias, and 7 inches greater than at Eastport at the northeast corner of the project area. Hence, average precipitation for the project area is less than the average for Machias. Annual runoff of the Machias River at Whitneyville ranged from 17.27 inches in 1957 to 43.54 inches in 1954 and averaged 27 inches during 1945-72. Of the water that runs off, perhaps as much as 40 percent is derived from precipitation that has percolated to the water table, where it was temporarily stored, and hence moved laterally to streams (Hayes, 1966, p. 22).

Most of the difference between precipitation and runoff, 19 or 20 inches per year, is evaporated or transpired.

Years of above-average precipitation are normally years of above-average ground-water levels and streamflow (annual water-level and runoff graphs). No apparent trends in precipitation, ground-water levels, or streamflow are indicated by the graphs.

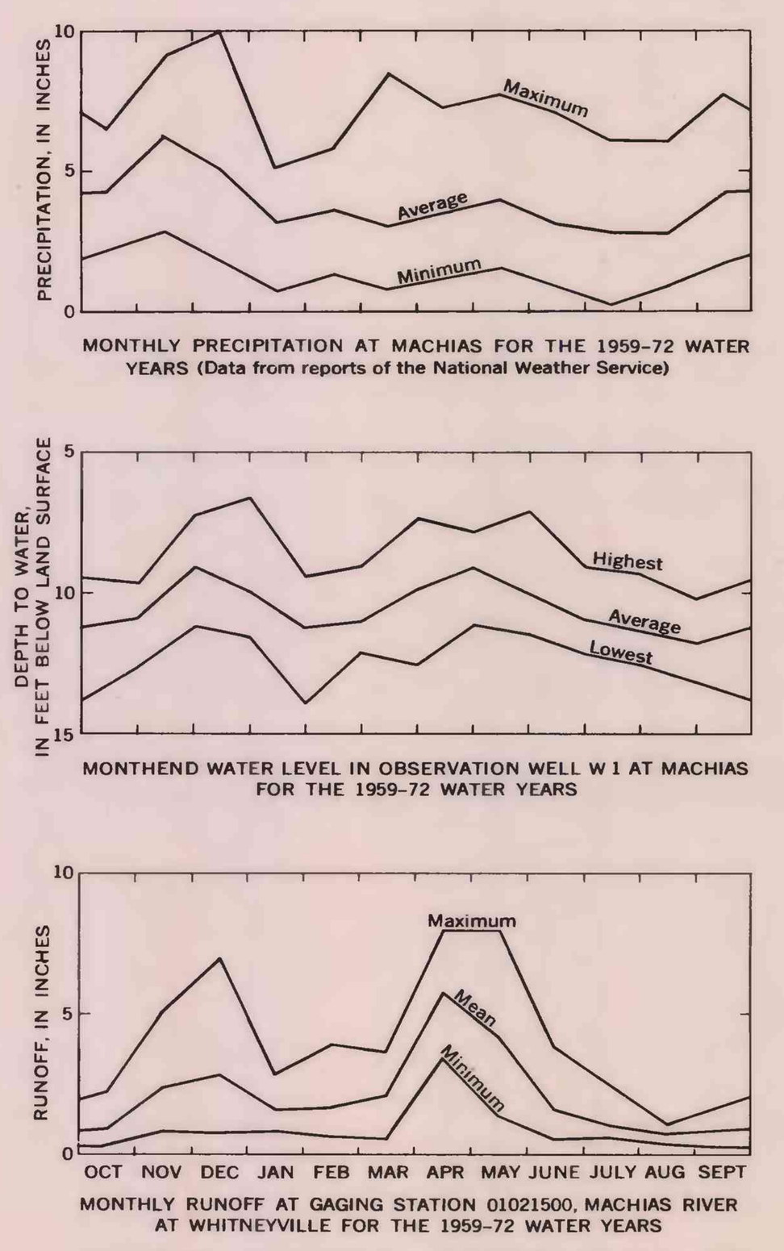


GRAPHS SHOWING CORRELATION OF ANNUAL PRECIPITATION, GROUND-WATER LEVELS, AND RUNOFF

Monthly fluctuations in ground-water levels and streamflow are due principally to variations in character and amount of precipitation and other climatic factors. During the 1959-72 water years (the period during which data on ground-water levels at Machias are available for comparison with precipitation and runoff data), November and December received the highest monthly precipitation, averaging 6.18 and 5.01 inches. July and August with 2.89 and 2.78 inches have been the driest months (monthly precipitation graph). Ground-water levels normally reach their lowest point during August as the result of low rainfall and high evapotranspiration during the summer. In September rainfall increases, evapotranspiration rates decline, ground-water levels rise, and streamflow increases. During December, despite a high rate of precipitation, ground-water levels generally decline because much of December precipitation may be stored as snow or the ground may be frozen, thus inhibiting ground-water recharge. Streamflow generally continues to rise during December, either as a result of direct runoff from December rains or snowmelt, or from overland or subsurface runoff of late November precipitation. Ground-water levels and streamflow decline from the end of December until late February or early March, when water from snowmelt or rain again has the opportunity to percolate into the ground and recharge the body of ground water or to run off in streams (monthly water-level and runoff graphs). With the coming of the growing season and increased evapotranspiration, ground-water levels and streamflow again decline.

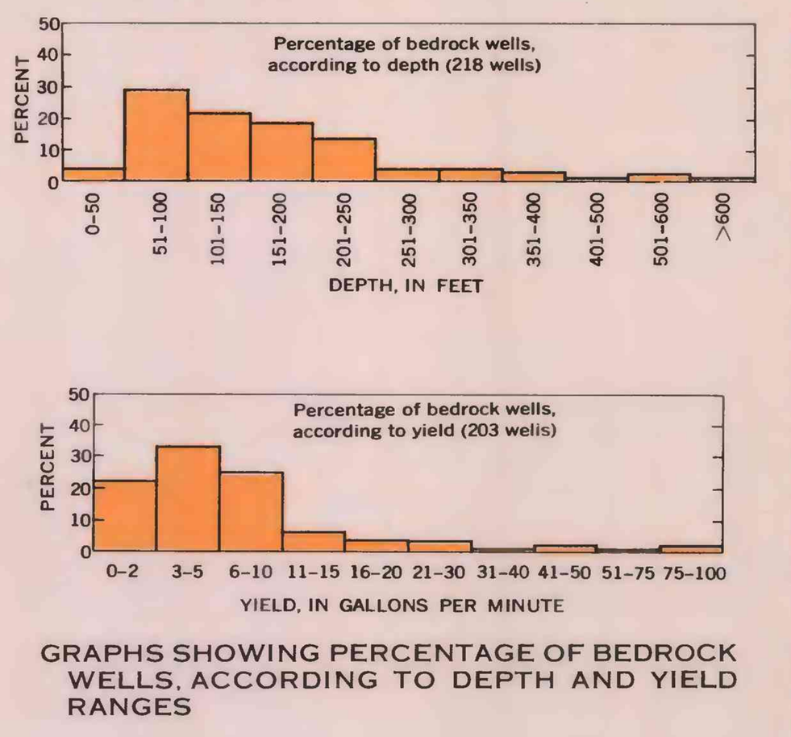
GROUND WATER IN BEDROCK

The depth of 218 bedrock wells ranged from 20 to 855 feet. The average depth was 168 feet, and the median depth was 140 feet. About 80 percent of the wells were in the 51- to 250-foot range, 5 percent were 50 feet or less in depth, 15 percent were deeper than 250 feet, and 10 percent exceeded 300 feet (bedrock well graphs). In general the well depths reflect the depth necessary to drill for supplies adequate for domestic purposes. Of 21 wells deeper than 300 feet, 11 were drilled in the hope of obtaining yields larger than those needed for domestic use. Only two of these were successful, obtaining 50 and 60 gpm (gallons per minute) respectively.



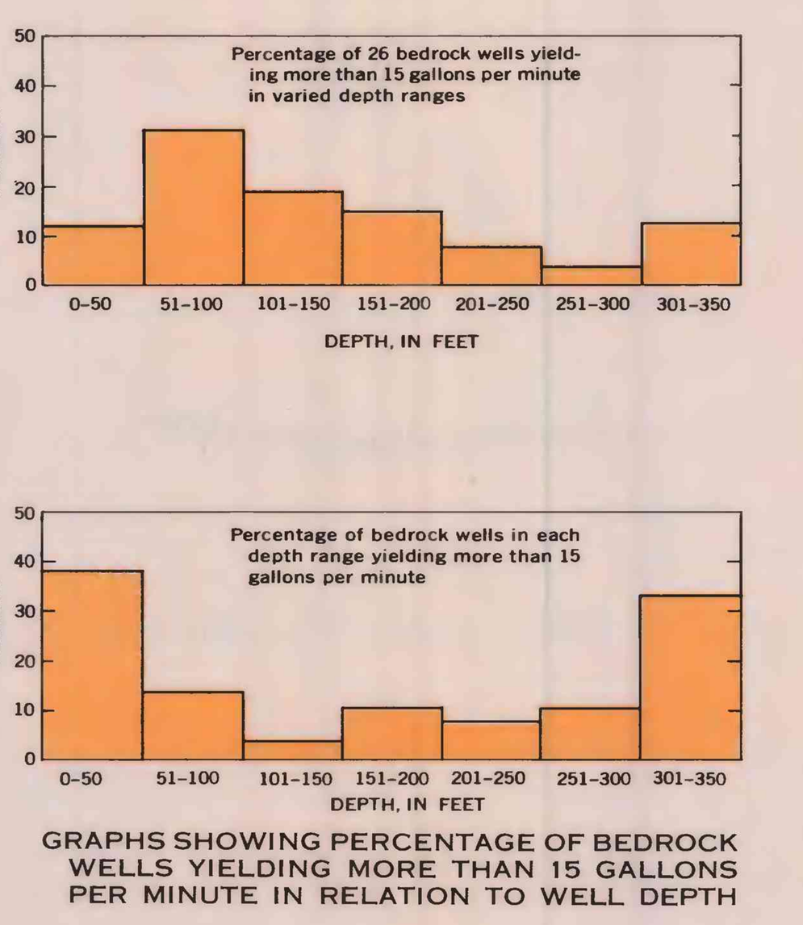
GRAPHS SHOWING CORRELATION OF MONTHLY PRECIPITATION, MONTHEND GROUND-WATER LEVEL, AND MONTHLY RUNOFF

The yield of wells ranged from less than a gallon per minute to 100 gpm. The average yield was 10 gpm, and the median yield was 5 gpm. The yield of 77 percent of the wells was 3 gpm or more. However, the yield of more than half of those drilled deeper than 300 feet was less than 3 gpm. The yield of the 855-foot well was only 1 gpm. One well 700 feet in depth had a reported yield of 8 gpm.



GRAPHS SHOWING PERCENTAGE OF BEDROCK WELLS, ACCORDING TO DEPTH AND YIELD RANGES

Thirteen percent of the bedrock wells had a yield exceeding 15 gpm (bedrock well graphs). Most of these were in the 51-to 100-foot depth range, which also includes the largest number of wells. The table below shows the number of wells in each depth range, with maximum, minimum, average, and median yields.



GRAPHS SHOWING PERCENTAGE OF BEDROCK WELLS YIELDING MORE THAN 15 GALLONS PER MINUTE IN RELATION TO WELL DEPTH

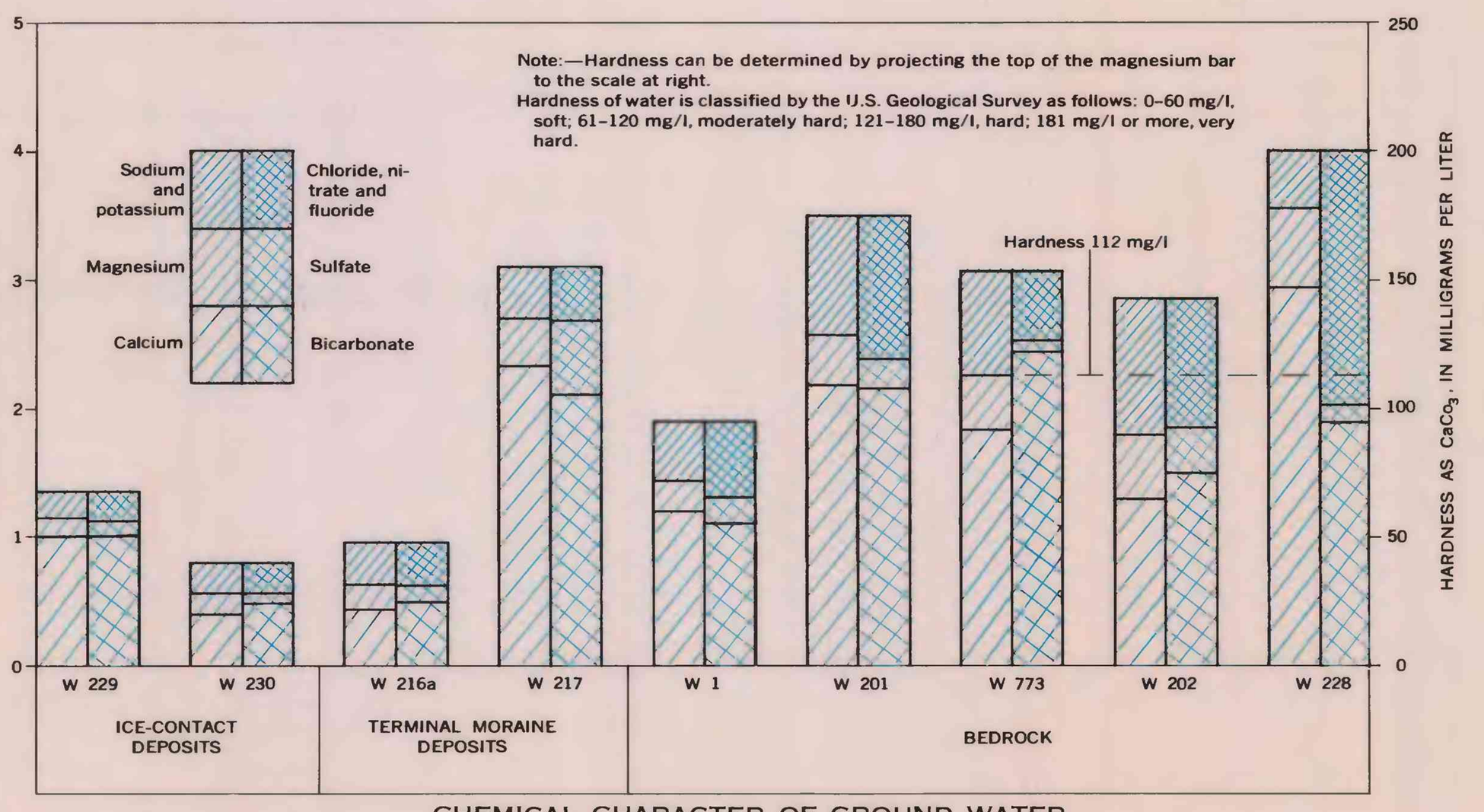
WATER QUALITY

The quality of the ground water is generally good for most purposes. It is normally low in dissolved solids, soft, and in most places is free from constituents that would limit its usefulness. However, many wells along the immediate coast, particularly those drilled to depths below sea level, yield water with a higher chloride concentration than wells inland or coastal wells that are finished above sea level.

Water from wells and springs in the unconsolidated deposits is commonly less highly mineralized than water from wells in bedrock, principally because water in unconsolidated deposits normally has been in the ground a shorter time than water in the bedrock and has had less time to dissolve mineral matter from the earth materials through which it moves. However, water from well W 217 in terminal moraine deposits at Lubec is more highly mineralized than water from bedrock wells W 1, W 773, and W 202 (chemical character diagrams). Well W 217 is 0.6 mile from the ocean and is drilled to below sea level. It is pumped at about 150 gpm for a public supply. The aquifer underlies 20 to 30 feet of marine deposits, from which much of the mineral matter in the water may be derived. Well W 1 at Machias is a shallow bedrock well and does not reach to sea level. The water level in the well fluctuates readily as the result of recharge from precipitation, so it seems that rain and snowmelt infiltrate to the well rather quickly before having an opportunity for prolonged contact with the water-bearing formation. Wells W 202 and W 773 are at Bucks Harbor and 0.25 mile from the sea. Both are drilled to below sea level, but the altitude of the water-bearing zones is not known. Water from well W 201, also at Bucks Harbor and drilled about to sea level, is more highly mineralized than that from well W 217. Well W 228 at Edmunds is drilled to about 120 feet below sea level, and its water is the most highly mineralized of all water sampled. Chloride concentrations in available chemical analyses ranged from 6.5 to 79 mg/l (milligrams per liter) and do not exceed the U.S. Public Health Service (1962) recommended limit of 250 mg/l chloride. Water from relatively small number of wells, for which information was obtained, was too salty to use.

Aside from the ocean, the other possible sources of undesirable constituents in ground water are: salt used to deice roads, especially in storage sites; and effluent from septic tanks, barnyards, and fertilized fields, which may contribute excessive amounts of nitrate, chloride, phosphate, or coliform bacteria. Concentrations of iron or manganese greater than the U.S. Public Health recommended limits may be derived from some of the bedrock formations or unconsolidated deposits. These problems are localized and affect only individual wells. Aside from excessive concentrations of iron and manganese in a few water samples, none of these problems are indicated by the available chemical analyses.

The temperature of seven samples of ground water ranged from 6.5 °C to 9.0 °C (44 to 48 °F).



CHEMICAL CHARACTER OF GROUND WATER

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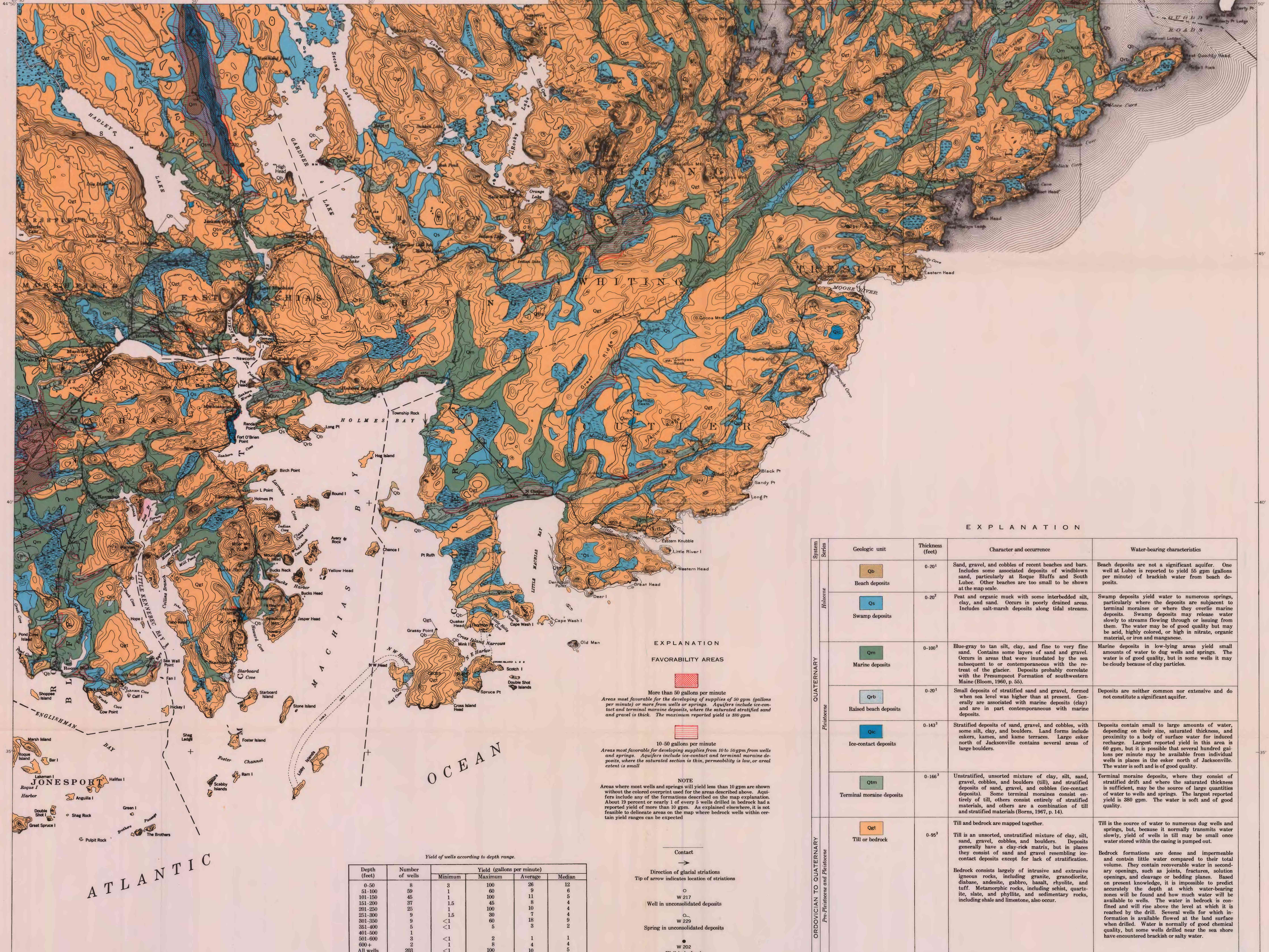

EXPLANATION

FAVORABILITY AREAS

More than 50 gallons per minute
Areas most favorable for the developing of supplies of 50 gpm (gallons per minute) or more from wells or springs. Aquifers include ice-contact and terminal moraine deposits, where the saturated stratified sand and gravel is thick. The maximum reported yield is 380 gpm

10-50 gallons per minute
Areas most favorable for developing supplies from 10 to 50 gpm from wells and springs. Aquifers include ice-contact and terminal moraine deposits, where the saturated section is thin, permeability is low, or areal extent is small

NOTE

Areas where most wells and springs will yield less than 10 gpm are shown without the colored overprint used for the areas described above. Aquifers include any of the formations described on the map explanation. About 19 percent or nearly 1 of every 5 wells drilled in bedrock had a reported yield of more than 10 gpm. As explained elsewhere, it is not feasible to delineate areas on the map where bedrock wells within certain yield ranges can be expected

Contact

Direction of glacial striations
Tip of arrow indicates location of striations

W 217
Well in unconsolidated deposits

W 229
Spring in unconsolidated deposits

W 202
Well in bedrock

Yield of wells according to depth range.

Depth (feet)	Number of wells	Yield (gallons per minute)			
		Minimum	Maximum	Average	Median
0-50	8	3	100	26	12
51-100	59	1	60	9	6
101-150	45	1	100	11	5
151-200	37	1.5	45	8	4
201-250	25	1	100	10	4
251-300	9	1.5	30	7	4
301-350	9	<1	60	18	9
351-400	5	<1	5	3	2
401-500	1				
501-600	3	<1	2	1	1
600+	2	1	8	4	4
All wells	203	<1	100	10	5

E X P L A N A T I O N

System	Series	Geologic unit	Thickness (feet)	Character and occurrence	Water-bearing characteristics
QUATERNARY	*Holocene*	Qb Beach deposits	0-20[1]	Sand, gravel, and cobbles of recent beaches and bars. Includes some associated deposits of windblown sand, particularly at Roque Bluffs and South Lubec. Other beaches are too small to be shown at the map scale.	Beach deposits are not a significant aquifer. One well at Lubec is reported to yield 55 gpm (gallons per minute) of brackish water from beach deposits.
		Qs Swamp deposits	0-20[2]	Peat and organic muck with some interbedded silt, clay, and sand. Occurs in poorly drained areas. Includes salt-marsh deposits along tidal streams.	Swamp deposits yield water to numerous springs, particularly where the deposits are subjacent to terminal moraines or where they overlie marine deposits. Swamp deposits may release water slowly to streams flowing through or issuing from them. The water may be of good quality but may be acid, highly colored, or high in nitrate, organic material, or iron and manganese.
	Pleistocene	Qm Marine deposits	0-100[3]	Blue-gray to tan silt, clay, and fine to very fine sand. Contains some layers of sand and gravel. Occurs in areas that were inundated by the sea subsequent to or contemporaneous with the retreat of the glacier. Deposits probably correlate with the Presumpscot Formation of southwestern Maine (Bloom, 1960, p. 55).	Marine deposits in low-lying areas yield small amounts of water to dug wells and springs. The water is of good quality, but in some wells it may be cloudy because of clay particles.
		Qrb Raised beach deposits	0-20[1]	Small deposits of stratified sand and gravel, formed when sea level was higher than at present. Generally are associated with marine deposits (clay) and are in part contemporaneous with marine deposits.	Deposits are neither common nor extensive and do not constitute a significant aquifer.
		Qic Ice-contact deposits	0-143[3]	Stratified deposits of sand, gravel, and cobbles, with some silt, clay, and boulders. Land forms include eskers, kames, and kame terraces. Large esker north of Jacksonville contains several areas of large boulders.	Deposits contain small to large amounts of water, depending on their size, saturated thickness, and proximity to a body of surface water for induced recharge. Largest reported yield in this area is 60 gpm, but it is possible that several hundred gallons per minute may be available from individual wells in places in the esker north of Jacksonville. The water is soft and is of good quality.
		Qtm Terminal moraine deposits	0-166[3]	Unstratified, unsorted mixture of clay, silt, sand, gravel, cobbles, and boulders (till), and stratified deposits of sand, gravel, and cobbles (ice-contact deposits). Some terminal moraines consist entirely of till, others consist entirely of stratified materials, and others are a combination of till and stratified materials (Borns, 1967, p. 14).	Terminal moraine deposits, where they consist of stratified drift and where the saturated thickness is sufficient, may be the source of large quantities of water to wells and springs. The largest reported yield is 380 gpm. The water is soft and of good quality.
ORDOVICIAN TO QUATERNARY	*Pre-Pleistocene and Pleistocene*	Qgt Till or bedrock	0-95[3]	Till and bedrock are mapped together. Till is an unsorted, unstratified mixture of clay, silt, sand, gravel, cobbles, and boulders. Deposits generally have a clay-rich matrix, but in places they consist of sand and gravel resembling ice-contact deposits except for lack of stratification. Bedrock consists largely of intrusive and extrusive igneous rocks, including granite, granodiorite, diabase, andesite, gabbro, basalt, rhyolite, and tuff. Metamorphic rocks, including schist, quartzite, slate, and phyllite, and sedimentary rocks, including shale and limestone, also occur.	Till is the source of water to numerous dug wells and springs, but, because it normally transmits water slowly, yield of wells in till may be small once water stored within the casing is pumped out. Bedrock formations are dense and impermeable and contain little water compared to their total volume. They contain recoverable water in secondary openings, such as joints, fractures, solution openings, and cleavage or bedding planes. Based on present knowledge, it is impossible to predict accurately the depth at which water-bearing zones will be found and how much water will be available to wells. The water in bedrock is confined and will rise above the level at which it is reached by the drill. Several wells for which information is available flowed at the land surface when drilled. Water is normally of good chemical quality, but some wells drilled near the sea shore have encountered brackish or salty water.

[1]Maximum value estimated.
[2]Maximum value from Bastin and Williams (1914, p. 12).
[3]Maximum value from well record.

Base from U.S. Geological Survey
Eastport, 1943; Gardner Lake, Machias, 1941
and Cutler, 1917

APPROXIMATE MEAN DECLINATION, 1974

SCALE 1:62 500
1 ½ 0 1 2 3 4 5 MILES
1 .5 0 1 2 3 4 5 KILOMETRES
CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1974

Geology mapped in 1972. Location of terminal moraines adapted and modified from material supplied by H. W. Borns, Jr. (1967, and unpublished).

GROUND-WATER FAVORABILITY AND SURFICIAL GEOLOGY OF THE MACHIAS—LUBEC AREA, WASHINGTON COUNTY, MAINE

By
Glenn C. Prescott, Jr.

1974

For sale by U.S. Geological Survey, Reston, Virginia 22092, price $1.00