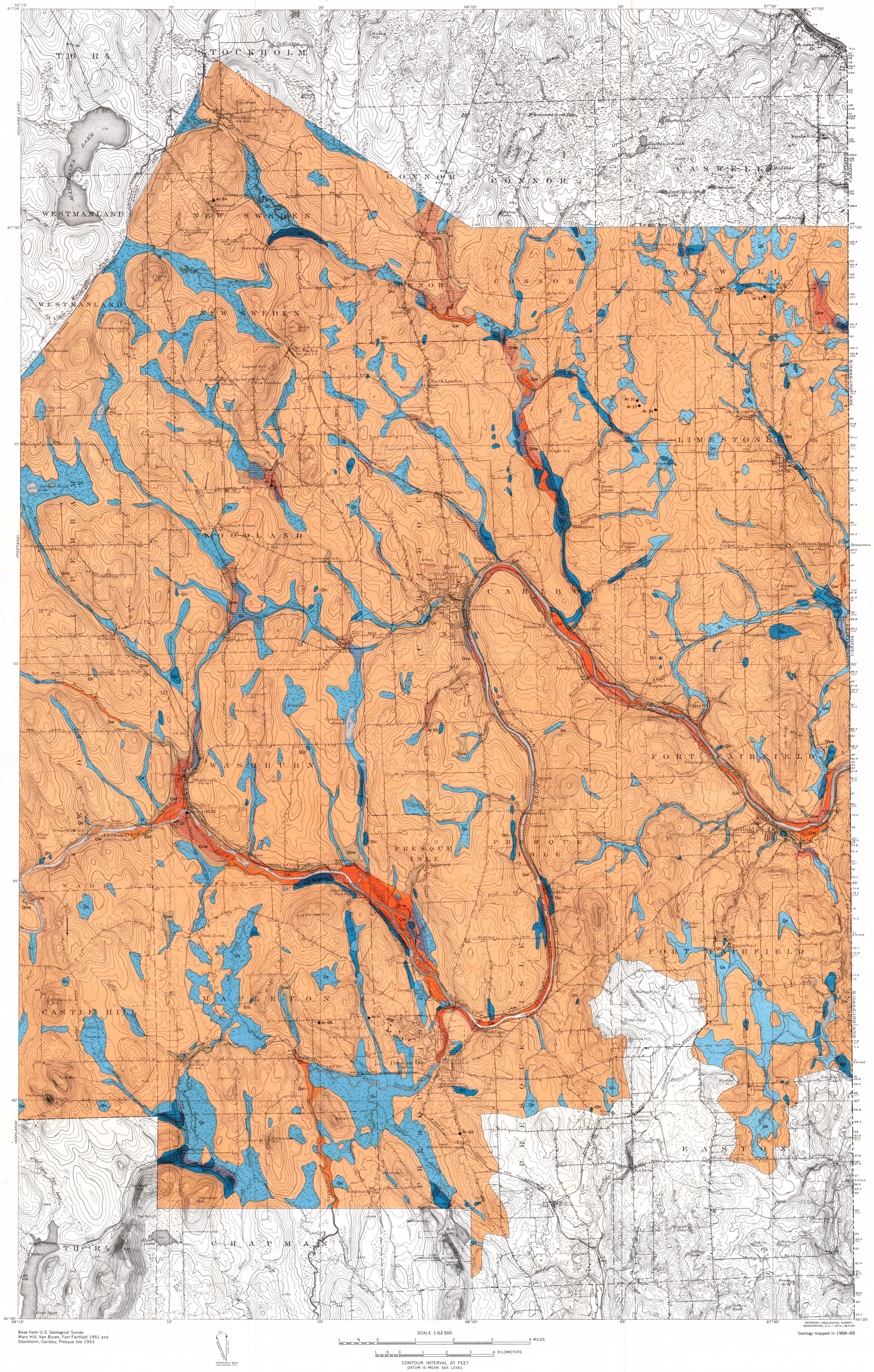
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
STATE OF MAINE PUBLIC UTILITIES COMMISSION

HYDROLOGIC INVESTIGATIONS
ATLAS HA-443



EXPLANATION

SURFICIAL GEOLOGY

System	Series	Geologic unit	Thickness (feet)	Character	Water-bearing characteristics
QUATERNARY	Holocene	Qal Alluvium (*Shown only where extensive*)	0–40 [a]	Sand, gravel, cobbles, silt, and clay, underlying stream channels, flood plains, and low river terraces.	In valleys of small streams alluvium may occur as small discontinuous patches, but, in places, particularly along the Aroostook and Little Madawaska Rivers and along Presque Isle Stream, it forms a mappable unit. Where alluvial gravel underlies the stream channels it is not considered an aquifer because of its generally submerged position. Where alluvium underlies flood plains or low terraces adjacent to stream channels it is generally thin and fine grained and not an important aquifer. In places along the Aroostook River alluvium overlies outwash, which may yield several hundred gallons per minute to individual wells.
		Qs Swamp deposits (*Shown only where extensive*)	0–10 [b]	Peat, organic muck, and some intermixed silt, clay, and sand of alluvial or colluvial origin. Many of the ribbonlike deposits lie along streams that have been dammed by beavers and are probably only a foot or two in thickness.	Not known to yield water to wells in the area. In places holes dug to collect water to be used for spraying apparently obtain water from swamp deposits. Swamp deposits also release water slowly to underlying formations and to streams flowing through or issuing from them.
	Pleistocene	Ql Lacustrine deposits	0–90 [c]	Blue to gray laminated silt and clay occurring in a few outcrops and in the subsurface in the valley of the Aroostook River between Washburn and Presque Isle.	Not known to yield water to wells.
		Qow Outwash	0–110 [a]	Stratified sand and gravel deposits in valley trains or outwash plains. Contains some silt and clay and cobbles.	Outwash is known to yield 20 to 70 gpm (gallons per minute) to 6-inch diameter, open-end drilled wells and as much as 1,700 gpm to one properly developed and screened well of 18-inch diameter, in areas, particularly along the Aroostook River, where the thick deposits are recharged by the river under pumping conditions. The water is of good quality for most purposes but is in the moderately hard to very hard range.
		Qic Ice-contact deposits	0–100 [d]	Well-stratified to poorly stratified deposits of sand, gravel, and cobbles, with some silt, clay, and boulders. Landforms consist largely of kames and kame terraces, but also include some deltas and eskers or crevasse fillings.	Many of the outcrops of ice-contact deposits are isolated and topographically too high relative to nearby bodies of surface water to be important aquifers. In a few places, particularly where ice-contact deposits are adjacent to the Aroostook and Little Madawaska Rivers, probably several hundred gallons per minute would be available to individual wells that were properly constructed and developed. Largest known yield from ice-contact deposits in this area is 75 gpm. Water is of good quality but hard.
ORDOVICIAN TO QUATERNARY	Pre-Pleistocene and Pleistocene	Till or bedrock	0–80 [a]	Till and bedrock are mapped together. Till is a heterogeneous mixture of clay, silt, sand, gravel, cobbles, and boulders. In some exposures upper few feet appear to have been crudely sorted by running water. In some potato fields erosion has removed the finer materials from the soil zone, leaving a gravelly soil that resembles stratified glacial deposits (outwash or ice-contact deposits). The till is generally very dense. Bedrock consists largely of blue-gray limestone, and calcareous shale and siltstone of the Carys Mills and Spragueville Formations. Also includes shale, siltstone, and argillite of the Perham Formation; sandstone and mudstone of the Chapman Sandstone; and sandstone, siltstone and conglomerate of the Mapleton Sandstone. Outcrops of intrusive igneous rocks such as granite and diabase, and volcanic igneous rocks such as andesite, rhyolite, and tuff, also occur.	Till is the source of water to some dug wells and springs and to a few drilled wells. Sustained yields of dug wells are generally less than 1 gpm. Dug wells may become dry in summer and late winter. Water is hard. Bedrock formations contain water primarily in secondary openings such as cleavage or bedding planes, joints, fractures, or solution openings. It is possible that formations such as the Chapman and Mapleton Sandstone contain some recoverable water between grains where cementing may be poor. The amount of water available from bedrock wells depends on the number, size, and degree of interconnection of the openings that contain the water. It is not possible to predict accurately the depth at which water-bearing zones will be found or how much water will be available to wells. The water in bedrock is generally confined under artesian conditions--that is, the water will rise to a level above that at which it is reached by the drill. Several wells for which information is available flowed. Water is of good chemical quality but is hard.

a Maximum value estimated from well record.
b Maximum value from driller's log.
c Maximum value from report by Leavitt and Perkins, 1935, p. 174. See table of selected references.
d Maximum value estimated.

FAVORABILITY AREA

More than 50 gpm

Areas most favorable for the location of wells that will yield more than 50 gpm from unconsolidated deposits, chiefly glacial outwash and ice-contact deposits. The largest yields are obtainable from wells drilled in valleys where the saturated part of the deposits is thick and where they are in hydraulic continuity with an adjacent body of surface water that provides a source of induced recharge. The largest reported yield is 1,700 gpm. The specific yield of this well is 285 gpm per foot of drawdown. The water in outwash and ice-contact deposits is generally of good quality for most purposes but is in the moderately hard to very hard range

10 to 50 gpm

Areas where properly constructed wells in sand and gravel deposits may yield from 10 to 50 gpm. Aquifers are ice-contact deposits or outwash where the saturated thickness is 5 to 15 feet or where deposits are relatively fine grained

NOTE

Areas where most wells dug or drilled in unconsolidated deposits overlying bedrock will yield less than 10 gpm are shown without color overprint. Aquifers may be till, alluvium, or thin or isolated deposits of outwash or ice-contact sand and gravel. The water is generally of good quality for most purposes but is in the moderately hard to very hard range

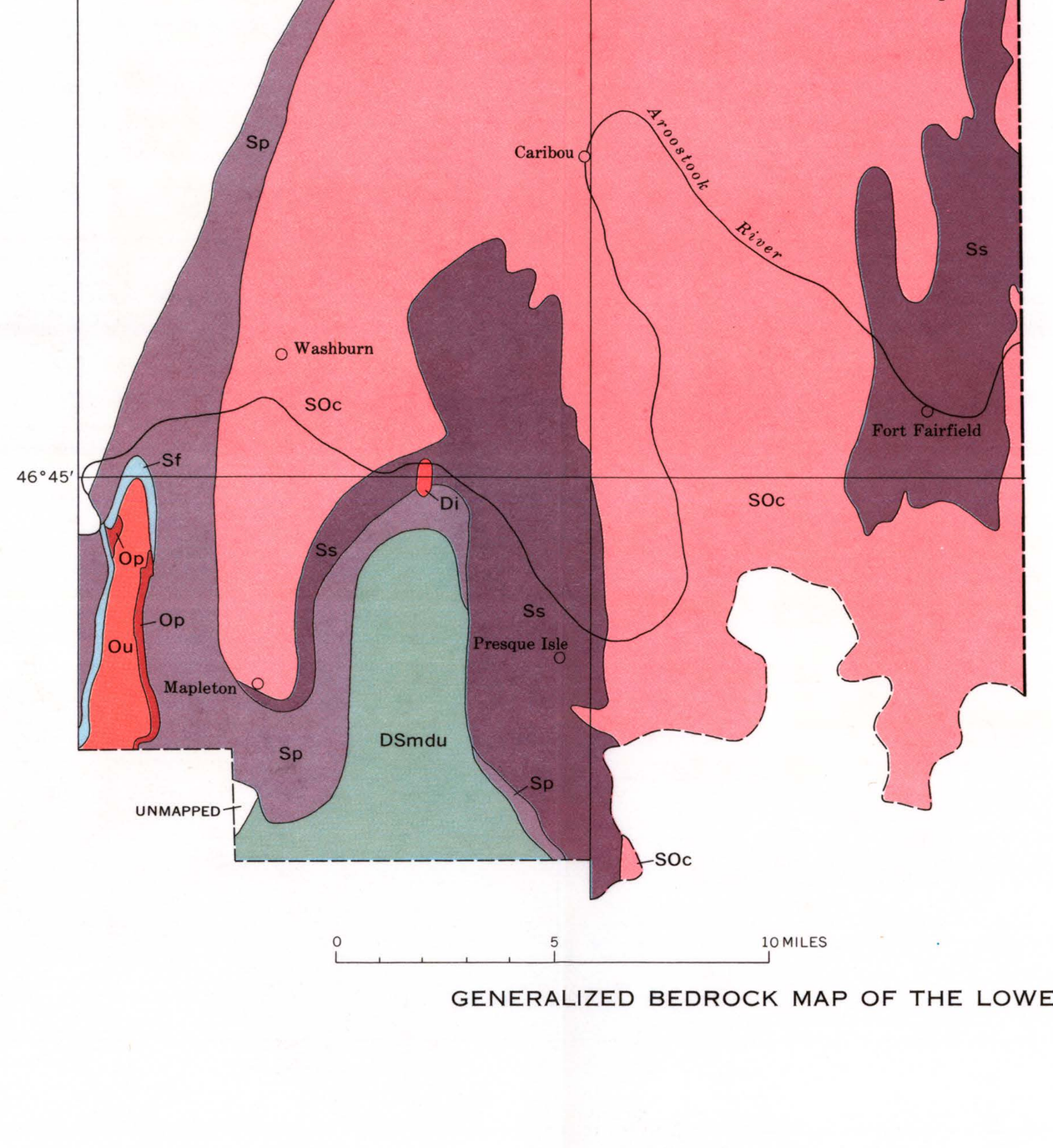
Contact

Direction of glacial striations
Tip of arrow indicates location of striations

○ Ar 85
Well in unconsolidated deposits

● Ar 24
Well in bedrock

▲ 1-0170
Surface-water gaging station



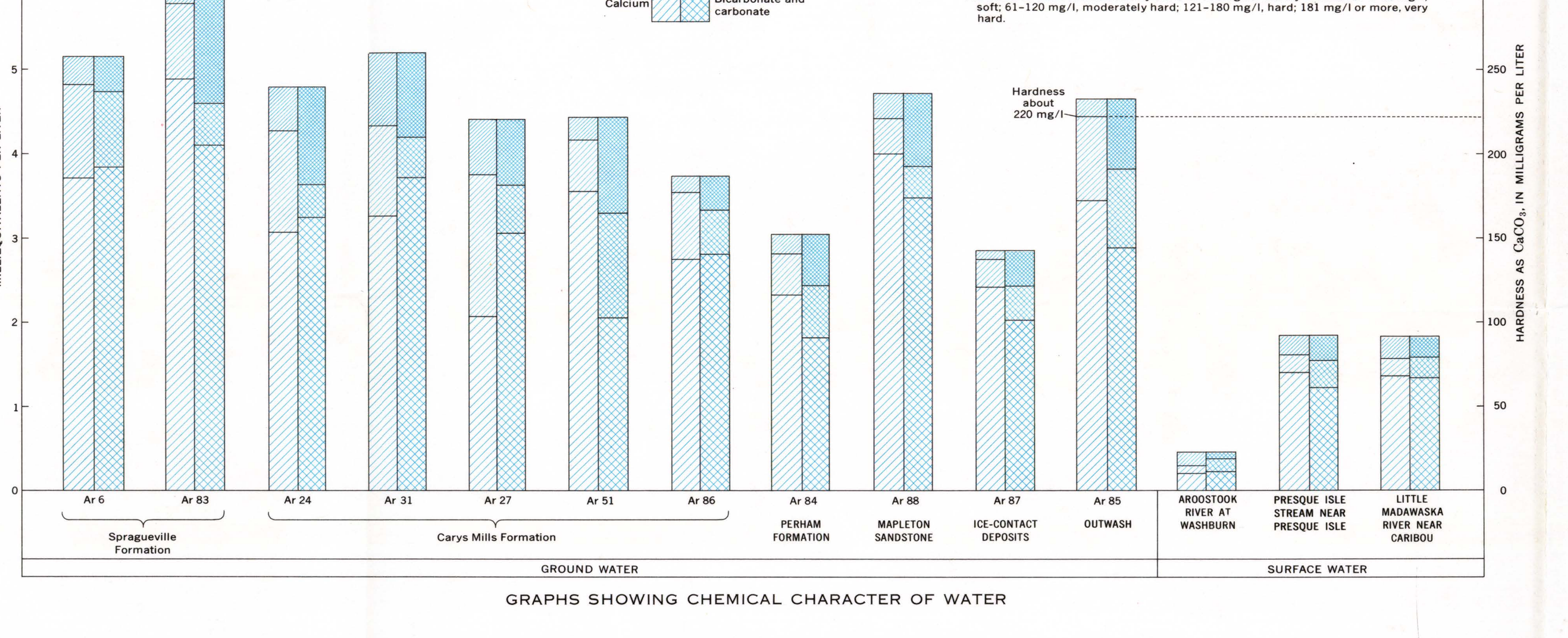
EXPLANATION

Age	Geologic unit	Water-bearing characteristics
DEVONIAN	Di Granitic rocks	Very small outcrop area. Not known to be an aquifer.
SILURIAN AND DEVONIAN	DSmdu Mapleton Sandstone and Dockendorff Group undivided	Yields small amounts of water to drilled wells, particularly from sandstone members. Yields range from 3 to 35 gpm and average 16 gpm.
SILURIAN	Sf Frenchville Formation	Outcrop area small. Yields small amounts of water to a few wells.
	Sp Perham Formation	Yields water to numerous wells. Yields range from 2 to 100 gpm and average 14 gpm.
	Ss Spragueville Formation	Yields small to moderate amounts of water to wells. Yields range from 2 to 400 gpm and average 32 gpm.
ORDOVICIAN AND SILURIAN	SOc Carys Mills Formation	The most widespread formation. Yields water to many wells. Maximum reported yield is 560 gpm. Average yield is 41 gpm.
ORDOVICIAN	Op Pyle Mountain Argillite	Outcrop area small. Not known to be an aquifer.
	Ou Undivided rocks	Outcrop area small. Not known to be an aquifer.

Contact

Boundary of area

GENERALIZED BEDROCK MAP OF THE LOWER AROOSTOOK RIVER BASIN (AFTER PAVLIDES, 1968, PL. 1)

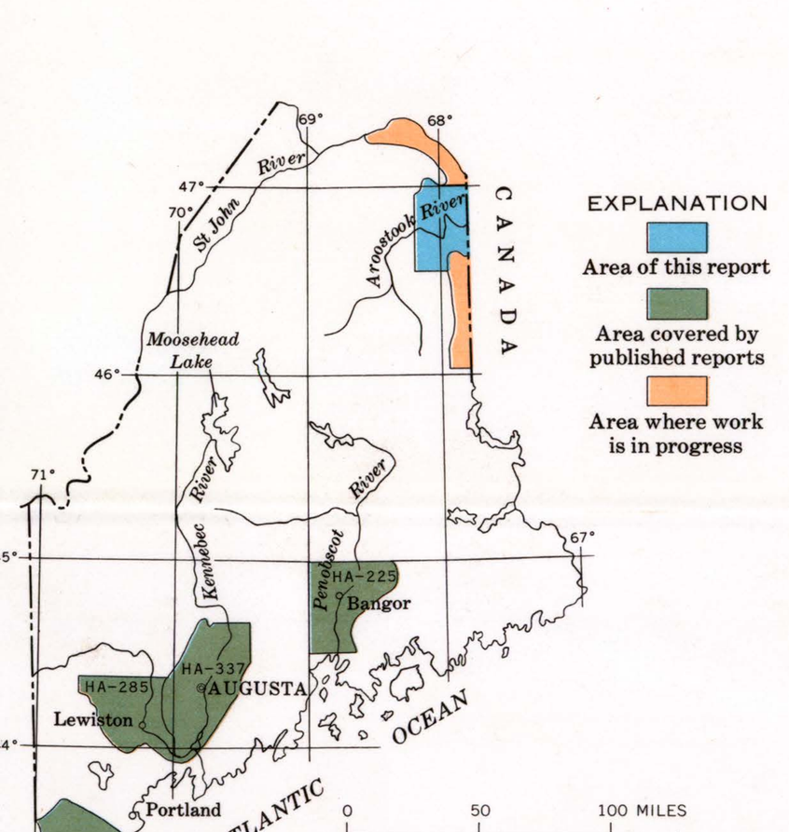


GRAPHS SHOWING CHEMICAL CHARACTER OF WATER

INTRODUCTION

The lower Aroostook River basin, as described in this report, includes 536 square miles in northeastern Aroostook County in northern Maine. Included in the area are the cities of Caribou and Presque Isle and part or all of the following towns: Castle Hill, Caswell, Chapman, Connor, Easton, Fort Fairfield, Limestone, Mapleton, New Sweden, Perham, Stockholm, Wade, Washburn, Westmanland, and Woodland. Loring Air Force Base, the largest Strategic Air Command base in the East is in Limestone.

This report is one of a series describing the geologic and hydrologic conditions governing the occurrence of ground water in Maine (see index map). The purpose of the report is to provide information that would be of use to those planning for or developing water supplies—particularly supplies large enough for public, industrial, or commercial use—from ground-water sources.

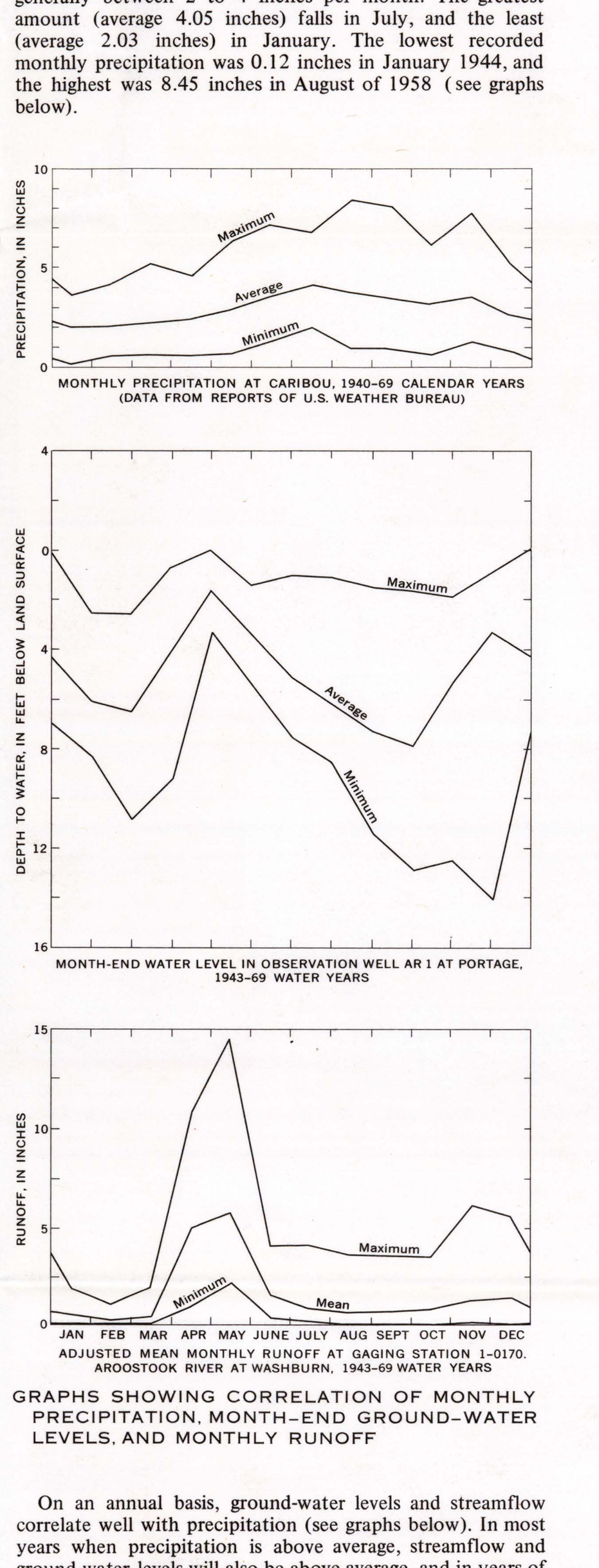


INDEX MAP SHOWING AREAS OF GROUND-WATER INVESTIGATIONS

The magnitude of yields that might be expected from properly located and constructed wells in unconsolidated deposits is indicated by the map showing surficial geology and ground-water favorability. This map presents a generalized interpretation of observed geologic and hydrologic data. It provides a logical basis for directing detailed exploration for ground water but does not eliminate the need for such exploration. The most favorable areas for developing large supplies of water from bedrock wells are the areas underlain by limestones (see generalized bedrock geologic map).

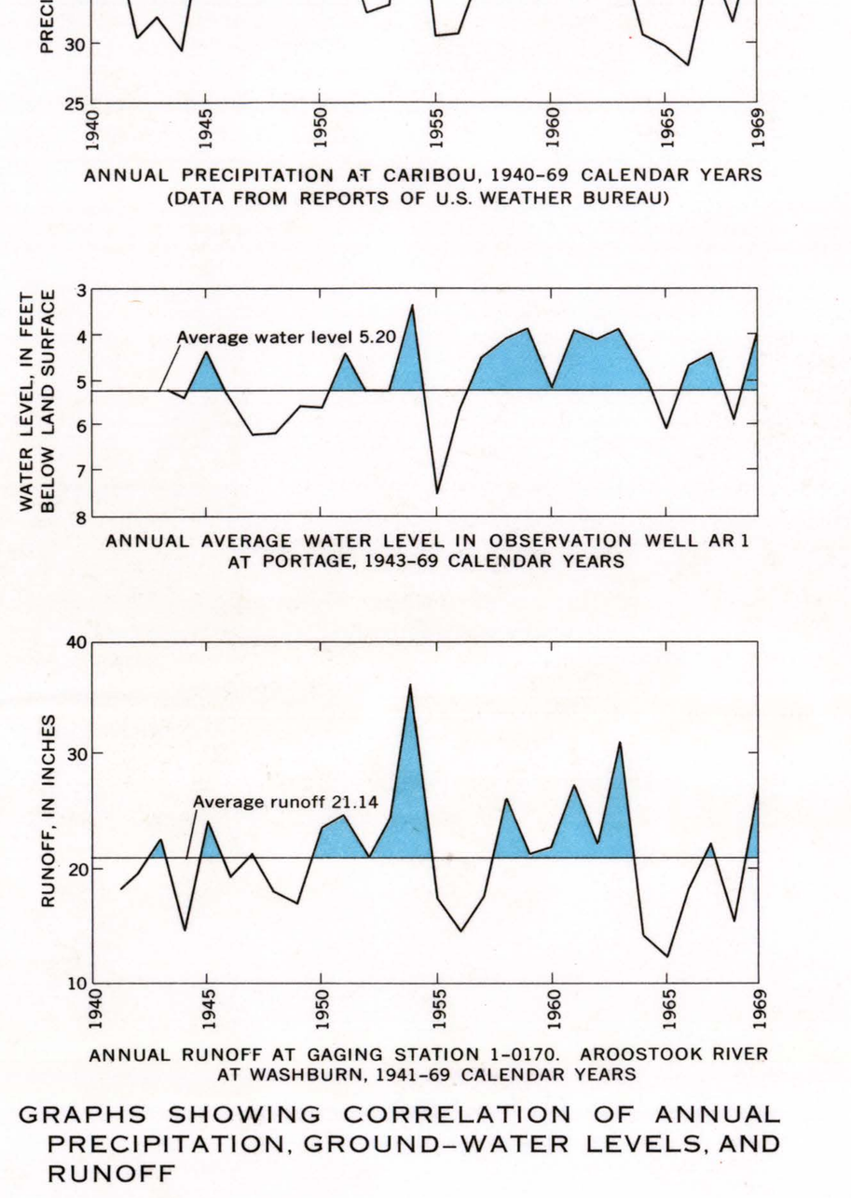
RELATION OF CLIMATE TO AVAILABILITY OF WATER

According to records of the U.S. Weather Bureau, average annual precipitation for this area is about 36 inches. During 1940–69, annual precipitation at Caribou has ranged from 27.92 inches in 1966 to 51.11 inches in 1954. Precipitation is generally between 2 to 4 inches per month. The greatest amount (average 4.05 inches) falls in July, and the least (average 2.03 inches) in January. The lowest recorded monthly precipitation was 0.12 inches in January 1944, and the highest was 8.45 inches in August of 1958 (see graphs below).



GRAPHS SHOWING CORRELATION OF MONTHLY PRECIPITATION, MONTH-END GROUND-WATER LEVELS, AND MONTHLY RUNOFF

On an annual basis, ground-water levels and streamflow correlate well with precipitation (see graphs below). In most years when precipitation is above average, streamflow and ground-water levels will also be above average, and in years of below-average precipitation streamflow and water levels are usually below average, as indicated in the figure.

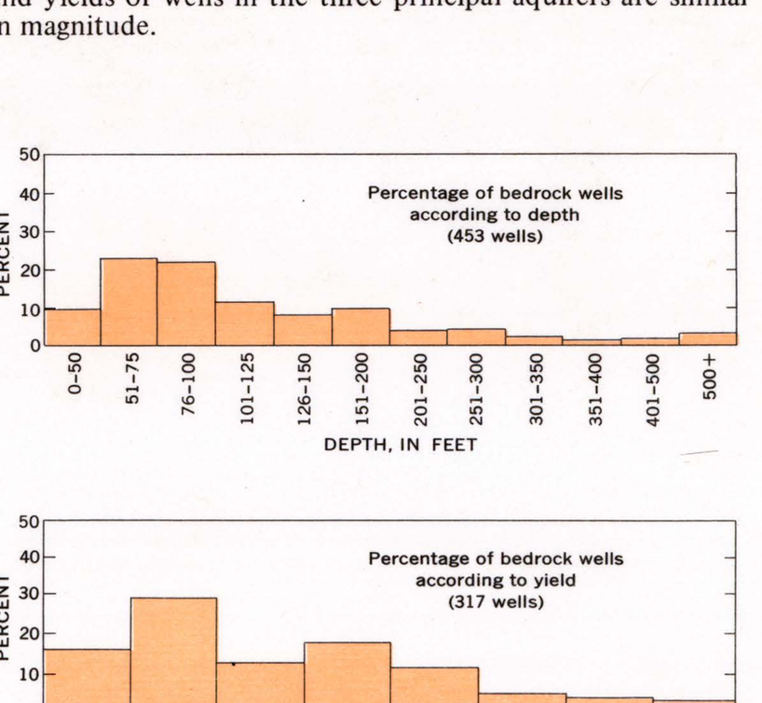


GRAPHS SHOWING CORRELATION OF ANNUAL PRECIPITATION, GROUND-WATER LEVELS, AND RUNOFF

As might be expected, ground-water levels and streamflow fluctuate seasonally as the result of climatic changes, rather than directly with precipitation. Of the approximately 36 inches of precipitation in the area, about 21 inches runs off in streams in part as ground-water outflow, and most of the remaining 15 inches is evaporated or transpired by growing vegetation. Because of evapotranspiration, recharge is small and runoff declines during the summer. At the end of the growing season ground-water levels and streamflow are usually at low stages. Streamflow increases and ground-water levels rise in the fall, when evapotranspiration is reduced and rainfall has a greater opportunity to run off or to reach ground-water reservoirs. Streamflow and ground-water levels again decline during the winter, when most of the precipitation, which occurs mainly as snow, remains on the ground. Frozen ground is also another deterrent to ground-water recharge. When the accumulated winter snow (which has an average water content of about 8 inches in this area) melts, it is a significant source of streamflow and ground-water recharge, as indicated by the spring peaks on the runoff and ground-water-level hydrographs.

GROUND WATER IN BEDROCK

Information on the depth of 453 bedrock wells and on the yield of 317 of these wells was obtained during the investigation. The percentage of wells, according to depth and yield, is shown in the graphs below and yield and depth data for the principal aquifers are tabulated below. The Carys Mills Formation is the source of water to more than 60 percent of the wells for which information is available. A considerable number of the wells drilled in the Carys Mills were to supply water for Loring Air Force Base and subsidiary installations or for industrial purposes. Most of these wells required more water than typical farm and home wells and therefore were of larger diameter and were drilled deeper than most farm and home wells. Because of this, the average depth and yield of wells drilled in the Carys Mills Formation are considerably greater than the average depth and yield of wells drilled in the other aquifers. Median depths and yields of wells in the three principal aquifers are similar in magnitude.



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

Depth of wells

	Number	Range (ft)	Average (ft)	Median (ft)
All wells	453	23–800	142	98
Carys Mills Fm.	263	23–800	164	105
Spragueville Fm.	61	50–425	129	110
Perham Fm.	89	36–325	108	95
Other aquifers	19	42–150	75	70

Yield

	Number	Range (gpm)	Average (gpm)	Median (gpm)
All wells	317	0–560	34	15
Carys Mills Fm.	198	0–560	41	15
Spragueville Fm.	41	2–400	32	15
Perham Fm.	52	2–100	14	10
Other aquifers	10	3– 35	16	18

A comparable amount of data on wells—especially for those deeper than 300 feet—in the various aquifers is not available, but apparently the largest yields are obtainable from the Carys Mills Formation. Of 27 wells capable of producing 100 gpm or more, 24 derived water from the Carys Mills. Two wells obtained more than 100 gpm from the Spragueville, and one well obtained 100 gpm from the Perham. The sparse data precludes generalizations on the availability of water in other formations, such as the Chapman and Mapleton Sandstones, except that ordinarily enough water for farm and home use can be obtained within a reasonable drilling depth.

Water in the bedrock formations occurs largely in joints, fractures, bedding planes, or solution openings. Apparently water percolating through openings in the limestone has enlarged them sufficiently in places so that the calcareous formations, particularly the Carys Mills and Spragueville, may contain and transmit larger quantities of water than noncalcareous rocks.

Though large yields may be obtained from wells drilled in limestone, it is still possible to drill a well in limestone without finding appreciable amounts of water. Several 700- to 800-foot wells at Loring Air Force Base had very poor yields. Possibly the poorest of these, 768 feet deep, produced 4.5 gpm with a drawdown of 180 feet, giving a specific capacity of 0.025 gpm per foot of drawdown. In contrast, another Air Force well was pumped at 325 gpm with a drawdown of 11 feet, giving a specific capacity of 30 gpm per foot of drawdown. Several deep wells, presumably in limestone, at the former Northern Maine Sanitarium in Presque Isle produced very small amounts of water.

WATER QUALITY

The quality of the ground water in the area is generally good, but the water is in the hard to very hard range (see water-quality graphs). The hardness values (as $CaCO_3$) from 87 samples of ground water ranged from 134 to 290 mg/l (milligrams per liter). Average hardness and median hardness were both 200 mg/l. In comparison, the hardness of 13 samples of surface water ranged from 15 to 105 mg/l, which is from soft to moderately hard. The average hardness of the surface-water samples was 56 mg/l.

Chloride concentration in ground-water samples ranged from 2.2 to 98 mg/l. The sample containing the highest chloride is thought to have been contaminated by brine from a water softener at Loring Air Force Base. Average chloride was 22 mg/l and median chloride was 18 mg/l. Nitrate, as NO_3, ranged from 0 to 33 mg/l. The highest nitrate may have resulted from recharge from drainage of a fertilized field or other source of contamination. Average nitrate concentration was 6.3 and median was 2.4 mg/l. A few samples contained undesirable quantities of iron, which may have been derived from the rocks through which the water moves or may have been the result of corrosion of well casings or distribution pipes. Hydrogen sulfide gas (H_2S) was reported in a few wells at Loring Air Force Base.

The ground water was generally alkaline; the average and median pH of 88 samples was 7.4. Values of pH ranged from 6.8 to 8.2.

The temperatures of 68 samples of ground water ranged from 4 to 14°C (40 to 57°F) and averaged 7°C (45°F).

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GROUND-WATER FAVORABILITY AND SURFICIAL GEOLOGY OF THE LOWER AROOSTOOK RIVER BASIN, MAINE

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1972