DESCRIPTION OF THE STUDY AREA

The New England Coastal Basins study unit encompasses 23,000 mi^2 in western and central Maine, eastern and central New Hampshire, eastern Massachusetts, and most of Rhode Island. The study unit includes the drainage basins of the Kennebec, Androscoggin, Saco, Merrimack, Charles, Blackstone, Taunton, and Pawcatuck Rivers, as well as small coastal drainage basins between these major river basins (fig. 1). Almost two-thirds of New Hampshire is in the study area, as well as a third of Maine, half of Massachusetts, and 85 percent of Rhode Island (Flanagan and others, 1999).

Two principal aquifer types underlie the study area—(1) the surficial stratified-drift aquifers, which are discontinuous, and (2) fractured-bedrock aquifers, which are continuous and underlie stratified drift and (or) glacial till (Flanagan and others, 1999). The highly permeable, relatively shallow, discontinuous stratified-drift aquifers that occupy most river valleys in New England are the principal source of drinking water for many communities that obtain all or part of their public-water supply from ground water. Conversely, fractured-bedrock aquifers are the primary source of drinking water for rural households, for many small communities and trailer parks, and for non-community water suppliers such as restaurants and businesses.

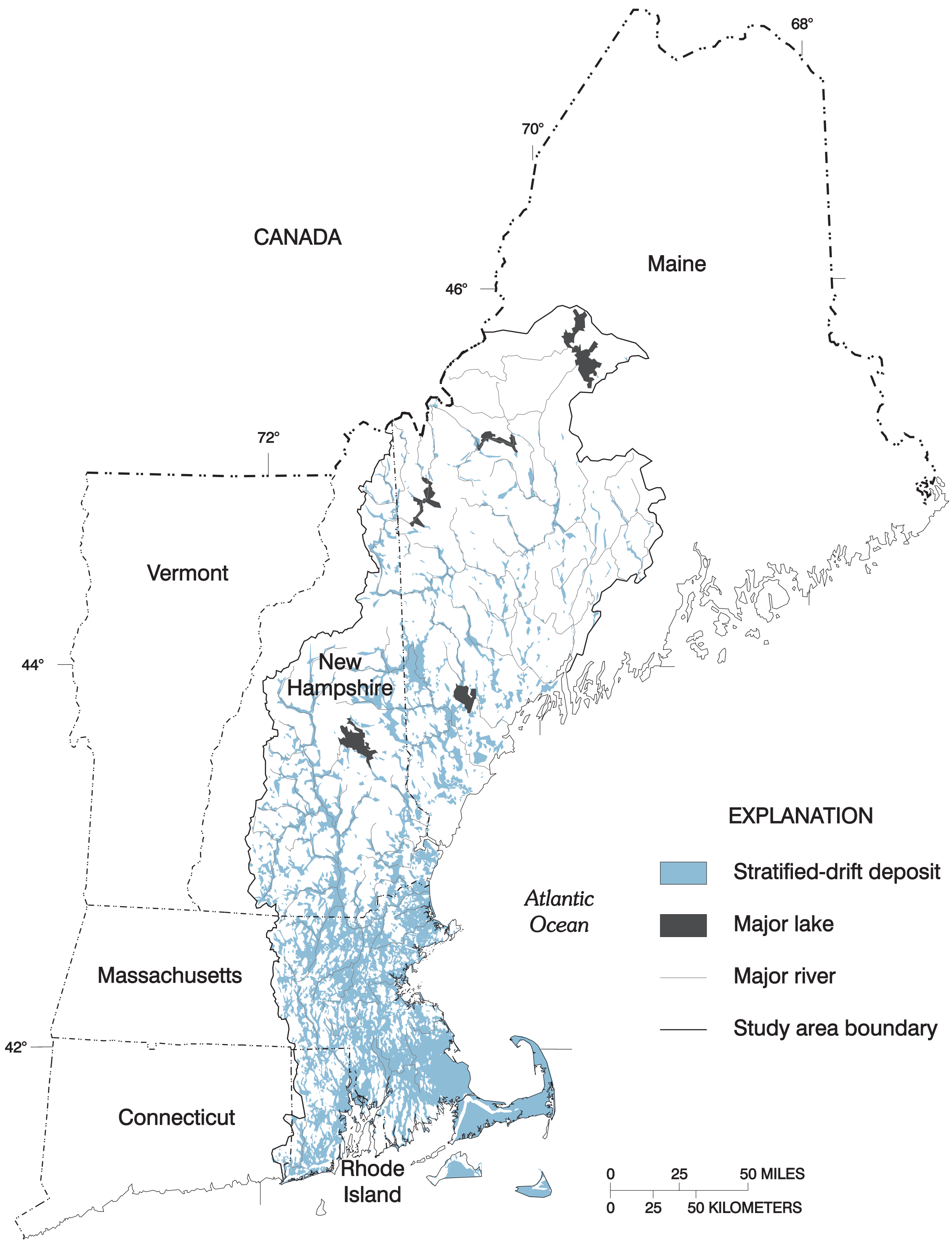
Stratified-Drift Aquifers

Stratified-drift aquifers consist primarily of sand and gravel deposits that were deposited in layers by meltwater streams flowing from the retreating glacial ice. This aquifer type was formed primarily in valleys in the northern parts of the study area, and is of limited extent (fig. 2). In the southern third of the study area, the stratified-drift aquifers formed on broad plains as glaciers retreated and cover a wide geographic area (fig. 2). Stratified-drift aquifers contain significant amounts of coarse-grained, ice-contact, and outwash deposits and where saturated, are characterized by hydraulic conductivities that range from 35 to 1,000 ft/d. Ground-water residence time in stratified-drift aquifers is relatively short, where the flow is restricted to narrow glacial valleys. Recharge to these aquifers is generally from the surface and at the edges of the valleys from upland runoff. Discharge generally is to valley streams and rivers, though water can leave these surficial aquifers by recharging an underlying bedrock aquifer. As these aquifers often yield large amounts of water to wells, they are used wherever possible as public water supplies.

Bedrock Aquifers

Fractured-bedrock aquifers underlie the entire study area (Flanagan and others, 1999). These bedrock aquifers are dense, relatively impermeable, and have low porosity. Bedrock, in the study unit, ranges in age from Precambrian to Cretaceous and includes primarily fractured crystalline igneous and metamorphic rocks. Fractured-bedrock aquifers store and transmit water primarily through intersecting fractures. These fractures were formed by stresses caused by the erosion of overlying rock, the melting of glacial ice sheets that once covered New England, tectonic activity, and cooling stresses associated with igneous intrusion (Hansen and Simcox, 1994).

Single-hole hydraulic testing by Hsieh and others (1993) indicated that the hydraulic conductivity in New England fractured crystalline bedrock varies over four orders of magnitude, ranging from 2.8×10^{-4} to 2.8 ft/d. Other sources (Randall and others, 1988; Harte, 1992; Paillet and Kapucu, 1989) reported ranges in hydraulic conductivity for fractured crystalline bedrock in New England to be between 3.5×10^{-3} to 26 ft/d. Bedrock aquifers are recharged by infiltration through overlying unconsolidated materials (low to moderate permeability glacial till and low to high permeability stratified drift). Water discharges from bedrock aquifers into hillside streams, springs, rivers and lakebeds, overlying stratified-drift aquifers, and, at the coast, to the ocean. Flows modeled in New England bedrock terrain suggest that flow paths are limited to the upper 700-1,000 ft below the land surface (Harte, 1992), largely because fracture density decreases with depth. Residence times vary widely depending on the local or regional nature of a particular flowpath, and the degree of interconnections of fractures in an aquifer. Water in some wells in the bedrock aquifers at Mirror Lake, N.H., has been shown to be older than 50 years (Busenberg and Plummer, 1993) and potentially could be much older.



Base from U.S. Geological Survey digital data, 1:2,000,000, 1972
Albers Equal-Area Conic projection
Standard parallels 29°30′ and 45°30′ and central meridian

Figure 2. Location of stratified-drift deposits in the New England Coastal Basins study unit. (From Flanagan and others, 1999)

Water Use

In the New England Coastal Basins study unit, drinking water is supplied from public and private sources. People living in large metropolitan areas and large cities and towns generally are connected to public supplies that come from surface-water reservoirs, stratified-drift aquifers, or bedrock aquifers. People living in rural communities and on the outskirts of metropolitan areas generally obtain their water from private wells drilled into the bedrock aquifers, with some private wells in stratified-drift aquifers. In the Cape Cod area of southeastern Massachusetts, however, almost all wells are in stratified-drift aquifers, or till aquifers—unsorted, unconsolidated material overlying bedrock.

In 1995, approximately 47 percent of all drinking water in the New England Coastal Basins, or about 247 Mgal/d, came from ground water (USGS Aggregate Water-Use Data System (AWUDS) data bases in Maine, New Hampshire, Massachusetts, and Rhode Island, accessed October 1997; data are available from individual District USGS offices in each state). More than 30 percent of that ground water, or about 74 Mgal/d, is self-supplied, coming predominantly from private domestic wells drilled in bedrock aquifers. The remaining 70 percent, or about 173 Mgal/d, is publicly-supplied ground water which comes primarily from stratified-drift aquifers with a lesser amount coming from the bedrock aquifers.

The amount of water withdrawn from the bedrock aquifers for public supply is difficult to assess. Many community public-supply systems use bedrock ground water to supplement stratified-drift aquifer or surface-water sources. Most non-community public-supply systems (including restaurants and businesses) withdraw water from the bedrock aquifers but at low rates compared to the rates for community suppliers—probably less than 10 gal/min (F. Chormann, New Hampshire Department of Environmental Services, oral commun., 1998). In relatively few cases, high-yielding bedrock wells are the sole source or major component of a community supply.

To better define water use by aquifer type from public-supply wells in the study unit, a data base of community public-supply wells was generated from a subset of the USEPA Safe Drinking-Water Information System (SDWIS) data base, retrieved in August 1997. This data set contains USEPA identification numbers (ID’s), population-served data, and individual/source descriptions (discrete wells) among other fields. Aquifer type was assigned to each well, where possible, for any given system (M.A. Horn, U.S. Geological Survey, written commun., December 1998). In the New England Coastal Basins study unit, approximately 1,145 systems, (including entire counties that are only partially in the study unit) use only ground water and do not purchase additional water. Aquifer-type data were available for wells in 734 of these systems. Data from these 734 systems were used to compute the percent of ground water withdrawn from stratified-drift and bedrock aquifers; using a factor of 70 gal/d/person, an estimated 71.0 Mgal/d are withdrawn by these systems. About 92 percent of this ground water is derived from stratified drift and about 8 percent comes from bedrock aquifers (table 1). This relation holds when the data

Table 1. Summary of estimated water use for community water supplies by aquifer type in the New England Coastal Basins study unit

[Mgal/d, million gallons per day]

State	Total systems (excluding purchased water and surface water)	Number of systems in dataset (percent of total)	Total withdrawals for systems (Mgal/d)	Stratified-drift aquifer	Bedrock aquifer
				Percent of water from above aquifer	
Maine	237	62 (26)	4.34	98.0	2.0
New Hampshire	611	527(86)	15.6	71.4	28.6
Massachusetts	242	137 (57)	49.7	97.8	2.2
Rhode Island	55	8 (15)	1.42	98.6	1.4
Entire New England Coastal Basins study unit	1,145	734 (64)	71.0	92.0	8.0

are arranged by state except for the New Hampshire part of the study unit where an estimated 71 percent comes from stratified-drift aquifers and 29 percent from bedrock aquifers. Whereas these data indicate about 8 percent of public ground water is supplied from the bedrock aquifer, the number is probably somewhat larger because this data set does not include any non-community supplies.

Assuming that about 8 percent of all public ground water for drinking water in the study unit comes from the bedrock aquifer, about 14 Mgal/d (8 percent) comes from bedrock aquifers. This rate, in addition to the 74 Mgal/d from bedrock that is self-supplied, brings the estimated total from bedrock aquifers to approximately 88 Mgal/d (about 36 percent) for all ground water used for drinking water. In addition, the population growth trends indicate that the population of communities in the northern part of the study unit, in particular in southern New Hampshire and coastal Maine, is increasing rapidly (Flanagan and others, 1999) and that the bedrock aquifers are an important water resource for this continued growth.