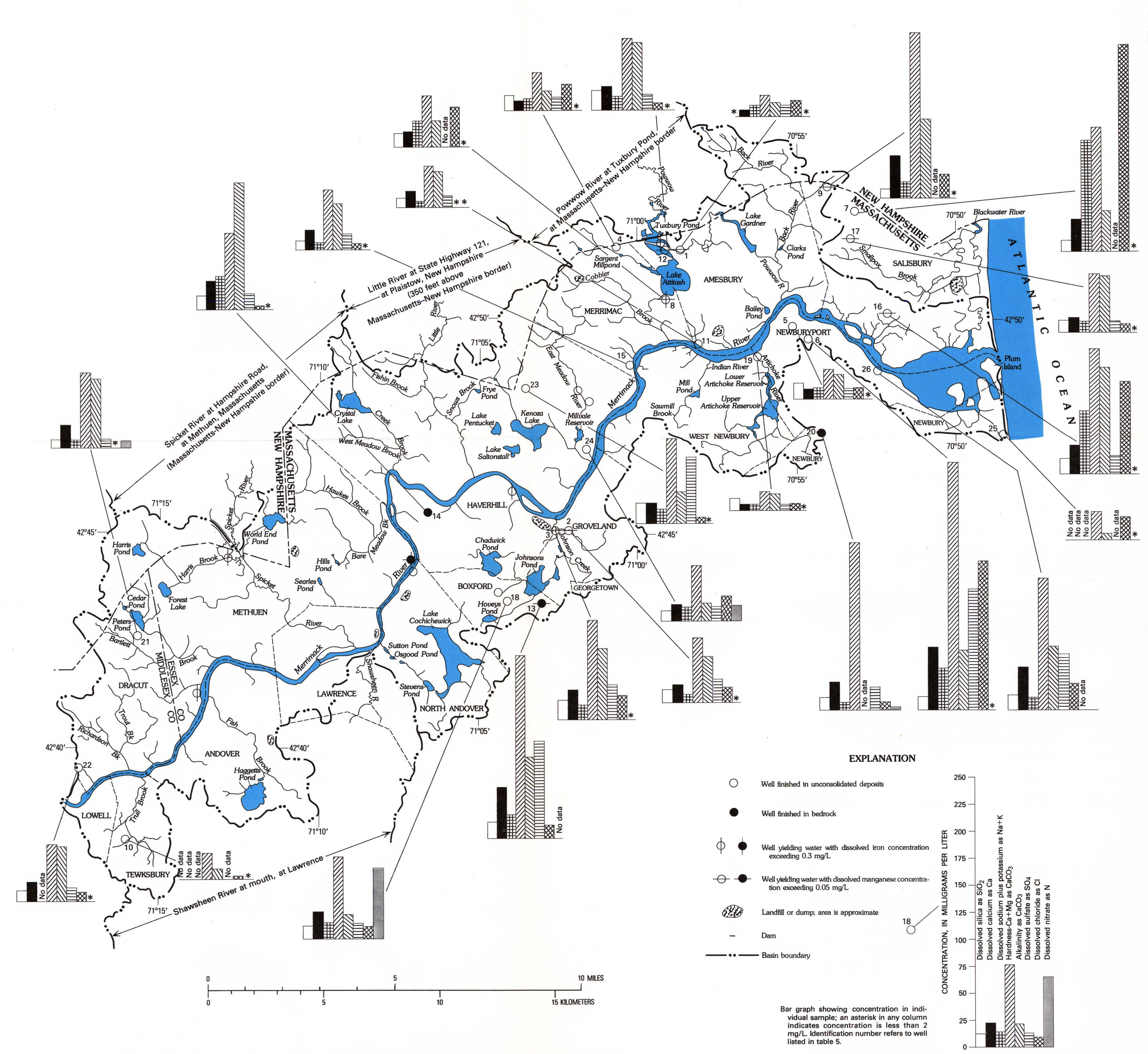
PREPARED IN COOPERATION WITH THE
COMMONWEALTH OF MASSACHUSETTS WATER RESOURCES COMMISSION

QUALITY OF WATER

GROUND WATER



Bar graph showing concentration in individual sample; an asterisk in any column indicates concentration is less than 2 mg/L. Identification number refers to well listed in table 5.

0 5 10 MILES
0 5 10 15 KILOMETERS

GROUND-WATER QUALITY IS GENERALLY GOOD THROUGHOUT THE LOWER MERRIMACK RIVER BASIN, AND THE WATER IS SUITABLE FOR MOST USES.—A summary of chemical analyses of ground water and brief physical description of some wells are given in tables 4 and 5. The hardness of ground water, in milligrams per liter of calcium carbonate, ranges from soft to moderately hard (0–120 mg/L). Water from some wells in Salisbury and Newburyport, near the mouth of the Merrimack River, is hard to very hard (121 to greater than 180 mg/L) and has higher chloride concentrations than water from wells in the rest of the study area.

Ground water having dissolved iron concentrations exceeding 0.3 mg/L and dissolved manganese concentrations exceeding 0.05 mg/L, the limits for drinking water recommended by the National Academy of Sciences and National Academy of Engineering (1974), occurs in many places in the basin and may require treatment. The geographic distribution of these places seems random, but iron and manganese problems are most often reported in or near swamps.

Ground-water quality near sources of pollution, such as landfills and subsurface sewage-disposal systems, may be poor. If ground-water quality is to be managed, its movement from pollution sources to wells, springs, and seeps must be considered. Pumping from wells near the Merrimack River estuary (from Rocks Bridge, West Newbury, to the mouth), tidal streams and marshes, and the ocean can cause saltwater to intrude coastal aquifers and contaminate ground-water supplies.

TABLE 4.—SUMMARY OF CHEMICAL ANALYSES OF GROUND WATER

Constituent	Concentration[1,2] Maximum	Minimum	Median	Number of samples analyzed
Silica (SiO_2)	19	1.6	12	24
Copper (Cu)	.05	.00	.00	10
Iron (Fe)	6.0	.00	.07	36
Manganese (Mn)	1.3	.00	.00	33
Calcium (Ca)	60	5.5	19.5	24
Magnesium (Mg)	22	.2	4.4	24
Sodium (Na)	100	3.2	9.0	24
Potassium (K)	9.9	.14	2.2	22
Bicarbonate (HCO_3)	142	7.3	52.4	25
Sulfate (SO_4)	114	4.4	14	21
Chloride (Cl)	192	1.5	13	26
Nitrate (N)	65	.00	.7	24
Hardness (Ca+Mg as $CaCO_3$)	232	17	63.5	26
Alkalinity ($CaCO_3$)	116	6	43	25
pH (Units)	8.1	6.0	6.6	26
Color (Platinum-cobalt units)	45	0	3	25
Specific conductance (micromhos per centimeter at 25°C)	680	69	220	23

[1]Concentration of dissolved constituents in milligrams per liter except as indicated.
[2]Based on analyses by the Massachusetts Department of Public Health (Lawrence Laboratory), U.S. Geological Survey, and private laboratories.
Wells are located on map.

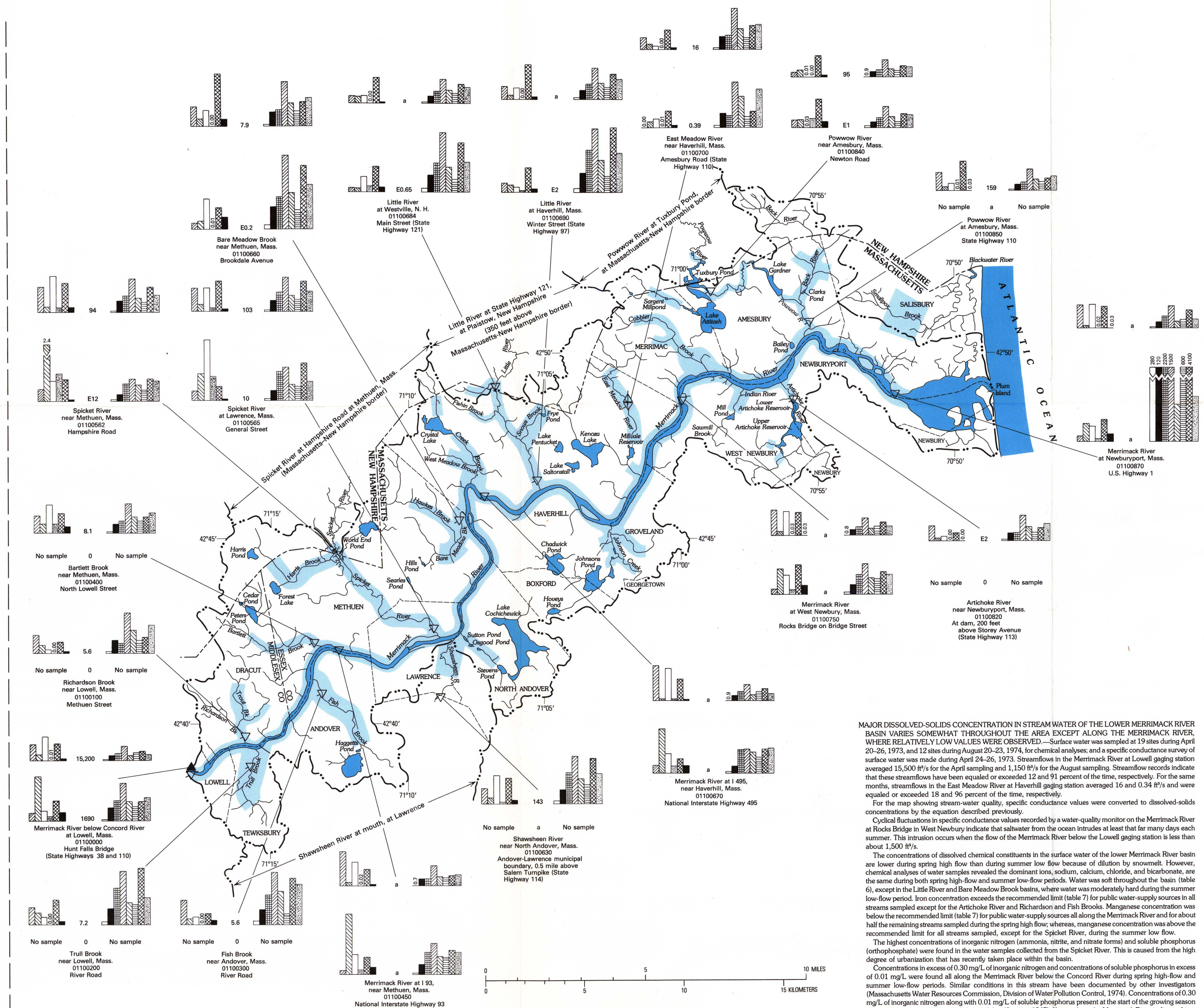
TABLE 5.—IDENTIFICATION AND DESCRIPTION OF SELECTED WELLS

Map identification no.	U.S. Geological Survey well no.	Owner well identification/water use	Well type	Date sampled	Aquifer (dominant material listed first)
1	AHW–185	Amesbury/public	S–12	9–16–74	Sand and gravel
2	GVW–18	Groveland No. 1/public	GP	12– 4–74	Sand and gravel
3	GVW–19	Groveland No. 2/public	GP	6– 3–74	Silty sand and gravel
4	MRW–13	Merrimac Sargent pit well field/public	S–8	4–12–74	Sand and gravel
5	NJW–35	Newburyport No. 1/public	GP	7–10–74	Sand and gravel
6	NJW–36	Newburyport No. 2/public	GP	3–18–74	....
7	SBW–33	Salisbury Water Co. No. 6/public	GP	11–18–74	Sand and gravel
8	MRW–1	Merrimac Lake Attitash well field/public	T	1–21–75	Medium to coarse sand and gravel
9	SBW–34	Salisbury Water Co. No. 7/public	GP	11–18–74	Sand and gravel
10	TNW–132	Tewksbury test well/unused	T	9– 9–60	Sand and gravel
11	AHW–6	Alton Synder/domestic	D	3–19–62	Sand and gravel
12	AHW–7	Charles Millis/domestic	....	6– –63	Sand
13	BJW–272	Rosamund Price/domestic	R	3– –62	Granite
14	HLW–2	Elvin Bowe/domestic	R	3–15–62	Quartzite
15	MRW–7	A. Zalenski/domestic	D	3–16–62	Till
16	SBW–8	Edwin Oliveira/domestic	D	9– –63	....
17	SBW–30	Birger Johnson/domestic	D	6– –63	Silty clay
18	BJW–271	Stanwood Morse/domestic	D	3– –62	Till
19	NJW–3	Hellen Moseley/domestic	D	6–13–63	Sandy gravel
20	NIW–40	Donald Hudson/domestic	R	4– –60	Gabbro diorite
21	D1W–160	Abraham Brox/domestic	D	1–12–55	Till
22	D1W–192	Harold Dupree/domestic	R	6–14–54	Gabbro diorite
23	HLW–162	Kirby/domestic	D	6–12–63	Till
24	HLW–110	J. Yokley/domestic	D	3–16–62	....
25	NIW–10	National Park Service test well/unused	....	9–20–66	....
26	NJW–38	Fenner Steiger Seafoods/industrial	T	4–25–74	Fine sand, gravel and clay

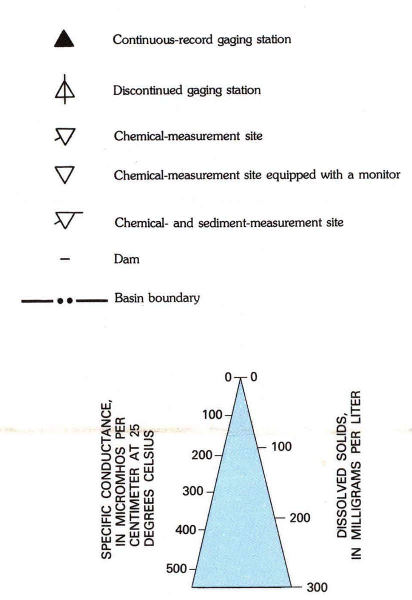
Wells sampled were of the following type:
- T Driven well
- GP Gravel-packed well
- D Dug well
- S Naturally developed, screened well
- R Bedrock well; number is casing diameter, in inches

Chemical analyses 1–10, by Massachusetts Department of Public Health (Lawrence Laboratory); 11–24, by U.S. Geological Survey; 25 and 26, by private laboratories.

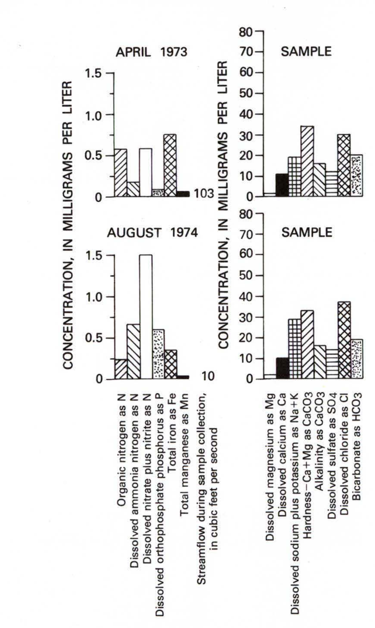
SURFACE WATER



EXPLANATION



Width of pattern indicates dissolved-solids concentration and specific conductance for the April 24–26, 1973 survey, except along the Merrimack River where these values are half of that shown.



E Estimated
a Not determined
Spicket River at Lawrence, Mass. Station name
01100565 Station number, in downstream order. Number from U.S. Geological Survey's data-collection network
General Street Location on river course

0 5 10 MILES
0 5 10 15 KILOMETERS

MAJOR DISSOLVED-SOLIDS CONCENTRATION IN STREAM WATER OF THE LOWER MERRIMACK RIVER BASIN VARIES SOMEWHAT THROUGHOUT THE AREA EXCEPT ALONG THE MERRIMACK RIVER, WHERE RELATIVELY LOW VALUES WERE OBSERVED.—Surface water was sampled at 19 sites during April 20–26, 1973, and 12 sites during August 20–23, 1974, for chemical analyses; and a specific conductance survey of surface water was made during April 24–26, 1973. Streamflows in the Merrimack River at Lowell gaging station averaged 15,500 ft^3/s for the April sampling and 1,150 ft^3/s for the August sampling. Streamflow records indicate that these streamflows have been equaled or exceeded 12 and 91 percent of the time, respectively. For the same months, streamflows in the East Meadow River at Haverhill gaging station averaged 16 and 0.34 ft^3/s and were equaled or exceeded 18 and 96 percent of the time, respectively.

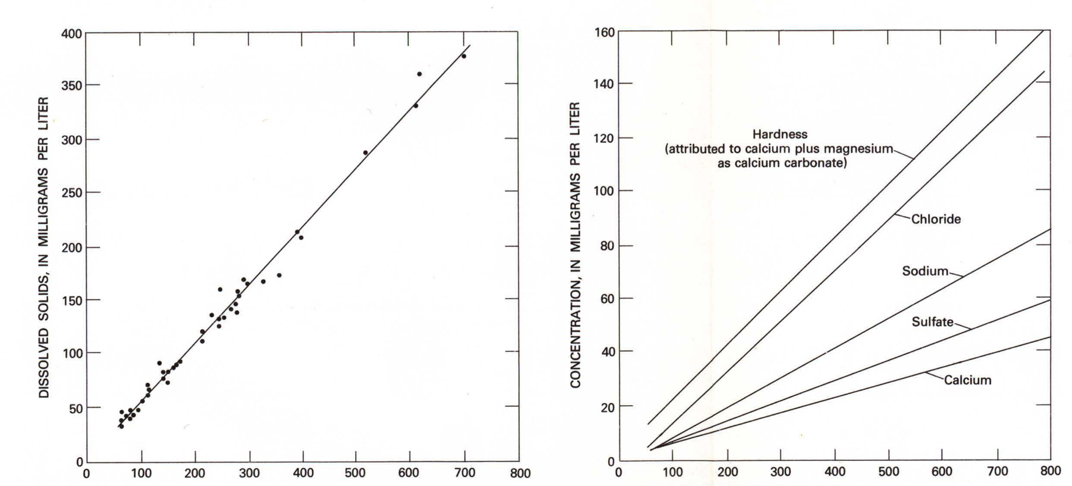
For the map showing stream-water quality, specific conductance values were converted to dissolved-solids concentrations by the equation described previously.

Cyclical fluctuations in specific conductance values recorded by a water-quality monitor on the Merrimack River at Rocks Bridge in West Newbury indicate that saltwater from the ocean intrudes at least that far many days each summer. This intrusion occurs when the flow of the Merrimack River below the Lowell gaging station is less than about 1,500 ft^3/s.

The concentrations of dissolved chemical constituents in the surface water of the lower Merrimack River basin are lower during spring high flow than during summer low flow because of dilution by snowmelt. However, chemical analyses of water samples revealed the dominant ions, sodium, calcium, chloride, and bicarbonate, are the same during both spring high-flow and summer low-flow periods. Water was soft throughout the basin (table 6), except in the Little River and Bare Meadow Brook basins, where water was moderately hard during the summer low-flow period. Iron concentration exceeds the recommended limit (table 7) for public water-supply sources in all streams sampled except for the Artichoke River and Richardson and Fish Brooks. Manganese concentration was below the recommended limit (table 7) for public water-supply sources all along the Merrimack River and for about half the remaining streams sampled during the spring high flow; whereas, manganese concentration was above the recommended limit for all streams sampled, except for the Spicket River, during the summer low flow.

The highest concentrations of inorganic nitrogen (ammonia, nitrite, and nitrate forms) and soluble phosphorus (orthophosphate) were found in the water samples collected from the Spicket River. This is caused from the high degree of urbanization that has recently taken place within the basin.

Concentrations in excess of 0.30 mg/L of inorganic nitrogen and concentrations of soluble phosphorus in excess of 0.01 mg/L were found all along the Merrimack River below the Concord River during spring high-flow and summer low-flow periods. Similar conditions in this stream have been documented by other investigators (Massachusetts Water Resources Commission, Division of Water Pollution Control, 1974). Concentrations of 0.30 mg/L of inorganic nitrogen along with 0.01 mg/L of soluble phosphorus present at the start of the growing season can produce nuisance blooms of algae in lakes (Sawyer, 1947). If water from the Merrimack River is diverted to a reservoir, the observed concentrations of inorganic nitrogen and soluble phosphorus could lead to overenrichment of water in that reservoir and nuisance blooms of algae.



CONCENTRATION OF MAJOR CHEMICAL CONSTITUENTS DISSOLVED IN SURFACE WATERS CAN BE ESTIMATED FROM SPECIFIC CONDUCTANCE.—Specific conductance is a measure of the capacity of water to conduct an electric current and varies directly with the concentration and degree of ionization of different salts in solution.

Equations relating specific conductance to dissolved constituents were developed from chemical analyses of surface-water samples collected during March, April, and June 1973 and August 1974 at 46 sites in the lower Merrimack, Shawsheen, and Mystic River basins in Massachusetts. The equations listed below were fitted by the least-squares method and, within the range shown in the illustration, can be used to estimate the concentrations of chemical constituents in stream water under conditions similar to those in 1973–74. The correlation coefficients shown are an indication of the degree of dependence between the two variables, with 1.0 being perfect and 0.0 indicating none.

Large or persistent deviations from these relations would be an indication of a change due to human activities, such as modification of in-basin waste disposal.

Equations	Correlation coefficients
Dissolved solids=0.54 (specific conductance) +2.7	0.99
Hardness (attributed to calcium plus magnesium as calcium carbonate)=0.197 (specific conductance) +4.6	0.96
Dissolved chloride=0.188 (specific conductance)−3.5	0.98
Dissolved sodium=0.111 (specific conductance)−1.5	0.98
Dissolved sulfate=0.075 (specific conductance)+1.0	0.93
Dissolved calcium=0.055 (specific conductance) +2.4	0.94

TABLE 6.—HARDNESS CLASSIFICATION[1]

Hardness range, in milligrams per liter of calcium carbonate ($CaCO_3$)	Description
0–60	Soft
61–120	Moderately hard
121–180	Hard
More than 180	Very hard

[1]Source: Durfor and Becker, 1964

TABLE 7.—MAXIMUM CONCENTRATION OF SOLUBLE SUBSTANCES IN PUBLIC WATER-SUPPLY SOURCES[1]

Soluble substance	Concentration, in milligrams per liter
Ammonia nitrogen	0.5
Chloride	250
Iron	0.3
Manganese	0.05
Nitrate nitrogen	10
Nitrite nitrogen	1
Sulfate	250

[1]Recommended by the National Academy of Sciences and National Academy of Engineering, 1974

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HYDROLOGY AND WATER RESOURCES OF THE LOWER MERRIMACK RIVER BASIN, MASSACHUSETTS, FROM CONCORD RIVER, LOWELL, TO PLUM ISLAND, NEWBURYPORT

By
Frederick B. Gay and David F. Delaney

1980