DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

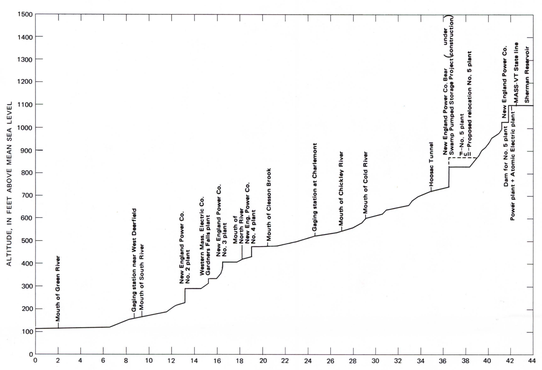
Prepared in cooperation with the
COMMONWEALTH OF MASSACHUSETTS
WATER RESOURCES COMMISSION

HYDROLOGIC INVESTIGATIONS
ATLAS HA-506 (SHEET 2 OF 2)

# SURFACE WATER

## AVAILABILITY

### PROFILE AND USE OF THE DEERFIELD RIVER




MAJOR HYDROELECTRIC STORAGE RESERVOIRS IN THE DEERFIELD RIVER BASIN

| Reservoir (downstream order) | Location | Drainage area (sq mi) | Usable capacity (million gallons) | Date completed |
|---|---|---|---|---|
| Somerset | Somerset, Vt. | 30.0 | 18,700 | 1913 |
| Harriman | Whitingham, Vt. | 184. | 37,850 | 1924 |
| Sherman | Rowe, Mass. | 236. | 509 | 1927 |

To convert usable capacity of million gallons to million cubic feet divide by 7.48

DRAINAGE AREAS OF MAJOR TRIBUTARIES TO THE DEERFIELD RIVER IN MASSACHUSETTS

| Stream name (downstream order) | Drainage area (sq mi) |
|---|---|
| Cold River | 31.6 |
| Chickley River | 27.4 |
| Clesson Brook | 21.2 |
| North River | 92.3 |
| South River | 26.3 |
| Green River | 89.4 |

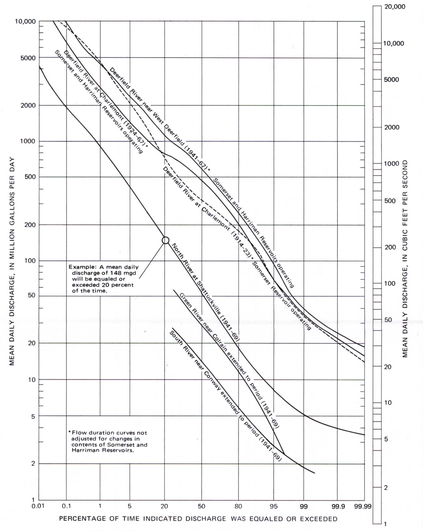
THE STEEP GRADIENT AND ABUNDANT WATER MAKES THE DEERFIELD RIVER AN EXCELLENT CHOICE FOR ELECTRIC POWERPLANTS.–Dams at the "run of the river" hydroelectric generating stations, such as New England Power Company plants No. 2, 3, 4, and 5, are used to divert water, maintain constant head, and provide minor storage. Water released during periods of power generation at these sites causes diurnal fluctuation in streamflow. Backwater from these dams seldom extends more than 1½ miles upstream and is usually contained in the original channel of the river.

Water used to operate the "run of the river" generating stations is stored in Somerset and Harriman Reservoirs, which are capable of storing half the mean annual runoff from the area above Harriman Reservoir or 17 percent of the mean annual runoff from the entire basin. These reservoirs thus provide flood control and low-flow augmentation of the Deerfield River in Massachusetts.

Sherman Reservoir is a dual-purpose reservoir–it serves as a re-regulating reservoir to store temporarily any large amounts of water released from Harriman Reservoir and, therefore, provides a more controlled release to downstream hydroelectric generating stations, and it serves as a heat sink for the atomic electric plant at Rowe.

More than 200 mgd is withdrawn from the Sherman Reservoir to cool the nuclear-fueled thermal electric plant at Rowe. This cooling water is returned to the reservoir and used repeatedly at six downstream hydroelectric powerplants. In 1969, an average of 3,160 mgd was used for hydroelectric power generation. One additional pumped storage hydroelectric powerplant is presently under construction.

### FLOW DURATION

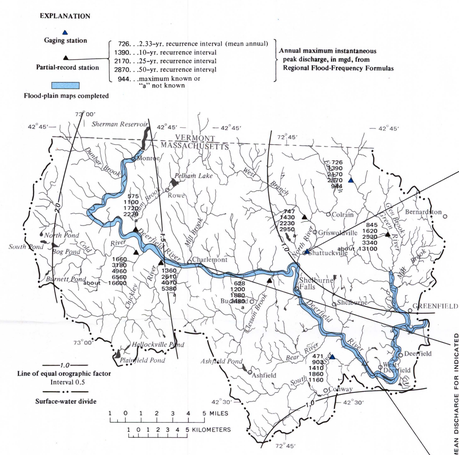


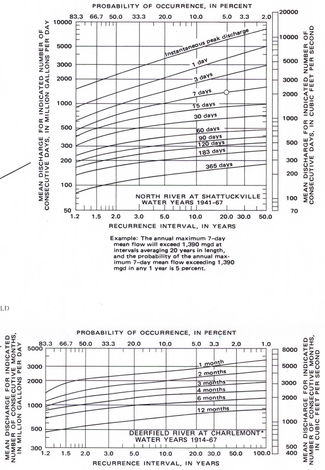

THE GEOHYDROLOGIC CHARACTERISTICS OF A DRAINAGE BASIN MAY BE INFERRED FROM THE SHAPE OF THE FLOW-DURATION CURVE.– A steep slope at the upper end of the duration curve indicates flood flows run off rapidly. A steep slope (low base flow) at the lower end indicates negligible ground-water storage, whereas a more gentle or flat slope (high base flow) indicates more ground-water storage. If conditions that govern runoff do not change from the period of record, the curves can be used to predict the percentage of time future flows will be equaled or exceeded.

The effect of changing flow conditions can be seen by comparing the curves for the Deerfield River at Charlemont before and after Harriman Reservoir began operation. The high flows are subdued on the latter curve because part of the flows were stored in the reservoir. Later release of this stored water causes the pronounced bump in the middle part of the flow-duration curve. Downstream, on the Deerfield River near West Deerfield, the flow-duration curve is somewhat smoothed by the natural flow from 196 square miles of intervening drainage area.

The flatter slope near the lower end of the flow-duration curve for the North River at Shattuckville is caused by ground-water storage in the sands and gravels along the East Branch North River.

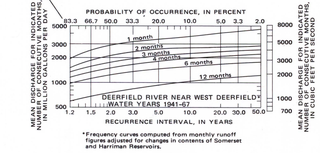
## HIGH STREAMFLOWS










REGIONAL FLOOD-FREQUENCY FORMULAS (Knox and Johnson, 1965)

$Q1.2 = 1.23AS^{0.5}O^{1.2}$

$Q2.33 = 2.06AS^{0.5}O^{1.2}$

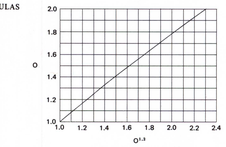
$Q5 = 2.91AS^{0.5}O^{1.2}$

$Q10 = 3.95AS^{0.5}O^{1.2}$

$Q25 = 6.16AS^{0.5}O^{1.2}$

$Q50 = 8.14AS^{0.5}O^{1.2}$

$Q100 = 10.5AS^{0.5}O^{1.2}$

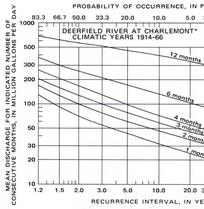


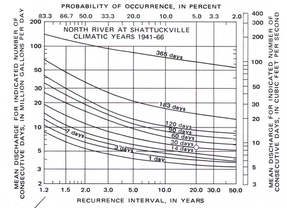

Q50 = Peak-flood discharge for 50-year frequency, or recurrence interval, in million gallons per day.
A = Drainage area, in square miles.
S = Slope factor, in feet per mile, as determined by extending the main channel of the stream to the drainage-basin divide on the topographic map, picking off the altitudes of the points 85 and 10 percent of the total length above the site, dividing the difference in altitude, in feet, by the length, in miles, between the two points, and obtaining feet per mile.
O = Orographic factor from map above.
To convert million gallons per day to cubic feet per second, multiply by 1.547.

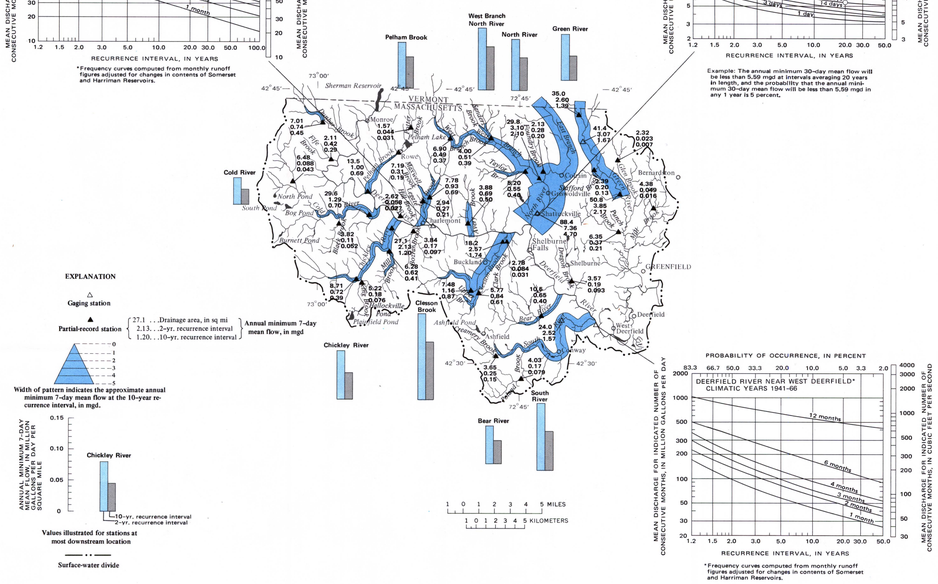
THE MAGNITUDE OF A FLOOD FOR ANY LOCATION WHERE THE DRAINAGE AREA IS GREATER THAN 10 SQUARE MILES CAN BE ESTIMATED FROM REGIONAL FLOOD-FREQUENCY FORMULAS, PROVIDED FLOOD PEAKS ARE NOT AFFECTED MATERIALLY BY MAN-MADE REGULATION, SUCH AS THAT ON THE MAIN STEM, DEERFIELD RIVER.

Along tributary streams the rugged topography, relatively impervious soils, and practically nonexistent surface storage cause immediate runoff. However, losses due to flooding have been small compared with other areas because of limited development on the flood plains.

## LOW STREAMFLOWS



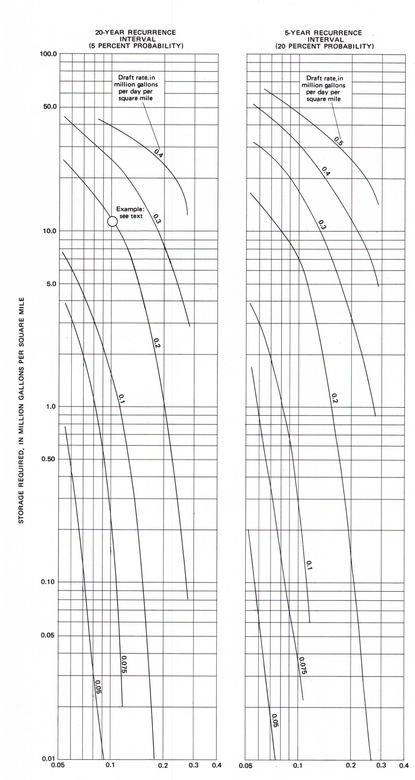




REGIONAL PLANNING OF RIVER BASINS FOR WATER SUPPLY, WATER-POLLUTION ABATEMENT, AND (OR) RECREATION REQUIRE ADEQUATE KNOWLEDGE OF THE LOW-FLOW POTENTIAL OF THE AREA.

Differences in low streamflow per unit area are caused by nonuniformity of geology, evapotranspiration, water-table slope, precipitation, diversion of water from streams, pumpage of wells, or discharge of waste water. Most of the streams are perennial and nearly all basins over 2 square miles in area yield some water at the annual minimum 7-day mean flow at the 10-year recurrence interval. Low-flow-frequency analyses are based on the climatic year, which begins April 1 of the year designated.

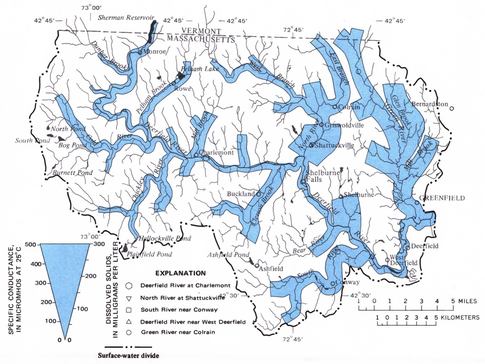
## REGIONAL STORAGE ANALYSIS



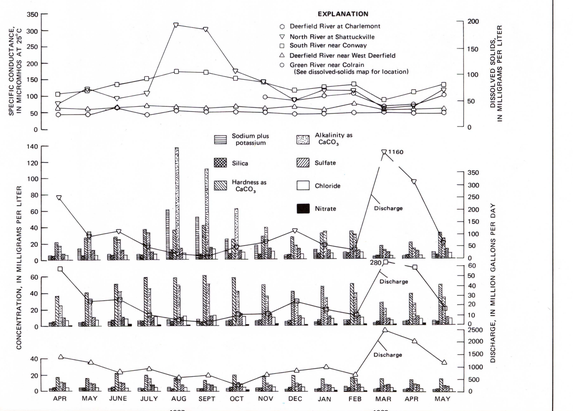

REGIONAL DRAFT-STORAGE-FREQUENCY ANALYSIS USED IN CONJUNCTION WITH LOW-FLOW INFORMATION (LOW-STREAMFLOWS MAP) PROVIDES WATER MANAGERS OR REGIONAL PLANNERS WITH INFORMATION NECESSARY FOR SELECTION AND DESIGN OF RESERVOIRS.–These values do not take into consideration losses of storage to seepage, evaporation (approximately 25 inches per year), or sedimentation. These curves were developed using the within-year storage method (reservoir assumed full each year).

EXAMPLE: Assume the reservoir has a 10-square mile drainage area and a median annual (2-year recurrence interval) minimum 7-day mean flow of 1.0 mgd or 0.1 mgd per sq mi. To maintain a draft rate of 0.2 mgd per sq mi, a storage of 12 mg per sq mi will not suffice 1 year out of every 20 years on the average, and the probability that a storage of 12 mg per sq mi will not suffice in any 1 year is 5 percent.

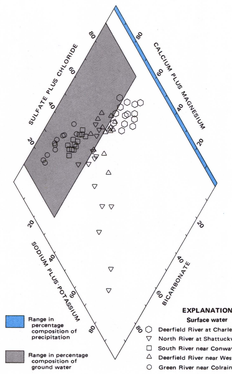
## QUALITY



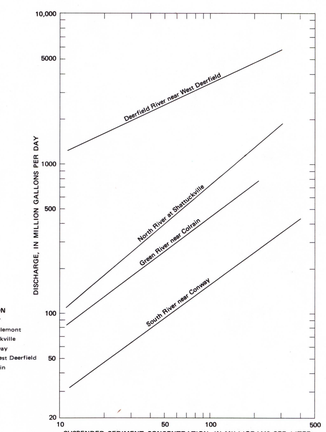

DISSOLVED-SOLIDS CONTENT OF STREAM WATER VARIES AREALLY BECAUSE OF DIFFERENCES IN SOLUBILITY OF SOILS AND ROCKS AND BECAUSE WASTE PRODUCTS ARE ADDED TO THE STREAMS.–Most rocks are relatively insoluble except for small lenses of relatively soluble marble (calcium carbonate) in the eastern part of the basin. The diagram of specific conductance and estimated dissolved solids was prepared from measurements at 56 sites during August 1968, when streamflow was at approximately the 90 percentile of the flow duration. At this time, dissolved oxygen ranged from 7.1 to 10 milligrams per liter (74 to 106 percent saturation), pH ranged from 6.6 to 8.4, except for one measurement of 10.2 near the mouth of the North River, and temperature ranged from 15 to 23°C (59 to 82°F). Dissolved solids in stream water, in milligrams per liter, are equal to 0.59 × specific electrical conductance, in micromhos, at 25°C.




THE CONCENTRATION OF DISSOLVED CONSTITUENTS IN WATER VARIES INVERSELY WITH SEASONAL CHANGES IN DISCHARGE IN TRIBUTARY STREAMS BUT IS NEARLY CONSTANT IN THE DEERFIELD RIVER.–The retention of water in reservoirs on the Deerfield River allows mixing and masks flow-related changes. Industrial waste added to the North River changes the water type (see percentage composition graph) and enhances the seasonal changes.




THE PERCENTAGE COMPOSITION OF DISSOLVED SOLIDS IN WATER IN THE DEERFIELD RIVER IS AFFECTED BY WATER OF DIFFERENT PERCENTAGE COMPOSITION FLOWING IN FROM ITS TRIBUTARIES.–The percentage composition of dissolved solids generally reflects the geologic environment. Marble (calcium carbonate) lenses in the eastern part of the basin cause the water in the South and Green Rivers to be relatively high in these constituents. The North River receives industrial waste, which changes the water to a sodium bicarbonate type during some periods. (See dissolved-solids hydrograph.) Water flowing into the Deerfield River between Charlemont and West Deerfield increases the percentage composition of calcium and magnesium bicarbonate by about 10 percent. Analyses of samples taken monthly at each site are shown.




THE CONCENTRATION OF SUSPENDED SEDIMENT VARIES WITH DISCHARGE AND IS HIGHEST DURING PERIODS OF SPRING RUNOFF.–The above concentration-discharge curves were prepared from samples collected during the spring runoff periods in 1968 and 1969 and show the general range of concentration to be expected with changes in discharge. The suspended sediment is derived from erosion of soils and stream banks.

### SELECTED REFERENCES

Benson, M.A., 1962, Factors influencing the occurrence of floods in a humid region of diverse terrain: U.S. Geol. Survey Water-Supply Paper 1580-B, 64 p.

Knox, C.E., and Johnson, C.G., Jr., 1965, Flood-frequency formulas for Massachusetts: U.S. Geol. Survey open-file rept., 10 p., 1 pl.

Pierce, H.H., and Dean, H.J., 1916, Surface waters of Massachusetts: U.S. Geol. Survey Water-Supply Paper 415, p. 89–116.

Riggs, H.C., 1966, Hydrologic data for reservoir design: Internat. Assoc. of Sci. Hydrol. Pub. 71, v. 2, Symposium of Garda, p. 540–550.

Searcy, J.K., 1959, Flow-duration curves *in* Manual of hydrology, pt. 2, Low-flow techniques: U.S. Geol. Survey Water-Supply Paper 1542-A, p. 1–33.

U.S. Geological Survey, 1966–69, Water resources data for Massachusetts, New Hampshire, Rhode Island, and Vermont–Part 1, Surface water records, part 2, Water quality records: Boston, Mass., Water Resources Div., issued annually.

——1954, Compilation of records of surface waters of the United States through September 1950, pt. 1-A, North Atlantic slope basins, Maine to Connecticut: U.S. Geol. Survey Water-Supply Paper 1301, 380 p.

——1964, Compilation of records of surface waters of the United States, October 1950 to September 1960, pt. 1-A, North Atlantic slope basins, Maine to Connecticut: U.S. Geol. Survey Water-Supply Paper 1721, 317 p.

——1969, Surface water supply of the United States 1961–65, pt. 1, North Atlantic slope basins, v. 1, Maine to Connecticut: U.S. Geol. Survey Water-Supply Paper 1901, 1027 p.

U.S. Geological Survey, 1969, Map of flood-prone areas of the Ashfield quadrangle, Massachusetts: U.S. Geol. Survey.

——1969, Map of flood-prone areas of the Greenfield quadrangle, Massachusetts: U.S. Geol. Survey.

——1969, Map of flood-prone areas of the Rowe quadrangle, Massachusetts: U.S. Geol. Survey.

——1969, Map of flood-prone areas of the Shelburne Falls quadrangle, Massachusetts: U.S. Geol. Survey.

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# HYDROLOGY AND WATER RESOURCES OF THE DEERFIELD RIVER BASIN, MASSACHUSETTS

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