WATER-RESOURCES ACTIVITIES IN NEW ENGLAND, FISCAL YEAR 1993

Compiled By Marianne F. Orlando

U.S. GEOLOGICAL SURVEY
Open-File Report 94-339

Marlborough, Massachusetts
1994

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, *Secretary*

U.S. GEOLOGICAL SURVEY
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Message from the Area Hydrologist

The U.S. Geological Survey is an earth-science information agency. It has no regulatory role, but is recognized for its impartial fact-finding and research mission. The Water Resources Division accomplishes this mission by collecting and interpreting hydrologic data and conducting research that enables water-resources managers to make decisions based on objective scientific information. This report describes the current (1993) activities of the Water Resources Division in New England.

Water-resources studies in New England are conducted from offices located in each of the New England States. Staff in these offices receive support from specialists at the Area and Regional level, from the National Water Quality Laboratory, and from staff of the National Research Program. Quality assurance/quality control systems, a National Training Center, and Nationally designed data systems ensure that Water Resources Division activities at all locations are accomplished by consistent proven methods.

The Survey also engages in other programs in New England that encompass geology, offshore minerals assessment and topographic mapping. These activities are administered by other divisions and are directed from regional offices in Reston, Va.

Most of the Survey's water-resources studies conducted in New England are done in cooperation with State and local agencies or with other Federal agencies. These cooperators and the general public are our customers and we strive to keep our products and services relevant to our customers needs and otherwise meet their expectations. To meet these needs and expectations, we continue to provide a balance of hydrologic data collection, resource appraisals, and research relevant to the water-resources information needs in New England. We thank you, our cooperators and customers, for your continued support.

I hope that you find this report interesting and informative. If you would like more information on the activities described, please contact me or any of the District Chiefs listed in the report.

Ivan C. James, II

Area Hydrologist, New England Program Area
Marlborough, Massachusetts

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U.S. GEOLOGICAL SURVEY,
Water Resources Division

BASIC MISSION AND PROGRAM

The mission of the Water Resources Division is to provide the hydrologic information and understanding needed for the optimum utilization and management of the Nation's water resources for the overall benefit of the people of the United States.

This is accomplished, in large part, through cooperation with other Federal and non-Federal agencies, by:

1. Collecting, on a systematic basis, data needed for the continuing determination and evaluation of the quantity, quality, and use of the Nation's water resources.

2. Conducting analytical and interpretive water-resource appraisals describing the occurrence and availability, and the physical, chemical, and biological characteristics of surface and ground water.

3. Conducting supportive basic and problem-oriented research in hydraulics, hydrology, and related fields of science to improve the scientific basis for investigations and measurement techniques and to understand hydrologic systems sufficiently well to quantitatively predict their response to stress, either natural or manmade.

4. Disseminating the water data and the results of these investigations and research through reports, maps, computerized information services, and other forms of public releases.

5. Coordinating the activities of Federal agencies in the acquisition of water data for streams, lakes, reservoirs, estuaries and ground water.

6. Providing scientific and technical assistance in hydrologic fields to other Federal, State, and local agencies, to licensees of the Federal Energy Regulatory Commission, and to International agencies on behalf of the Department of State.

Water-Resources Activities In New England, Fiscal Year1993

Compiled by Marianne F. Orlando

INTRODUCTION

The Water Resources Division of the U.S. Geological Survey is responsible for appraising and describing the quantity and quality of the Nation's water resources, and for scientific investigation of existing or potential water problems. Technical information describing the source, occurrence, movement, availability, use, quantity, and quality of the waters is available to all concerned with development and management of water and related land resources.

Programs of the Water Resources Division are financially supported by direct appropriations from Congress, transfer of funds from other Federal agencies, and, primarily, by Joint-Funding Agreements with State and local government agencies. Under Joint-Funding Agreements, the costs of mutually planned programs are usually shared by the Federal government and the cooperating agency with the Federal share not to exceed one-half the cost of the program. Such sharing assures that Water Resources Division programs are responsive to both local and National priorities.

NEW ENGLAND PROGRAM AREA

The New England Program Area includes a staff of hydrologists, hydrologic technicians, computer specialists, scientific illustrators, reports specialists, administrative and clerical personnel, and drillers. Hydrologists have backgrounds in biology, chemistry, engineering, geology, hydrology, and mathematics. Duties of the staff include collecting, compiling, and interpreting hydrologic data, and preparing reports for publication.

Districts are supported at Regional and National levels by technical experts in surface- and ground-water technology; in the physical, chemical, and biological properties of water; in automatic data processing; in systems analysis; in borehole geophysics; and in drilling, sampling, and testing geologic materials. A central laboratory system ensures timely analyses of water and sediment samples, strict quality control in testing procedures, and entry of most data into the National Water Information System, the Water Resource Division's extensive data base, and into STORET, a data base maintained by the U.S. Environmental Protection Agency.

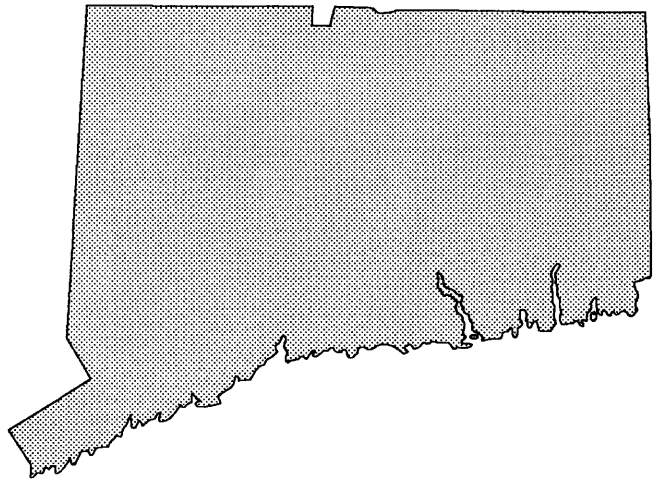
Publications include basic-data reports, interpretive reports, and journal articles that describe the occurrence, and quantity, and physical, chemical, and biological characteristics of surface and ground water.

ABOUT THE REPORT: This report briefly describes the Water Resources Division's New England Program Area and water-resource projects that were active in each District as of September 30, 1993 (the end of the fiscal year). It also provides a bibliography, by District and author, of reports published since 1977.

ADDITIONAL INFORMATION: Further information may be obtained from the Chiefs of District Offices in Augusta, Maine; Marlborough, Massachusetts; Augusta, Maine; Bow, New Hampshire; and Subdistrict Office in Providence, Rhode Island (addresses inside back cover). A field office also is located in Montpelier, Vermont.

PAGE 3 FOLDS

Connecticut District



COOPERATORS

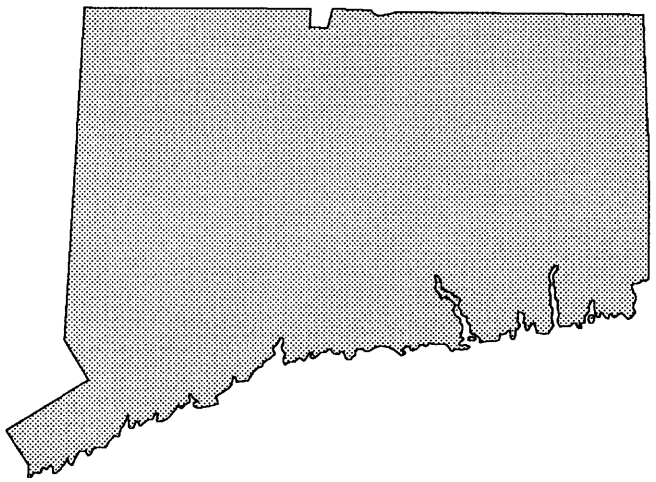
City of Meriden
City of New Britain
City of Torrington
Connecticut Department of Environmental Protection
Connecticut Department of Transportation
Federal Emergency Management Agency
Holyoke Water Power Company
Lake Waramaug Interlocal Commission
Lake Waramaug Task Force
Quinebaug Partnership
South Central Connecticut Regional Water Authority
Town of Fairfield
U.S. Department of the Army, Corps of Engineers
U.S. Department of Justice, Federal Bureau of Investigation
U.S. Department of Transportation, Federal Highway Administration
U.S. Environmental Protection Agency

> PAGE 5 FOLLOWS

Surface-Water Stations

PROJECT CHIEF:
Michael A. Cervione, Jr.

PERIOD OF PROJECT:
Continuous since July 1928



COOPERATOR(S): City of New Britain; City of Torrington; Connecticut Department of Environmental Protection; U.S. Department of the Army, Corps of Engineers; Holyoke Water Power Company; Quinebaug Partnership; South Central Connecticut Regional Water Authority; and Town of Fairfield, Lake Waramaug Interlocal Commission; Lake Waramaug Task Force

PROBLEM: Surface-water sources supplied about 85 percent of the total offstream freshwater used in Connecticut during 1990—about 902 million gallons per day. Thermoelectric-power generation (530 million gallons per day) and public supply (302 million gallons per day) were the two largest uses of surface water. About 2,760,000 people, or 66 percent of Connecticut's population, used surface-water supplies. The largest surface-water withdrawals are in the Lower Connecticut, Farmington, and Saugatuck River Basins. Water quality in streams in Connecticut generally is suitable for most uses. Streamflow monitoring is essential for surveillance, planning, design, hazard warning, operation, and management. Streamflow monitoring also is essential for water supply, hydroelectric power, flood control, irrigation, bridge and culvert design, wildlife management, pollution abatement, flood-plain management, and water-resources development. To provide this information, an appropriate data base is necessary.

OBJECTIVE: A. Collect surface-water data sufficient to satisfy needs for current-purpose uses, such as (1) assessment of water resources, (2) operation of reservoirs or industries, (3) flow forecasting, (4) disposal of wastes and pollution controls, (5) publication of discharge data to accompany water-quality measurements, (6) conformity to compact and legal requirements, and (7) research or special studies. B. Collect data necessary for analytical studies to define for any location the statistical properties of, and trends in, the occurrence of water in streams, lakes, estuaries, etc., for use in planning and design.

APPROACH: To meet the stated objectives, this project collects stream discharge, and stream and lake stage data from a network of gaging stations, including daily discharge, periodic discharge, daily stage, and periodic stage stations to define streamflow and stage conditions in the State of Connecticut. Standard methods of data collection will be used as described in the series, "Techniques of Water-Resources Investigations of the U.S. Geological Survey."

PROGRESS: Surface-water data from 77 continuous streamflow, stage, tidal, partial record, and miscellaneous measurement stations were collected, compiled, and published for the 1992 water year. Surface-water data for the 1993 water year were collected and are being processed for publication in the annual Water Resources Data report. Real-time data were acquired using data-collection platforms (DCP's) at four end-of-month index stations, at two streamflow allocation basin management stations, and at two remote sites for geographic control in southeastern and northwestern Connecticut.

PLANS NEXT YEAR: Statewide data collection will continue. Ten stations, equipped with satellite-relay data in transmitters—eight owned by the U.S. Geological Survey (USGS) and two owned by the U.S. Army Corps of Engineers and serviced by the USGS—will continue to supply real-time transmission of streamflow information as primary record sites.

COMPLETED REPORTS: This project contributes to the annual report "Water Resources Data—Connecticut." Data on stream discharge and stage and on lake or reservoir levels, through September 1960, were published annually under the title "Surface-Water Supply of the United States, Part A." For the 1968 through 1970 water years, the data were published in two 5-year reports. Beginning with the 1961 water year through the 1974 water year, data relating to the quantities of surface water were published in "Water Resources Data for Connecticut." Beginning with the 1975 water year, the report title was changed to "Water Resources Data—Connecticut (water year)."

OTHER REPORTS:

Bigwood, B.L., and Thomas, M.P., 1955, A flood-flow formula for Connecticut: U.S. Geological Survey Circular 365, 16 p.

Cervione, M.A., Jr., 1972, Time of travel of a dye in Quinnipiac River, Connecticut: Connecticut Department of Environmental Protection Bulletin 2, 11 p.

Lai, Chintu, Ruggles, F.H., Jr., and Weiss, L.A., 1971, Evaluation of flow in tidal reaches of the Connecticut River by mathematical model: U.S. Geological Survey open-file report, 24 p.

Shepard, T.B., and Weiss, L.A., 1988, Cost-effectiveness of the U.S. Geological Survey's stream-gaging program in Connecticut: U.S. Geological Survey Water-Resources Investigations Report 85-4333, 63 p.

Thomas, M.P., 1972, Gazetteer of natural areas of streams and water bodies within the State of Connecticut: Connecticut Department of Environmental Protection Bulletin 1, 89 p.

Weiss, L.A., 1971, Dispersion computation and temperature simulation for the Connecticut River estuary by mathematical model, in Geological Survey Research 1971: U.S. Geological Survey Professional Paper 750-B, p. B211-B217.

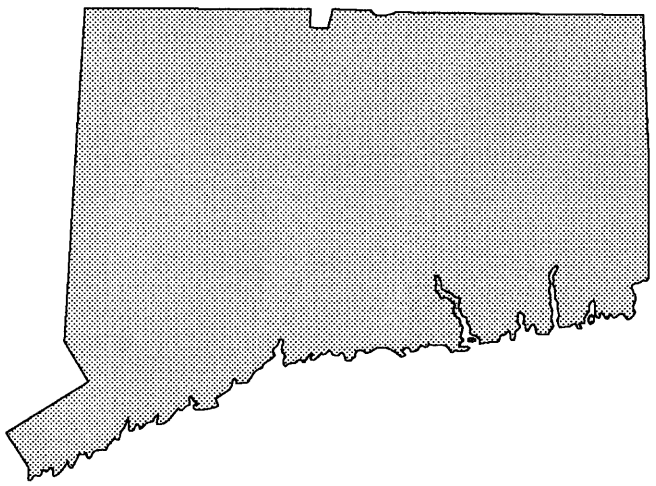
____ 1971, Mathematical model to compute reaeration coefficients for the Connecticut River, in Geological Survey Research 1971: U.S. Geological Survey Professional Paper 750-D, p. D165-D170.

____1988, Rainfall-runoff relationships of the Hop Brook basin, Manchester, Connecticut: U.S. Geological Survey Water-Resources Investigations Report 85-4327, 22 p.

Ground-Water Stations

PROJECT CHIEF:
Michael A. Cervione, Jr.

PERIOD OF PROJECT:
Continuous since July 1960



COOPERATOR(S): Connecticut Department of Environmental Protection

PROBLEM: Ground-water sources supplied about 15 percent of the total offstream freshwater used in Connecticut during 1990—about 165 million gallons per day. About 1,130,000 people, or 34 percent of Connecticut's population, used ground-water supplies. Public-supply (72.5 million gallons per day) and domestic self-supply (46.3 million gallons per day) were the two largest uses of ground water. The largest ground-water withdrawals were from the glacial-deposit and crystalline-bedrock aquifers in the Lower Connecticut and Housatonic River Basins. Ground water beneath more than 90 percent of the land in the State is considered to be suitable for drinking without treatment; however, the urbanized and industrialized nature of parts of Connecticut has resulted in many incidents of ground-water contamination. Long-term water-level monitoring is needed to evaluate the effects of climatic variations on the recharge to and discharge from the ground-water systems, to provide a data base from which to measure the effects of development, to assist in the prediction of future supplies, and to provide data for management of the resource.

OBJECTIVE: (1) Collect ground-water-level data sufficient to provide a data base so that the general response of the hydrologic system to natural climatic variations and induced stresses is known and potential problems can be defined early enough to allow proper planning and management. (2) Provide a data base against which the short-term records acquired in areal studies can be analyzed. (3) Develop master quadrangle or town maps of ground-water and geophysical information generated and updated through a digital system (GIS).

APPROACH: Evaluation of regional geology allows broad, general definition of aquifer systems and their boundary conditions. Within this framework and with some knowledge of the stress on the system in time and space, and the hydrologic properties of the aquifers, a subjective decision can be made on the most advantageous locations for observation of long-term system behavior. This subjective network can be refined as records become available and detailed areal studies of the ground-water system more closely define the aquifers, their properties, and the stresses to which they are subjected. Base maps will be generated for each Connecticut quadrangle or town of ground-water and geophysical information using Geographical Information System (GIS) techniques. These data will be digitized using both the Survey's (USGS) computer hardware, ARC/INFO geographic software, and related information and graphic software in the USGS Distributed Information System (DIS) and the Connecticut Department of Environmental Protection (DEP) ARC/INFO GIS program. All digital data will be from 1:24000 scale source maps. Attributes will be selected from data source in System 2000.

PROGRESS: Ground-water data for 46 wells in the observation network were entered into computer storage, reviewed, and published for the 1992 water year. Water-level measurements were made twice a month in 59 wells used in the long-term State observation network for the 1993 water year. Thirteen new wells were drilled in the 1993 water year for the modified observation network.

PLANS NEXT YEAR: Data collection, compilation, and answering requests for ground-water information in Connecticut will continue. Ground-water-level measurements will continue on a twice a month schedule. All data will be published in the annual data-report series. Water-level measurements at six new wells will be initiated and incorporated into the statewide network. Arrays will show water-level fluctuations in hilltops, hillsides, and valley bottoms. The program will be modified to incorporate 73 wells in the statewide-observation network for data entry and water-resource management decisions. Water-level information is contributed to the monthly "Water Resources Conditions in Connecticut" based on 14 observation wells with long-term records. Digitization of ground-water and geophysical information using GIS format to generate master base maps will continue.

COMPLETED REPORTS: This project contributes to the annual report "Water Resources Data—Connecticut." Water levels for the 1935 through 1974 water years were published under the title "Ground-Water Levels in the United States." Beginning in the 1971 water year, ground-water data were published in "Water Resources Data for Connecticut" on an annual basis. Beginning with the 1975 water year, the report title was changed to "Water Resources Data—Connecticut (water year)."

OTHER REPORTS:

LaSala, A.M., Jr., 1962, Ground-water levels in Connecticut, 1956-1959: Connecticut Water Resources Bulletin 2, 33 p.

Meikle, R.L., 1967, Ground-water levels in Connecticut, 1965-66: Connecticut Water Resources Bulletin 13, 12 p.

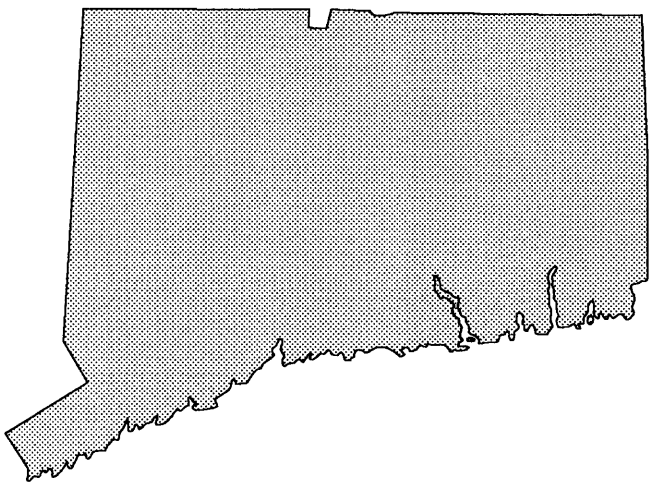
Meikle, R.L., and Baker, J.A., 1965, Ground-water levels in Connecticut, 1960-1964: Connecticut Water Resources Bulletin 7, 26 p.

Melvin, R.L., 1986, Connecticut observation wells—guidelines for network modification: U.S. Geological Survey Water-Resources Investigations Report 85-4079, 24 p.

Quality Of Water Stations

PROJECT CHIEF:
Denis F. Healy

PERIOD OF PROJECT:
Continuous since July 1955



COOPERATOR(S): Connecticut Department of Environmental Protection

PROBLEM: The State of Connecticut is required to monitor, compile and analyze data on the quality of its surface waters. The U.S. Geological Survey (USGS) also requires water-quality information to accomplish its mission of appraising the quality of the Nation's water. Water-resource planning and water-quality assessment require a nationwide base level of relatively standardized information on chemical, physical, bacteriological, and biological qualities of surface and ground water for proper planning and realistic assessment of water supplies and resources.

OBJECTIVE: The objective of this project is to collect, store, document, provide, and publish an unbiased inventory of water-quality data from a network of water-quality sites in Connecticut. This information provides an assessment of water quality that can be used for (1) planning and management of the State's water resources, (2) determining changes and trends in water quality over time, and (3) evaluating cause-effect relations in water quality.

APPROACH: A network of water-quality stations was established and operated to provide data on the chemical, physical, bacteriological, and biological concentrations, loads, and trends as required by the needs of the State and Federal planning and management agencies. The network is reviewed, appraised, and revised to meet present and future requirements, needs, and trends in data collection, analytical methods, parameters, frequency and areal distribution. Standard methods of data collection are used as described in the "National Handbook of Recommended Methods for Water-Data Acquisition" and Water Resources Division manuals and memorandums.

PROGRESS: Daily water-quality data were collected at nine stations—three National Stream Quality Accounting Network (NASQAN) stations, one Federal station, and five State stations. Water-quality data were collected at 29 surface-water network stations—one quarterly, two bi-monthly, and 26 with 11-month frequency. Data for the 1991 water year were published in the annual report "Water Resources—Connecticut" report. Analysis of water-quality trend data continued.

PLANS NEXT YEAR: Collect water-quality data periodically at sites throughout Connecticut. Collect water data from continuous monitors at two stations on the Connecticut River. Continue two daily water temperature stations in the Housatonic River. Collect water-quality samples at 29 network stations—sample 2 on a quarterly frequency, 2 on a bi-monthly frequency, and 25 sites 8 times during the water year. Support the National Assessment Water Quality (NAWQA) program through additional sampling. For NAWQA, eight water-quality stations are needed—four in the statewide network and four non-network sites. Continue analysis of water-quality trend data for correlations with changing water use, land use, and

population density. Continue network evaluation. Review, compile, and publish the data collected in water year 1993.

COMPLETED REPORTS: This project contributes to the annual report "Water Resources Data—Connecticut." Data on chemical quality, temperature, and suspended sediments for the 1941 through 1970 water years were published annually under the title "Quality of Surface Waters of the United States." Beginning in the 1964 water year, water-quality data were published annually in "Water Resources Data for Connecticut." Beginning with the 1975 water year, the report title was changed to "Water Resources Data—Connecticut (water year)."

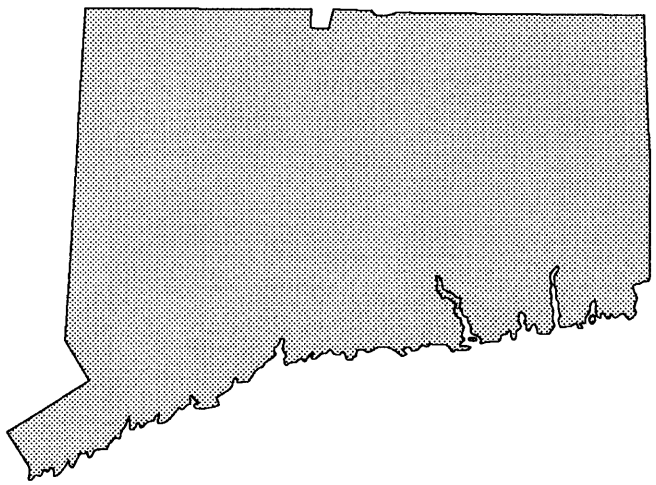
OTHER REPORTS:

Kulp, K.P., 1982, Quality of surface waters in Wilton, Connecticut: U.S. Geological Survey Water-Resources Investigations Open-File Report 82- 260, 51 p.

Sediment Stations

PROJECT CHIEF:
Chester E. Thomas, Jr.

PERIOD OF PROJECT:
Continuous since July 1975



COOPERATOR(S): Connecticut Department of Environmental Protection

PROBLEM: Water-resource planning and water-quality assessment require a base level of sediment information. Sediment concentrations and sediment discharges in rivers and streams must be defined and monitored.

OBJECTIVE: To develop a data base adequate to assess sedimentation characteristics of various drainage areas as required for planning and management of State and Federal programs.

APPROACH: A network of sediment stations was established and operated for a selected period of time to provide trends of sediment concentration, sediment discharge, and particle size of sediment being transported by rivers and streams. Standard methods of data collection are used as described in the "National Handbook of Recommended Methods for Water-Quality Acquisition" and Water Resources Division manuals and memorandums.

PROGRESS: Sediment data for the 1992 water year were published in the annual report. Quarterly suspended-sediment samples were collected and analyzed for concentration and particle size at four National Stream Quality Accounting Network (NASQAN) sites and miscellaneous sediment samples were collected at seven National Water Quality Assessment (NAWQA) sites.

PLANS NEXT YEAR: Continue data collection, tabulation, and analysis at four NASQAN sites. Publish the data collected in water year 1993 in the annual data-report series. Write a report on sediment characteristics of three streams in the Connecticut River basin—Coginchaug River, Salmon River, and Stony Brook.

COMPLETED REPORTS: This project contributes to the annual report "Water Resources Data—Connecticut."

OTHER REPORTS:

Haeni, F.P., McKeegan, D.K., and Capron, D.R., 1987, Ground penetrating radar study of the thickness and extent of sediments beneath Silver Lake, Berlin and Meriden, Connecticut: U.S. Geological Survey Water-Resources Investigations Report 85-4108, 19 p.

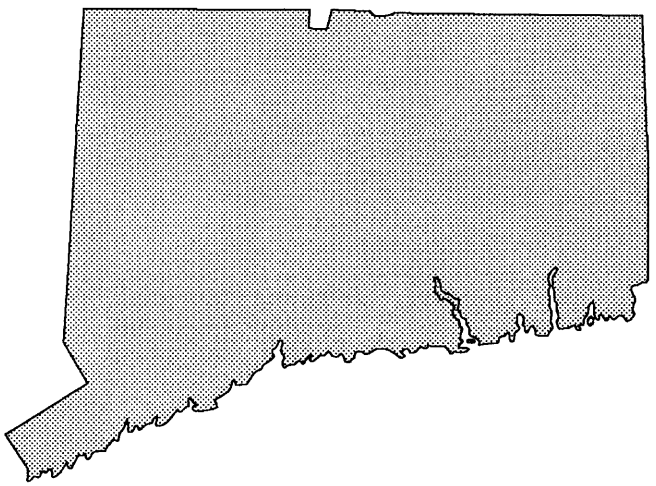
Kulp, K.P., 1983, Suspended-sediment characteristics of the Yantic River at Yantic, Connecticut: Connecticut Water Resources Bulletin 39, 34 p.

____1991, Suspended-sediment characteristics of Muddy Brook at Woodstock, Connecticut, *with a section on* The water quality of Roseland Lake and its major tributaries, Muddy Brook and Mill Brook: Connecticut Water Resources Bulletin 43, 64 p.

HUD Flood Insurance Studies

PROJECT CHIEF:
Michael A. Cervione

PERIOD OF PROJECT:
July 1972 to September 1995



COOPERATOR(S): Federal Emergency Management Agency

PROBLEM: The National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973 provide for the operation of a Flood Insurance Program. The Federal Emergency Management Agency (FEMA) needs flood restudies, and study updates through their Limited Map Maintenance Program, in selected developing Connecticut communities to more accurately determine applicable flood insurance premium rates.

OBJECTIVE: Conduct the necessary hydrologic and hydraulic restudies of selected areas assigned by FEMA on a month by month basis, and develop the most efficient procedures to attain the accuracy specified by FEMA.

APPROACH: The necessary surveys will be conducted by ground and (or) photogrammetric methods. Develop flood-discharge-frequency relations from local historic information, gaging-station records, and applicable reports. Develop water-surface profiles through step-backwater models for inclusion in reports to be published by FEMA.

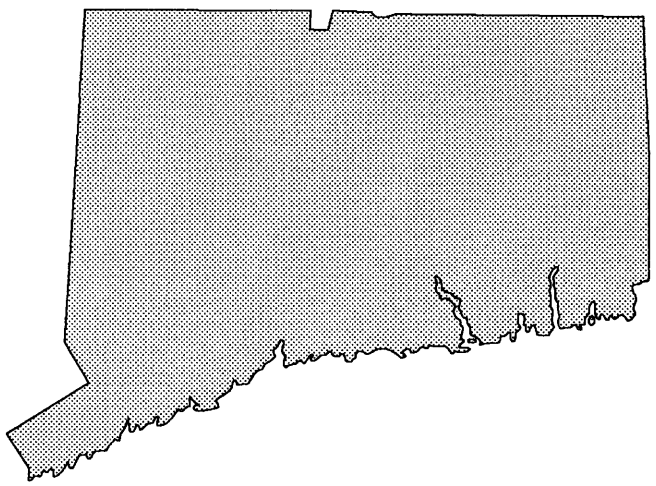
PROGRESS: Hydraulic analysis for restudies for the Federal Emergency Management Agency (FEMA) of East Granby, Ellington, and Granby, Connecticut were completed. Field survey for type-19 restudy of Clinton, Connecticut was completed.

PLANS NEXT YEAR: Complete final reports for East Granby, Ellington, and Granby, Connecticut, and submit to FEMA. Complete hydraulic analysis for the restudy of Clinton, Connecticut, and submit to FEMA. Submit the final reports to FEMA for Meriden and New Britain, Connecticut studies. Submit proposals to FEMA for a type-19 restudy of Naugatuck, Connecticut.

Water Use

PROJECT CHIEF:
Barbara A. Korzendorfer

PERIOD OF PROJECT:
Continuous since July 1977



COOPERATOR(S): Connecticut Department of Environmental Protection

PROBLEM: Relatively little information has been systematically collected describing where, how, and in what quantities water is presently being used in Connecticut. Current water-use data are essential to determine what part of the State's water resources remains available for future use. Connecticut's long range plan for conservation and development cites water-use data as a fundamental and integral element of the program. The National Water-Use Data System (NWUDS) coordinator will develop a Connecticut water-use program that will meet the needs of Connecticut's water-data users and the National water-use program.

OBJECTIVE: (1) To establish and implement a plan for a water-use program in Connecticut that serves the State's future water planning needs and is compatible with a National Water-Use Program. (2) To implement the support software needed for the Connecticut water-use system. (3) To insure that the State's water-use needs, as well as the National water-use needs are met by the proposed system.

APPROACH: Specific requirements which must be met in order to develop a State water-use system that is compatible with the National System will be identified. These requirements will be identified through discussions and meetings with various agencies within the State. Information from the files of local, State, and Federal agencies that collect water-use data will be evaluated for completeness and usefulness to the State Water-Use Data System (SWUDS) computer program. Each category (such as public water supply, industrial water use, commercial, etc.) will be analyzed for availability of data. Methods will be identified for Statewide collection of data in each category. Some geographically smaller areas such as river basins may be selected for special data collection and analysis. The information will be computerized and reports written and published by the USGS and (or) the State of Connecticut.

PROGRESS: Work was begun on compiling, analyzing, evaluating, and automating site-specific data on public-supply systems and industrial use. Water-use map report based on 1990 data received Director's approval. Manuals on processing data on public-supply and wastewater disposal are on hold until the guidelines for the new National Water Information System (NWIS-II) have been developed. Reports on "Estimated Use of Water in New England, 1990" and "Wastewater collection and return flow" have been written as first drafts. Plans for moving water-use data from NWIS-I to NWIS-II have begun to be implemented.

PLANS NEXT YEAR: Compile public supply water-use data work, hold an industrial workshop in April, and continue processing of industrial water-use data. Publish the six map reports, "Wastewater collection and return flow in New England" and "Estimated Use of Water in New England." Move data from NWIS-I to NWIS-II and prepare the first draft of a public supply report for New England.

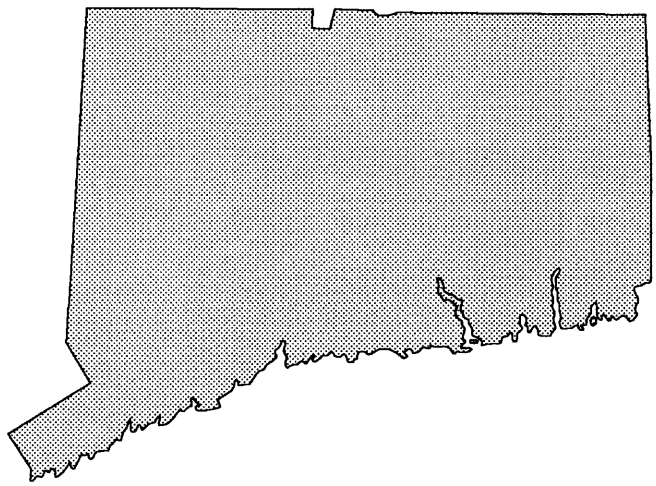
COMPLETED REPORTS:

Bigham, D.K., and Bohr, J.R., 1989, Offstream freshwater use in Connecticut, 1985: U.S. Geological Survey Open-File Report 88-457, 1 sheet.

Technical Support

PROJECT CHIEF:
F. Peter Haeni

PERIOD OF PROJECT:
October 1990 to October 1999



FUNDING SOURCE: USGS Water Resources Division, Office of Ground Water

PROBLEM: The Water Resources Division (WRD) has advocated the use of surface geophysics in hydrologic investigations, and is making a significant effort to train and provide technical support to hydrologists in the use of surface geophysics. The following steps are needed: (1) Select the appropriate surface geophysical methods that are applicable to hydrologic studies. (2) Prepare a series of manuals—"Techniques of Water-Resources Investigations of the U.S. Geological Survey" (TWRI) and journal articles. (3) Purchase field equipment for each technique. (4) Provide technical support and training to District personnel.

OBJECTIVE: (1) Make information, equipment, and training on existing techniques readily available to project chiefs. (2) Investigate new techniques that have the greatest potential for use in water-resources investigations.

APPROACH: Surface geophysical techniques will be surveyed and classified for their direct applicability to hydrologic studies. Individual modules or packages for each geophysical technique will be developed. Each module would consist of the following elements: (1) a TWRI and one or more journal articles on each technique, (2) one set of field equipment, and (3) interactive computer programs for interpretation, and Technical assistance will be provided to district, regional, and research staffs.

PROGRESS: Numerous Water Resource Division (WRD) districts were given technical assistance on surface geophysical methods. Experiments with nuclear magnetic resonance (NMR) methods were carried out in Colorado, Connecticut, New Hampshire, Nevada, and Montana. Research was conducted at Mirror Lake, N.H. for the detection of fractures in bedrock. Various state-of-the-art surface geophysical and borehole radar methods were used.

PLANS NEXT YEAR: Continue providing technical support to various District, Headquarter, and research personnel. Develop and write field experiment techniques for transfer of analog and digital data to personal computers (PC). Continue writing and developing interfacing programs and interpretation programs. Continue experiments with Land Seismic Reflection methods, including three-dimensional surveys. Compile, review, and interpret the collected NMR field data. Continue research into methods for detecting fractures in bedrock.

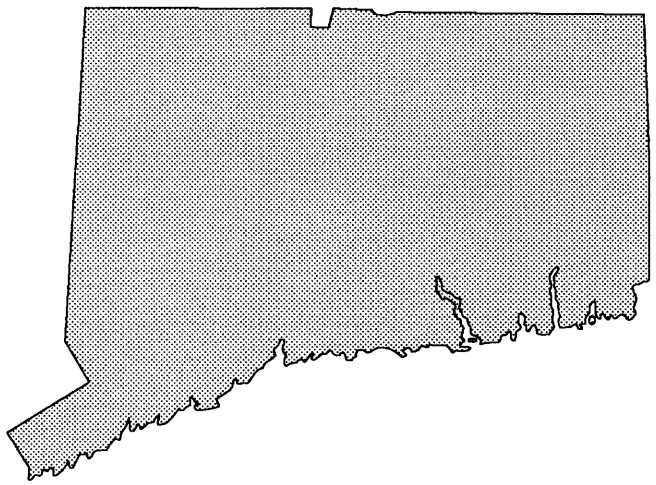
COMPLETED REPORTS:

Beres, Milan, Jr., and Haeni, F.P., 1991, Application of ground-penetrating-radar methods in hydrogeologic studies: Ground Water, v. 29, no. 3, p. 375-386.

Development and Use of Surface Geophysical Techniques in Ground-Water Investigations

PROJECT CHIEF:
F. Peter Haeni

PERIOD OF PROJECT:
Continuous since October 1980



COOPERATOR(S): Connecticut Department of Transportation, Federal Highway Administration; U.S. Environmental Protection Agency; U.S. Department of Justice, Federal Bureau of Investigation

PROBLEM: A variety of surface geophysical methods can help solve hydrologic problems. The Water Resources Division (WRD) has advocated the use of surface geophysics in hydrologic investigations; and is making a significant effort to train, and provide technical support to hydrologists in the use of surface geophysics. In order to carry out this goal, the following steps are needed. (1) Select the appropriate surface geophysical methods that are applicable to hydrologic studies. (2) Prepare a series of manuals—"Techniques of Water-Resources Investigations of the U.S. Geological Survey" (TWRI) and journal articles. (3) Purchase field equipment for each technique. (4) Provide technical support and training to district personnel. (5) Conduct research into potentially useful new techniques.

OBJECTIVE: (1) Identify the surface geophysical techniques that are appropriate for use in hydrologic studies. (2) Make information, equipment, and training on existing techniques readily available to project chiefs. (3) Investigate new techniques and modifications of existing techniques that have the greatest potential for use in water-resources investigations.

APPROACH: Surface geophysical techniques will be surveyed and classified for direct applicability to hydrologic studies. Individual modules or packages for each geophysical technique will be developed. Each module would consist of the following elements: (1) a TWRI and one or more journal articles on each technique, (2) one set of field equipment, and (3) interactive computer programs for interpretation. Technical assistance will be provided to district, regional, and research staffs. Research will be conducted on new surface geophysical techniques. USGS will work with other Federal agencies on the use of surface geophysical methods in order to solve common problems.

PROGRESS: Personnel, Division-wide were assisted in using surface-geophysical methods. Experiments in field application of ground-penetrating radar, borehole radar, continuous seismic reflections, and seismic reflection methods continued to be studied. Research programs in cooperation with U.S. Geological Survey (USGS), Low level Nuclear Waste Hydrology Program, USGS Toxic Substance Hydrology program, U.S. Environmental Protection Agency (USEPA), and Federal Highway Administration (FHWA) continued. The bridge scour research program with the FHWA at the Baldwin Bridge at Saybrook and at Bulkeley Bridge at Hartford, Connecticut, was reviewed, data evaluated, and study continued. The staff collected and interpreted geophysical data at USGS fractured rock research site at Mirror Lake, New Hampshire.

PLANS NEXT YEAR: Field experiments and development of techniques for transfer and downloading of analog and digital data to personal computers to enhance interpretation is a continuing program. The geophysical unit staff will be developing and writing interface programs and will continue developing the interpretation programs. The program in the state-of-the-art use of geophysics for bridge scour program for FHWA and use of surface geophysical techniques for detecting fractures in bedrock for both USEPA and USGS Toxic Substances Hydrology Program will continue. Borehole radar studies at Mirror Lake, New Hampshire, fractured bedrock research site will be conducted.

COMPLETED REPORTS:

Gorin, S.R., and Haeni, F.P., 1989, Use of surface-geophysical methods to assess riverbed scour at bridge piers: U.S. Geological Survey Water- Resources Investigations Report 88-4212, 33 p.

Haeni, F.P., 1986, Application of continuous seismic-reflection methods to hydrologic studies: Ground Water, v. 24, no. 1, p. 23-31.

Haeni, F.P., 1986, Application of seismic-refraction methods in ground-water modeling studies in New England: Geophysics, v. 51, no. 2, p. 236-249.

Haeni, F.P., 1986, The use of electromagnetic methods to delineate vertical and lateral lithologic changes in glacial aquifers, *in* National Water Well Association Conference on Surface and Borehole Geophysical Methods and Ground Water Instrumentation, Denver, Colorado, October 15-17, 1986, Proceedings: Worthington, Ohio, National Water Well Association, p. 259- 282.

Haeni, F.P., 1988, Application of seismic-refraction techniques to hydrologic studies: U.S. Geological Survey Techniques of Water-Resources Investigations, book 2, chap. D2, 86 p.

Haeni, F.P., and Gorin, S.R., 1989, Post-flood measurement of a refilled scour hole at the Bulkeley Bridge in Hartford, Connecticut, *in* Bridge Scour Symposium, McLean, Virginia, October 17-19, 1989, Proceedings: McLean, Virginia, Federal Highway Administration, not paginated.

Haeni, F.P., and Melvin, R.L., 1984, High resolution continuous seismic-reflection studies of a stratified-drift deposit in Farmington, Connecticut, *in* Nielson, D.M., and Curl, Mary, eds., National Water Well Association/Environmental Protection Agency Conference on Surface and Borehole Geophysical Methods in Ground-Water Investigations, San Antonio, Texas, Proceedings: Worthington, Ohio, National Water Well Association, p. 237-256.

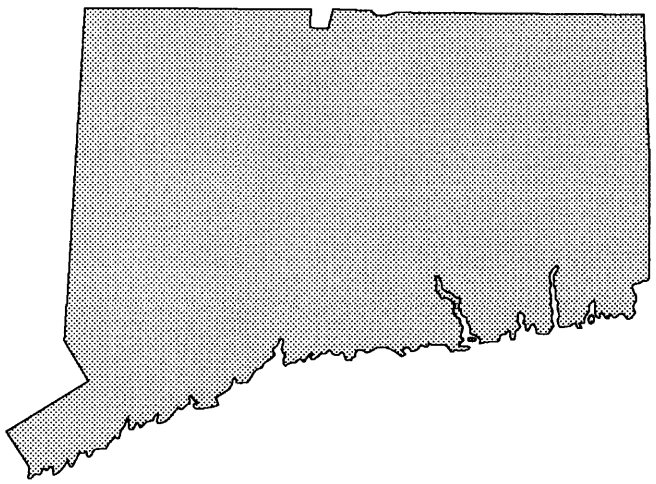
Knoll, M.D., Haeni, F.P., and Knight, R.J., 1991, Characterization of a sand and gravel aquifer using ground-penetrating radar, Cape Cod, Massachusetts, *in* Mallard, G.E., and Aronson, D.A., eds., U.S. Geological Survey Toxic Substances Hydrology Program—Proceedings of the technical meeting, Monterey, California, March 11-15, 1991: U.S. Geological Survey Water-Resources Investigations Report 91-4034, p. 29- 35.

Tucci, Patrick, Haeni, F.P., and Bailey, Z.C., 1991, Delineation of subsurface stratigraphy and structures by a single channel, continuous seismic-reflection survey along the Clinch River, near Oak Ridge, Tennessee: U.S. Geological Survey Water-Resources Investigations Report 91-4023, 27 p.

Atmospheric Deposition Chemistry and Distribution in Connecticut

PROJECT CHIEF:
Position Vacant

PERIOD OF PROJECT:
July 1981 to September 1994



COOPERATOR(S): Connecticut Department of Environmental Protection

PROBLEM: Recent studies indicate that atmospheric deposition can have significant adverse effects on the environment. Insufficient information on the chemistry and distribution of atmospheric deposition preclude assessing its impact on Connecticut. A comprehensive data-collection and analysis program in the State is required to provide needed information. These data are also essential for adequately assessing the regional and national aspects of atmospheric deposition.

OBJECTIVE: (1) Determine the chemical properties of atmospheric deposition in Connecticut. (2) Determine the spatial distribution of atmospheric deposition chemistry in the State. (3) Determine relations between atmospheric deposition chemistry and air mass movements. (4) Provide baseline data that can be used to determine trends and estimate loads.

APPROACH: (1) Three representative sampling sites will be selected. (2) Each site will be equipped with automatic wet/dry collector and recording rain gage. (3) Samples of pH, major ions and cations, macronutrients, and selected heavy metals will be collected and analyzed. (4) Loads will be estimated. (5) Data on air mass movements relative to samples will be obtained. (6) Spatial distribution and relationships of chemistry to air mass movements will be determined. (7) Trends will be determined and loads will be estimated. (8) Four sites bordering Long Island Sound will be established in order to provide baseline data to interpret atmospheric deposition to Long Island Sound for the U.S. Environmental Protection Agency/National Oceanic and Atmospheric Administration (EPA/NOAA) study.

PROGRESS: Precipitation sampling at the three baseline ambient stations was discontinued. Data were compiled. The Project Chief transferred. The report is in the initial stages of development.

PLANS NEXT YEAR: A new author will be assigned to the project. Precipitation data will be analyzed for the period of record, 1983-91. The report outline will be submitted for review; preparation of the report will begin.

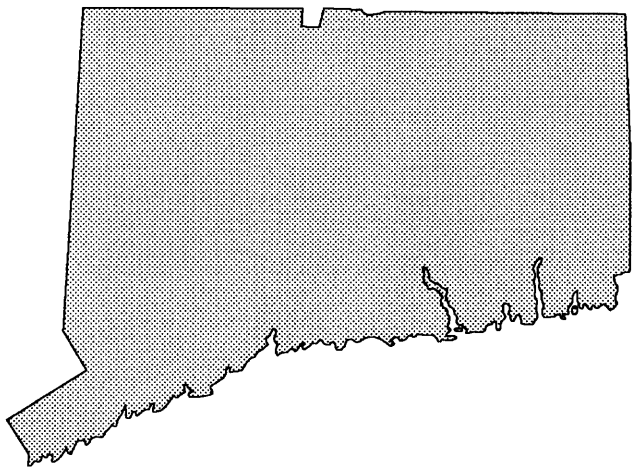
COMPLETED REPORTS:

Kulp, K.P., and Hunter, B.W., 1987, Precipitation chemistry in Connecticut, 1981-83: Connecticut Water Resources Bulletin 40, 28 p.

Major Connecticut Aquifers

PROJECT CHIEF:
Robert L. Melvin

PERIOD OF PROJECT:
March 1982 to September 1992



COOPERATOR(S): Connecticut Department of Environmental Protection

PROBLEM: Stratified-drift aquifers in several parts of Connecticut have potential for future water-resources development. Demand for additional water is high in these areas and hydrogeologic information is needed to plan and manage development of these aquifers.

OBJECTIVE: Quantitative hydrogeologic information on Connecticut stratified-drift aquifer systems needs to be provided for planning and future management. This information includes: (1) Determining the geometry and heterogeneity of stratified-drift deposits. (2) Determining the quantity of water available from the aquifer systems under various conditions. (3) Potential impacts of ground-water development on selected elements of the hydrologic system. (4) Current quality of ground water and hydraulically connected surface-water bodies.

APPROACH: (1) Hydrogeologic and water-quality data will be reviewed to determine data deficiencies. (2) A model will be initially constructed, using either an analytical model based on the Theis equation and method of images programmed for computer solution, or a two-dimensional numerical model. (3) Hydrologic data needed to model flow system and evaluate present water quality will be collected and analyzed. (4) A final model will be constructed and water that can be withdrawn under long-term average and drought conditions will be simulated and estimated.

PROGRESS: Map unit descriptions for 1:24,000 surficial materials maps that are in digital format in Connecticut's Geographic Information System (GIS) data base have been completed. Geologic interpretation and average thickness of stratified-drift data for digital map and report on volume of coarse aggregate was given to the Connecticut Department of Environmental Protection in assistance to their overall mapping program. Unit descriptions for the Quaternary geologic map of Connecticut were completed. The stratified-drift aquifers report in the Titicus River valley was approved and published as Water-Resources Investigations Report 87-4144.

PLANS NEXT YEAR: The Quaternary geologic map work should be completed and submitted for colleague review.

COMPLETED REPORTS:

Bingham, J.W., 1991, Water availability and quality from the stratified drift in Anguilla Brook basin, Stonington and North Stonington, Connecticut: U.S. Geological Survey Water-Resources Investigations Report 85-4276, 49 p.

Grady, S.J., Weaver, M.F., and Bingham, J.W., 1992, Ground-water availability and water quality in the Titicus River valley, Ridgefield, Connecticut: U.S. Geological Survey Water-Resources Investigations Report 87-4144, 50 p.

Mazzaferro, D.L., compiler, 1986b, Ground-water yields for selected stratified-drift areas in Connecticut: Connecticut Geological and Natural History Survey, Natural Resources Atlas Series Map, scale 1:125,000.

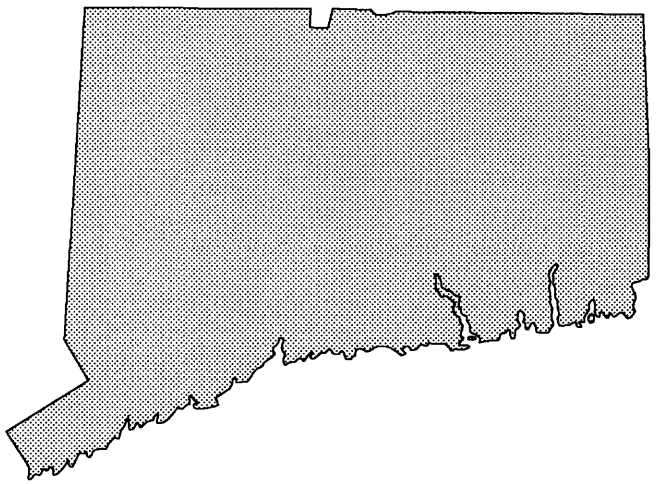
Melvin, R.L., and Bingham, J.W., 1991, Availability of water from stratified-drift aquifers in the Farmington River valley, Simsbury, Connecticut: U.S. Geological Survey Water-Resources Investigations Report 89-4140, 77 p.

Melvin, R.L., Thomas, H.F., and Moore, R.E., 1988, Cooperative efforts in ground-water protection—A Connecticut history: U.S. Geological Survey Yearbook, Fiscal Year 1987, p. 8-18.

Water-Quality Assessment of Connecticut Lakes

PROJECT CHIEF:
Denis F. Healy

PERIOD OF PROJECT:
March 1989 to September 1992



COOPERATOR(S): Connecticut Department of Environmental Protection

PROBLEM: Lake eutrophication, acidification, and contaminated bottom sediments are major problems in the northeastern United States. Water-quality information on Connecticut lakes is insufficient for accessing their trophic condition, degree of acidification, and contamination of bottom sediments by toxic substances. Identification of problem lakes will allow development of programs to restore and maintain water quality at a level that will provide maximum use and benefits.

OBJECTIVE: (1) Determine the trophic state of 49 public-access lakes in Connecticut. (2) Determine if, and to what extent, the lakes thermally stratify during the summer. (3) Determine the degree of acidification of the lakes. (4) Determine changes in water quality that have occurred over the last 15 years at 13 lakes that were previously studied. (5) Determine the concentration of selected toxic substances in the bottom sediments of 12 lakes that have received waste discharges. (6) Provide baseline water-quality data for future assessments.

APPROACH: (1) Forty-nine lakes will be selected for investigation, including 13 previously studied in the 1970's and 12 known or suspected to have received toxic contaminants. (2) Each lake will be sampled during spring overturn and summer stratification for nutrients, alkalinity, and transparency. Temperature, pH, specific conductance, and dissolved-oxygen concentrations will be determined at various depths in the lake. (3) In summer, Surface chlorophyll-*a* concentration and the areal coverage, density, and dominant types of macrophytes will be determined. (4) Representative samples of bottom sediments from selected lakes will be collected and analyzed for concentrations of heavy metals and polyaromatic hydrocarbons. (5) Trophic level and degree of acidification of lakes will be determined.

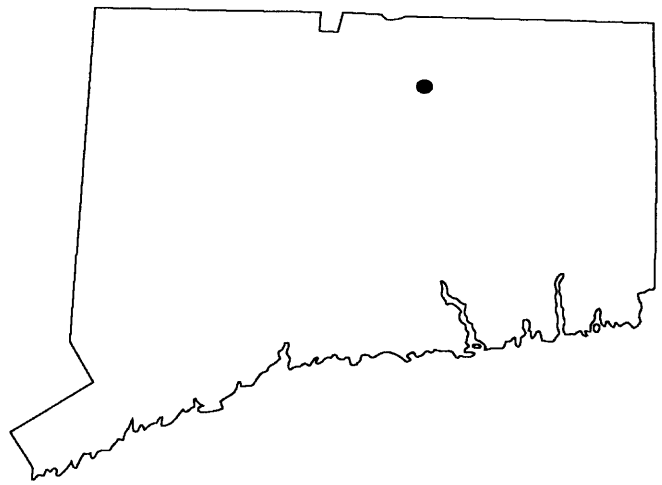
PROGRESS: New project chief reviewed data and completed data entry into data base. Project is complete except report; the draft of final report is complete and is in review.

PLANS NEXT YEAR: Final report will be submitted for Director's approval June 1994.

Ground-Water Flow in Riparian Areas

PROJECT CHIEF:
John R. Mullaney

PERIOD OF PROJECT:
January 1991-January 1994



COOPERATOR(S): Connecticut Department of Environmental Protection

PROBLEM: An experiment to evaluate the effects on water quality of changing riparian land from agricultural (corn production) to native forest (trees and shrubs) requires a detailed hydrogeologic characterization of the study site. The detailed information is needed to estimate the quantity of ground water flowing through the riparian areas and to design a network of multilevel sampling wells that will provide data on the concentrations and mass flux of nutrients and other selected constituents, entering, leaving, and within the saturated zone beneath the riparian areas.

OBJECTIVE: (1) Characterize the local hydrogeology and determine the boundaries of the ground-water flow system in relation to different land-use areas within and adjacent to the study site. (2) Estimate the ground-water flux through the riparian areas where forest will be established and where agricultural use will continue. (3) design a network of multilevel sampling wells sufficient for determining the vertical distribution of constituent concentrations and for calculating the approximate mass constituents in the saturated zone beneath and at upgradient and downgradient limits of the two types of riparian areas.

APPROACH: Hydraulic gradients and subsurface geology will be characterized in a reconnaissance phase consisting of limited piezometer installation, coring, and seismic-refraction surveys. Head data from a dense piezometer network and hydraulic conductivity estimates from slug tests will be used to construct flow nets. The flow nets will be used to establish boundaries of the ground-water flow system in the areas of interest. Ground-water flow through the riparian zone will be estimated using the flow nets or a flow model. The network of multilevel sampling wells will be designed using the information on subsurface geology and head distribution in the saturated zone.

PROGRESS: Additional drilling was conducted to collect cores of stratified drift and till for subsequent grain-size analysis. Slug tests were conducted at 18 wells. Hydraulic conductivity values were estimated from this data, and flownets were constructed to determine the seasonal ground-water runoff to Muddy Brook. A report outline was prepared and approved. A draft of the final report "Hydrogeology and ground-water flow at the Muddy Brook Riparian Zone, North-Central Connecticut" was written and an editorial review was completed.

PLANS NEXT YEAR: Estimates of hydraulic conductivity and ground-water flow need to be reviewed and updated before the report is submitted for further review.

USEPA Technical Assistance

PROJECT CHIEF:
Robert L. Melvin

PERIOD OF PROJECT:
June 1992 to September 1994

COOPERATOR(S): U.S. Environmental Protection Agency

PROBLEM: The U.S. Environmental Protection Agency (USEPA), Region I, Waste Management Division needs hydrogeological technical assistance for ongoing project work at Connecticut and other New England Superfund sites. The USEPA Waste Management Division is faced with the task of understanding complex hydrologic environments at hazardous waste sites in order to propose remedial action at those sites.

OBJECTIVE: Provide geohydrologic investigations for USEPA at Superfund sites and technical assistance.

APPROACH: The approach of this project to achieve the desired results will be as follows: (1) A geohydrologic reconnaissance will be performed near designated sites to assist USEPA in scoping of remedial investigation/feasibility studies (RI/FS) activities and thereby streamline the RI/FS process. (2) Site managers will be advised on proper scope of technical work at Superfund sites. (3) RI/FS, workplan, technical summaries, and final drafts will be reviewed for technical content and accuracy. (4) USGS will participate in technical meetings and negotiations with USEPA contractors and responsible parties. (5) Remedial action alternatives will be reviewed. (6) Numerical ground-water models of sites will be reviewed. (7) Surface and borehole geophysical work will be reviewed. (8) USGS will direct USEPA contractors that are performing hydrogeologic work. (9) Hydrogeological field problems will be solved. (10) USGS will serve as expert technical consultant in the development of enforcement actions for cost recovery of third party cleanup.

PROGRESS: The study of the Gallups' Quarry site was completed. The report was approved by Director on July 26, 1993. A new study was begun at Durham Meadows Superfund site. Review of literature and unpublished data in Federal and local agency files was completed. Geophysical surveys were conducted consisting of dc resistivity, electromagnetic, and ground-penetrating radar on properties adjacent to this site. A borehole geophysical survey of 13 on-site and off-site wells was completed as part of this project. The geological reconnaissance mapping and gaging of four streams in the area were completed and information is being compiled.

PLANS NEXT YEAR: The final report on the Durham Meadows site will be prepared and submitted for Directors' approval. A third Connecticut Superfund site will begin in fiscal year 1994.

Geophysical Technical Assistance at USEPA Hazardous Waste Sites

PROJECT CHIEF:
F. Peter Haeni

PERIOD OF PROJECT:
January 1992 to September 1997

COOPERATOR(S): U.S. Environmental Protection Agency

PROBLEM: The U.S. Environmental Protection Agency, (USEPA), Region V, needs technical assistance in the use of geophysical methods at hazardous waste sites. The region lacks the qualified personnel required to plan and conduct all types of geophysical studies.

OBJECTIVE: The objective of this project is to provide technical assistance to the USEPA in the field of geophysics. The assistance will include reviewing reports and proposals from USEPA contractors, purchasing and setting up geophysical equipment, providing and (or) contracting out geophysical services, and conducting special studies. This technical assistance will enable USEPA to better utilize geophysics in their contamination studies.

APPROACH: The approach will be to purchase equipment, train personnel, conduct special studies and interpret results, review reports, and review proposals at the request of Region V, USEPA. This assistance will be provided on an as needed basis depending on the requirements of USEPA.

PROGRESS: The geophysical staff provided various technical assistance to Region V USEPA personnel on selected projects. Some geophysical equipment was purchased under this agreement.

PLANS NEXT YEAR: Technical assistance will continue to be provided to Region V USEPA personnel and a radar system will be purchased and staff will be trained in its application.

Geophysical Assistance to USEPA Region V

PROJECT CHIEF:
F. Peter Haeni

PERIOD OF PROJECT:
April 1993 to September 1997

COOPERATOR(S): U.S. Environmental Protection Agency

PROBLEM: The United States Environmental Protection Agency, (USEPA), Region V, needs technical assistance in the use of geophysical methods at hazardous waste sites. The region lacks the qualified personnel required to plan and conduct all types of geophysical studies.

OBJECTIVE: The objective is to provide technical assistance to USEPA in the field of geophysics. The assistance will include purchasing and setting up geophysical equipment, providing and (or) contracting out geophysical services, and conducting special studies. This technical assistance will enable USEPA to better utilize geophysics in their contamination studies.

APPROACH: The approach will be to purchase equipment, train personnel, conduct special studies and interpret results at the request of Region V, USEPA. This assistance will be provided on an as needed basis depending on the requirements of USEPA.

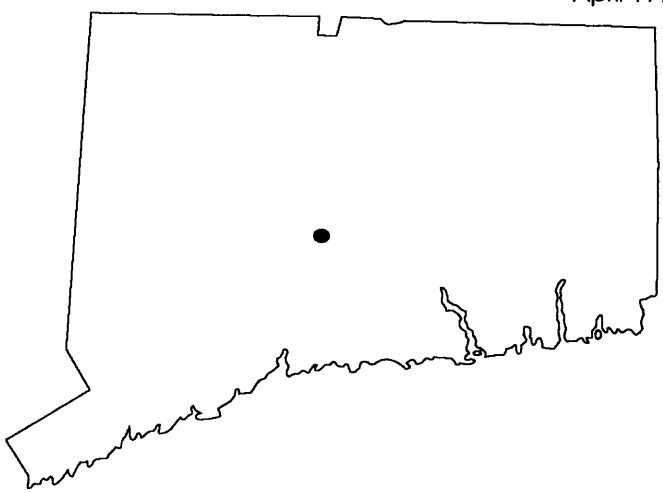
PROGRESS: Borehole radar studies were conducted and the data interpreted at two superfund sites. Numerous bedrock fractures were delineated with the equipment. A borehole radar unit was purchased. Field tests of two ground penetrating radar (GPR) systems were conducted.

PLANS NEXT YEAR: Auxiliary and support equipment for the GPR and borehole radar system purchases will be completed. A GPR system will be set up similar to the U.S. Geological Survey (USGS) system. Further field tests will be conducted of GPR systems. The collected borehole radar data interpretation will be finished. Training on the use of the borehole radar systems and the interpretation of data will continue.

Hydraulic Analysis of Harbor Brook

PROJECT CHIEF:
Michael A. Cervione, Jr.

PERIOD OF PROJECT:
April 1993 to September 1993



COOPERATOR(S): City of Meriden

PROBLEM: Flooding, even at low frequencies, affects numerous buildings in Meriden. Flood-control reservoirs and conversion of existing ponds are not feasible solutions. Channel improvements and bridge replacements may be effective solutions.

OBJECTIVE: To provide city officials with information on the effects of flooding in the urban area.

APPROACH: Information will be provided by: (1) determining the effect of modifying stream channels (and valley cross sections) on flood elevations, and (2) determining the effect of replacing existing bridges and culverts with larger size structures. Computer modeling using modified stream channel, valley cross sections, and bridge and culvert data will be used based on prescribed methods. New flood elevations will be the result of the U.S. Geological Survey's (USGS) Step-Backwater Model.

PROGRESS: All computer modeling efforts were completed. The text, figures, and tables were completed and reviewed in-house. Authors were revising the report based on reviewer comments.

PLANS NEXT YEAR: The final report will receive a technical colleague review and be submitted for Directors' approval by June 1994.

Beres, Milan, Jr., and Haeni, F.P., 1991, Application of ground-penetrating-radar methods in hydrogeologic studies: Ground Water, v. 29, no. 3, p. 375-386.

Bigham, D.K., and Bohr, J.R., 1989, Offstream freshwater use in Connecticut, 1985: U.S. Geological Survey Open-File Report 88-457, 1 sheet.

Bingham, J.W., 1984, Hydrogeologic reconnaissance of the stratified-drift aquifers near Simsbury, Connecticut: U.S. Geological Survey Water-Resources Investigations Report 83-4145, 16 p.

____1991, Water availability and quality from the stratified drift in Anguilla Brook basin, Stonington and North Stonington, Connecticut: U.S. Geological Survey Water-Resources Investigations Report 85-4276, 49 p.

Bingham, J.W., McKeegan, D.K., and Potterton, R.S., Jr., 1987, Hydrogeologic data for southwest Connecticut: Connecticut Water Resources Bulletin 33A, 54 p.

Bingham, J.W., and Todd, A.R., 1979, Proximity of agricultural areas to major aquifers in Connecticut: U.S. Geological Survey Miscellaneous Field Studies Map MF-981-F, scale 1:125,000.

Brackley, R.A., and Thomas, M.P., 1979, Map showing estimated 7-day, 10-year low flow of streams in the Connecticut Valley urban area, central New England: U.S. Geological Survey Miscellaneous Investigations Series Map I-1074-H, scale 1:125,000, 2 sheets.

Cervione, M.A., Jr., 1982, Streamflow information for Connecticut with applications to land-use planning: Connecticut Water Resources Bulletin 35, 35 p.

Cervione, M.A., Jr., Davies, B.S. 3rd, Bohr, J.R., and Bingham, J.W., 1989, Water resources data—Connecticut, water year 1988: U.S. Geological Survey Water-Data Report CT-88-1, 346 p.

Cervione, M.A., Jr., Davies, B.S. 3rd, Bohr, J.R., and Hunter, B.W., 1990, Water resources data—Connecticut, water year 1989: U.S. Geological Survey Water-Data Report CT-89-1, 336 p.

____1991, Water resources data—Connecticut, water year 1990: U.S. Geological Survey Water-Data Report CT-90-1, 274 p.

____1992, Water resources data—Connecticut, water year 1991: U.S. Geological Survey Water-Data Report CT-91-1, 255 p.

Cervione, M.A., Jr., Davies, B.S. 3rd, Bohr, J.R., and Hunter, B.W., 1993, Water resources data—Connecticut, water year 1992: U.S. Geological Survey Water-Data Report CT-92-1, 261 p.

Cervione, M.A., Jr., Melvin, R.L., and Cyr, K.A., 1982, A method for estimating the 7-day, 10-year low flow of streams in Connecticut: Connecticut Water Resources Bulletin 34, 17 p.

Cervione, M.A., Jr., Shepard, T.B., Gasperini, I.S., and Bingham, J.W., 1986, Water resources data—Connecticut, water year 1984: U.S. Geological Survey Water-Data Report CT-84-1, 347 p.

Cervione, M.A., Jr., Weiss, L.A., Bohr, J.R., and Bingham, J.W., 1987, Water resources data—Connecticut, water year 1985: U.S. Geological Survey Water-Data Report CT-85-1, 279 p.

____1988, Water resources data—Connecticut, water year 1986: U.S. Geological Survey Water-Data Report CT-86-1, 263 p.

____1989, Water resources data—Connecticut, water year 1987: U.S. Geological Survey Water-Data Report CT-87-1, 295 p.

Dupuy, C.J., Healy, D.F., Thomas, M.A., Brown, D.R., Sinisculchi, A.J., and Dembek, Z.F., 1991, A survey of naturally occurring radionuclides in groundwater in selected bedrock aquifers in Connecticut and implications for public health policy, *in* Gilbert, C.E., and Calabrese, E.J., eds., Regulating drinking water quality: Boca Raton, Florida, Lewis Publishers, p. 95-119.

Frimpter, M.H., 1980, Ground-water availability in the north part of the Connecticut Valley urban area, central New England: U.S. Geological Survey Miscellaneous Investigations Series Map I-1074-I, scale 1:125,000.

Frink, C.R., Sawhney, B.L., Kulp, K.P., and Fredette, C.G., 1982, PCBs in Housatonic River sediments in Massachusetts and Connecticut—Determination, distribution, and transport: Connecticut Agricultural Experiment Station Bulletin 800, 43 p.

Goldsmith, Richard, 1985, Bedrock geologic map of the Old Mystic and part of the Mystic quadrangles, Connecticut, New York, and Rhode Island: U.S. Geological Survey Miscellaneous Investigations Series Map I-1524, scale 1:24,000, 8 p.

Gorin, S.R., and Haeni, F.P., 1989, Use of surface-geophysical methods to assess riverbed scour at bridge piers: U.S. Geological Survey Water-Resources Investigations Report 88-4212, 33 p.

Grady, S.J., 1989a, Use of electromagnetic methods in ground-water contamination studies—an application at the sanitary landfill, Farmington, Connecticut: Connecticut Water Resources Bulletin 41, 58 p.

____1989b, Statistical comparison of ground-water quality in four land-use areas of stratified-drift aquifers in Connecticut, *in* Mallard, G.E., and Ragone, S.E., eds., U.S. Geological Survey Toxic Substances Hydrology Program—Proceedings of the technical meeting, Phoenix, Arizona, September 26-30, 1988: U.S. Geological Survey Water-Resources Investigations Report 88-4220, p. 473-481.

____1993, Analysis of nonpoint source ground-water contamination in relation to land use—Chapter B, Effects of land use on water quality in stratified-drift aquifers in Connecticut: U.S. Geological Survey Open-File Report 91-200, 87 p.

Grady, S.J., and Garabedian, S.P., 1991, National Water-Quality Assessment Program; the Connecticut River and Long Island Sound coastal rivers: U.S. Geological Survey Open-File Report 91-0159, 2 p.

Grady, S.J., and Haeni, F.P., 1984, Application of electromagnetic techniques on determining distribution and extent of ground-water contamination at a sanitary landfill, Farmington, Connecticut, *in* Nielson, D.M., and Curl, Mary, eds., National Water Well Association/U.S. Environmental Protection Agency, Surface and borehole geophysical methods in ground-water investigations, San Antonio, Texas, Proceedings, p. 338-367.

Grady, S.J., and Handman, E.H., 1983, Hydrogeologic evaluation of selected stratified-drift deposits in Connecticut: U.S. Geological Survey Water-Resources Investigations Report 83-4010, 51 p.

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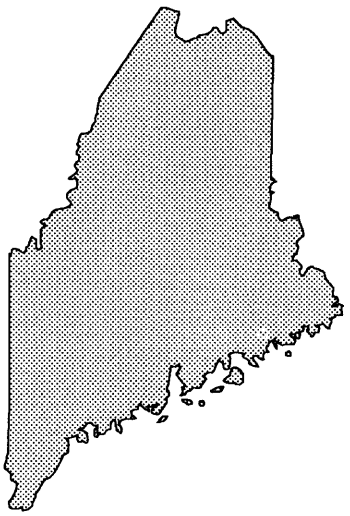
Maine District



COOPERATORS

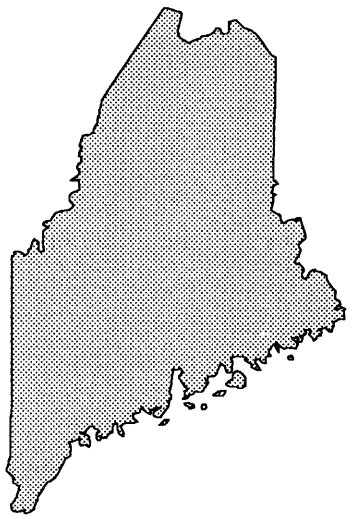
Aroostook County Water and Soil Management Board
Department of Conservation, Maine Geological Survey
Department of Environmental Protection
Department of Human Services
Department of Transportation
Federal Emergency Management Agency
Federal Energy Regulatory Commission
Greater Portland Council of Governments
Northern Kennebec Valley Regional Planning Commission
Northern Maine Regional Planning Commission
Penobscot Indian Nation
Town of Jay
University of Maine
U.S. Department of State, International Joint Commission
U.S. Environmental Protection Agency
U.S. Department of the Army, Corps of Engineers,
Cold Regions Research and Engineering Laboratory
Veteran's Administration

- PAGE 33 FOLLOWS

Surface-Water Stations

PROJECT CHIEF:
Joseph P. Nielsen

PERIOD OF PROJECT:
Continuous since July 1909



COOPERATOR(S): Maine Department of Conservation; Maine Department of Transportation; International Joint Commission; Federal Energy Regulatory Commission; Veteran's Administration; University of Maine; Northern Kennebec Valley Regional Planning Commission

PROBLEM: Surface-water information is needed for purposes of surveillance, planning, design, hazard warning, operation, and management, in water-related fields such as water supply, hydroelectric power, flood control, irrigation, bridge and culvert design, wildlife management, pollution abatement, flood-plain management, and water resources development. To provide this information, an appropriate data base is necessary.

OBJECTIVE: A. To collect surface-water data sufficient to satisfy needs for current-purpose uses, such as (1) assessment of water resources, (2) operation of reservoirs, (3) flow forecasting, (4) disposal of wastes and pollution controls, (5) publication of discharge data to accompany water-quality measurements, (6) conformity to compact and legal requirements, and (7) research or special studies. B. To collect data necessary for analytical studies to define the statistical properties of, and trends in, the occurrence of water in streams, lakes, and estuaries, for use in planning and design.

APPROACH: Stage and discharge of streams and stage and contents of lakes and reservoirs will be measured and recorded. Standard methods of data collection will be used as described in the series, "Techniques of Water-Resources Investigations of the United States Geological Survey." Partial-record gaging will be used instead of complete-record gaging, where it serves the required purpose.

PROGRESS: Data collection and analysis continues. The 1992 Annual Water Resources Data report was compiled and published.

PLANS NEXT YEAR: Statewide data collection and analysis will continue. The 1993 Annual Water Resources Data report will be compiled and published. Real-time data-collection will be added at two additional sites. This will complete the installation of real-time equipment at all 43 continuous-record streamflow stations.

COMPLETED REPORTS: This project contributes to the annual report "Water Resources Data—Maine." Data on stream discharge and stage and on lake or reservoir contents, through September 1960, were published annually under the title "Surface-Water Supply of the United States, Part 1A." For the 1961 through 1970 water years, the data were published in two 5-year reports.

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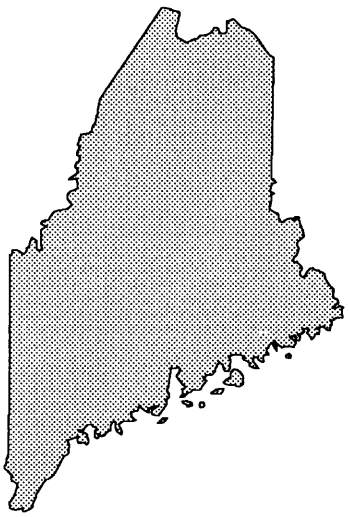
Ground-Water Stations

PROJECT CHIEF:
Robert G. Lippert

PERIOD OF PROJECT:
Continuous since October 1942



COOPERATOR(S): Maine Department of Conservation

PROBLEM: Long-term water-level records are needed to evaluate the effects of climatic variations on the recharge to and discharge from the ground-water systems, to provide a data base from which to measure the effects of development, to assist in the prediction of future supplies, and to provide data for management of ground-water resources.

OBJECTIVE: A. To provide a long-term data base so that the general response of the hydrologic system to natural climatic variations and induced stresses is known and potential problems can be defined to allow proper planning and management. B. To provide a data base against which short-term records acquired in areal studies can be analyzed to provide: (1) an assessment of the ground-water resources; (2) capability to predict future conditions; and (3) the data base necessary for management of the resource.

APPROACH: Ground-water-level data will be recorded, analyzed, and published annually. Standard methods of data collection will be used as described in the "National Handbook of Recommended Methods for Water-Data Acquisition."

PROGRESS: Data collected at network stations during the 1992 water year were published in the Maine Annual Water-Resources Data Report. One ground-water sample was collected for chemical analysis at a new well, PE 594. The statewide climate effects network is now complete with the addition of this new well in Penobscot County.

PLANS NEXT YEAR: Water-level data collected in the 1993 water year will be compiled and published. Statewide network water-level data will be collected and analyzed for the 1994 water year. Some wells may need to be discontinued as a result of proposed funding cuts.

COMPLETED REPORTS: This project contributes to the annual report "Water Resources Data— Maine." Records of ground-water levels for the 1935 through 1955 water years were published under the title "Water Levels and Artesian Pressures in Observation Wells in the United States." and from 1956 through 1974 water years were published under the title "Ground-Water Levels in the United States," on an annual basis. Beginning with the 1975 water year, the report title was changed to "Water Resources Data—Maine (water year)."

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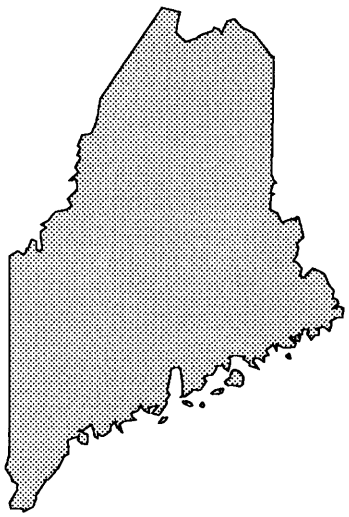
Quality of Water Stations

PROJECT CHIEF:
Wayne B. Higgins

PERIOD OF PROJECT:
Continuous since January 1967



COOPERATOR(S): Greater Portland Council of Governments; Town of Jay; Penobscot Indian Nation; Maine Department of Environmental Protection; International Joint Commission; Federal Energy Regulatory Commission; U.S. Department of the Army, Corps of Engineers, Cold Regions Research and Engineering Laboratory; Northern Kennebec Valley Regional Planning Commission; Northern Maine Regional Planning Commission

PROBLEM: Water-resource planning and water-quality assessment require a statewide and nationwide base level of relatively standardized information. For planning and assessment, the chemical and physical quality of the resource must be defined and monitored.

OBJECTIVE: To provide a state and national bank of water-quality data for broad planning and action programs and to provide data for management of interstate and international waters, and for State management of intrastate waters.

APPROACH: Operation of a network of water-quality stations to provide information about chemical concentrations, loads, and trends as required by planning and management agencies.

PROGRESS: Bi-monthly or quarterly water samples for chemical and physical parameters were collected and analyzed for seven NASQAN and one HBM station. Multi-parameter monitoring for hourly measurements of specific conductance, dissolved oxygen, water temperature, and pH was conducted for periods ranging from 4 to 12 months at 11 stations. The water-quality data collected during the 1992 water year were compiled and published in the Maine Annual Water Resources Data Report. The water-quality monitoring network is instrumented with telephones and electronic data loggers. The water-quality information recorded at these sites is now available on a near real-time basis using this data transmitting equipment.

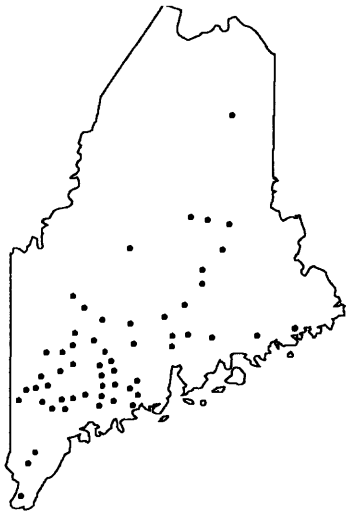
PLANS NEXT YEAR: Data collection and analysis will continue at all active sites. The NASQAN stations in Maine will be cut from seven to five, with the elimination of stations 01049265 Kennebec River at North Sidney, Maine and 01059400 Androscoggin River at Brunswick, Maine. The continuous air and water temperature monitor at the HBM station 01054200 Wild River at Gilead, Maine, will be discontinued. A new three parameter monitor will be installed on the Androscoggin River at Turner Bridge, Maine.

COMPLETED REPORTS: This project contributes to the annual report "Water Resources Data—Maine." Data on chemical quality, temperature, and suspended sediments for the 1941 through 1970 water years were published annually under the title "Quality of Surface Waters of the United States."

Flood Insurance Studies for Federal Emergency Management Agency (FEMA)

PROJECT CHIEF:
Scott A. Olson

PERIOD OF PROJECT:
January 1984 to September 1994



COOPERATOR(S): Federal Emergency Management Agency

PROBLEM: The National Flood Insurance Act provides that the Federal Emergency Management Agency (FEMA) operate a flood insurance program. FEMA needs flood studies in selected communities to determine applicable flood insurance premium rates.

OBJECTIVE: Conduct the necessary hydrologic and hydraulic studies of the areas assigned by FEMA and develop the most efficient procedures to attain the flood elevation accuracy specified by FEMA in the most appropriate format.

APPROACH: Flood studies will be completed by conducting necessary surveys by ground and photogrammetric methods, preparing computer models of drainage networks, computing magnitudes and profiles of floods of specified frequencies, and furnishing results in reports prepared to FEMA specifications.

PROGRESS: Flood insurance reports for Auburn, Poland, and Holden, Maine, and Bridgewater, New Hampshire were completed and submitted to FEMA. Final community meetings were held in Mercer, Hartford, Randolph, Gardiner, Farmingdale, Chelsea, Hallowell, and Augusta, Maine. Fieldwork for the Bethel, Maine Flood Insurance study is complete.

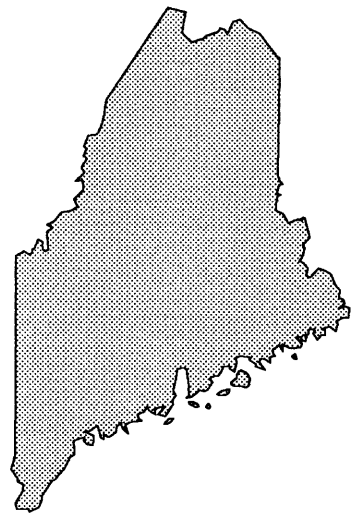
PLANS NEXT YEAR: Seven flood study reports, currently in progress, will be compiled, reviewed, and submitted to FEMA during 1994.

COMPLETED REPORTS: All final reports are published by FEMA.

Water Use

PROJECT CHIEF:
Marilee A. Horn

PERIOD OF PROJECT:
August 1980 to September 1994



COOPERATOR(S): Maine Department of Conservation and Maine Department of Human Services

PROBLEM: Competition for Maine's water necessitates that available supplies be matched with optimum uses. Information is being collected describing quantity and quality of available water, but relatively little information is being collected describing water use. Without adequate information on uses of water, decision makers cannot resolve many critical water problems such as water-quality issues, environmental impact, energy development, and resource allocation.

OBJECTIVE: (1) Provide water-use information for the optimum utilization and management of Maine's water resources for the overall benefit of the people. (2) Develop and operate a system to collect, store, and disseminate water-use data to complement data on availability and quality of the State's water resources. (3) Respond to the data needs of local users, the U.S. Geological Survey (USGS) and other Federal agencies.

APPROACH: Responsibilities will be divided between the cooperator and the USGS to reflect the most efficient means of meeting the objectives of the program. Together, the cooperator and the USGS will (1) identify and document water-use data requirements; (2) compile and evaluate water-use data collected by local, State, and Federal agencies; (3) develop methods to collect data not already available from these agencies; and (4) analyze and enter data into the USGS New England Water-Use Data System (NEWUDS). Data will be presented as published reports at appropriate intervals.

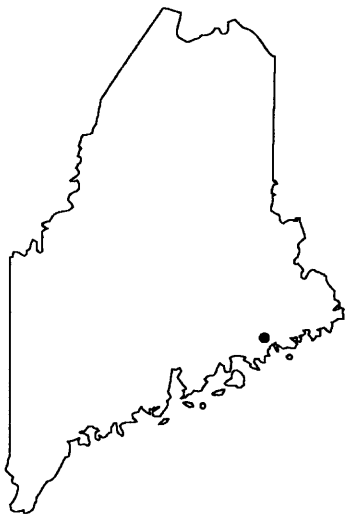
PROGRESS: Work was begun on compiling, analyzing, evaluating, and automating site-specific data on public-supply systems and industrial uses. The Maine water-use map report, based on 1990 data, received approval for publication. Regional reports on "Estimated Use of Water in New England, 1990" and "Wastewater Collection and Return Flow" have been drafted.

PLANS NEXT YEAR: Statewide water-use data-collection activities will continue. A workshop on the collection of industrial water-use data is planned for April 1994. All reports in progress will be published and distributed. The first draft of the "Public Water Supply Report" for New England will be completed.

Hydrology Of Peat Bogs in Maine

PROJECT CHIEF:
William J. Nichols, Jr.

PERIOD OF PROJECT:
April 1980 to September 1994



COOPERATOR(S): Maine Department of Conservation

PROBLEM: Maine's glacial history has led to the formation of depression wetlands. Many wetlands have evolved into marshes and bogs. Bogs containing peat have been identified by the Maine Geological Survey (MGS) as having an economic resource potential as an alternative energy source. To assess adequately the impact of peat removal on these bogs and downstream areas, information on the hydrology and nutrient and trace metal mobilization or entrapment is needed.

OBJECTIVE: Determine the hydrology of two peat bog systems, to be applied to a flow analysis and characterize the accumulation of trace metals and nutrients in the bog systems.

APPROACH: Two bogs will be instrumented to measure precipitation, pan evaporation, ground-water levels, and streamflow. Evapotranspiration and water movement through the bogs will be analyzed. Trace metal and nutrient data will be obtained and analyzed to investigate accumulation and transport of those constituents and define short term and seasonal trends in both surface and ground water.

PROGRESS: The water-quality section of the final report has been rewritten and forwarded to the District Chief for processing for final approval for publication.

PLANS NEXT YEAR: The final report submitted for Director's approval. The project chief will work with the Maine Geological Survey to publish and distribute the final report upon approval.

COMPLETED REPORTS:

Nichols, W.J., Jr., 1983, Hydrologic data for the Great and Denbow Heaths in eastern Maine, October 1981 through October 1982: U.S. Geological Survey Open-File Report 83-865, 29 p.

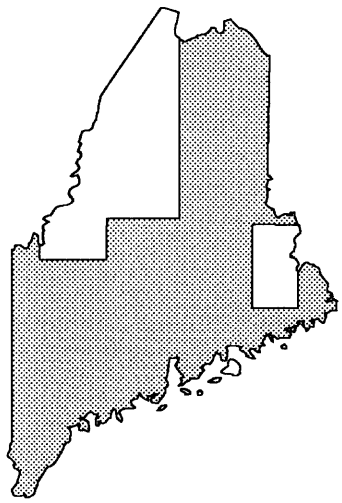
Nichols, W.J., Jr., Smath, J.A., and Adamik, J.T., 1983, Hydrologic data for the Great and Denbow Heaths in eastern Maine, October 1980 through September 1981: U.S. Geological Survey Open-File Report 83-866, 43 p.

Nichols, W.J., Jr., Frost, L.R., Adamik, J.T., Thurman, E.M., Tolman, A.L., and Smath, J.A., (In preparation) Hydrology of the Great and Denbow Heaths in Eastern Maine: U.S. Geological Survey Open-File Report.

Hydrogeology and Water Quality of Significant Sand and Gravel Aquifers in Maine

PROJECT CHIEF:
William J. Nichols, Jr.

PERIOD OF PROJECT:
November 1992 to September 1995



COOPERATOR(S): Maine Department of Conservation; Maine Department of Environmental Protection

PROBLEM: Sand and gravel aquifers are the primary sources of ground water capable of meeting the water-supply requirements of municipalities and industries in Maine. They are also the source of water for many domestic wells. Information from detailed aquifer mapping, seismic work, resistivity work, and test drilling is required in order to effectively evaluate, manage, and protect these ground-water resources.

OBJECTIVE: (1) Identify significant aquifers and accurate mapping of their boundaries; (2) Determine aquifer yield, stratigraphy, depth to water table, and depth to bedrock and (3) Characterize regional ground-water chemistry.

APPROACH: Detailed surficial mapping will define aquifer boundaries more closely in some previously mapped areas. Seismic refraction will be used to determine depths to water table and bedrock. Test drilling will provide data on aquifer thickness, stratigraphy, yield, water-level fluctuations, and water quality.

PROGRESS: Compilation of information for the 1989, 1990, and 1992 study areas was continued. Fieldwork for the 1993 study area was completed.

PLANS NEXT YEAR: The 1989 and 1990 field area reports will be submitted for Director's approval. Compilation of data and text for the 1991, 1992, and 1993 field area reports will be completed and these reports will be sent for technical and editorial reviews. Fieldwork will begin in June 1994 to map significant sand and gravel aquifers in the Moosehead Lake area.

COMPLETED REPORTS:

Tepper, D.H., Williams, J.S., Tolman, A.L., and Prescott, G.C., Jr., 1985, Hydrogeology and water quality of significant sand and gravel aquifers maps 10, 11, 16, 17, and 32, in parts of Androscoggin, Cumberland, Franklin, Kennebec, Lincoln, Oxford, Sagadahoc, and Somerset Counties, Maine: Maine Geological Survey Open-File Report 85-82A.

Tepper, D.H., and Lanctot, E.M., 1985, Hydrogeologic data for significant sand and gravel aquifers map 16, in parts of Androscoggin, Franklin, Kennebec, and Oxford Counties, Maine: Maine Geological Survey Open-File Report 85-82D, scale 1:50,000.

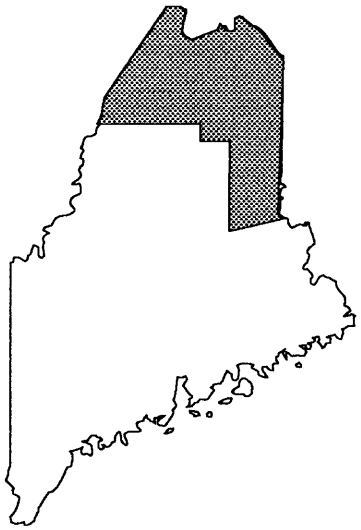
Tepper, D.H., and Lanctot, E.M., 1985, Hydrogeologic data for significant sand and gravel aquifers map 32, in parts of Franklin, Kennebec, Oxford, and Somerset Counties, Maine: Maine Geological Survey Open-File Report 85-82F, scale 1:50,000.

Tepper, D.H., and Lanctot, E.M., 1987, Hydrogeologic data for significant sand and gravel aquifers map 13, in parts of Cumberland, Oxford, and York Counties Maine: Maine Geological Survey Open-File Report 87-1b, scale 1:50,000.

Low-Flow Characteristics of Maine Streams

PROJECT CHIEF:
William P. Bartlett, Jr.

PERIOD OF PROJECT:
October 1986 to September 1994



COOPERATOR(S): Aroostook County Water and Soil Management Board

PROBLEM: The demand for information on the low-flow characteristics of Maine streams is rapidly increasing. Federal, State, and local agencies and consulting engineers require the data for determining adequacy of streamflow for disposal of wastes, development as a water supply, minimum flow requirements for hydroelectric projects, maintenance of aquatic habitat, and other uses. Low-flow characteristics are also useful for estimating the amount of ground-water flow to a stream.

OBJECTIVE: Develop and improve techniques for estimating the low-flow characteristics of unregulated streams in Maine.

APPROACH: The study plan includes the following steps: (1) Literature and data will be compiled and collected. (2) Existing data will be analyzed using methods described by H.C. Riggs, 1972, "Techniques of Water-Resources Investigations of the U.S. Geological Survey, Low-flow investigations", book 4, chap. B7, 18 p., and Surface Water Branch (SWB) memo No. 85.09. (3) Division experts on supplemental network design will be consulted. (4) Supplemental stream-gage stations will be established. (5) Select baseflow measurement sites. (6) Develop drought-period action plan for collection of low-flow data. (7) Prepare low-flow study reports every 3 years.

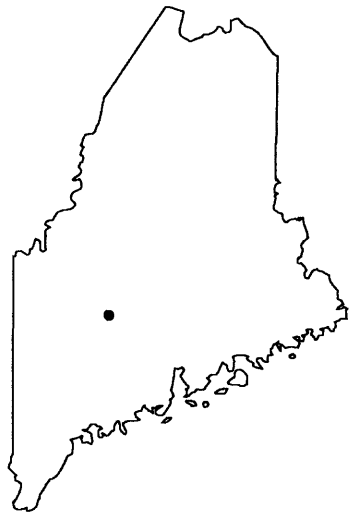
PROGRESS: Low-flow measurement sites were selected in eastern Aroostook County. Statistical summaries of flow characteristics at unregulated stations in northern Maine were updated using data through the 1992 water year.

PLANS NEXT YEAR: Three or four series of low-flow measurements will be made at the sites selected in eastern Aroostook County. Statistical summaries of streamflow characteristics will be updated using data collected through the 1993 water year.

Loadings of Phosphorus and Selected Trace Metals from Rural Highways

PROJECT CHIEF:
Scott A. Olson

PERIOD OF PROJECT:
September 1991 to September 1994



COOPERATOR(S): Maine Department of Transportation and Maine Department of Environmental Protection

PROBLEM: Rural highways are a potential source of phosphorus and trace metals to surface waters. Non-point source control programs have identified rural highways as a potential significant source of these elements. Existing studies have not examined water-quality characteristics of rural highway systems in the northeastern United States. Determination of highway runoff export coefficients for phosphorus and selected trace metals will help define the magnitude of the problem and provide information to help develop mitigation measures.

OBJECTIVE: (1) Determine export coefficients for total phosphorus, dissolved phosphorus, and suspended solids for three sections of rural highway in central Maine. (2) Also analyze loadings of dissolved and total copper, chromium, lead, nickel, and zinc.

APPROACH: Literature on the chemical characteristics of highway runoff will be further reviewed. Technical specialists will be consulted to help refine the data collection system. Three sites will be selected and equipped with an approach box, v-notch weir, stage recording equipment, and a programmable automated sampler for collection of water-quality samples. Discharge-weighted samples will be collected for each runoff event over a 1-year period. Field measurements will include specific conductance and pH. Laboratory analyses will include suspended solids and dissolved and total phosphorus, copper, chromium, lead, nickel, and zinc. The runoff volumes and constituent concentrations will be used to calculate export coefficients for each of the sites during the study period.

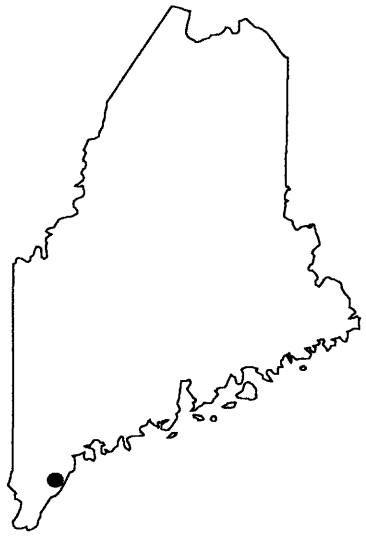
PROGRESS: Discharge-weighted highway runoff samples were collected at the three study sites through September 1993. Analytical data were analyzed and preliminary estimates of runoff loadings for phosphorus and suspended solids were made for individual runoff events. Digestion studies were made with varying strength digestion and different sediment particle-size groups to help estimate the likely availability of phosphorus to the environment.

PLANS NEXT YEAR: Analytical data will be reviewed and summarized. Runoff loadings will be calculated and estimated for phosphorus and suspended solids. Annual runoff coefficients will be estimated for each site. Two final reports will be written; one will contain data collected during the project and the second will be a journal article reporting the findings of the study.

Saco Landfill

PROJECT CHIEF:
Martha G. Nielsen

PERIOD OF PROJECT:
April 1993 to June 1994



COOPERATOR(S): U.S. Environmental Protection Agency

PROBLEM: Hydrogeological technical assistance is needed by the U.S. Environmental Protection Agency, Region I, Waste Management Division (USEPA), for ongoing project work at Maine and other New England SUPERFUND sites. This effort is authorized under terms of an Interagency Agreement (IAG) between USEPA and USGS. The USEPA Waste Management Division is faced with the task of understanding complex hydrologic environments in order to propose remedial action at hazardous waste sites.

OBJECTIVE: Provide the USEPA with an improved understanding of the geology and hydrology of the area surrounding the Saco Landfill and a conceptual model of ground-water and surface-water flow in the vicinity of the landfill.

APPROACH: A geohydrologic study will be performed in the vicinity of the Saco Landfill site, to include the following data-collection elements: (1) ground-water levels, (2) seismic refraction, (3) borehole geophysics, (4) streamflow, (5) water quality, and (6) geohydrologic mapping. These studies will assist USEPA in the scoping of remedial investigation/feasibility studies (RI/FS) activities and thereby streamline the RI/FS process.

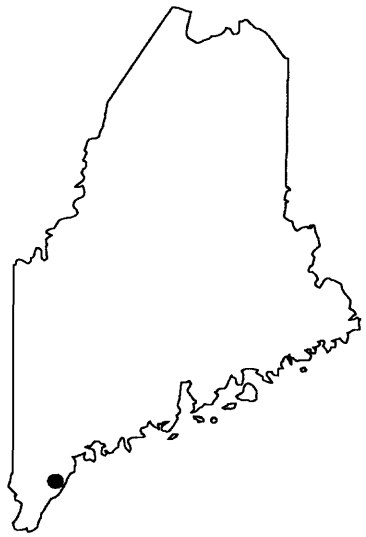
PROGRESS: Two continuous-record surface-water data-collection sites and four miscellaneous surface-water data-collection sites were located at the Saco Landfill; data collection began in July 1993. Electro-magnetic and seismic refraction surveys were completed. A ground-water-level monitoring program began in September 1993. Geologic mapping, test drilling, and geophysical surveys have established glacial overburden thicknesses and configurations at the site.

PLANS NEXT YEAR: Collection and analysis of hydrologic data and information will continue. A review of existing water-quality data will be completed. Ground-water levels and water chemistry data collected will be used to help delineate flow paths and ground-water discharge areas. The final report draft will be completed in April 1994.

Saco Tannery

PROJECT CHIEF:
William J. Nichols, Jr.

PERIOD OF PROJECT:
November 1992 to September 1995



COOPERATOR(S): U.S. Environmental Protection Agency

PROBLEM: The U.S. Environmental Protection Agency (USEPA) periodically needs technical assistance at hazardous waste sites in USEPA Region I which may include review of documents, participation at meetings, field sampling of soil and water, review of remedial actions, ground-water flow modeling, installation of wells, hydrologic monitoring, borehole geophysical logging, and surface geophysics.

OBJECTIVE: (1) Provide technical assistance to USEPA at the Saco Tannery Superfund Site, including continuous monitoring of ground-water-level data for about 1 year. (2) Report monitoring results to USEPA.

APPROACH: Instrumentation will be installed to continuously monitor ground-water levels in eight previously constructed wells. Ground-water-level data will be provided to the USEPA in an administrative report. Additional work will be accomplished as requested and funded by the USEPA.

PLANS NEXT YEAR: Collection of ground-water level data will begin in June 1994. Data will be compiled and provided to the USEPA and published in the Maine Annual Water Resources Data Report.

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____1986, Water resources data—Maine, water year 1986: U.S. Geological Survey Water-Data Report 86-1, 159 p.

____1987, Water resources data—Maine, water year 1987: U.S. Geological Survey Water-Data Report 87-1, 173 p.

____1988, Water resources data—Maine, water year 1988: U.S. Geological Survey Water-Data Report 88-1, 183 p.

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Brewer, Thomas and Prescott, G.C., Jr., 1980, Sand and gravel aquifers map 84, Aroostook County, Maine: Maine Geological Survey Open-File Report 80-32, 6 p., scale 1:50,000.

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Caldwell, D.W. and Prescott, G.C., Jr., 1981, Sand and gravel aquifers map 40, Penobscot and Piscataquis Counties, Maine: Maine Geological Survey Open-File Report 81-72, 6 p., scale 1:50,000.

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Cotton, J.E., Welsh, Michael, and Prescott, G.C., Jr., 1981, Sand and gravel aquifers map 30, Somerset, Kennebec, Waldo, and Penobscot Counties, Maine: Maine Geological Survey Open-File Report 81-62, 6 p., scale 1:50,000.

Cowing, D.J., 1983, National Water Summary, Maine water issues: U.S. Geological Survey Water-Supply Paper 2250, p. 138-140.

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Cowing, D.J., and Scott, M., 1977, Limnological data report for the Maine Department of Environmental Protection—U.S. Geological Survey Cooperative Lake Studies Project: U.S. Geological Survey Open-File Report 77, 145 p.

Fontaine, R.A., 1978, Drainage areas of surface water bodies of the Saco River basin in southwestern Maine: U.S. Geological Survey Open-File Report 78-556B, 24 p.

____1980, Limnological study of 43 selected Maine lakes: U.S. Geological Survey Water-Resources Investigations Report 80-69, 132 p.

____1979a, Drainage areas of surface-water bodies of southern Maine coastal river basins: U.S. Geological Survey Open-File Report 78-556D, 23 p.

____1979b, Drainage areas of surface-water bodies of the Androscoggin River basin in southwestern Maine: U.S. Geological Survey Open-File Report 78-556C, 42 p.

____1980a, Drainage areas of surface-water bodies of the Kennebec River basin in southwestern Maine: U.S. Geological Survey Open-File Report 78-556E, 83 p.

____1981, Drainage areas of surface-water bodies of the Penobscot River basin in central Maine: U.S. Geological Survey Open-File Report 78-556F, 92 p.

____1982a, Cost effective stream-gaging strategies for Maine: U.S. Geological Survey Open-File Report 82-507, 43 p.

____1982b, Drainage areas of surface water bodies of central Maine coastal river basins: U.S. Geological Survey Open-File Report 78-556I, 27 p.

____1982c, Drainage areas of surface water bodies of eastern Maine coastal river basins: U.S. Geological Survey Open-File Report 78-556H, 54 p.

____1983, Uncertainties in the records annual mean discharge for Maine: U.S. Geological Survey Water-Resources Investigations Report 83-4025, 108 p.

____1984, National Water Summary, Record late-spring 1984 floods in New England: U.S. Geological Survey Water-Supply Paper 2275, p. 37-39.

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____1989, Hydrologic and meteorologic data for the Bald Mountain area, Aroostook County, Maine--June 1979 through June 1984: U.S. Geological Survey Open-File Report 85-174, 166 p.

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Fontaine, R.A. and Maloney, T.J., 1987, National Water Summary, Flood of 1987 in Maine: U.S. Geological Survey Water-Supply Paper 2350, p. 41-44.

Fontaine, R.A., Moss, M.E., Smath, J.A., and Thomas, W.O., 1984, Cost-effectiveness of the stream-gaging program in Maine: U.S. Geological Survey Water-Supply Paper 2244.

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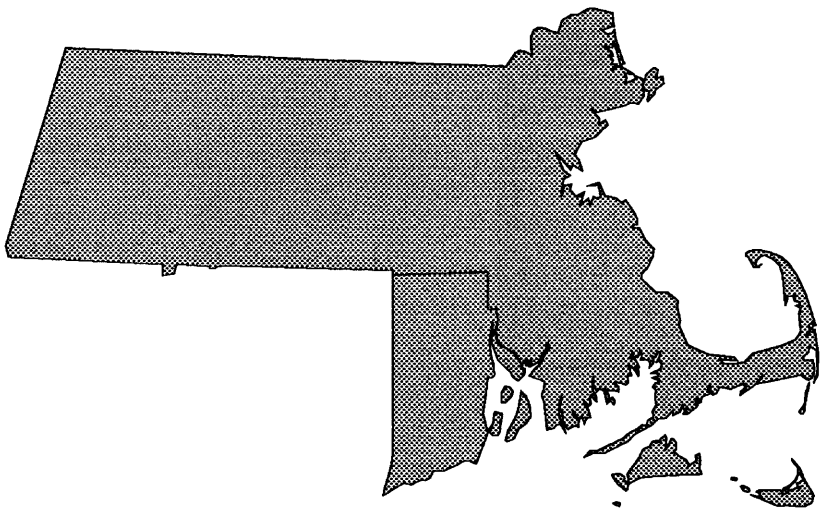
- PAGE 51 FOLLOWS

Massachusetts—Rhode Island District



COOPERATORS

Massachusetts

Barnstable County

Cape Cod Commission

Massachusetts Department of Environmental Management, Division of Resource Conservation, Office of Water Resources

Massachusetts Department of Environmental Protection, Division of Water Pollution Control

Massachusetts Department of Environmental Protection, Division of Water Supply

Massachusetts Department of Environmental Protection, Office of Watershed Management

Massachusetts Department of Fisheries, Wildlife, and Environmental Law Enforcement, Division of Fisheries and Wildlife

Massachusetts Department of Public Works

Massachusetts Highway Department

Metropolitan District Commission, Division of Watershed Management, Parks Engineering and Construction Division

National Guard Bureau

U.S. Department of the Army, Corps of Engineers

U.S. Environmental Protection Agency, Waste Management Division

Rhode Island

City of Providence Water Supply Board

Rhode Island Water Resources Board

Rhode Island Department of Environmental Management

Town of New Shoreham

U.S. Department of the Army, Corps of Engineers

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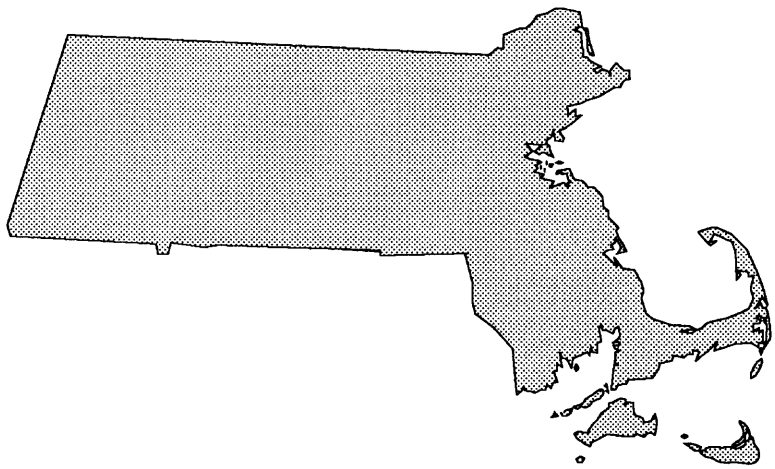
Surface-Water Stations

PROJECT CHIEF:
Russell A. Gadoury

PERIOD OF PROJECT:
Continuous since March 1904



COOPERATOR(S): Massachusetts Department of Environmental Management, Division of Resource Conservation; Massachusetts Department of Environmental Protection, Division of Water Pollution Control; Metropolitan District Commission, Division of Watershed Management, Parks Engineering and Construction Division; Massachusetts Department of Fisheries, Wildlife, and Environmental Law Enforcement, Division of Fisheries and Wildlife

PROBLEM: Surface-water information is needed for purposes of surveillance, planning, design, hazard warning, operation, and management in water-related fields such as water supply, hydroelectric power, flood control, bridge and culvert design, pollution abatement, flood-plain management, and water resources development. To provide this information, an appropriate data base is necessary.

OBJECTIVE: A. To collect surface-water data sufficient to satisfy needs for current purpose uses, including (1) assessment of water resources, (2) operation of reservoirs or industries, (3) flow forecasting, (4) disposal of wastes and pollution control, (5) publication of discharge data to accompany water-quality measurements, (6) conformity to compact and legal requirements, and (7) research or special studies. B. To collect data necessary for analytical studies to define for any location the statistical properties of, and trends in, the occurrence of water in streams, lakes, estuaries, etc., for use in planning and design.

APPROACH: Stage and discharge of streams and stage and contents of lakes and reservoirs will be measured and recorded. Standard methods of data collection will be used as described in the series, "Techniques of Water-Resources Investigations of the United States Geological Survey." Partial-record data will be collected instead of continuous-record data when it serves the required purpose.

PROGRESS: The Annual Water Resources Data Report for water year 1992 was sent to the printer in July 1993. The report was somewhat delayed by an opportunity to obtain discharge measurements during the highest flood stages in Massachusetts since 1987. A total of 72 discharge measurements were made at 37 gaging stations between March 26 and April 10, including measurements made from seven cableways replaced or refurbished in the past 3 years. Satisfactory stage-discharge rating tables were developed using four discharge measurements obtained at each of six sites in the Blackstone River Basin; the ratings were used to provide discharges for synoptic water quality sampling studies being done by the University of Rhode Island. Nine discharge measurements were obtained and a rating developed at Town Brook at Lanesborough, Massachusetts, in cooperation with the Berkshire County Commissioners Office, in support of an Environmental Protection Agency Clean Lakes Grant.

PLANS NEXT YEAR: Plans are being made to repair or rebuild four to six cableways in 1992. New concrete mass anchors must be poured at most of these cable-

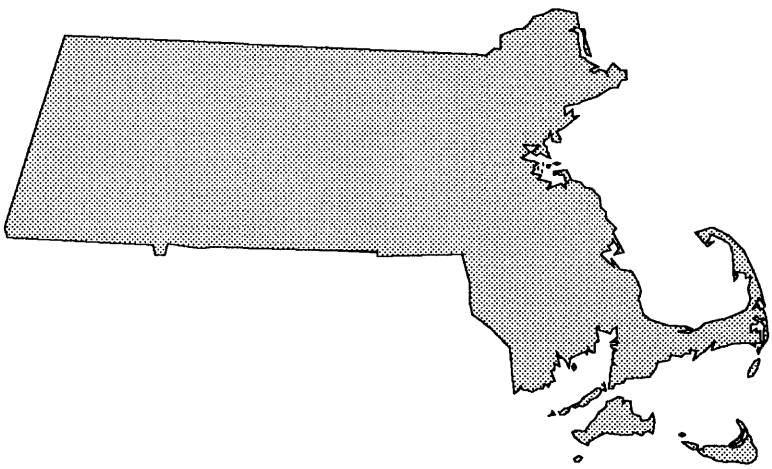
ways. Sufficient reliability has been demonstrated to make DCP's the primary source of record at 16 of the 17 gages with U.S. Geological Survey (USGS) DCP's; digital recorders will be used as backups at those gages. A schedule will be developed to fulfill a USGS mandate to replace mercury manometers in 30 gages in the next 5 years. Intake pipes at several stilling well gages will be replaced; advanced age has resulted in several breaking off at the bank or losing static tubes, creating potential drawdown problems at the high end of ratings.

COMPLETED REPORTS: This project contributes to the annual report "Water Resources Data—Massachusetts and Rhode Island." Data on stream discharge and stage and on lake or reservoir contents, through September 1960, were published annually under the title "Surface-Water Supply of the United States, Parts 1A and 1B." For the 1961 through 1970 water years, the data were published in two 5-year reports.

Ground-Water Stations

PROJECT CHIEF:
Roy Socolow

PERIOD OF PROJECT:
Continuous since June 1936



COOPERATOR(S): Massachusetts Department of Environmental Management, Division of Resource Conservation; Cape Cod Commission

PROBLEM: Ground water in Massachusetts is close to land surface, generally within 5 to 20 feet in materials of glacial and stratified drift. Ground-water distribution is highly variable and is related to geologic influences and to natural and manmade stresses. Monitoring of ground-water levels is essential for adequate development planning and construction designs, ground-water quality management, and water supply.

OBJECTIVE: (1) Maintain a data base of ground-water levels that will enable evaluation of climatic and seasonal variations on ground-water conditions. (2) Provide long-term water-level data that can be used as indexes of long-term trends. (3) Provide information of ground-water storage for ground-water management, and on water-level gradients for ground-water quality management; provide a base of index observations which can be used to correlate and estimate conditions at other sites for design and regulation of septic systems.

APPROACH: Water-level data recorded continuously and water-level data measured monthly or bi-monthly will be entered into a computer data base. Standard methods of data collection will be used as described in the "National Handbook of Recommended Methods for Water-Data Acquisition" and Water Resources Division memos and memorandums.

PROGRESS: The Data Report for water year 1992 was sent to the printer in July 1993. Observation wells were maintained (checked for responsiveness, repaired as needed) on Cape Cod. Lockable pipe capes were installed on four wells during water year 1993. An in-well water-level data logger was installed in well Lakeville 14, and provided substantially improved record. The contract to measure 31 wells in eastern Massachusetts was eliminated. Measurement of the 31 wells was assumed by personnel from the Massachusetts U.S. Geological Survey office. The contract to measure 31 wells in western Massachusetts was continued. Information provided in the monthly publication, "Current Water Resources Conditions in Central New England" was expanded to include additional data pertinent to observation-well site descriptions and historical statistics.

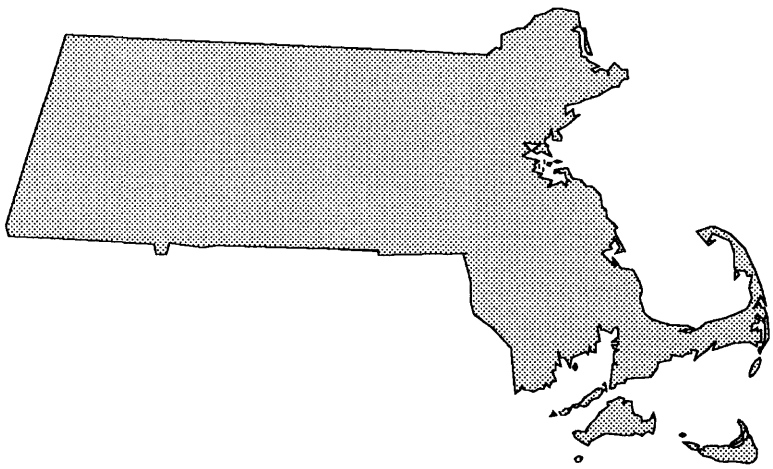
PLANS NEXT YEAR: Perform general maintenance and install lockable pipe caps at 20 additional wells. Replace the digital recorder at one well with a data logger.

COMPLETED REPORTS: This project contributes to the annual report "Water Resources Data—Massachusetts and Rhode Island." Records of ground-water levels for the 1936 through 1974 water years were published under the title "Ground-Water Levels in the United States," on an annual basis. Beginning with the 1975 water year, the report title was changed to "Water Resources Data—Massachusetts and Rhode Island, (water year)."

Quality of Water Stations

PROJECT CHIEF:
Gerald Girouard

PERIOD OF PROJECT:
Continuous since January 1966



FUNDING SOURCE: USGS National Stream Quality Accounting Network

PROBLEM: Water-resource planning and water-quality assessment require a nationwide base level of relatively standardized information. For planning and realistic assessment of the water resource, its chemical and physical quality must be defined and monitored.

OBJECTIVE: To provide a national bank of water-quality data for broad Federal planning and action programs and to provide data for Federal management of interstate waters.

APPROACH: A network of water-quality stations will be operated to provide records of changes in concentrations of chemical constituents and properties in order to assess the trends of water quality and to provide data for planning and management agencies.

PROGRESS: The 1993 National Stream Quality Accounting Network (NASQAN) data acquisition, analysis, and computer entry was completed. Complete transects were run during the summer season at Merrimack River above Lowell, Massachusetts, Blackstone River at Millville, Massachusetts, and Charles River at Dover, Massachusetts. The results of the transects indicated good mixing at the sampling sites. The technicians responsible for the collection of NASQAN data have implemented clean methods to NASQAN sampling. In June, clean methods for trace metal sampling were implemented and continued at all NASQAN implementation locations. Every effort is being made to insure proper protocol for the remainder of Fiscal Year 93. The Mass.—R.I. District's water-quality vehicle is being used for sampling at all water-quality sites.

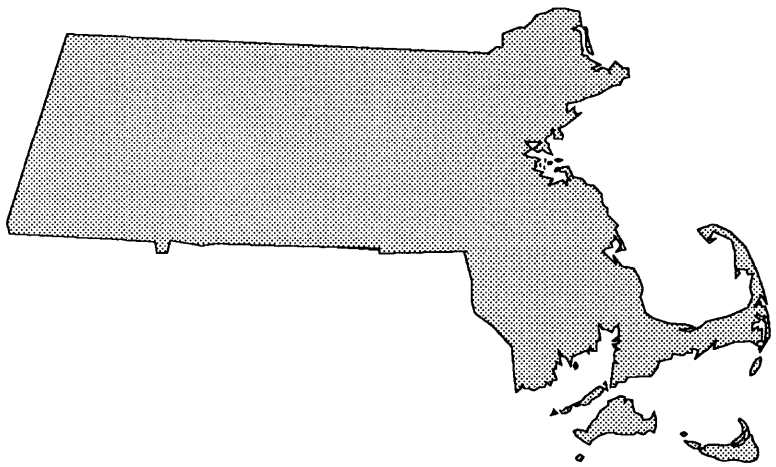
PLANS NEXT YEAR: Continue to sample NASQAN sites at the Blackstone, Charles, and Merrimack River stations at the frequencies prescribed by the Water-Quality Coordinator. No additions to the program are anticipated. Reconcile discrepancies between the sampling method taught at the NASQAN training course and those prescribed in the 1992 NASQAN implementation memorandum. Insure proper protocol for the remainder of fiscal year 92 and continue in Fiscal Year 93. Use the Mass.—R.I. District's water-quality vehicle for sampling at all water-quality sites.

COMPLETED REPORTS: This project contributes to the annual report "Water Resources Data—Massachusetts and Rhode Island." Data on chemical quality, temperature, and suspended sediments for the 1941 through 1970 water years were published annually under the title "Quality of Surface Waters of the United States."

Water Use

PROJECT CHIEF:
Michael Horgan

PERIOD OF PROJECT:
Continuous since September 1977



COOPERATOR(S): Massachusetts Department of Environmental Management, Division of Resource Conservation; Massachusetts Department of Environmental Protection, Division of Water Supply.

PROBLEM: In Massachusetts, the demand for water resources is increasing for domestic, industrial, and agricultural uses. Water conservation and greater protection of water quality are public policy. Competition for diverse water uses dictates that available supplies are matched with optimum uses. Information is currently being obtained to describe quantity and quality of available water, but relatively little information is being obtained to describe water use. Adequate information on uses of water is needed by the cooperators to resolve problems with respect to water-quality enhancement, environmental impact of water withdrawals and diversions, energy development, and resource allocations for supply and waste transport.

OBJECTIVE: (1) Provide water-use information to optimize utilization and management of Massachusetts water resources for the overall benefit of the public. (2) Develop and operate a system to collect, store, and disseminate water-use data to complement data on availability and quality of the States' water resources. (3) Make the system responsive to the data needs of local users, USGS, and other Federal agencies.

APPROACH: Responsibilities will be divided between the cooperator and U.S. Geological Survey (USGS) to reflect the most efficient means of meeting objectives of the program. Direction, management, and standards development to meet National needs will be the responsibility of the USGS. Field activities for the collection and preliminary storage of the data will be the primary responsibility of the Massachusetts Department of Environmental Management. Final data summarization and storage will be on the USGS computer system.

PROGRESS: The data base framework linking wastewater-treatment facilities, wastewater-collection systems, and the towns those systems serve were completed. Site-specific data on wastewater-treatment systems were compiled, analyzed, evaluated, and entered into Site Specific Water-Use Data System. Work began on the report "Wastewater collection and return flow in New England." Work continued on the Ten Mile River Basin water-use budget report. The water-use map report based on the 1990 Rhode Island water-use compilation received Director's approval and is being prepared for publication.

PLANS NEXT YEAR: Compile, analyze, evaluate, and enter water-use data into New England Water-Use Data Base site specific data on Massachusetts public-supply systems. Hold a workshop on industrial water use to help USGS and cooperator personnel understand the processes and data availability of industrial water use. Begin compiling industrial water-use data will begin. Obtain Director's approval and publish the report, "Estimation of Imported and Exported Water Use and Consumptive Use, and Water Use in New England," based on the data collected for the 1990 compilation. Obtain Director's approval and publish a report on wastewater collection and return flow in New England. Begin preparation of a report on public water-supply and distribution in New England.

Effectiveness of Highway-Drainage Systems in Preventing Salt Contamination of Ground Water, Route 25 from Wareham to the Cape Cod Canal, Massachusetts

PROJECT CHIEF:
Peter E. Church

PERIOD OF PROJECT:
January 1979 to December 1996

COOPERATOR(S): Massachusetts Department of Public Works

PROBLEM: Sodium and calcium chloride salts are frequently applied to roadways in the northern United States during winter storms to maintain ice-free road surfaces. Salt contamination of adjacent surface and ground water commonly results. Constructing roadways near public-water supplies can present a significant problem because high concentrations of sodium in drinking water is a health hazard. Specially designed highway-drainage systems have been constructed along sections of a new highway located near public-water supplies. Effectiveness of these drainage systems in preventing contamination of ground water by road salts has not been determined. Cost effectiveness of alternative methods of protecting ground-water supplies from contamination by road salts cannot be adequately accomplished without knowledge of effectiveness of the drainage systems.

OBJECTIVE: Determine the relative effectiveness of four types of highway-drainage systems in preventing road-salt contamination of ground water.

APPROACH: Four test sites along Route 25, Wareham to Cape Cod Canal, Massachusetts, have been established to monitor highway-related ground-water contamination. Each site represents a different type of drainage-system design. Ground-water samples will be collected monthly from networks of observation wells at each test site and analyzed for concentrations of sodium, calcium, and chloride—the primary constituents of road salt. Borehole-induction logs, which can be used to infer road-salt contamination of ground water, will be performed monthly to ensure that water samples collected represent all of the road-salt contaminated water near each well. Monthly quantities of sodium, calcium, and chloride transported in ground water downgradient from Route 25 at each test site will be computed from the chemical-concentration data. Continuous records of stage and specific conductance are collected at highway-drainage-monitoring stations during highway-runoff events to determine the quantity of road salt discharging through the highway-drainage system. Data collection will continue through 1995.

PROGRESS: Water-quality samples were collected monthly from the 10 clusters of 5-foot screened wells installed in 1990, four at site A and two each at sites B, C, and D, for analysis of sodium, calcium, and chloride concentrations. The mass flux of sodium, calcium, and calcium in the road salt plume were estimated monthly for each test site. Borehole-induction logs were obtained from 10 wells, each located immediately upgradient of a well cluster. These logs were used to monitor changes in background water-quality upgradient of the highway and changes in the vertical location, thickness, and water quality of the road-salt plume downgradient of the highway. Records of stage and specific conductance were collected continuously from the highway-drainage monitoring stations during

runoff events. Stage/discharge and specific conductance/chloride relations were used to compute road-salt chloride discharge from the highway-drainage systems.

PLANS NEXT YEAR: Collect water-quality samples monthly from the well clusters and analyze for chloride, sodium, and calcium concentrations. Continuously monitor stage and specific conductance at the highway-drainage monitoring stations. Obtain monthly borehole-induction logs at each well cluster in order to monitor the vertical location and thickness of the road-salt plume. Compute the mass flux of road salt in ground water and the discharge of road salt through the highway-drainage monitoring stations on a monthly basis for each test site. Compare these data with records of road salt applied to the highway and compared between test sites.

COMPLETED REPORTS:

Church, P.E., 1991, A study to evaluate the effectiveness of highway-drainage systems in preventing ground-water contamination *in* Abstracts from the technical sessions of the U.S. Geological Survey Water-Quality Workshop, Northeastern Region, 1st meeting, Skyland, Virginia, March 31-April 3, 1986: U.S. Geological Survey Open-File Report 91-225, p. 31.

Church, P.E., and Friesz, P.J., 1993, Delineation of a road-salt plume in ground water and traveltime measurements for estimating hydraulic conductivity by use of borehole-induction logs *in* J.K. Hallenburg, ed., Geotechnical and Environmental Applications—Proceedings of Fifth International Symposium on Geophysics for Minerals, October 24-28, 1993, Minerals and Geotechnical Logging Society, Tulsa, Oklahoma, v. 5, chap. Y, p. 1-16.

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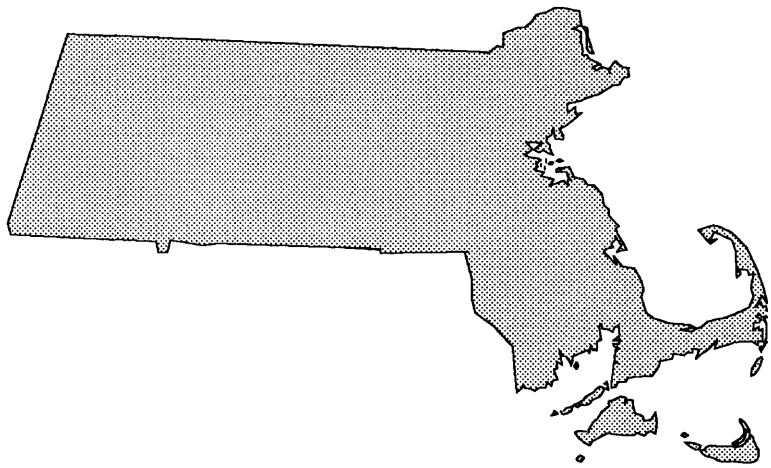
Quality of Precipitation from Air Masses Moving Over Massachusetts

PROJECT CHIEF:
J. Michael Norris

PERIOD OF PROJECT:
October 1982 to September 1985



COOPERATOR(S): Massachusetts Department of Environmental Protection, Division of Water Pollution Control

PROBLEM: Air which flows over the industrialized Ohio Valley, eastern seaboard, and southeastern United States is believed to be responsible for the chemical quality of precipitation in New England. Problems with corrosivity, nutrient content, and heavy-metal mobilization are common in Massachusetts. The quality of surface and ground water in Massachusetts is vulnerable to the effects of acid precipitation because soil and rock contain little natural buffering capacity. There is a need to systematically collect, analyze, and relate atmospheric deposition to the air-mass trajectories and sources to determine future inputs from precipitation in Massachusetts and New England.

OBJECTIVE: (1) Measure the quantities of selected water-quality properties and constituents from samples of individual wet-atmospheric deposition events and relate them to air-mass trajectories, sources, type of storm, and seasons of the year. (2) Determine the ongoing contribution of wet-atmospheric deposition to dissolved constituents in surface and ground water, corrosivity in water-supply distribution systems, and mobilization of heavy metals.

APPROACH: Precipitation variables such as storm type, storm duration, season of the year, air mass trajectory and other factors will be related to chemical composition and amounts collected at two sites in eastern Massachusetts and one Electric Power Research Institute (EPRI) site in central Massachusetts. National Weather Service (NWS) meteorological information and reports will be used to guide sampling and to identify precipitation variables. Chemical and physical data collected from the project sampling sites and composite samples from the National Atmospheric Deposition Program (NADP) and Department of Energy/Environmental Measurements Laboratory sites will be used to compute annual and seasonal loads of trace metals, nutrients, acids, and common constituents.

PROGRESS: Report was rewritten by Steve Melching, Illinois District, and is at colleague review.

PLANS NEXT YEAR: Obtain Director's approval for report.

Processes Controlling Transport of Solutes in a Sewage Plume in Ground Water at Otis Air Base, Cape Cod, Massachusetts

PROJECT CHIEF:
Denis R. LeBlanc

PERIOD OF PROJECT:
April 1983 to September 1995

FUNDING SOURCE: USGS Toxic Substances Hydrology Program

PROBLEM: Prediction of solute transport in ground water requires identification and field measurement of aquifer and flow-system characteristics that affect transport. Field studies have shown that macroscale dispersion is caused by heterogeneity of hydraulic conductivity and porosity, but practical methods to quantify heterogeneity and predict dispersion are not available. Vertical movement of plumes in aquifers with mostly horizontal flow has been observed in the field, but most models have only considered two-dimensional areal transport. Practical methods are needed to measure the three-dimensional characteristics of plumes and to incorporate these data into predictive models that adequately describe the fate of reactive and nonreactive solutes in aquifers.

OBJECTIVE: (1) Develop and test deterministic and stochastic methods for describing the spatial and temporal variability of hydrologic and geochemical characteristics of contaminated aquifers and (2) Develop and test predictive models of the complex interactions between this variability and the physical, chemical, and microbiological processes that affect solute transport.

APPROACH: The spatial and temporal variability of hydrologic and geochemical characteristics will be measured at various scales in the sandy aquifer, and stochastic and deterministic methods will be used to quantify the variability. Physical, chemical, and microbiological processes that affect solutes in ground water will be measured during laboratory tests, tracer experiments, and field studies of the sewage plume. Predictive models of reactive and nonreactive solute transport in the heterogeneous aquifer will be developed and tested by comparison of the models' predictions to observations of solute transport in the sewage plume and the tracer experiments.

PROGRESS: The spatial variability of hydraulic and geochemical characteristics in the Cape Cod aquifer were examined at several spatial scales. Geologic models were coupled with measurements of hydraulic conductivity to determine spatial trends of conductivity over distances of kilometers; these large-scale trends were superimposed on small-scale trends over distances of meters. Measurements of the capacity of the sandy sediments to sorb trace metals showed that the spatial variability of this geochemical capacity is similar to the variability of hydraulic conductivity. Six groundwater tracer experiments were conducted using inorganic, organic, and microbial tracers. In the largest experiment, more than 2,000 gallons of water containing lead, zinc, nickel, and other trace metals were injected into the aquifer, and water samples were collected monthly from an array of multilevel wells to observe the tracers' movement and attenuation. Preliminary results from this experiment, which was still underway in October 1993, showed that spatial variations of pH and dissolved-oxygen concentrations in the sewage plume affect the transport of metals. Development of predictive models that simulate the results of the tracer experiments began. A numerical model of the 1985-88

large-scale natural-gradient tracer experiment was used to show that the downward movement of bromide tracer cloud was caused by two processes: areal recharge from precipitation and density-induced vertical flow. This downward movement can increase the amount of vertical mixing of contaminants in ground water.

PLANS NEXT YEAR: Complete trace-metals tracer experiment. Continue to describe the spatial variability of the capacity to sorb metals. Begin development of stochastic and deterministic models to transport of reactive trace metals. Analysis of the downward movement of the bromide tracer cloud during the 1985-88 experiment will be described in a Masters thesis. About 260 wells in the sewage plume will be sampled as a first step in a planned study of changes in the plume after sewage disposal ceases in 1995.

COMPLETED REPORTS:

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Franks, B.J., ed., 1987, U.S. Geological Survey Program on Toxic Waste—Ground-Water Contamination: Proceedings of the third technical meeting, Pensacola, Florida, March 23-27, 1987: U.S. Geological Survey Open-File Report 87-109, 214 p.

Garabedian, S.P., 1987, Large-scale dispersive transport in aquifers: Field experiments and reactive transport theory: Cambridge, Mass., Massachusetts Institute of Technology, Dept. of Civil Engineering, unpublished Ph.D. thesis, 290 p.

____1991, A comparison of results from small- and large-scale tracer tests in a heterogeneous aquifer, Cape Cod, Massachusetts, in Fliermans, C.B., and Hazen, T.C., eds., Proceedings of the First International Symposium on Microbiology of the Deep Subsurface, Orlando, Florida, January 15-19, 1990: Aiken, S.C., Westinghouse Savannah River Company, p. 7-167 to 7-176.

Garabedian, S.P., Gelhar, L.W., and Celia, M.A., 1988, Large-scale dispersive transport in aquifers: Field experiments and reactive transport theory: Cambridge, Mass., Massachusetts Institute of Technology, Dept. of Civil Engineering, Ralph M. Parsons Laboratory, Hydrology and Water Resources Systems Report No. 315, 290 p.

Garabedian, S.P., and LeBlanc, D.R., 1987, A natural-gradient tracer experiment to verify stochastic models of solute transport, Cape Cod, Massachusetts, in Proceedings of International Congress on Hazardous Materials Management, International Congress of Environmental Professionals, Chattanooga, Tenn., June 8-12, 1987: Northbrook, Ill., Pudvan Publishing, p. 187-197.

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Garabedian, S.P., LeBlanc, D.R., Gelhar, L.W., and Celia, M.A., 1991, Large-scale natural-gradient tracer test in sand and gravel, Cape Cod, Massachusetts: 2. Analysis of spatial moments for a nonreactive tracer: Water Resources Research, v. 27, no. 5, p. 911-924.

Harvey, R.W., and Garabedian, S.P., 1991, Use of colloid filtration theory in modeling movement of bacteria through a contaminated sandy aquifer: Environmental Science and Technology, v. 25, no. 1, p. 178-185.

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Hess, K.M., Wolf, S.H., Celia, M.A., and Garabedian, S.P., 1991, Macrodispersion and spatial variability of hydraulic conductivity in a sand and gravel aquifer, Cape Cod, Massachusetts: Ada, Oklahoma, Robert S. Kerr Environmental Research Laboratory, U.S. Environmental Protection Agency, Environmental Research Brief EPA/600/M-91/005, 9 p.

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Chemistry of Precipitation During Storm Events

PROJECT CHIEF:
James B. Shanley

PERIOD OF PROJECT:
October 1985 to September 1988

COOPERATOR(S): Massachusetts Department of Environmental Protection, Division of Water Pollution Control

PROBLEM: In the course of a previous project "Quality of Precipitation from Air Masses Moving over Massachusetts" (MA060), significant variations in water chemistry and the erratic presence of varying amounts and character of particulate residue found in water samples were potentially related to geographic source areas. Although other researchers have related dissolved constituents in precipitation to sources such as coal burning for power generation in the Ohio Valley, the particulates in precipitation have not been extensively studied. There is a need to relate and further describe not only the dissolved constituents of precipitation with respect to source, but to determine the composition and relative abundances of these particulate constituents in precipitation.

OBJECTIVE: (1) Establish a baseline characterization of precipitation quality affecting central Massachusetts according to storm type and season of the year. (2) Identify and describe chemical-constituent assemblages of dissolved and particulate constituents in precipitation samples that may be signatures of sources. (3) Compare two methods of identifying sources of dissolved and particulate emissions: (a) the method using chemical-constituent assemblages of dissolved and particulate materials; and (b) the method using air-mass trajectory analysis. (4) Identify and describe the within-storm variability of common chemical constituents for various storm types.

APPROACH: Precipitation samples will be collected from four types of storm patterns each season for chemical analyses of both dissolved and particulate matter at a Massachusetts Division of Air Quality Control weather site on Quabbin Summit in central Massachusetts. Each season each storm pattern will be sampled twice: once for storms yielding less than 0.25 inch of water and the other time for storms yielding greater than 0.25 inch of water. The four storm patterns are: (1) advancing cold front where cold air overtakes and replaces warm air, (2) advancing warm front where warm air overtakes and replaces cold air, (3) land cyclone where the low-pressure center tracks just to the west of the site so that both advancing warm and cold air masses are overtaken in turn, and (4) coastal cyclone where the low--pressure center tracks east of the site, probably over the Atlantic Ocean, so that the cold air mass is not replaced. Quantitative microanalytical electron microscopy techniques will be used to determine the chemical composition, and to possibly identify the particulate matter in precipitation. The chemical data from these water and particulate analyses will be used to determine chemical "signatures" of storm events, which then may be used to compare to the chemical signatures of particulates emitted from possible sources. Backward air-mass trajectories for up to a 5-day period starting at the end of a storm event will be computed for storms using the Branching Atmospheric Trajectory computer model developed by the National Oceanic and Atmospheric Administration. These air-mass trajectory analyses will be compared with a list of possible sources determined from the chemical data to relate the backward air-mass trajectory to possible geographic sources.

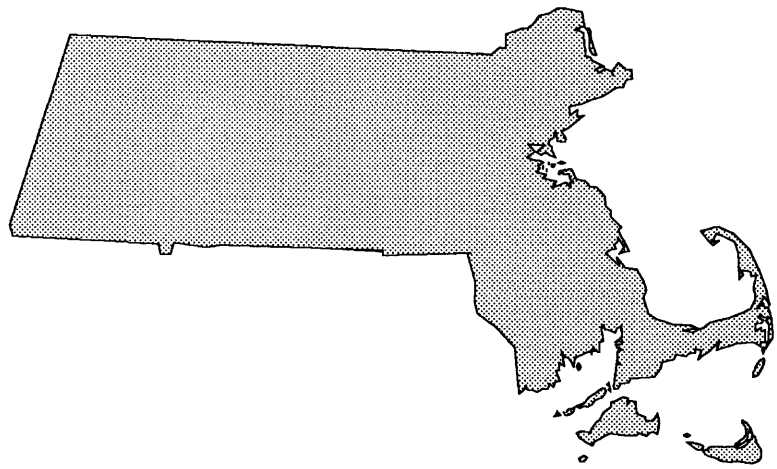
PROGRESS: The report was written and submitted for colleague review. Project is complete except report.

PLANS NEXT YEAR: Obtain Director's approval for the report.

Physically Based Low-Flow Models and Record Extension for Low-Flow Frequency Studies

PROJECT CHIEF:
J. Michael Norris

PERIOD OF PROJECT:
October 1986 to September 1989



COOPERATOR(S): Massachusetts Department of Environmental Protection, Division of Water Pollution Control

PROBLEM: Low-flow frequency estimates are used by governmental agencies, consultants, planners, and engineers for planning, design, and regulatory purposes. These estimates are extremely important for waste-load allocation, water-supply design, groundwater management, and aquatic-habitat protection. Accuracy goals for planning and design data were calculated during a nationwide evaluation of the streamflow data program. In general, existing low-flow regression equations yield estimates for ungaged sites with large standard errors of estimate that exceed accuracy goals in each state or region. Most locations where such low-flow statistics are required do not coincide with stream-gage sites. Improved techniques/models are needed to estimate low-flow statistics for ungaged sites.

OBJECTIVE: Apply scientific advances in low-flow frequency estimation, streamflow-record augmentation procedures, and regional regression analyses that show promise for improvement of regional equations for estimating low-flow statistics at ungaged sites. Investigate alternative forms of the low-flow frequency estimating equation that have a physical basis with parameters that are hydrologically meaningful with respect to the hydrogeology and physiography of the basin.

APPROACH: Estimates of low-flow characteristics at short-term gaged sites will be developed by streamflow record extension techniques. Low-flow characteristics at partial-record sites will be estimated with the unbiased moment techniques. Basins with diverse hydrologic responses will be analyzed to test the usefulness of an instantaneous flow relation to transfer low-flow volumes to partial-record sites. Alternative functional forms of the low-flow model will be evaluated including new physically based parameters as independent variables. Generalized least-squares regression analysis will be used to define the physically based low-flow models. Selected low-flow estimating equations will be verified with a new and independent data set.

PROGRESS: The report was written and submitted for colleague review. Project is complete except report.

PLANS NEXT YEAR: Obtain Director's approval for the report.

Demonstration of the Use of Three-Dimensional Ground-Water Modeling for Delineation of Recharge Zones of Public-Supply Wells, Cape Cod, Massachusetts

PROJECT CHIEF:
Paul M. Barlow

PERIOD OF PROJECT:
October 1986 September 1990

COOPERATOR(S): Massachusetts Department of Environmental Management, Division of Water Resources; Massachusetts Department of Environmental Protection, Division of Water Supply; Barnstable County

PROBLEM: Massachusetts regulations require delineation of recharge areas to public-supply wells. Cape Cod is underlain by a water-table aquifer which is its sole source of water. The aquifer is multi-layered in many locations, and wells commonly penetrate less than 10 percent of the total aquifer thickness. Many areas contain multiple wells with superimposed zones of contribution. A multi-agency task force has determined that analytical and two-dimensional modeling approaches to recharge-area delineation are insufficient to assess the complex hydrogeologic system.

OBJECTIVE: (1) Demonstrate the use of the U.S. Geological Survey modular three-dimensional flow model to delineate recharge zones of public-supply wells under a range of recharge and pumping conditions, by modeling existing conditions in Barnstable and planned future development conditions in Eastham, and (2) describe the process of determining minimum initial data requirements.

APPROACH: Two, multi-layer, three-dimensional models of the fresh ground-water flow system on the Cape will be developed and calibrated. Recharge areas of public-supply wells will be determined by flow-net analyses of calculated hydraulic heads, both in plan view and cross-section as confirmed by three-dimensional particle tracking. The models have been tested to assess changes in the dimensions of the recharge area due to variation in initial and boundary conditions.

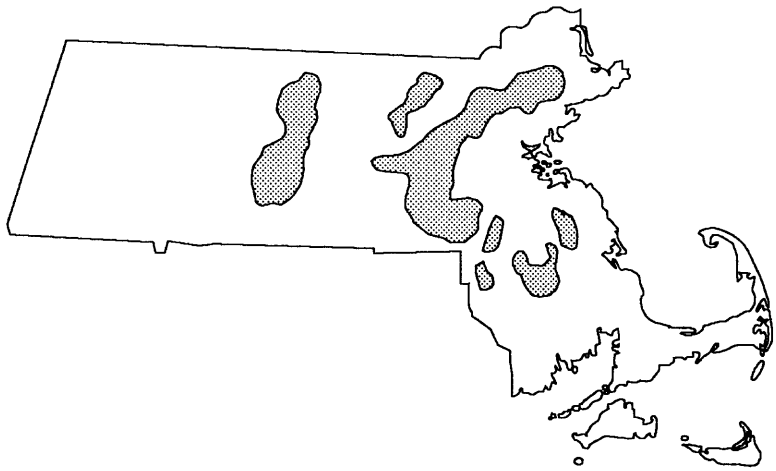
PROGRESS: Final report has been approved as an Open-File Report pending publication as a Water-Supply Paper.

PLANS NEXT YEAR: Publish the Open-File Report.

Predicting Wetland Influences on Stream-Water Quality

PROJECT CHIEFS:
David S. Armstrong

PERIOD OF PROJECT:
October 1987 September 1990



COOPERATOR(S): Massachusetts Department of Environmental Protection, Division of Water Pollution Control

PROBLEM: Water quality in streams in Massachusetts can frequently be predicted using existing methods and equations. However, it has been found that these models are ineffective when applied to streams with contiguous wetlands. This represents approximately 10 percent of the waterways in Massachusetts. There exists a need to measure and define the processes under which wetlands affect stream-water quality so that reliable predictions can be made.

OBJECTIVE: To identify and define physical, ecologic, and hydrologic characteristics that affect stream quality in wetland streams.

APPROACH: Water-quality data will be obtained from a combination of field analyses and data already obtained from the State. The additional water-quality data that will be generated will represent a wider range of hydrological conditions and wetland characteristics than are currently represented by the State data base. A determination will be made as to whether the existing databases can be used to develop empirical equations for the prediction of dissolved oxygen and nutrients in wetland streams.

PROGRESS: Data report was approved for publication. Expected distribution date is February 1994. After meeting with the cooperator, report plans have been changed and new topical and annotated outlines have been prepared to rescope the interpretive report. Project is complete except report.

PLANS NEXT YEAR: Prepare first draft of the interpretive report and begin colleague review process.

COMPLETED REPORTS:

Suurballe, Nancy C., 1992, Effects of a wetland on quality of Natty Pond Brook, Massachusetts, 1985-86: U.S. Geological Survey Water-Resources Investigations Report 91-4144, 52 p.

Investigation of Watershed Management Impacts on Watershed Hydrology and Aquatic Chemistry

PROJECT CHIEF:
James B. Shanley

PERIOD OF PROJECT:
October 1987 to September 1990

COOPERATOR(S): Metropolitan District Commission

PROBLEM: The Metropolitan District Commission (MDC) plans to apply forest management to increase the watershed yield to Quabbin Reservoir, the primary source of water for the Boston metropolitan area. This reservoir, located in the central highlands of the State, is located in a terrain underlain by silicate rock that has little capacity to buffer acidity introduced by precipitation. The MDC is making selective clear cuts of forests and converting them to open grassy fields. Because of the susceptibility of the reservoir to acidification, assessment of the effect of this land change on water quality is needed to guide MDC's future management decisions.

OBJECTIVE: Determine the effect of watershed management on stream-water alkalinity, acidity, and general chemistry, and to determine the change in watershed yield in response to management.

APPROACH: Water quality and stream discharge are being measured in two small subbasins tributary to the reservoir prior to selected clear cutting in one of the basins. Comparisons of the before and after conditions in both the cut basin and in the undisturbed control basin will be used to assess the nature and magnitude of the effects of management on water quality and yield. Analytical and numerical techniques, including paired regression between the control and experimental basins, precipitation-runoff modeling, and numerical models of aqueous geochemistry will be applied.

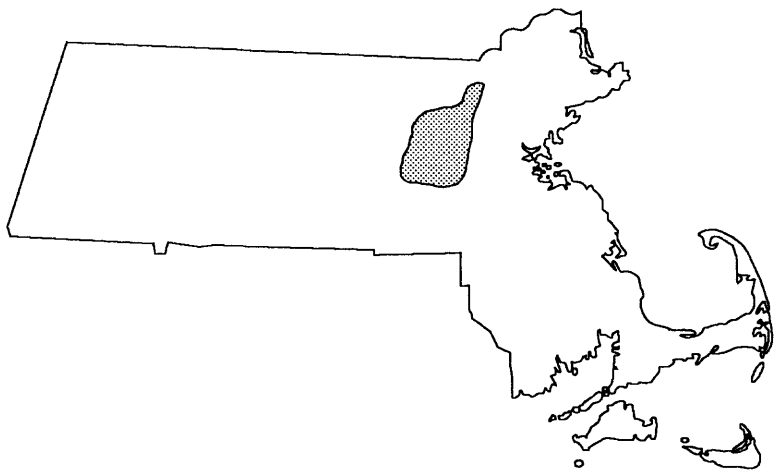
PROGRESS: First draft of the report was written and has received in-house review. Project is complete except for report.

PLANS NEXT YEAR: Obtain Director's approval for final report.

Ground-Water and Low-Flows in the Sudbury, Assabet, and Concord River Basins, Massachusetts

PROJECT CHIEF:
Gene W Parker

PERIOD OF PROJECT:
October 1989 to September 1992



COOPERATOR(S): Massachusetts Department of Environmental Management, Office of Water Resources

PROBLEM: Although Massachusetts is rich in water resources, the urbanized eastern part of the State has been developed to the extent that water demand has approached and, in some instances, outstripped the capacity of local resources. The Massachusetts Water Management Act requires the State to quantify water resources in each planning basin. The potential yields of the aquifers in the SUdbury, ASsabet, and COncord (SUASCO) River Basin have not been estimated. Planning and management of water resources requires knowledge of the capacity of these resources and then an accounting of the effects of all withdrawals and discharges on the low-flow of streams.

OBJECTIVE: To determine the volume of water available and to understand the interaction between surface-water and ground-water systems.

APPROACH: The study will investigate the degree of interaction between the surface-water and ground-water systems, estimate the quality of water involved, and simulate the processes with identifiable limits. A monthly time-step streamflow-tabulation model will estimate low-flow responses to water-use pattern along reaches which could not accommodate the daily time-step model. Low-flow measurements will be made at specified subbasin locations.

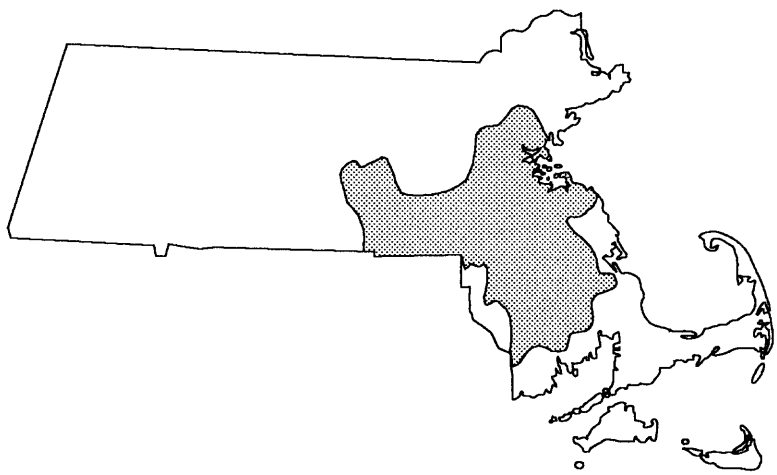
PROGRESS: The report was written and reviewed. Some major changes were made in the section on surface-water/ground-water interaction. Revisions were made and the report has gone through colleague review.

PLANS NEXT YEAR: Publish the report.

Application of Physically Based Low-Flow Models to the Determination of Basin Yields, Massachusetts

PROJECT CHIEF:
Kernell G. Ries, III

PERIOD OF PROJECT:
October 1988 to September 1991



COOPERATOR(S): Massachusetts Department of Environmental Management, Division of Resource Conservation, Office of Water Resources

PROBLEM: The Massachusetts Office of Water Resources (MOWR) is responsible for development of basin management plans for the efficient and environmentally sound use of water within the State's 27 planning basins. The single most critical piece of information required for these basin plans is an estimate of basin yield during low surface-water flow conditions. Basin yield must be expressed in terms of low-flows equaled or exceeded a specific percentage of the time. Estimates of basin yield in this form are currently unavailable in most of Massachusetts.

OBJECTIVE: (1) To develop a physically based low-flow model similar to that developed by the Northeast Regional Aquifer Systems Analysis Project, but which describes low flows in terms of percent flow duration and which uses a base period selected by MOWR. (2) Apply the model in several planning basins selected by MOWR. (3) Design a low-flow discharge measurement program for field measurement of low flow at selected subbasins anticipated by MOWR and USGS as sites where field measurement of low flow is a critical need. (4) Determine subbasin yields in selected planning basins using the physically based model.

APPROACH: A low-flow model will be derived initially by regression of a currently available data base of easily measured basin characteristics against flow-duration characteristics for gaged sites in central New England. Established record-extension techniques will be used to compute flow durations for gaged sites which were not in operation for the entire base period. Geographic Information System (GIS) technology will be used to retrieve the basin-characteristics data for designated ungaged sites in the planning basins, and for the gaged sites used to derive the model. The model will be adjusted for use with the GIS data, tested with an independent data set, and used to estimate yields for the designated ungaged sites. Low-flow measurements will provide low-flow discharge at critical sites.

PROGRESS: The report received Director's approval as a Water-Supply Paper in January 1993, with initial release as an Open-File Report. Camera-ready copy of the OFR was prepared and sent to the printers. Final revisions were made to the Water-Supply Paper.

PLANS NEXT YEAR: Distribute the Open-File Report January 1994. The Water-Supply Paper may be distributed before the end of the fiscal year.

Effects of a Septage Treatment Plant on Ground-Water Quality, Orleans, Massachusetts

PROJECT PERSONNEL:
Leslie A. De Simone

PERIOD OF PROJECT:
October 1988 to September 1993

COOPERATOR(S): Massachusetts Department of Environmental Protection, Division of Water Pollution Control

PROBLEM: Most studies of contaminated ground-water plumes are after-the-fact studies, the results of which are imprecise because of poorly defined source terms. In Massachusetts, disposal of nutrient rich sludge from septic systems is a severe problem. A solution which is gaining wider acceptance is to design septage only treatment plants coupled with land disposal of effluent. Studies need to examine the chemical setting within a sand and gravel aquifer prior to, at initiation of, and during the land application of the septage effluent. Chemical and physical processes controlling the transport of the contaminants within the aquifer need to be examined as the plume of contaminants develops.

OBJECTIVE: Describe, over time, the development of a nitrogen-contaminated ground water plume created by infiltration of treated septage-plant effluent in order to (1) characterize the chemical quality of the ground-water plume, (2) determine what processes control its transport, and (3) determine mass loss and gain of its dissolved constituents.

APPROACH: Measure, analyze, and interpret the various basic physical and chemical processes of attenuation that influence the transport of several solutes in a plume of contaminated ground water. The study will focus on the development of a plume as it travels from its source to a projected discharge area in a salt water marsh about 1,000 feet downgradient. Aquifer properties and stresses will be quantified in sufficient detail to simulate the ground-water flow system controlling the plume. Mass-balance accounting for plume constituents, particularly those in the nitrogen series, will be made both spatially and temporally on a basis of repetitive samples taken from a three-dimensional array of monitoring wells.

PROGRESS: Field work and data-collection phases of the project were completed in December 1992, with a fifth and final synoptic sampling round of 69 ground-water observation wells within and surrounding the plume. Final analysis of all lithologic, hydrologic, and water-quality data was completed, including mass-balance calculations for major chemical constituents in the plume. Text and draft figures for sections of the final report describing hydrogeology of the site and physical and chemical processes controlling plume development were completed.

PLANS NEXT YEAR: Complete preparation and review of final report, and obtain Director's approval for publication.

Aquifer Yields in the Cape Cod, Martha's Vineyard, and Nantucket Island Ground-Water Basins, Massachusetts

PROJECT CHIEF:
John P. Masterson

PERIOD OF PROJECT:
October 1989 to September 1992

COOPERATOR(S): Massachusetts Department of Environmental Management, Division of Resource Conservation, Office of Water Resources.

PROBLEM: Under Massachusetts law, the Massachusetts Office of Water Resources (MOWR) is responsible for the development of management plans for the efficient and environmentally-sound use of water within the State. The Massachusetts legislature has approved a bill to fund cooperatively, with the U.S. Geological Survey, the development of basin hydrologic information to support the need. Survey studies will provide the State with the basic scientific information that it needs to begin water management plans.

OBJECTIVE: This project will develop estimates of basin yields in the Cape Cod, Martha's Vineyard, and Nantucket Island ground-water basins, Massachusetts. This work will include: (1) Determination of ground-water yields at MOWR-designated sites in the Cape Cod, Martha's Vineyard and Nantucket Island basins under long-term average climatological conditions and during periods of little to no recharge. (2) Determination of the relation between ground-water levels, pond levels, and streamflows in the three basins. (3) Examination of the impacts of increased ground-water withdrawals on the area ground-water and pond levels, streamflows, and the potential for saltwater intrusion.

APPROACH: All available, pertinent hydrologic data from the Cape Cod, Martha's Vineyard, and Nantucket Island basins will be inventoried, assembled, and intergrated into existing numerical models and models will be modified where appropriate. Using numerical models, the effects of increased ground-water withdrawals from both existing and hypothetical pumping centers will be superimposed on the long term average water table elevation, pond levels, and streamflows to provide accurate estimates of potential yields for the Cape Cod flow cells. Qualitative work is planned for Martha's Vineyard and Nantucket Island where flow models have not been developed.

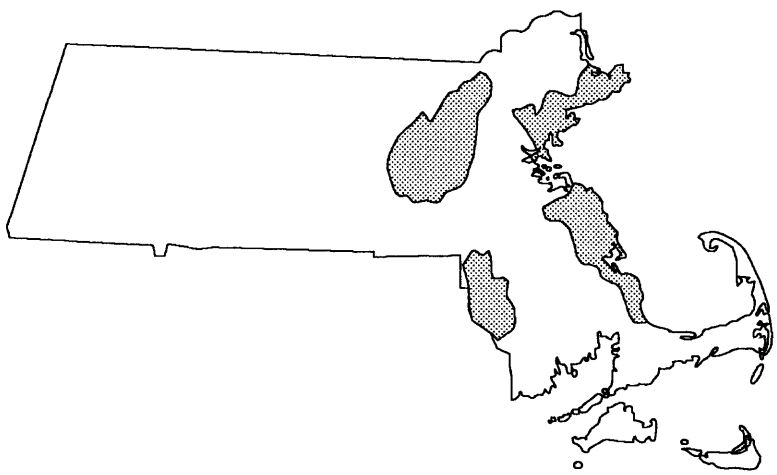
PROGRESS: The final draft of the report was written. The report has been through colleague review.

PLANS NEXT YEAR: Submit report for Director's approval as an Open-File Report pending publication as a Water-Supply Paper. Receive approval and publish the report as an Open-File Report by June 1994.

Application of Physically Based Low-Flow Models to the Determination of Basin Yields, Massachusetts

PROJECT CHIEF:
Kernell G. Ries, III

PERIOD OF PROJECT:
October 1990 to September 1993



COOPERATOR(S): Massachusetts Department of Environmental Management, Division of Resource Conservation, Office of Water Resources

PROBLEM: The Massachusetts Division of Resource Conservation (MDRC) is responsible for development of basin management plans for the efficient and environmentally sound use of water within the State's 27 planning basins. The single most critical piece of information required for these basin plans is an estimate of basin yield during low surface-water flow conditions. Basin yield must be expressed in terms of low-flows equaled or exceeded a specific percentage of the time. Estimates of basin yield in this form are currently unavailable in most of Massachusetts.

OBJECTIVE: (1) Refine the regression models developed from a previous study (MA089) to make improved estimates for eastern Massachusetts by incorporating pre-existing low-flow sites and modifying model parameters. (2) Use low-flow sites established for this study to confirm or calibrate the new models and (or) those developed for MA089 for local conditions. (3) Provide estimates of natural low flows for ungaged sites in the North Coastal, South Coastal, Concord, Tenmile, and Narragansett basins. (4) Use water use/water supply data from State Water Use Data System (SWUDS) to adjust natural flow estimates for the Tenmile basin to actual conditions.

APPROACH: Regression models developed in the original Basin Management project will be refined using additional partial-record sites and Generalized Least Squares (GLS) techniques (as opposed to using Ordinary Least Squares techniques which were used in MA089). New enhancements in the Geographic Information system (GIS) database that were not available in MA089 will be utilized and may reduce error in the models. Flow measurements from low-flow sites established for the study will be used for model verification. At regulated sites, measured low flows will be adjusted using water use data.

PROGRESS: Measurement of basin characteristics was completed for all of the sites used to develop the regression equations. The basin characteristics were measured from digital data bases available on a nationwide basis or developed for this project using Geographic Information Systems computer software. The characteristics included: drainage area, area of stratified-drift deposits, total stream length, mean basin slope, maximum, mean, and minimum basis altitude, the maximum mean, and minimum altitude in the stratified-drift deposits. A surrogate measure of the head in the stratified-drift deposits (GWHEAD) was computed by subtracting the minimum basis altitude from the mean basis altitude. A more direct measure of the head in the stratified-drift deposits (GWRELIEF) was computed by subtracting the minimum altitude in the deposits from the maximum altitude in the deposits.Generalized-least-squares regression analyses were done using the 99-,98-, and 95-percent duration discharges as the dependent variables and the basin characteristics above as the independent variables. A total of 61 sites were used in the regression analyses, including 41 sites used for the MA089 study, and 20 low-flow partial-record sites added for this study. The report writing was begun.

PLANS NEXT YEAR: Complete writing the report, submit it for colleague and regional review, get Director's approval, and publish the report as a Water-Resources Investigations Report.

Nitrogen Transformations in a Developing Septage Plume

PROJECT CHIEF:
Leslie A. DeSimone

PERIOD OF PROJECT:
October 1990 to September 1993

COOPERATOR(S): Massachusetts Department of Environmental Protection, Division of Water Pollution Control

PROBLEM: An understanding of microbially mediated nitrogen transformations is essential to evaluating impacts of sewage or septage effluent discharges on ground-water quality. The process of denitrification is of particular importance because it is a pathway for the removal of nitrogen from the ground-water flow system. However, the factors that control denitrification in the subsurface are not well understood. Land disposal of treated septage effluent is gaining greater acceptance, as other disposal methods become unacceptable, so understanding the factors governing nitrogen fate and transport in subsurface are of considerable importance.

OBJECTIVE: Describe and quantify the microbially-mediated nitrogen transformations that occur during the development of a septage effluent ground-water plume. Primary emphasis is on understanding denitrification and the factors controlling the denitrification process.

APPROACH: Nitrogen transformation processes will be measured through laboratory incubations of aquifer samples taken prior to and during development of the ground-water plume. Controlling factors on denitrification will be investigated through manipulation of laboratory incubation experiments and repeated measurements of nitrogen species, oxygen, and available organic carbon in the ground water. A nitrogen budget will be constructed based on known nitrogen inputs and the empirically measured rates, testing our understanding of the transformation processes involved by comparing predicted outputs with measured outputs.

PROGRESS: Field work and data-collection phases of the project were completed in December 1992, with a fifth and final synoptic sampling round of 69 ground-water observation wells within and surrounding the plume, for analysis of dissolved dinitrogen gas, nitrous oxide, and inorganic carbon. Final analysis of field data, all ammonia-sorption data, and some denitrification-rate-measurement data was completed. Text and draft figures for 50 percent of the sections of the final report describing nitrogen transformations during plume development was completed.

PLANS NEXT YEAR: Complete preparation and review of final report, and obtain Director's approval for publication.

Screening for Potential Public Water Supply Sites Using a Geographic Information System for Cape Cod, Massachusetts

PROJECT CHIEF:
Peter A. Steeves

PERIOD OF PROJECT:
October 1990 to September 1993

COOPERATOR(S): Cape Cod Commission

PROBLEM: Ground-water in the sole-source, sand and gravel aquifer on Cape Cod is presently of good chemical quality, but there is agreement that continued unchecked development threatens this resource. A technical screening approach is needed to search and identify areas which should be set aside for future water supplies. An effective method is also needed to interpret and describe the data used in the screening approach, and have the data widely accessible. Geographic Information System (GIS) technology has emerged as a tool for storage, analysis, and display of spatial data essential for such a screening procedure.

OBJECTIVE: Develop methods for screening hydrologic, geologic, land use, ground-water-quality, and potential point-and non-point-source data for identification, analysis, and interpretation of potential water-supply areas on Cape Cod. Apply the methods to identify potential water-supply areas having yields adequate for municipal, community, and non-community supply needs.

APPROACH: The Survey will provide technical assistance to the cooperator by contributing our knowledge and expertise of the hydrologic regime of the Cape. An automated screening procedure will be developed using Arc Macro Language (AML) that will scan the Cape for remaining ground-water supply areas. The screening procedure will integrate a complex assortment of hydrogeologic, land use, contamination source, and current water-quality data; GIS technology will utilize the large amount of available and newly digitized Cape-wide data layers to evaluate the relative quality of the potential water-supply areas identified.

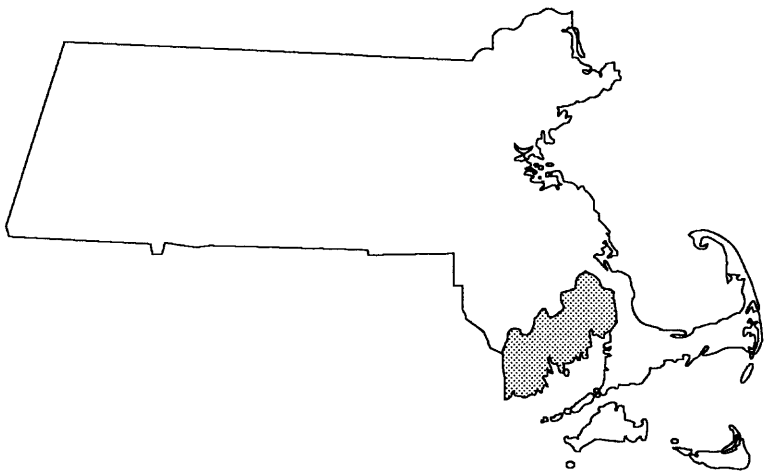
PROGRESS: The project has been completed except the report. The menu-driven application will be completed and converted to ARC/INFO Rev 6.0. Report writing will start.

PLANS NEXT YEAR: Submit the report for Director's approval.

Stream-Aquifer Interactions and Yields of Stratified-Drift Aquifers in Buzzards Bay Planning Basin

PROJECT CHIEF:
Gardner C. Bent

PERIOD OF PROJECT:
April 1991 to September 1995



COOPERATOR(S): Massachusetts Department of Environmental Management, Division of Resource Conservation, Office of Water Resources

PROBLEM: By authority of Chapter 800 of The Acts of 1979 of the Massachusetts legislature, the Massachusetts Department of Environmental Management, Division of Resource Conservation, Office of Water Resources is responsible for developing water management plans to assess water resources in the State's 27 river planning basins. The Office of Water Resources has requested the U.S. Geological Survey to estimate ground-water availability for the Buzzards Bay planning basin, to help the State to avert water shortages from drought and increased demand. State and local officials have concerns regarding long-term effects of increased withdrawals on ground-water levels and streamflow.

OBJECTIVE: Determine the potential yield of the major stratified-drift aquifers in the Buzzards Bay planning basin and describe the ground-water and surface-water interaction for stratified-drift aquifers in the planning basin.

APPROACH: All available hydrologic information on the basin will be reviewed. Where there is inadequate information on stratified-drift aquifer characteristics, field work will provide additional information. Yields will be estimated for several sites by use of flow-duration curves constructed from low-flow measurements. Several wells will be installed near stream channels to determine if a correlation between ground-water levels and stream discharge exists. Grain-size analyses and (or) permeameter tests of core samples will be used to estimate vertical hydraulic conductivity of the streambed. Drive-point wells will be installed in streambeds to measure vertical head gradients. Seepage runs will be done two to three times to determine possible effects of pumping wells on streamflow. The Jenkins analytical model will be used to estimate the number of days until pumping affects streamflow and its effects on streamflow for different scenarios.

PROGRESS: Data from 12 seismic-refraction surveys and 335 well logs obtained for this study indicate that the current U.S. Geological Survey saturated thickness and transmissivity maps do not need to be revised. Low-flow duration analyses were completed for the 14 low-flow partial record sites in Buzzards Bay Planning Basin. Streamflow records from 1967 to 1991 for six nearby continuous streamflow-gaging stations were used to compute values of mean annual ground-water discharge per unit area, and ground-water recharge for Buzzards Bay Planning Basin. Regression analyses were done to determine the relation between simultaneous measurements of stream discharge and adjacent ground-water levels and gradients. Three sets of stream-discharge measurements at five locations along the Pashamanset River were analyzed to assess the effects of nearby well pumping on streamflow. The Jenkins Analytical Model was not used to assess the effects of well pumping on streamflow in Buzzards Bay Planning Basin, because it does not discriminate between how much water is coming from streamflow versus intercepted ground-water discharge.

PLANS NEXT YEAR: Complete report writing and submit the report for Director's approval.

Simulation of Ground-Water Flow on the Massachusetts Military Reservation

PROJECT CHIEF:
John P. Masterson

PERIOD OF PROJECT:
October 1991 to September 1996

COOPERATOR(S): National Guard Bureau

PROBLEM: An understanding of the interaction of factors affecting ground-water flow, including recharge, pumping, aquifer structure and properties, and hydrologic boundaries is required to address issues of ground-water supply and contamination on the Massachusetts Military Reservation (MMR). Because ground-water flow models can integrate these factors, they are valuable tools for addressing MMR concerns. Additionally, the well-defined hydrologic system and several contaminant plumes at MMR provide an unique opportunity to field test recently developed modeling techniques.

OBJECTIVE: To determine ground-water-flow rates, directions, and fluid particle flowpaths within the Cape Cod aquifer beneath and near the Massachusetts Military Reservation.

APPROACH: (1) Develop a three-dimensional flow model of the aquifer near and within the MMR, using available hydrogeologic data. (2) Collect additional hydrogeologic data to address specific questions or to decrease model uncertainty if the need arises. (3) Calibrate the model to observed ground-water levels, measured streamflows, and contaminant plume paths. (4) Address questions of ground-water supply and contaminant migration within Massachusetts Military Reservation using model and particle tracking.

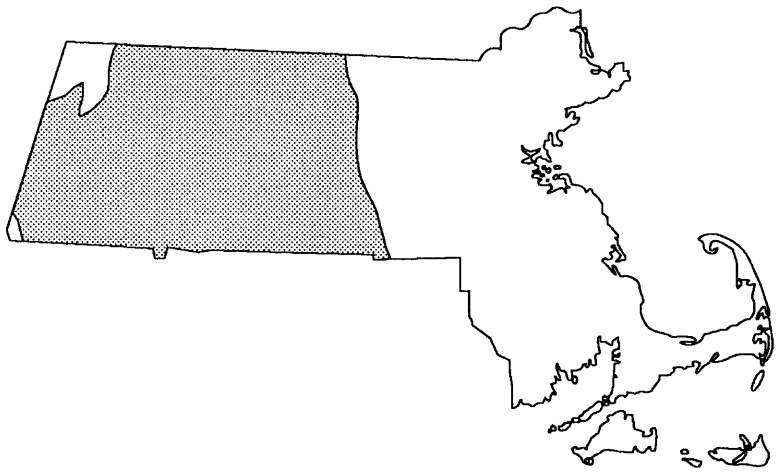
PROGRESS: All existing hydrogeologic data has been inventoried. Lithologic sections have been constructed to characterize the hydrogeology of the study area.

PLANS NEXT YEAR: Complete model scenario runs for analysis of the effects of simulated hydrogeologic conditions on ground-water flow and contaminant transport in the vicinity of the Massachusetts Military Reservation. Conduct geophysical logging on deep borings in the vicinity of the Massachusetts Military Reservation to aid in the interpretation of the hydrogeology. Finalize hydrogeologic cross-sections and describe in a separate map report. Use advanced visual system computer graphics to illustrate the results of the modeling investigation. Construct a water-table map from the synoptic water level, pond elevation and streamflow measurements from March 22-25, 1993.

Connecticut, Housatonic, and Thames River Basins National Water Quality Assessment Study

PROJECT CHIEF:
Stephen P. Garabedian

PERIOD OF PROJECT:
Continuous since October 1991



FUNDING SOURCE: USGS National Water Quality Assessment

PROBLEM: The protection and enhancement of the quality of the nation's surface water and ground water resources is a high priority. Effective management of these resources requires information on current water quality conditions and trends. There also are regional and local needs for information on water-quality conditions in order to address specific problems. Regional concerns include, but are not limited to, water-quality problems arising from industrial, municipal, and agricultural activities.

OBJECTIVE: (1) Provide a nationally consistent description of current water quality conditions for the Connecticut, Housatonic, and Thames River Basins. (2) Define long-term trends (or lack of trends) in water quality. (3) Identify, describe, and explain, to the extent possible, the major factors that affect observed water quality conditions and trends. (4) Develop a regional water-quality sampling network and related activities which addresses local needs for water-quality information.

APPROACH: Existing water quality information will be identified, compiled, reviewed, and analyzed to characterize past conditions and problems, and to help in the design of water quality sample collection activities. Fixed station and synoptic sampling networks will be developed to address specific water quality information needs. Intensive sampling will be used for the characterization of water quality conditions. Project data analysis will include both statistical and modeling approaches, and will be summarized in reports. A low intensity sampling phase will follow to allow for long-term monitoring and identification of water-quality trends.

PROGRESS: A review of the existing information and literature indicated that detectable concentrations of the pesticides atrazine and ethylenedibromide were detected in ground water underlying agricultural areas in the study unit. Trends of increasing nitrite plus nitrate concentrations were detected at five surface-water quality stations in the study unit. Trends of decreasing ammonia concentrations were detected at 11 surface-water quality stations. Trends of decreasing total phosphorus concentrations were detected in 13 stations and dissolved phosphorus at 12 stations, respectively. In general, water-quality conditions at surface-water sites draining urban and forested areas were well represented, but water-quality conditions in agricultural areas were not well characterized.

PLANS NEXT YEAR: Initiate two phases of the project: (1) retrospective analysis of existing information and (2) reconnaissance-sampling effort. The retrospective analysis includes components for the environmental setting, pesticides, nutrients, sediments, metals, and biological assessments. The reconnaissance-sampling effort includes personnel training, identification of equipment needs, and collection of critical water-quality information needed for the planning of the intensive sampling phase.

COMPLETED REPORTS:

Grady, S.J., and Garabedian, S.P., 1991, National water-quality assessment program—The Connecticut River and Long Island Sound Coastal Rivers: U.S. Geological Survey Open-File Report 91-159, 1 sheet.

Hydrogeological Technical Assistance to USEPA Waste Management Division, Region I, Boston, Massachusetts

PROJECT CHIEF:
Forest P. Lyford

PERIOD OF PROJECT:
Continuous since October 1991

COOPERATOR(S): U.S. Environmental Protection Agency, Waste Management Division

PROBLEM: Hydrogeological technical assistance is needed by the U.S. Environmental Protection Agency (USEPA), Region I, Waste Management Division, for ongoing project work at New England Superfund sites. The Waste Management Division of USEPA is faced with the task of understanding complex hydrologic environments in order to propose remedial action at hazardous waste sites.

OBJECTIVE: Provide technical assistance and consultation to USEPA on matters pertaining to geology, hydrology, and water quality.

APPROACH: U.S. Geological Survey personnel will offer advice to USEPA site managers on proper scopes of technical work at Superfund sites. The work will also include review of remedial investigation/feasibility studies (RI/FS), workplans, technical summaries, and final drafts for technical content and accuracy. U.S. Geological Survey personnel will also participate in technical meetings and negotiations with USEPA contractors and responsible parties. The U.S. Geological Survey will do investigations, as requested by USEPA, to help fulfill the goals of the Superfund Program. Activities by U.S. Geological Survey may include borehole logging, surface geophysical surveys, aquifer testing, and hydrologic analysis of Superfund sites.

PROGRESS: Geohydrologic studies were continued or initiated at three Superfund sites: Gallups Quarry, Plainfield, Connecticut; Durham Meadows, Durham, Connecticut; and Saco Landfill, Saco, Maine. Surface geophysical surveys and streamflow monitoring were done at the Gilson Road Superfund site, Nashua, New Hampshire. Borehole geophysical logging and surface geophysical surveys were done at the New Hampshire Plating Superfund Site, Merrimack, New Hampshire. Wells were installed in a pond near the Ottati and Goss Superfund site to monitor water-quality trends below the pond. Water levels were monitored at the Saco Tannery Waste Pits Superfund site in Saco, Maine, and low-flow statistics were computed for Quiggle Brook near the Union Chemical Superfund site in South Hope, Maine. Borehole geophysical logging and surface geophysical surveys were done at the Savage Well Superfund site in Milford, New Hampshire. Borings for water-quality sampling were also installed.

A report "Geohydrological Reconnaissance of the Gallup's Quarry Superfund Site, Plainfield, Connecticut" by R. L. Melvin, J.R. Stone, P.A. Craft, and J.W. Lane, Jr., has been approved by the Director for publication. U.S. Geological Survey personnel reviewed 24 documents for USEPA for technical adequacy.

PLANS NEXT YEAR: Continue to review documents and attend meetings as requested by USEPA. Complete geohydrologic studies at Durham Meadows and Saco Landfill sites. Initiate a new study at another site to be specified by USEPA. Provide modeling support for design of a ground-water remediation program at the Savage Well site, Milford, New Hampshire.

COMPLETED REPORTS:

Izbicki, J.A., and Parker, G.W., 1991, Water depth and thickness of sediments in reservoirs 1 and 2, Framingham and Ashland, Massachusetts: U.S. Geological Survey Open-File Report 91-508, 1 p.

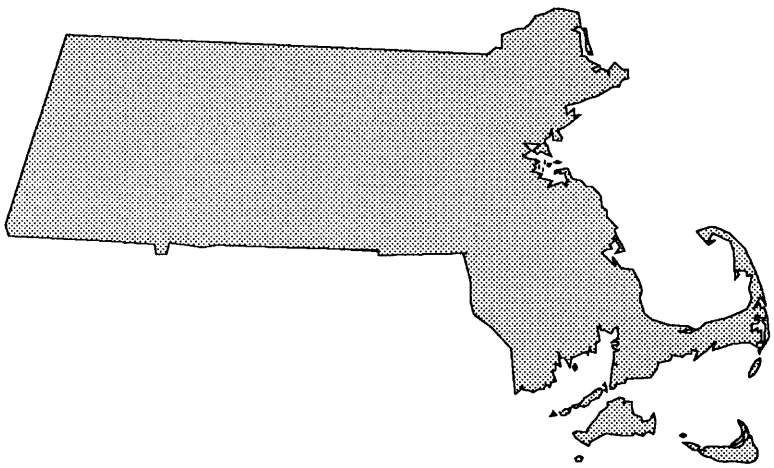
Hansen, B.P., 1993, Results of geophysical surveys at Hocomonco Pond, Westborough, Massachusetts: U.S. Geological Survey Open-File Report 92-646, 19 p.

Hansen, B.P., 1993, Locations of fracture intervals inferred from borehole logs of eight wells at the Holton Circle Superfund Site, Londonderry, N.H.: U.S. Geological Survey Open-File Report 92-647, 33p.

Assessment and Evaluation of Stream Stability and Scour at Bridges in the Commonwealth of Massachusetts

PROJECT CHIEF:
Gene W. Parker

PERIOD OF PROJECT:
July 1992 to September 1997



COOPERATOR(S): Massachusetts Highway Department

PROBLEM: Bridge failures over water are caused primarily by scour and channel instability. Inadequate knowledge and understanding of scour at bridges increases public risk. Scour processes include local scour, contraction scour, and channel instability. These processes are functions of interrelated factors which must all be analyzed to conduct a complete scour evaluation at a bridge site. The Massachusetts Highway Department (MHD) has identified 2,408 bridges in Massachusetts that span water.

OBJECTIVE: (1) Overall bridge assessment phase (at 2, 408 bridges): (a) assess overall channel stability and map and archive channel stability characteristics, (b) identify bridge sites with potential stream stability and scour problems, and (c) identify bridge sites with observable scour problems. (2) Evaluation phase (at 100 selected bridge sites): (a) develop or update regional equations for estimating peak flows, and (b) evaluate scour potential and channel stability during 100-year and 500-year flood events

APPROACH: The assessments will include both a review of construction records and a field inspection at each bridge site. Quality-assurance protocols will be developed to ensure consistent, accurate assessments. At least 100 bridges with observed or high scour potential will be selected for more detailed evaluation. Equations will be used to estimate the 100-year and 500-year floods at the 100 selected bridges. A calibrated hydraulic model for each selected bridge will be used to estimate water-surface profile and velocities.

PROGRESS: After completing training, 3 full time assessors and 3 part-time assessors completed work on 20 percent of the bridge sites. Two additional full-time assessors have been added to the project staff.

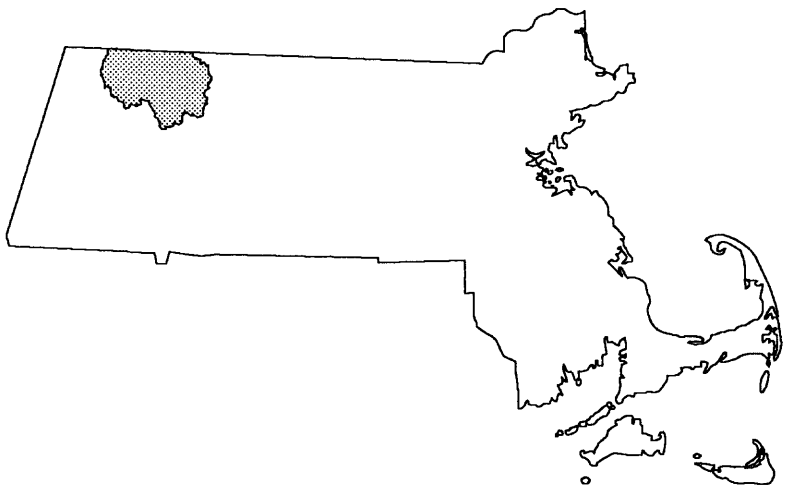
The flood frequency component of the project is on schedule, excluding regression analysis. The regression analysis has been delayed until all peak flow and basin characteristics have been reviewed for all the gaging stations. It is expected that all tasks will be completed on schedule. The stream stability index variables have been approved by both the Massachusetts Highway Department and the USGS. The MHD is developing a technique to convert the index variables into an FHWA I-113 rating.

PLANS NEXT YEAR: Complete stream stability assessments on 75 percent of the bridge sites. Complete flood-frequency analysis and start the report. Complete stream-stability index report and review process. MHD to identify which assessed bridge sites will require level II evaluations. Complete level II evaluations on 10 of the identified bridges.

Ground-Water Resources of the Deerfield River Basin, Massachusetts

PROJECT CHIEF:
Paul J. Friesz

PERIOD OF PROJECT:
October 1992 to June 1996



COOPERATOR(S): Massachusetts Department of Environmental Management

PROBLEM: Information concerning ground-water availability and potential areas favorable for ground-water development is needed by the Massachusetts Department of Environmental Management to develop a basin-management plan for maintaining adequate in-stream water while balancing the needs of potentially competing users in the Deerfield River Basin. In addition, more knowledge is needed of the interactions between ground water and surface water, and between till and bedrock areas of stratified drift deposits.

OBJECTIVES: Revise previously constructed maps of saturated thickness and transmissivity of the stratified-drift deposits. Determine long-term potential yields of the major stratified-drift aquifers and till and bedrock drainage areas. Estimate recharge to stratified drift from the till and bedrock uplands.

APPROACH: The extent, thickness, and transmissive properties of the unconsolidated material will be better defined from: (1) historical data, (2) seismic reflection, (3) seismic refraction, (4) the response of ground-water levels to fluctuations in surface-water stage. Potential yields of selected subbasins will be determined from low-flow measurements. Potential yields from stratified-drift aquifers will be estimated by subtracting potential yields from upgradient till and bedrock areas from estimated subbasin potential yields for sites at the downstream ends of the stratified-drift aquifers. Recharge and its seasonal variability at a till and bedrock and stratified-drift interface will be determined by analyzing data collected from a network of observation wells, surface-water gages, and a precipitation gage.

PROGRESS: A topical outline of the project report was completed and approved by the Northeast Region. Historical hydrologic and geologic data since the last basin study was collected. Streamflow sites were selected and streamflows at low-flow conditions were obtained at these sites. Information from two observation wells, installed in a line perpendicular to the Deerfield River, were used to design a well network for transmissivity measurements. A marine-seismic reflection survey was conducted on the lower Deerfield River in the Connecticut Valley portion of the basin and analyzed to better define lithology.

PLANS NEXT YEAR: Complete an annotated outline of the project report. Estimate aquifer transmissivity from continuous ground-water level data, collected from observation wells that will be installed at a site adjacent to the Deerfield River. Conduct seismic-refraction surveys in the lower Connecticut Valley portion of the basin and analyze for depth to the water table and bedrock. Collect streamflow measurements at low-flow conditions, in addition to last year's measurements, and estimate aquifer yields of stratified-drift aquifers and till and bedrock areas. Design and install a data-collection network. Quantify recharge to stratified drift from upland till and bedrock from data collected from this network.

Fate of Nutrient-Rich Wastewater Plume in a Coastal Marsh, Orleans, Massachusetts

PROJECT CHIEF:
Peter K. Weiskel

PERIOD OF PROJECT:
October 1992 to March 1996

COOPERATOR(S): Massachusetts Department of Environmental Protection, Office of Watershed Management

PROBLEM: The siting of wastewater-treatment facilities in the United States is increasingly constrained by environmental quality considerations. The capacity of coastal-sedimentary environments to attenuate the large, concentrated plumes generated by such facilities may be substantial, but has not been well studied.

OBJECTIVES: (1) Identify zones of ground-water discharge in the Namskaket Marsh/Creek System. (2) Determine the path of the wastewater plume into one or more of these zones. (3) Identify the processes controlling dissolved nitrogen concentrations in Namskaket Creek for a range of time scales. (4) Quantify the effects, if any, of the wastewater plume on nitrogen export from the inland part of the marsh.

APPROACH: Ground-water discharge zones will be located through field investigation of the lithology, salinity, and hydraulic head distribution in the marsh subsurface. The path of the plume will be determined by the installation and sampling of transverse sets of nested wells in the upland. If and when the plume reaches the marsh, additional sets of wells will be installed in the marsh, and a nested piezometer transect will be installed in the plume's long axis. Concentrations of nitrogen species will be determined from semi-monthly water-quality sampling in the creek that drains the marsh, before and after plume discharge. Concentrations will be determined from semi-monthly samplings from March 1993 through March 1995.

PROGRESS: A stage recorder and specific conductance/temperature monitor were installed on Namskaket Creek; the creek water-quality sampling program began. Manual measurements of discharge in the creek were made over numerous tidal cycles, and the relations between conductance, stage, the rate of change of conductance with respect to time, and discharge were determined. Peat thicknesses were measured, cores were collected, and piezometers were installed along a principal marsh transect. A network of shallow, pore-water samplers was installed in the marsh for the delineation of ground-water discharge zones. Numerous wells were installed in the upland between the plume's leading edge and the marsh for the purpose of plume detection and water-table definition.

PLANS NEXT YEAR: Continue baseline surface-water monitoring in Namskaket Creek, biweekly. Continue tracking the movement of the wastewater plume toward the marsh, using borehole geophysics and ground-water sampling of the existing well network. Measure the transport of plume-associated nitrogen, relative to other non-reactive species in the wastewater-contaminated ground water.

Ground-Water and Surface-Water Resources of the Tenmile River Basin, Massachusetts

PROJECT CHIEF:
Lisa Bratton

PERIOD OF PROJECT:
January 1993 to July 1996

COOPERATOR(S): Massachusetts Department of Environmental Management

PROBLEM: Detailed studies on current and potential ground-water and surface-water resources of river basins in Massachusetts are mandated by the Massachusetts legislature's Chapter 800 Act. Tenmile River Basin has had no studies in 20 years. In Massachusetts the surface- and ground-water systems are hydraulically connected and both require study in order to understand the water resources of the river basins.

OBJECTIVES: (1) Characterize the ground-water and surface-water resources of the Tenmile River Basin. (2) Describe the interaction between ground water and surface water in the basin. (3) Estimate aquifer recharge in the basin. (4) Estimate yields for selected till and sand and gravel aquifers in the basin.

APPROACH: An in-house and external literature search, and data retrieval will be done for existing well locations, lithology, surface-water flows and levels, ground-water levels. Seismic-refraction surveys will be done to define aquifer extent, depth, and thickness. Piezometers will be installed at selected sites to study ground-water and surface-water interactions and recharge. A precipitation gage will be installed. Sites will be located at upstream and downstream areas where streams flow over aquifer areas, in order to estimate available ground water.

PROGRESS: Several low-flow measurements were made. Replacement of several piezometers was attempted with cathode and was successful in two out of five sites. Some well and lithologic data were collected from a pump test report by a consultant for Plainville. Several landowners were contacted to place piezometers and about one-half responded. Precipitation gage is ready to be installed.

PLANS NEXT YEAR: Install piezometers at selected sites. Determine the areal extent and depth of the aquifer area in Seekonk using data from the seismic-reflection surveys.

The Transport of Phosphorus to Ashumet Pond, Cape Cod, Massachusetts

PROJECT CHIEF:
Donald A.Walter

PERIOD OF PROJECT:
June1993 to December 1994

COOPERATOR(S): National Guard Bureau

PROBLEM: The disposal of secondarily treated sewage at the Massachusetts Military Reservation has resulted in extensive contamination of the underlying sand and gravel aquifer. The discharge of sewage-contaminated ground water into nearby Ashumet Pond has increased phosphorus concentrations in the pond and may cause the onset of eutrophication. At present, few data exist regarding the geochemical and hydrogeologic controls on transport of phosphorus to the pond.

OBJECTIVES: (1) Determine the extent and geochemical composition of the phosphorus-containing zone of the plume. (2) Describe pond-aquifer interactions and ground-water flow where the plume intersects the pond. (3) Determine the geochemical processes that control the transport of phosphorus to the pond.

APPROACH: The delineation of the phosphorus plume will involve the sampling of existing wells and multi-level samplers as well as the installation and sampling of new wells, multi-level samplers, and drivepoints. Pond-aquifer interactions and local ground-water flow patterns will be determined using both existing and newly installed wells as well as piezometer nests and pond-bottom drivepoints. The geochemical controls on phosphorus transport will be investigated using batch and column tests on aquifer cores.

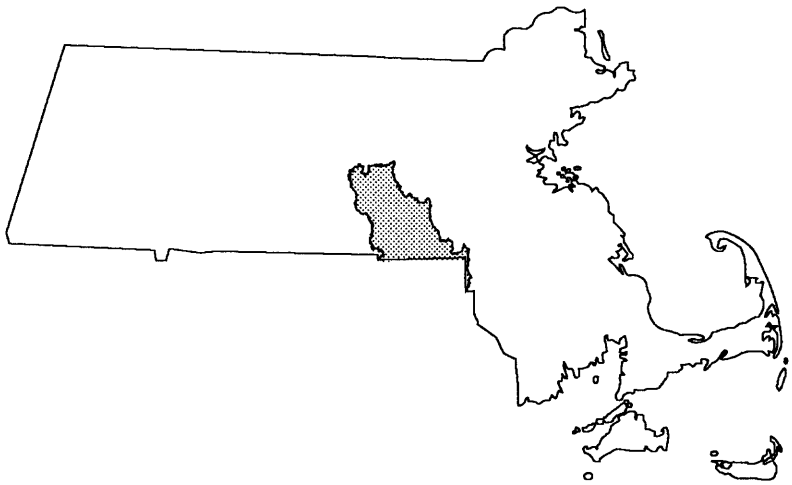
PROGRESS: From June to September 1993, a significant part of the fieldwork was completed. Completed activities included the installation of new wells and multi-level samplers, water-quality sampling of new and existing wells, and the collection of cores for geochemical analysis.

PLANS NEXT YEAR: Complete water-quality and hydrologic-data collection. Interpret field data. Submit a draft of the report by May 1994.

Metal Toxicity Reduction and Dissolved Concentration Control by Organic Material in Massachusetts Streams

PROJECT CHIEF:
John A. Colman

PERIOD OF PROJECT:
October 1992 to September 1993



COOPERATOR(S): Massachusetts Department of Environmental Protection, Division of Water Pollution Control

PROBLEM: Increased scrutiny of water-quality criteria has revealed discrepancies between the U.S. Environmental Protection Agency (USEPA) national aquatic life criteria for metal toxicities and the actual toxicities that are observed in many surface waters. As a result, the USEPA has initiated a program for setting standards on a site-specific basis by comparing toxicities in site waters with those in standard "laboratory" waters. Increases in the legal discharge of metals to streams that the site-specific criteria might allow necessitates research on the mechanism of altering toxicity, the longevity of the alteration, effects of alteration downstream from the site, and a general reconsideration of controls on dissolved metals in the riverine environment. Research aimed at improving the accuracy of predictions of toxicity without the need to complete test organism-toxicity tests at each site also is needed.

OBJECTIVES: (1) Compare the reduction of copper toxicity in river water and in an artificially prepared lab water. (2) Determine whether differences in toxicity can be accounted for by equilibrium speciation considerations with regards to organic and inorganic ligands and the toxic free-ion species. (3) Assess the transferability of the toxicity-study results among rivers by measuring organic-matter and trace-element concentrations and speciation in three effluent-dominated and two pristine Massachusetts rivers. (4) Compare the effect of interactions of metal and organic compounds on the influence of metal organic interactions on the transport and fate of dissolved metals in effluent-dominated and pristine streams.

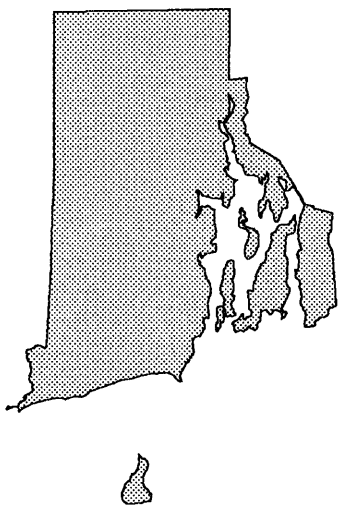
APPROACH: Water samples will be analyzed for dissolved trace metals, major ions, pH, dissolved-oxygen concentration, and alkalinity. Dissolved concentrations of 15 trace metals will be determined by custom analysis at the National Water-Quality Laboratory using ICP-MS analysis. Copper passing through the filter will be considered to be the total dissolved amount. Filtered samples will be brought back to the Marlborough laboratory for copper-ion titrations. Conditional formation constants and equivalent ligand concentrations for the copper-ligand complexes will be determined from the copper titration data by use of the computer program FITEQL. The fulvic-acid portion of the equivalent ligand concentration will be determined by copper titration of the fulvic acids after XAD-column separation.

PROGRESS: River sampling was begun. Analysis of samples and copper titrations of samples were initiated.

Surface-Water Stations

PROJECT CHIEF:
Lansen R. Ramsbey

PERIOD OF PROJECT:
Continuous since February 1929



COOPERATORS: Corps of Engineers; Rhode Island Water Resources Board; Rhode Island Department of Environmental Management

PROBLEM: Surface-water information is needed for purposes of surveillance, planning, design, hazard warning, cooperation, and management, in water-related fields such as water supply, hydroelectric power, flood control, bridge and culvert design, pollution abatement, flood plain management, and water resources development.

OBJECTIVE: A. Collect and publish surface-water data to meet the needs for (1) assessing water resources, (2) operating reservoirs or industries, (3) flow forecasting, (4) disposing of wastes and pollution controls, (5) publishing of discharge data to accompany water-quality measurements, (6) conformity to compact and legal requirements, and (7) research or special studies. B. Collect data necessary for analytical studies to define for any location the statistical properties of, and trends in, the occurrence of water in streams, lakes, and estuaries for use in planning and design.

APPROACH: Water-level data is recorded continuously and monthly into U.S. Geological Survey Ground-Water Site Inventory Database. Standard methods of data collection will be used as described in the "National Handbook of Recommended Methods for Water-Data Acquisition" and Water Resources Division manuals and memorandums.

PROGRESS: Data for 16 stations for Water Year 1991 were published. Data for Water Year 1993 are in the process of being compiled for 15 continuous record stations. Continuous record at the Nipmuc River at Harrisville has been restarted and a new station, the Catamint, has been added.

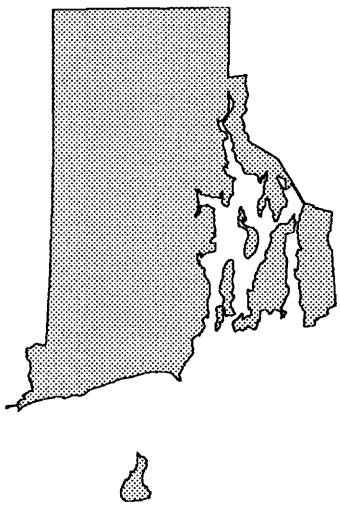
PLANS NEXT YEAR: Continue renovations or replacements of additional cableways, including renovations at a Federally funded station needed for National Water Quality Assessment sampling. Begin a new program with the University of Rhode Island (URI). Make four discharge measurements at each of six sites along the Blackstone River in order to develop stage-discharge ratings. These ratings are needed by URI to obtain discharges for water quality samples taken during storm events. Replace at least two mercury manometers in 1993.

COMPLETED REPORTS: This project contributes to the annual report "Water Resources Data—Massachusetts and Rhode Island." Data on stream discharge and stage and on lake or reservoir contents, through September 1960, were published annually under the title "Surface-Water Supply of the United States, Parts 1A and 1B." For the 1961 through 1970 water years, the data were published in two 5-year reports.

Ground-Water Stations

PROJECT CHIEF:
Lansen R. Ramsbey

PERIOD OF PROJECT:
Continuous since December 1944



COOPERATOR: Rhode Island Water Resources Board

PROBLEM: Long term water level records are needed to evaluate the effects of climatic variations on the recharge to and discharge from the ground-water systems, to provide a data base from which to measure the effects of development, to assist in the prediction of future supplies, and to provide data for management of the resource.

OBJECTIVE: Collect water-level data so that the general response of the hydrologic system to natural and induced stresses is known, and potential problems are identified to allow proper planning and management. Provide a data base against which the short-term records acquired in areal studies can be analyzed. This analysis must (1) provide an assessment of the ground-water resources, (2) allow prediction of future conditions, and (3) provide the data base necessary for management of the resource.

APPROACH: Water-level data is recorded continuously and monthly into U.S. Geological Survey Ground-Water Site Inventory Database. Standard methods of data collection will be used as described in the National Handbook of Recommended Methods for Water-Data Acquisition" and Water Resources Division manuals and memorandums.

PROGRESS: Water levels were monitored in a statewide network of 40 wells, which included 11 new wells drilled in till. Water levels in four of the wells were measured continuously, the rest were measured monthly with a steel tape.

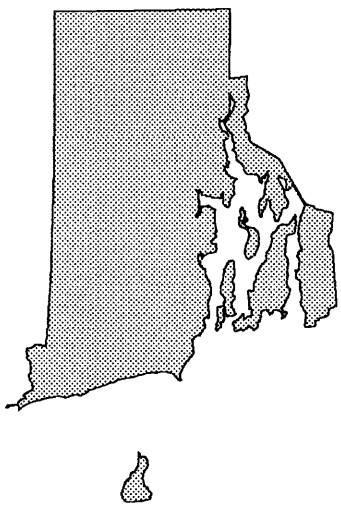
PLANS NEXT YEAR: Measurements will continue to be made in 29 of the wells. One well will be dropped because water levels are regularly above the top of casing. The eleven new wells will be added to the network bringing the total to 40 wells.

COMPLETED REPORTS: This project contributes to the annual report "Water Resources Data—Massachusetts and Rhode Island." Records of ground-water levels for the 1939 through 1974 water years were published under the title "Ground-Water Levels in the United States." on an annual basis. Beginning with the 1975 water year, the report title was changed to "Water Resources Data—Massachusetts and Rhode Island, (water year)."

Quality of Water Stations

PROJECT CHIEF:
Gerald G. Girouard

PERIOD OF PROJECT:
Continuous since November 1961



COOPERATOR: Rhode Island Department of Environmental Management

PROBLEM: Water resource planning and water-quality assessment require a nationwide base level of relatively standardized information. For intelligent planning and realistic assessment of the water resource, its chemical and physical characteristics must be defined and monitored.

OBJECTIVE: To provide the State with water-quality information on the major rivers in Rhode Island, to provide a national bank of water-quality data for broad federal planning and actions programs, and to provide data for federal management of interstate waters.

APPROACH: Operate a network of water-quality stations to provide average chemical concentrations, loads, and time trends as required by planning and management agencies.

PROGRESS: Six sites were added to the data collection network in September, 1990. These sites, which include two National Stream Quality Accounting Network (NASQAN) sites at which only supplemental sampling was done, were sampled monthly for nutrients, bacteria, temperature, pH, dissolved oxygen, and specific conductance; twice yearly for common constituents, trace metals, and organic compounds; and yearly for organic chemicals in bottom materials. The sites are the Blackstone River at Millville (01111230), Branch River at Forestdale, RI (01111500), Blackstone River at Manville, RI (01112900), Pawtuxet River at Cranston, RI (01116500), Pawtuxet River at Pawtuxet, RI (01116617), and the Pawcatuck River at Westerly, RI (01118500). Data collection at these sites were previously conducted under projects RI 79-016, RI 84-020, and RI 88-025. Specific conductance and temperature of streamflow were monitored continuously at the USGS gage on the Wood River at Hope Valley.

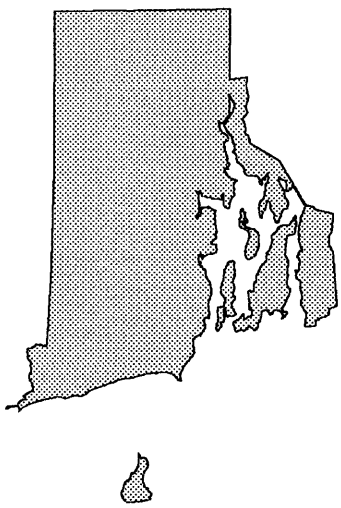
PLANS NEXT YEAR: Continue sampling at all sites. Project chief, subdistrict chief, and water-quality specialist to continue to work with the cooperator to adjust the sampling to better meet the State's needs. Publish all data in the annual Water Resources Data Report for Massachusetts and Rhode Island.

COMPLETED REPORTS: This project contributes to the annual report "Water Resources Data—Massachusetts and Rhode Island." Data on chemical quality, temperature, and suspended sediments for the 1941 through 1970 water years were published annually under the title "Quality of Surface Waters of the United States."

Water Use

PROJECT CHIEF:
Michael J. Horgan

PERIOD OF PROJECT:
Continuous since October 1979



COOPERATOR: Department of Environmental Management, Narragansett Bay Commission, Providence Water Supply Board

PROBLEM: In Rhode Island, the demand for water resources is increasing. Competition for diverse water uses dictates that available supplies are matched with optimum uses. Information is currently being obtained to describe quantity and quality of available water, but little information is being obtained to describe water use. Adequate information on uses of water is needed by the cooperators to resolve problems with respect to water-quality enhancement, environmental impact of water withdrawals and diversions, and resource allocations for supply and waste transport.

OBJECTIVE: Water use information will be provided to optimize the utilization and management of Rhode Island water resources. This program will develop and operate a system to collect, store, and disseminate water-use data. The system will be responsive to the data needs of local users, the Geological Survey, and other Federal agencies.

APPROACH: Together, the cooperators and the USGS will (1) identify and document water-use data requirements; (2) compile and evaluate water-use data; (3) develop new methods to collect data; and (4) analyze and enter data into the New England Water-Use Data System (NEWUDS). Data will be available to the cooperators in computer format and will be presented as published reports at appropriate intervals.

PROGRESS: Site specific data on wastewater-treatment systems were compiled, analyzed, evaluated, and entered into NEWUDS. Work began on the report "Wastewater collection and return flow in New England, 1990." Work continued on the report "Estimated Use of Water in New England, 1990." The report "Estimation of water withdrawal and distribution, water use and wastewater collection and return flow in Cumberland, Rhode Island, 1988" received Directors approval and is being prepared for publication. The water-use map report based on the 1990 Rhode Island water-use compilation received Directors approval and is being prepared for publication.

PLANS NEXT YEAR: Compile, analyze, evaluate, and enter into NEWUDS site-specific data on Rhode Island public-supply systems. Hold workshop on industrial water use to help USGS and cooperator personnel understand the processes and data availability of industrial water use. Begin compilation of industrial water-use data. Obtain approval and publish a report on wastewater collection and return flow in New England. Obtain Director's approval and publish an interpretative report on water use in New England. Begin preparation of a report on public water-supply and distribution in New England.

COMPLETED REPORTS:

Horn, M.A., and Craft, P.A., 1991, Plan for developing a water-use data program in Rhode Island: U.S. Geological Survey Water-Resources Investigations Report 90-4207, 26 p.

Ground-Water Appraisal of Block Island, Rhode Island

PROJECT CHIEF:
Position Vacant

PERIOD OF PROJECT:
October 1987 to September 1991

COOPERATOR: Town of New Shoreham

PROBLEM: Private and public wells draw water from unconsolidated deposits to supply drinking water for Block Island. Local officials and residents want to protect their water resource from contamination. Available geologic and hydrologic information is not sufficiently detailed to allow determination of how best to develop the island's supply of fresh ground water or how best to protect the quality of this water.

OBJECTIVE: (1) Assess the chemical quality of freshwater resources on Block Island. (2) Document significant changes in quality that may have occurred since a 1964 USGS appraisal of water quality on the Island. (3) Determine the approximate recharge areas to ponds that serve as sources of public water supply. (4) Obtain additional data on the vertical and lateral distribution of hydraulic head and other geohydrologic information needed to develop plans for management of the island's freshwater resources.

APPROACH: Water samples from wells and ponds will be analyzed for major inorganic constituents. Clusters of three small-diameter test wells will be drilled at six sites and lithologic samples will be collected and studied. Water levels will be measured in test wells and existing private and public wells. Electromagnetic, radar, and reflection geophysical surveys will be conducted to aid in mapping stratigraphy, salt-water interface and water table. This information will be used to describe the ground-water-flow system.

PROGRESS: Data analysis and report writing were completed. The water-table map and the data report were approved. Project is complete except report.

PLANS NEXT YEAR: Incorporate revisions from colleague reviewers into technical report and submit report for Director's approval.

Development Alternatives in the Usquepaug-Queen Ground-Water Reservoir, Rhode Island

PROJECT CHIEF:
David C. Dickerman

PERIOD OF PROJECT:
October 1988 to September 1995

COOPERATOR: Rhode Island Water Resources Board

PROBLEM: The Usquepaug-Queen aquifer is one of five aquifers in the Pawcatuck River basin in which the State is testing and purchasing well sites for future use. Improper location and operation of wells could cause substantial lowering of water levels in the aquifer, in overlying ponds and swamps, and could cause undesirable depletion of low streamflow. There is potential for ground water contamination by pesticides applied to fields overlying the aquifer. There is also potential for interbasin transfer of ground water between subbasins in the Pawcatuck River basin.

OBJECTIVE: Assess the impacts of alternative development schemes on water levels and streamflow. Identify areas of stratified drift contributing water to selected wells. Determine the present quality of ground water and surface water.

APPROACH: Lithologic logs, well construction data, and aquifer tests available from 1960 to 1990 will be analyzed to assess hydraulic characteristics of the aquifer. These and other data will be used to modify maps of the water table, bedrock surface, saturated thickness, and hydraulic conductivity of the stratified-drift aquifer. Monthly water-level data in 43 observation wells and at 11 stream sites will be used to calibrate the ground-water-flow model. The USGS modular ground–water-flow model (MODFLOW), with the stream package, will be used to assess the impacts of alternative development schemes. Areas of stratified drift that contribute water to selected wells will be delineated using a USGS particle-tracking algorithm MODPATH. Present quality of ground water and surface water will be determined and changes in chemical quality between 1958 and 1990 will be assessed. Ground water downgradient from commercially cultivated fields and along main highways will be sampled to monitor changes in ground-water quality caused by the application of fertilizer to turf and de-icing salt to road surfaces.

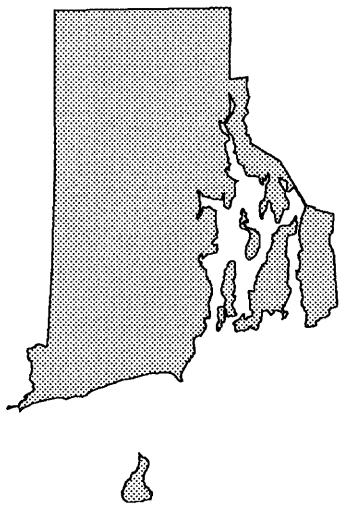
PROGRESS: Topical and annotated outlines approved by Northeast Region. The bedrock contour map was completed. The ground-water-flow model design and grid were completed and assembly of GIS data for the model was begun. Water samples were collected from 17 stream sites and 34 wells.

PLANS NEXT YEAR: Complete data report, submit for supervisory review during January 1994 and have Director's approval by April 29, 1994. Publish data report before the end of FY94. Complete ground-water-flow models runs and analysis of results for the steady state and transient conditions. Complete 75 percent of the text for the interpretive report.

Estimating Maximum Water-Table Elevations at Proposed Sites for Individual Sewage Disposal Systems

PROJECT CHIEF:
Roy S. Socolow

PERIOD OF PROJECT:
January 1990 to September 1991



COOPERATOR: Rhode Island Department of Environmental Management

PROBLEM: The Rhode Island Department of Environmental Management (RIDEM) requires that maximum water-table elevations be estimated at proposed sites for individual sewage disposal systems (ISDS). At most sites, estimates must be made by measuring water levels in wells and pits during the "wet season" (usually January through April) which is declared annually by RIDEM. RIDEM officials are seeking a scientifically defensible method for determining when to declare the "wet season" and for estimating long-term maximum elevations at proposed ISDS sites.

OBJECTIVE: To (1) develop statistical relationships, based on long-term USGS observation well data, that will assist in determining probable high water levels, (2) formulate a method for predicting long-term maximum altitude of the water table in different geologic and topographic settings throughout the State, and (3) prepare a "how to" guide for estimating water levels that will be suitable for use by State and local officials, engineers, and builders.

APPROACH: Periodic measurements of water-levels available for about 180 USGS observation wells in Rhode Island for periods ranging from one to 45 years will be examined to determine their suitability for providing representative data for areas of different geologic and topographic settings. Several long-term observation wells will be selected as index wells. Methodology developed for a USGS study to predict long-term water-level altitudes in Massachusetts will be modified to apply to conditions in Rhode Island. Selected criteria and probability or frequency analysis of current water-level data will be used to evaluate whether current monthly water-level conditions are suitable for making "wet season" measurements.

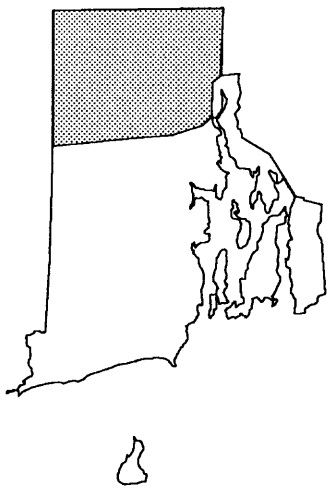
PROGRESS: Seven wells in till were located and measured monthly. These data were included in the analysis of probable ground-water level network. Revisions were made to the report in response to technical reviewers, district chiefs, and editorial comments. Project is complete except for report.

PLANS NEXT YEAR: Obtain Director's approval by March 1994 and publish report by September 1994.

Low-Flow Characteristics of Streams In Selected Water Supply Basins in Rhode Island

PROJECT CHIEF:
John D. Kliever

PERIOD OF PROJECT:
May 1993 to September 1995



COOPERATOR: Rhode Island Department of Environmental Management and City of Providence Water Supply Board

PROBLEM: Low-flow characteristics of streams are important elements in the planning and managing of water resources. Low-flow duration estimates provide an appropriate starting point for formulation of surface-water and ground-water basin-yield estimates. Only 15 continuous-record streamflow-gaging stations are currently operating in Rhode Island. In addition, planners and managers frequently need to know low-flow characteristics of streams at ungaged locations.

OBJECTIVE: The objective of this study is to provide estimates of low-flow characteristics of streams in selected water-supply basins in Rhode Island.

APPROACH: Four continuous-record, streamflow-gaging stations and 19 partial-record sites will be established in basins that are crucial to water-supply management because of the large number of people served. Estimated low-flow-duration curves at the partial-record stations for the range 50-99 percent will be made from the flow-duration curves at index stations. Median daily flows for the months of August, February, April, and May will be determined for the index stations and estimated for the partial-record sites. The new continuous-record sites will be treated the same as partial-record sites for these analyses.

PROGRESS: Nineteen partial record sites were established. Two continuous record sites were established. Ninety discharge measurements were made.

PLANS FOR NEXT YEAR: Establish two continuous record sites. Continue discharge measurements. Complete data analysis and write first draft of a Water-Resources Investigations Report.

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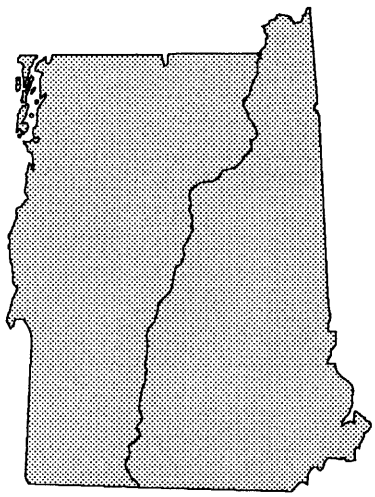
New Hampshire/Vermont District



COOPERATORS

New Hampshire

New Hampshire Department of Environmental Services,
Water Resources Division

New Hampshire Department of Environmental Services,
Water Supply and Pollution Control Division
Biology Bureau

Town of Lincoln

U.S. Environmental Protection Agency
Waste Management Division

Vermont

Vermont Department of Environmental Conservation,
Agency of Natural Resources, Solid Waste Division

Vermont Department of Environmental Conservation,
Public Water Supply Division

Vermont Department of Environmental Conservation,
Solid Waste Management Division

Vermont Department of Environmental Conservation,
Water Quality Division

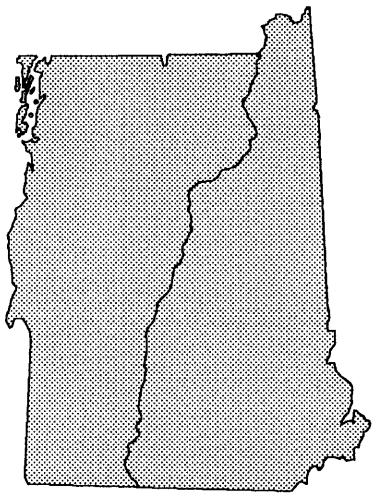
U.S. Environmental Protection Agency
Waste Management Division

- PAGE 109 FOLLOWS

Surface-Water Stations

PROJECT CHIEF:
Kenneth W. Toppin

PERIOD OF PROJECT:
Continuous since July 1904



COOPERATOR(S): New Hampshire Department of Environmental Services, Water Resources Division; Vermont Department of Environmental Conservation, Agency of Natural Resources

PROBLEM: Surface-water information is needed for the purpose of surveillance, planning, design, hazard warning, operation, and management in water-related fields such as water supply, hydroelectric power, flood control, bridge and culvert design, pollution abatement, flood-plain management, and water-resources development. To provide this information, an appropriate data base is necessary.

OBJECTIVE: Collect and publish surface-water data to meet the needs for (1) assessment of water resources, (2) operation of reservoirs or industries, (3) flow forecasting, (4) disposal of wastes and pollution, (5) publication of discharge data to accompany water-quality measurements, (6) conformity to compact and legal requirements, and (7) research or special studies. Collect data necessary for analytical studies to define, for any location, the statistical properties of and trends in the occurrence of water in streams, lakes, estuaries, etc., for use in planning and design.

APPROACH: Stage and discharge of streams and stage and contents of lakes and reservoirs will be measured and recorded. Standard methods of data collection will be used as described in the series, "Techniques of Water-Resources Investigations of The United States Geological Survey." Partial-record data will be collected instead of continuous-record data when it serves the required purpose.

PROGRESS: In New Hampshire, 32 continuous-record streamflow stations, one continuous lake station, and 18 partial-record stations were operated and records were collected. In Vermont, 34 continuous-record streamflow stations, 3 continuous lake stations, and 4 partial-record stations were operated and records were collected. Records for both States were published in the annual water-data report.

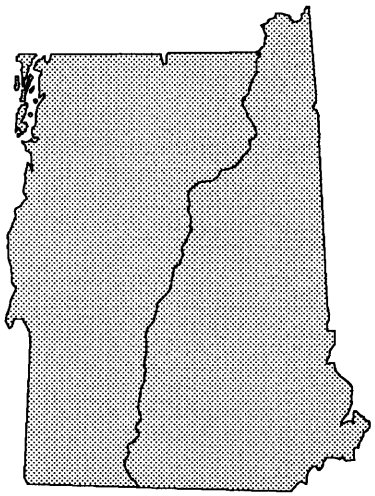
PLANS NEXT YEAR: In New Hampshire, continue same operation, including one new continuous-record station. In Vermont, continue same operation.

COMPLETED REPORTS: This project contributes to the annual report "Water Resources Data—New Hampshire and Vermont." Data on stream discharge and stage and on lake or reservoir contents, through September 1960, were published annually under the title "Surface-Water Supply of the United States, Parts 1 and 4." This series of annual reports for New Hampshire and Vermont began with the 1961 water year with a report that contained only data relating to the quantities of surface water and published as "Water Resources for Massachusetts, New Hampshire, Rhode Island, and Vermont." For the 1961 through 1970 water years, the data were published in two 5-year reports.

Ground-Water Stations

PROJECT CHIEF:
Kenneth W. Toppin

PERIOD OF PROJECT:
Continuous since January 1944



COOPERATOR(S): New Hampshire Department of Environmental Services, Water Resources Division; Vermont Department of Environmental Conservation, Agency of Natural Resources

PROBLEM: Long-term water level records are needed to evaluate the effects of climatic variations on the recharge to and discharge from the ground-water systems, to provide a data base from which to measure the effects of development, to assist in the prediction of future supplies, and to provide data for management of the resource.

OBJECTIVE: Collect water level data sufficient to provide a long-term base. In this way, the general response of the hydrologic system to natural climatic variations and induced stresses is known, and potential problems can be defined early in order to allow proper planning and management. Provide a data base against which the short-term records acquired in aerial studies can be analyzed. This analysis must (1) provide an assessment of the ground-water resources, (2) allow prediction of future conditions, and (3) provide the data base necessary for management of the resource.

APPROACH: Ground-water-level data will be recorded, analyzed, and published annually. Standard methods of data collection will be used as described in the "National Handbook of Recommended Methods for Water-Data Acquisition" and Water Resources Division Manuals and Memoranda.

PROGRESS: In New Hampshire, monthly water-level data from 13 wells were obtained. In Vermont, monthly water-level data from 14 wells were obtained.

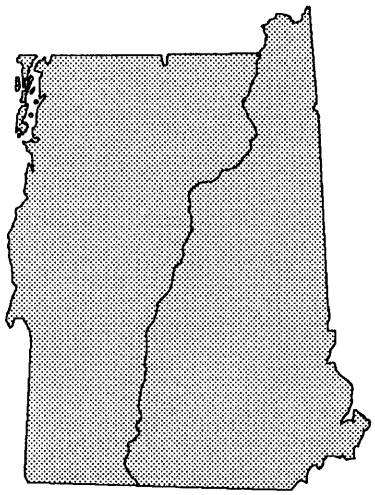
PLANS NEXT YEAR: Continue existing operation in New Hampshire and Vermont.

COMPLETED REPORTS: This project contributes to the annual report "Water Resources Data—New Hampshire and Vermont." Records of ground-water levels for the 1939 through 1974 water years were published under the title "Ground-Water Levels in the United States." on an annual basis. Beginning with the 1975 water year, the report title was changed to "Water Resources Data—New Hampshire and Vermont (water year)."

Quality of Water Stations

PROJECT CHIEF:
Kenneth W. Toppin

PERIOD OF PROJECT:
Continuous since July 1969



FUNDING SOURCE: USGS National Stream Quality Accounting Network

PROBLEM: Water-resources planning and water-quality assessment requires a nationwide base level of relatively standardized information. For intelligent planning and realistic assessment of the water resource, the chemical and physical quality of the water resource must be defined and monitored.

OBJECTIVE: Provide a State and National bank of water-quality data for broad Federal planning and action programs, and to provide data for Federal management of interstate and international waters, and for State management of intrastate waters.

APPROACH: Water-quality stations are operated to provide chemical concentrations, loads, and time trends as required by planning and management agencies.

PROGRESS: In New Hampshire, one site was sampled. In Vermont, one site was sampled. Data will be published in the annual water-data report.

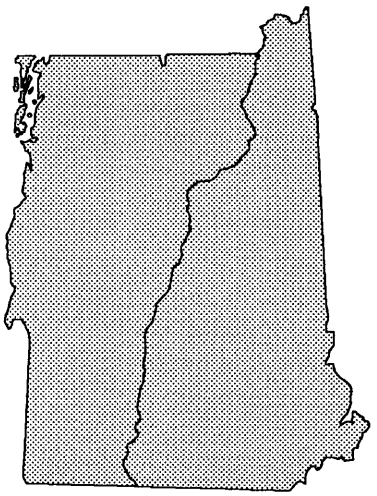
PLANS NEXT YEAR: Continue same operation in New Hampshire and Vermont, depending upon available funding.

COMPLETED REPORTS: This project contributes to the annual report "Water Resources Data—New Hampshire and Vermont." Data on chemical quality, temperature, and suspended sediments for the 1941 through 1970 water years were published annually under the title "Quality of Surface Waters of the United States."

New Hampshire and Vermont Water-Use Data Management Program

PROJECT CHIEF:
Laura Medalie

PERIOD OF PROJECT:
Continuous since October 1983



COOPERATOR(S): New Hampshire Department of Environmental Services, Water Resources Division; Vermont Department of Environmental Conservation, Public Water Supply Division

PROBLEM: The water resources in New Hampshire and Vermont are increasingly stressed by new demands. Competition for water necessitates that available supplies be matched with optimum uses and that demands for greater protection of both water quality and quantity be addressed. Some information is being obtained to describe the quantity and quality of available supplies, but relatively little information is being obtained to describe water use. Without adequate information on uses of water, decision makers cannot resolve many critical water problems, such as water-quality residuals, environmental impact, energy development, and resources allocation.

OBJECTIVE: (1) Provide water-use information for the optimum utilization and management of New Hampshire's and Vermont's water resources for the overall benefit of the States' residents. (2) Provide guidance to the State in the collection, analysis, computer entry, and dissemination of water-use data to complement data on availability and quality of the States' water resources. (3) Respond to data needs of State agencies, U.S. Geological Survey (USGS), and other Federal agencies.

APPROACH: Responsibilities will be divided between the cooperator and the USGS to most efficiently accomplish the objectives of the program. Water-use data requirements will be identified and documented; water-use data collected by local, State, and Federal agencies will be compiled and evaluated; methods will be developed to collect data not already available from these agencies; and data will be analyzed and entered into the USGS New England Water-Use Data System (NEWUDS). A communications interface will be developed between the States' computers and those of the USGS. Data will be available to the States in computer format and will be presented as published reports at appropriate intervals.

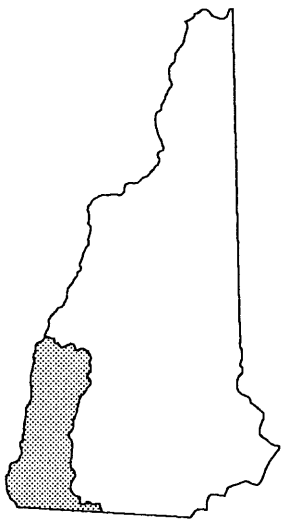
PROGRESS: Workshops on wastewater-disposal systems and public-supply systems were held. Site-specific data on wastewater-treatment systems were compiled, analyzed, evaluated, and entered into NEWUDS. The water-use map reports based on the 1990 water-use compilation for New Hampshire and Vermont were prepared, submitted for colleague review, and modified according to reviewers' comments. Work on a manual describing procedures for compiling, analyzing, and storing data on public wastewater disposal in New England was begun.

PLANS NEXT YEAR: Complete public supply water-use data compilation, analysis and computer entry. Hold an industrial water-use workshop in April and begin industrial water-use data processing. Prepare the first draft of a public-supply report for New England. Publish a map report for each of the six New England States and publish two New England-wide Water-Resources Investigations Reports.

Geohydrology and Water Quality of Stratified-Drift Aquifers in the Lower Connecticut River Basin, Southwestern New Hampshire

PROJECT CHIEF:
Richard B. Moore

PERIOD OF PROJECT:
October 1986 to September 1989



COOPERATOR(S): New Hampshire Department of Environmental Services, Water Resources Division

PROBLEM: Large increases in population in southern New Hampshire have created an increased demand for water supply. Towns and communities are interested in developing additional ground-water supplies and in protecting existing resources.

OBJECTIVE: (1) Describe the geometry and geohydrologic properties of sand and gravel aquifers in the study area. (2) Assess ground-water availability and potential yields of sand and gravel aquifers. (3) Determine background water quality and areal variation of water quality for aquifers in the study area.

APPROACH: A literature search will be completed. Geophysical investigations will be undertaken to determine saturated thickness. Drilling will be done to determine stratigraphy, water-table elevations, and depth to bedrock. Seepage runs will be done to determine ground--water runoff. Aquifer hydraulic conductivity will be estimated. Ground water will be sampled and analyzed. Potential aquifer yields will be estimated with an analytical model.

PROGRESS: The report is camera ready except for plates.

PLANS NEXT YEAR: Publish report in 1994.

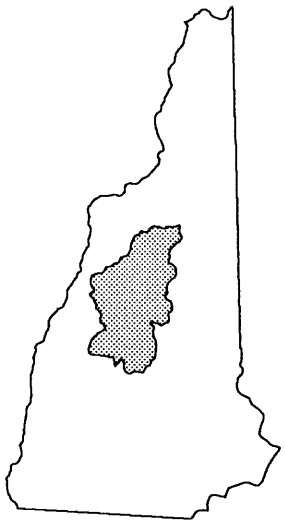
COMPLETED REPORTS:

Moore, R.B., Johnson, D.D., Ott, E.D., Geohydrology and water quality of stratified-drift aquifers in the Lower Connecticut River Basin, Southwestern New Hampshire: U.S. Geological Survey Water-Resources Investigations Report 92-4013.

Geohydrology and Water Quality of Stratified-Drift Aquifers in the Pemigewasset River Basin, Central New Hampshire

PROJECT CHIEF:
John E. Cotton

PERIOD OF PROJECT:
April 1987 to September 1990



COOPERATOR(S): New Hampshire Department of Environmental Services, Water Resources Division

PROBLEM: Large increases in population in New Hampshire have caused a greatly increased demand for water supply. Towns and communities are interested in developing additional ground-water supplies and in protecting existing resources.

OBJECTIVE: Describe the geometry and geohydrologic properties of sand and gravel aquifers in the study area. Assess ground-water availability and potential yields of sand and gravel aquifers. Determine background water quality for aquifers in the study area.

APPROACH: Literature search will be done. Geophysical investigations will be done to determine saturated thickness. Drilling will be done to determine stratigraphy, water table elevations, and depth to bedrock. Seepage runs will be done to determine ground-water runoff. Aquifer hydraulic conductivity will be estimated. Ground water will be sampled and analyzed. Potential aquifer yields will be estimated with analytical model.

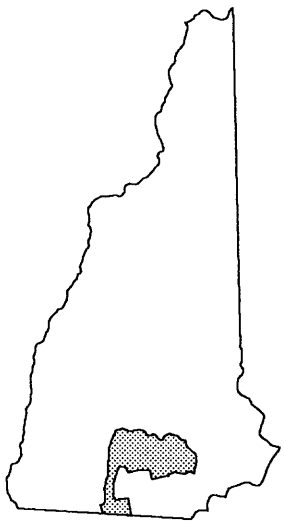
PROGRESS: A revised draft of the report was completed. An editorial review by the Area specialist was done. Plates were redrafted to obtain better paper review copies. Project is complete except report.

PLANS NEXT YEAR: Complete the final report and review process and submit for Director's approval.

Geohydrology and Water Quality of Stratified-Drift Aquifers in the Middle Merrimack River Basin, South-Central New Hampshire

PROJECT CHIEF:
Joseph D. Ayotte

PERIOD OF PROJECT:
October 1987 to September 1990



COOPERATOR(S): New Hampshire Department of Environmental Services, Water Resources Division

PROBLEM: Large increases in population growth and development in southern New Hampshire has led to increased demand for water supply. Communities are interested in identifying aquifers and determining the potential yield and quality of water in the aquifers so that future supplies can be protected.

OBJECTIVE: (1) Describe the physical dimensions and geohydrologic properties of sand and gravel aquifers in the study area. (2) Assess ground-water availability and potential yields of sand and gravel aquifers. (3) Evaluate, for selected aquifers, the hydrologic impacts of ground-water development on water levels and base flow of streams. (4) Determine "background" water quality and areal quality variations in the sand and gravel aquifers.

APPROACH: A literature search will be completed. Geophysical investigations will be undertaken to determine saturated thickness. Drilling will be done to determine stratigraphy, water table elevations, and depth to bedrock. Seepage runs will be done to determine ground--water runoff. Aquifer hydraulic conductivity and transmissivity will be estimated. Ground water will be sampled and analyzed. Potential aquifers yields will be estimated using analytical or numerical models.

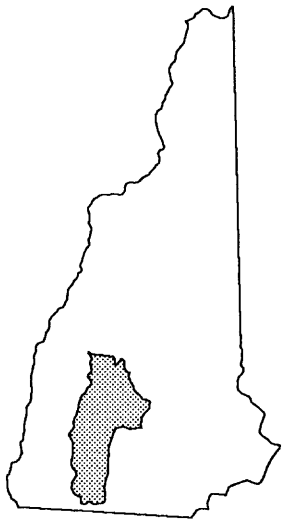
PROGRESS: Report approved by Director. Galley proof complete.

PLANS NEXT YEAR: Publish report in 1994.

Geohydrology and Water Quality of Stratified-Drift Aquifers in the Contoocook River Basin, New Hampshire

PROJECT CHIEF:
Phillp Harte

PERIOD OF PROJECT:
October 1987 to September 1991



COOPERATOR(S): New Hampshire Department of Environmental Services, Water Resources Division

PROBLEM: Rapid population growth and increased development in south central New Hampshire have greatly increased the demand for water supplies. The threat of contamination of water supplies has increased proportionately to development. In the Contoocook River watershed, one site is regulated by the Comprehensive Environmental Response Compensation and Liability Act, 1980 (CERCLA) and eight sites are regulated by Resource Conservation and Recovery Act, 1976 (RCRA). These sites are located in the most populous river valleys which generally also have the highest potential for ground-water resources in stratified-drift aquifers. Towns and communities are concerned with protecting their ground-water resources and developing additional ground water supplies.

OBJECTIVE: (1) Determine the aerial extent and saturated thickness of sand and gravel aquifers in the Contoocook River basin. (2) Describe geohydrologic properties and assess ground water availability and potential yields of sand and gravel aquifers in the study area. (3) Evaluate for selected aquifers, the hydrologic impact of ground-water development on water levels and base flow of streams. (4) Determine background water quality of sand and gravel aquifers.

APPROACH: Existing data on stratigraphy and saturated thickness of stratified-drift aquifers will be compiled. Detail of stratigraphy and saturated thickness will be increased, where appropriate, using data from seismic refraction and test drilling studies. Regional hydrologic system will be defined with results from (a) measurement of water levels in a network of wells to give synoptic and seasonal variations in water table (b) analysis of base-flow recessions in subbasins, and (c) studies of hydraulic properties of the aquifer as determined from pump test and analysis of stratigraphic logs. A well network will be sampled to determine background water quality. Impacts of ground-water development on hydrologic system will be estimated using a numerical model.

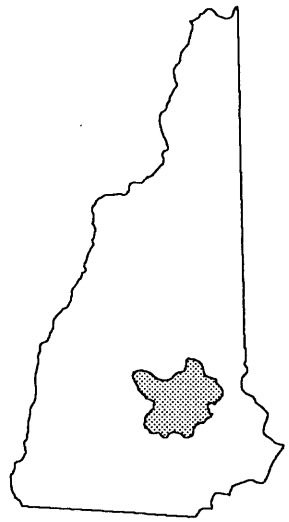
PROGRESS: The report "Geohydrology and water quality of stratified-drift aquifers in the Contoocook River basin, south-central New Hampshire" was approved. All text updates were made and placed into near camera-ready status. Work was started on final illustrations and plates.

PLANS NEXT YEAR: Publish report in 1994.

Geohydrology and Water Quality of Stratified-Drift Aquifers in the Upper Merrimack River Basin, South-Central New Hampshire

PROJECT CHIEF:
Position Vacant

PERIOD OF PROJECT:
October 1988 to September 1991



COOPERATOR(S): New Hampshire Department of Environmental Services, Water Resources Division

PROBLEM: Large increases in population in southern New Hampshire have created increased demands for water supply. Towns and communities are interested in developing additional ground-water supplies and in protecting existing resources

OBJECTIVE: Describe the physical dimensions and geohydrologic properties of sand and gravel aquifers in the study area. Assess ground-water availability and potential yields of sand and gravel aquifers. Evaluate, for selected aquifers, the hydrologic impacts of ground-water development on water levels and base flow of streams. Determine background water quality and areal quality variations in the sand and gravel aquifers.

APPROACH: Existing geohydrologic data will be collected, compiled, and interpreted. Geophysical investigations will be undertaken to determine bedrock depths, saturated thickness, and stratigraphy. Drilling will be done in order to determine stratigraphy, water table elevations, and depth to bedrock. Seepage runs will be done to determine streamflow gains and losses and ground-water runoff. Hydraulic conductivity will be estimated. Ground water will be sampled and analyzed. Potential aquifer yields will be estimated using analytical models.

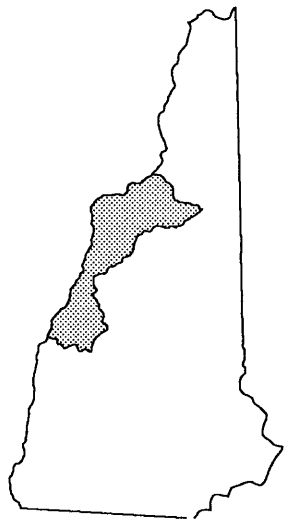
PROGRESS: Maps showing locations of well and auger data, seismic lines, stratified-drift boundaries, contours of equal saturated thickness and transmissivity, water-table altitude and flow directions are complete. Report text is 90-percent complete. Estimates of ground-water availability for selected aquifers is 100-percent complete. Project is complete except report.

PLANS NEXT YEAR: Complete the report text and illustrations. Prepare copies for colleague review.

Geohydrology and Water Quality of Stratified-Drift Aquifers in the Middle Connecticut River Basin, West-Central New Hampshire

PROJECT CHIEF:
Sarah M. Flanagan

PERIOD OF PROJECT:
October 1988 to June 1992



COOPERATOR(S): New Hampshire Department of Environmental Services, Water Resources Division

PROBLEM: Many towns within the Middle Connecticut River Basin are experiencing increasing demands on their water supply due to population growth and increasing tourist trade. Towns and communities are interested in developing additional ground-water supplies and protecting existing resources.

OBJECTIVE: Describe the physical dimensions and geohydrologic properties of sand and gravel aquifers in the study area. Assess ground-water availability and potential yields of sand and gravel aquifers. Evaluate, for selected aquifers, the hydrologic impacts of ground-water development on water levels and base flow of streams. Determine background water quality and areal quality variations in the sand and gravel aquifers.

APPROACH: Existing geohydrologic data will be collected, compiled, and interpreted. Geophysical investigations to determine bedrock depths, saturated thickness, and stratigraphy will be done. Drilling will be done to determine stratigraphy, water table elevations, and depth to bedrock. Seepage runs will be made to determine streamflow gains and losses and ground-water runoff. Hydraulic conductivity will be estimated. Ground water will be sampled and analyzed. Potential aquifer yields will be estimated using analytical models.

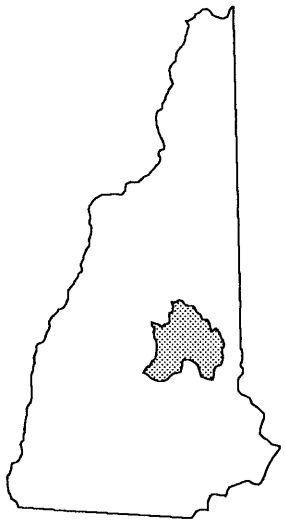
PROGRESS: All data collection, analysis, and compilation is 100-percent complete. Compilation of plates on 1:24,000 and 1:25,000 scale mylar quadrangles is 100-percent complete. Digitizing of the mylar quadrangle maps into plates for colleague review is approximately 80 percent complete. Writing of the first draft of the report is 60 percent complete. Began putting tables and figures into colleague-review format. Began calculating potential yields for selected aquifers using analytical methods. Project is complete except report.

PLANS NEXT YEAR: Complete the following report sections (1) description of selected aquifers, and (2) discussion of potential yield for selected aquifers in the study area. Submit report for colleague review and Director's approval. Begin preparation for publication.

Geohydrology and Water Quality of Stratified-Drift Aquifers in the Winnipesaukee River Basin, Central New Hampshire

PROJECT CHIEF:
Joseph D. Ayotte

PERIOD OF PROJECT:
October 1989 to September 1992



COOPERATOR(S): New Hampshire Department of Environmental Services, Water Resources Division

PROBLEM: Many towns within the Winnipesaukee River Basin study area are experiencing increasing demands on their water supply due to population growth and increasing tourist trade. Towns and communities are interested in developing additional ground-water supplies and protecting existing resources.

OBJECTIVE: (1) Describe the geometry and geohydrologic properties of sand and gravel aquifers. (2) Assess ground-water availability and potential yields of sand and gravel aquifers. (3) Determine background water quality and areal variation of water quality for aquifers in the study area.

APPROACH: Literature search will be done. Existing geohydrologic data will be collected, compiled, and interpreted. Geophysical investigations to determine saturated thickness will be done. Drilling to determine stratigraphy, water table elevations, and depth to bedrock or refusal will be done. Seepage runs during base flow will be run to determine ground-water contribution to streamflow. Aquifer hydraulic conductivity and transmissivity will be estimated. Ground water will be sampled and analyzed. Potential aquifer yields will be estimated using an analytical model.

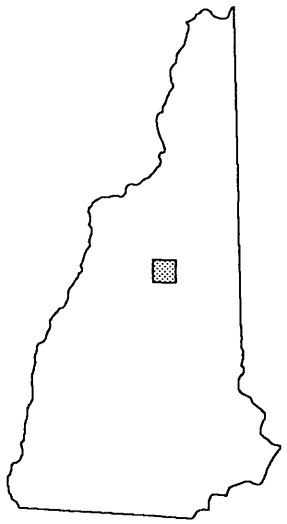
PROGRESS: Five additional test holes were drilled in aquifers that had little previous data. Aquifer boundaries have been mapped for the entire basin. Water-table contours have been completed for all six plates. Data compilation and analysis is ongoing. Project is complete except report.

PLANS NEXT YEAR: Continue with interpretation and compilation of data. Estimate aquifer yield of two significant aquifers in Belmont and Alton, New Hampshire. Write first draft of report and draft plates showing saturated thickness and transmissivity values for selected aquifers. Submit report for colleague review and Director's approval. Begin preparation of camera-ready materials for publication.

Evaluation of Hydraulic Interaction Between Crystalline Bedrock and Overburden, Mirror Lake, New Hampshire

PROJECT CHIEF:
Philip T. Harte

PERIOD OF PROJECT:
October 1989 to September 1994



COOPERATOR(S): USGS Toxics Waste Program

PROBLEM: Recent trends show an increase of contaminated bedrock wells. In most cases, contaminants are derived from point-sources situated in the overburden. In order to protect bedrock ground-water supplies, it is imperative that an evaluation of overburden and bedrock ground-water interaction be made.

OBJECTIVE: (1) Determine the spatial variability of ground-water flow between the glacial drift and bedrock. (2) Assess the relative impact of factors affecting ground-water movement between stratified drift and bedrock. (3) Estimate bedrock recharge sources from drift. (4) Determine transport rates and processes.

APPROACH: Both a regional and local perspective is needed to characterize ground-water movement between stratified drift and bedrock. A regional flow model will be constructed to help define flow. Natural and induced tracer tests are planned at several nested well sites.

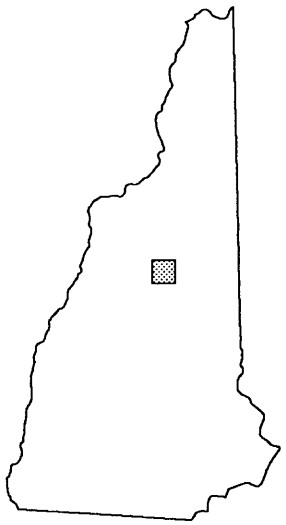
PROGRESS: Several reports were approved and published. The majority of reports focused on describing spatial patterns of bedrock recharge and factors controlling vertical flow between the drift and bedrock.

PLANS NEXT YEAR: Document final efforts—since this is the last year of funding. Publish a Water-Resources Investigations Report, journal articles, and abstracts as a result of the report.

Geologic, Lithologic and Fracture Characterization of the

PROJECT CHIEF:
Carole Johnson

PERIOD OF PROJECT:
October 1989 to September 1994



COOPERATOR(S): USGS Toxics Waste Program

PROBLEM: This geologic, lithologic, and fracture characterization project is an integral part of a larger collaborative research effort. A multidisciplinary approach is being used to characterize fluid movement and chemical transport in fractured bedrock and to improve ground-water flow models. The rock types, fracture occurrence and structure of the bedrock system must be better understood in order to evaluate the overburden-bedrock ground-water interaction (described in NH042a) and in order to characterize fluid movement and chemical transport in fractured rock.

OBJECTIVE: Identify lithologic and structural controls on fluid movement and chemical transport in bedrock in the Mirror Lake watershed. In order to do this, it is necessary to (1) identify the rock types and describe their spatial variability, (2) develop conceptual models that describe the distribution of fractures, (3) relate water-bearing characteristics of fractures to the type of host rock.

APPROACH: Rock types from the wells will be determined. Rock chips will be described and characterized by mineralogy and texture in order to improve the rock-type data base that describes spatial variability of rock type over the watershed. Rock core will be analyzed; mineralogy and texture will be described, noting the occurrence of fractures and characterizing the fracture surfaces. Relations between water-bearing zones and lithology and structural features will be identified using data determined from geologic and fracture mapping, hydraulic tests, tracer tests, borehole and surficial geophysical tests.

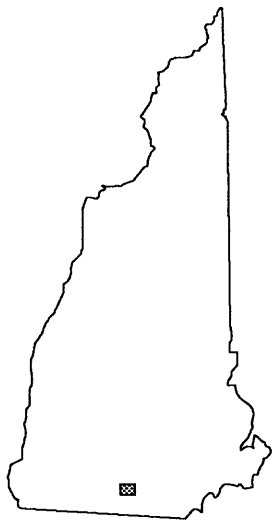
PROGRESS: Analysis of video logs were completed for all 29 bedrock wells in the study area. Detailed lithologic logs are being generated from analysis of the drill cuttings and video surveys. Rock fragments from 30 wells were described in terms of mineralogy and texture and were categorized according to rock type. Petrographic analyses and SEM-XRF analyses were performed on18 thin-section rock samples to verify mineralogy determined with hand lens, describe grain boundaries and iron migration in pore spaces. A publication and a documentary video illustrating the use of a borehole video camera were prepared.

PLANS NEXT YEAR: Complete a lithology report and statistical analyses. Drill four bedrock wells, obtain one 50-foot bedrock core and install 3 piezometers in the overburden. Work on video surveys in two 1,000-foot wells and three 200-foot wells.

Reassessment of Geohydrologic Data and Refinement of a Regional Ground-Water-Flow Model of the Milford-Souhegan Glacial-Drift Aquifer, Milford, New Hampshire

PROJECT CHIEF:
Joseph R. Olimpio

PERIOD OF PROJECT:
August 1990 to September 1993



COOPERATOR(S): U.S. Environmental Protection Agency, Waste Management Division

PROBLEM: From 1960-83, the town of Milford used the Savage well for municipal supply. During routine water-quality monitoring by the State of New Hampshire in 1982-83, several volatile organic compounds were detected. In December 1987, the U.S. Environmental Protection Agency (USEPA), Waste Management Division requested USGS technical assistance in performing an analysis of ground-water flow in the aquifer. As part of that study, all hydrogeologic and contamination-source data for the study area were collected and a ground-water-flow model was constructed. In early 1990, USEPA and the USGS held a series of meetings to discuss anticipated application of the flow model for testing possible pump-and-treat designs for remediation of ground-water in the vicinity of the Savage well. For this testing, additional hydrogeologic investigation of the aquifer in the vicinity of the Savage site, and refinements to the ground-water-flow model were identified.

OBJECTIVE: (1) Collect, compile, and incorporate into the existing model hydrogeologic data collected in the study area since November 1988. (2) Refine calibration of the model for steady-state conditions using these new data. (3) Verify the model and perform sensitivity analysis on the model. (4) Simulate advective transport of a conservative contaminant near the Savage well site.

APPROACH: Data on geology, characteristics of the ground-water-flow system, observation-well networks, contamination sources, surface water, and water quality available since 1988 will be compiled. Water levels in observation wells will be measured. Streamflow will be measured. The flow model will be refined and recalibrated by incorporating data collected since November 1988 into the model. The model grid near the Savage well will be discretized for use in testing possible remedial designs. The model will be recalibrated to steady-state conditions, and calibrated to transient conditions. The model will be verified. The model will be used to investigate advective transport for remedial design.

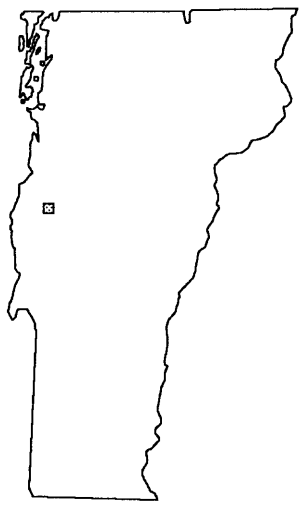
PROGRESS: First draft of the report "Reassessment of geohydrologic data and refinement of a regional ground-water flow model of the Milford—Souhegan glacial-drift aquifer, Milford, New Hampshire" has been written.

PLANS NEXT YEAR: Refine the model for colleague review. Start new phase of the study, with a focus on the OK Tool Company site, in spring of 1994.

Hydrology, Simulated Ground-Water Flow, and Ground-Water Quality at Two Landfills in Bristol, Vermont

PROJECT CHIEF:
Thomas J. Mack

PERIOD OF PROJECT:
April 1990 to September 1992



COOPERATOR(S): Vermont Agency of Natural Resources, Solid Waste Division

PROBLEM: The Vermont Agency of Natural Resources, Solid Waste Division (SWD) is required by law to perform geologic and hydrogeologic assessment of 72 landfills in Vermont over the next few years. The studies will be designed to provide critical information on the effects that landfills have on ground-water quality and their interaction with local and regional ground-water-flow systems. The technical staff of the SWD requests a demonstration project to provide guidance in state-of-the-art hydrogeologic investigative techniques that can be employed in the landfill studies.

OBJECTIVE: (1) Provide an organizational framework for planning and executing studies of landfills in glaciated terrains. (2) Demonstrate the use of various hydrogeologic methods for studies of solid-waste landfills in glaciated terrain. (3) Characterize ground-water quality beneath two landfills within a kame deposit in Bristol, Vermont, and determine regional ground-water flow patterns in the surrounding area.

APPROACH: A literature search of landfill studies in glaciated terrain and methods used in landfill studies will be conducted. Well and data inventory in the area around the Bristol landfills will be performed. Depth to water and bedrock will be mapped using seismic-refraction geophysics as outlined by Haeni (1986). Electromagnetic geophysics such as EM-34 and VLF will be used to detect conductive plumes that may be moving from the site. The hydraulic properties of the unconsolidated material in the vicinity of the landfills will be defined and mapped by analyzing stratigraphic logs, slug tests, and borehole geophysics. Split-spoon samples obtained during test drilling will be analyzed for grain-size distribution. Water-table altitudes in the vicinity of the landfills will be mapped from data collected above. Seepage runs on surface waters in the vicinity of the landfills will be conducted to define gaining and losing reaches during baseflow conditions. Wells will be sampled and analyzed for nutrients, major ions, trace elements, and organic compounds. Numerical models will be applied to evaluate movement of contaminants away from the landfills. A generalized work plan will be produced as a guide for future work.

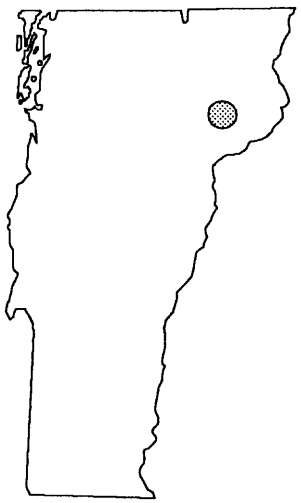
PROGRESS: The first draft of the interpretive report is complete. It describes the hydrogeology, simulated ground-water flow, and the ground-water quality at the two landfills. The chemical composition of contaminated ground water and its areal extent are described. A journal article was published in Ground Water Monitoring and Remediation in February 1993. Project is complete except report.

PLANS NEXT YEAR: Complete draft and editorial revisions; submit report for technical and regional reviews, and Director's approval. Prepare report for publication and submit for printing.

Water, Energy, and Biogeochemical Budgets (WEBB) at Sleepers River Research Watershed, Danville, Vermont

PROJECT CHIEF:
James B. Shanley

PERIOD OF PROJECT:
Continuous since October 1990



FUNDING SOURCE: USGS Global Change Hydrology Program

PROBLEM: Heightened concern over the possibility of global warming and other global environmental change has generated attempts to predict the consequences of these changes on global ecosystems. The current state of knowledge on the interrelations of hydrologic, energy, and biogeochemical processes is insufficient to adequately model these processes. A better understanding of Water, Energy, and Biogeochemical Budgets (WEBB) is needed over a range of scales, in a representative cross-section of global ecosystems.

OBJECTIVE: (1) Investigate and describe the linkages between soil hydrology and solute transport in the soil zone through detailed accounting of water and chemical flux at points on a hillslope. (2) Use carbon and oxygen isotopes to trace the movement of water and solutes. (3) Assess the sensitivity of trace gas budgets to changing land use and climate. (4) Determine the partitioning of hydrologic pathways as basin size increases. (5) Determine the distribution and magnitude of basin heat fluxes.

APPROACH: A hillslope in a small forested basin will be intensively instrumented to track the movement of water and solutes, measure trace gas fluxes, and establish energy budgets. A time-domain reflectometry (TDR) system will be installed to monitor changes in soil moisture. Soil water will be sampled by non-tension lysimeters and analyzed for major solutes and isotopes of carbon and oxygen. The spatial sampling density will increase downslope toward the stream. This design will provide the best possible observations of the evolution of rainwater and snowmelt chemistry to streamwater chemistry. In conjunction with the on-site energy budget, and with continuous monitoring of physical and chemical parameters, the processes responsible for the generation of streamflow and streamwater quality will be identified. The shifting importance of hydrologic flowpaths and biogeochemical processes as basin scale increases will be evaluated with chemical and isotopic data from higher-order basins.

PROGRESS: Although budget restraints limited new instrumentation, existing data-collection activities were continued and improved quality-control measures were implemented. Quality control was facilitated by the initiation of a customized database system, which allows efficient storage, retrieval, and editing of physical and chemical data. In W-9, the small forested headwater basin, new weirs were installed on each of the three tributaries that join just above the main weir. Flow data from these sites have helped to improve our understanding of hydrologic processes in W-9, the most intensively-monitored watershed within the WEBB project. Chemical sampling increased during Fiscal Year 1993. About 700 water samples were collected for analysis of major constituents. About one-half the samples were analyzed at the USGS, Albany, New York lab, and about one-half at the Cold Regions Research and Engineering Laboratory (CRREL) in Hanover, New Hampshire. Most of the additional sampling took place during the snowmelt season, when sampling was intensified at W-2 (the agricultural basin), and W-3 and W-5

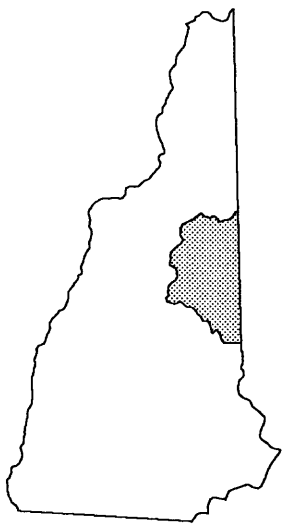
(the larger mixed land-use basins) relative to previous years. Also, four snowmelt lysimeters were deployed to monitor the temporal variation of meltwater chemistry and oxygen-18. The oxygen-18 data from the meltwater and stream samples at the four watersheds were used to demonstrate that shallow flowpaths increase in importance as basin size increases and (or) as land use changes from forested to agricultural. These data represent the basis for at least one journal article and one conference presentation. Collaboration with CRREL, USGS-NRP, and university researchers continued to be a major aspect of the Sleepers River WEBB project. Progress was made on data interpretation which will lead to journal publications.

PLANS NEXT YEAR: Collaborate with CRREL to improve energy flux measurements during the 1993-94 winter, and to address energy-balance question at Sleepers River. Make radiation measurements at several sites and perform additional snowmelt stratigraphy and snowmelt hydrology work. Upgrade the Sleepers River long-term meteorological monitoring network, which will expand and modernize all 13 meteorological sites and allow real-time data acquisition over phone lines via radiofrequency (RF) data transmission by Fiscal Year 1995. Make most of the sites on-line in Fiscal Year 1994. Interface all USGS data loggers with radios for data transmission to the base station. Use the RF system for remote monitoring (i.e., from the Montpelier office) of hydrologic conditions. Develop a large-scale (1:600) base map for W-9, and if budget permits, for W-2. Target the area(s) and fly them May 1994. Incorporate the three years of physical data collected to date into the new data base system.

Geohydrology and Water-Quality of Stratified-Drift Aquifers in the Saco and Ossipee Basins, East-Central New Hampshire

PROJECT CHIEF:
Richard B. Moore

PERIOD OF PROJECT:
October 1990 to September 1994



COOPERATOR(S): New Hampshire Department of Environmental Services, Water Resources Division

PROBLEM: Rapid growth and increased development in New Hampshire have increased the demand for potable water. Ground water in stratified-drift aquifers is capable of supplying large amounts of high-quality water, but is susceptible to contamination from various sources.

OBJECTIVE: (1) Describe the physical and geohydrologic properties of sand and gravel aquifers in the study area. (2) Assess ground-water availability and potential yields of sand and gravel aquifers in the area. (3) Evaluate, for a large selected aquifer, the hydrologic impacts of ground-water development on water levels and base flow of streams. (4) Determine background water quality in the stratified-drift aquifers.

APPROACH: Existing data on quality and altitude of ground-water, and saturated thickness and stratigraphy of aquifers will be compiled. A well and spring inventory will be conducted. The extent and saturated thickness of stratified-drift aquifers using data obtained from seismic refraction, continuous seismic reflection, and test drilling will be mapped. Hydraulic properties of aquifers from information gathered during drilling, from pump tests, and analyses of stratigraphic logs will be mapped. Water-table altitudes in the aquifers will be mapped. Sources of recharge to and discharge from the aquifers will be identified by measuring ground-water altitudes. A numerical technique will be used to estimate the impacts of ground-water development and long-term aquifer yield. Selected wells and springs will be sampled to define natural variation in water quality in the aquifers. The results of data collection and interpretation will be presented in a report.

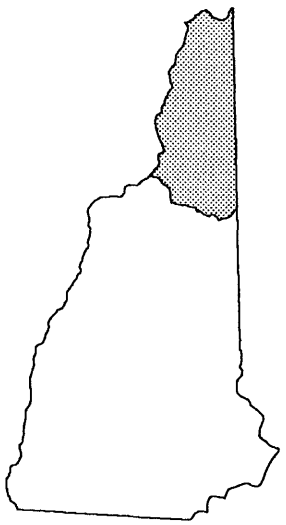
PROGRESS: Drilling was completed at 25 sites during the year. Eight lakes or ponds were studied with the seismic refraction technique. Four weeks of seismic refraction data collection was completed. Data for 306 newly constructed wells, field located by the U.S. Geological Survey, were loaded from the New Hampshire State data base to our Ground Water Site Inventory (GWSI) data base. Four weeks of aquifer boundary mapping and site selection were completed last year. Water-quality samples were collected at 29 sites within the study area (25 wells and 4 springs).

PLANS NEXT YEAR: Complete the review process and the report submit report for Director's approval.

Geohydrology and Water-Quality of Stratified-Drift Aquifers in the Upper Connecticut River Basin, Northern New Hampshire

PROJECT CHIEF:
Joseph R. Olimpio

PERIOD OF PROJECT:
January 1991 to December 1994



COOPERATOR(S): New Hampshire Department of Environmental Services, Water Resources Division

PROBLEM: Rapid growth and increased development in New Hampshire have increased the demand for potable water. Ground water in stratified-drift aquifers is capable of supplying large amounts of high-quality water.

OBJECTIVE: (1) Describe the physical dimensions and geohydrologic properties of sand and gravel aquifers in the study area. (2) Assess ground-water availability and potential yields of sand and gravel aquifers in the area. (3) Determine water quality in the sand and gravel aquifers.

APPROACH: Existing data on elevation of ground water, and saturated thickness and stratigraphy of aquifers will be compiled. A well and spring inventory will be conducted. The extent and saturated thickness of stratified-drift aquifers using data obtained from seismic refraction, test drilling, and existing well logs will be mapped. Hydraulic properties of aquifers from information gathered during drilling, from pump tests, slug tests, and analyses of stratigraphic logs will be mapped. Water-table elevations in the aquifers will be mapped. Sources of recharge to and discharge from the aquifers will be identified by measuring changes in streamflow and ground-water altitudes. Analytical or numerical modelling techniques will be used to estimate the impacts of ground-water development on aquifer yield. Selected wells will be sampled to define natural water quality in the aquifers. The results of data collection and interpretation will be presented in a report.

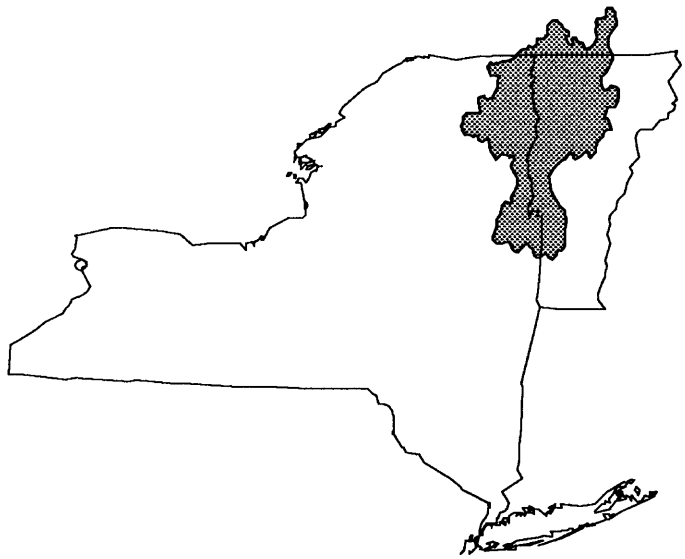
PROGRESS: Aquifer boundaries were field-checked in some areas of question. Report outline was prepared and report draft was begun.

PLANS NEXT YEAR: Prepare report for colleague review.

PCB and Trace Metal Loads to Lake Champlain from Tributary Streams

PROJECT CHIEF:
John A. Colman

PERIOD OF PROJECT:
April 1992 to September 1996



FUNDING SOURCE: USGS Federal Funds

PROBLEM: Water quality of Lake Champlain is being investigated under provisions of the Lake Champlain Special Designation Act. One of the concerns listed in the act is the effect of toxic materials on human and ecosystem health. Of the many toxic materials which might be of concern for Lake Champlain, mercury and PCBs represent a particular problem. Concentrations of these materials in some fish species have exceeded the U.S. Food and Drug Administration limits for safe consumption.

OBJECTIVE: Quantify the tributary inputs of trace metals and PCBs to Lake Champlain and to observe time trends in inputs. Specific objectives are (1) assess the concentrations of PCB's and trace metals in surficial streambed sediment of tributaries to Lake Champlain and scan samples of the same for the presence of hydrophobic organic compounds, (2) assess the contribution of PCB's in near-shore bed sediments from adjacent tributaries by comparing fingerprints of PCB congeners from the near-shore and tributary sediments, (3) determine tributary loads and trends of PCB's and trace metals to Lake Champlain by monitoring streamflow and constituent concentration at tributaries.

APPROACH: Streambed material of the 34 or so principal tributaries will be collected near their confluences with the lake during low stream flow. Analysis of these samples will determine which streams are important for tributary transport of hydrophobic materials. Near-shore samples of fine-grained deposits will be obtained for analysis of PCB cogeners and organic carbon. Only sediment surficial samples will be collected for comparison with the tributary samples. Following the streambed work, water samples will be collected at selected tributaries on a monthly basis. In addition, samples will be taken during several high-flow events including spring snow pack melting. Field parameters of temperature, conductivity, alkalinity, and pH will be recorded at each sampling. Load computation will be accomplished using a seven parameter regression model. Trends will be computed using the method of Hirsch and others.

PROGRESS: The bed sediments of 80 plus streams were sampled this year for 40 trace metals including mercury and for PCB cogeners. The results of the mercury analyses are back from the lab. The remaining elements are due from the lab shortly. One stream sample had a mercury concentration of 3.6 parts per million. The sample was taken from a mining area. Analysis of PCB's in the bed sediments has been completed for the in-lake samples only. The analytical work is continuing for the stream sediments.

PLANS NEXT YEAR: Analyze the results of the collected samples during the coming year. Prepare report based on the results of the bed sediment sampling, and submit for colleague review and Director's approval. Begin water column work, depending on status of funding.

USEPA Technical Assistance

PROJECT CHIEF:
John Cotton

PERIOD OF RECORD:
Continuous since 1988

COOPERATOR(S): U.S. Environmental Protection Agency, Waste Management Division

PROBLEM: Hydrogeological technical assistance is needed by the U.S. Environmental Protection Agency (USEPA), Region I, Waste Management Division, for ongoing project work at New England Superfund sites. USEPA's Waste Management Division is faced with the task of understanding complex hydrologic environments in order to propose remedial action at hazardous waste sites. The U.S. Geological Survey (USGS) can provide technical assistance and consultation to USEPA on problems related to ground-water hydraulics, surface-water monitoring, water-quality sampling, and analysis of hydrologic systems in general.

OBJECTIVE: Provide data collection and geohydrologic investigations for USEPA at Superfund sites and technical assistance and report review at other sites as needed.

APPROACH: USGS personnel will offer advice to USEPA site managers on proper scopes of technical work at Superfund sites. The work will also include review of remedial investigation/feasibility studies (RI/FS), workplans, technical summaries, and final drafts for technical content and accuracy. USGS personnel will also participate in technical meetings and negotiations with USEPA contractors and responsible parties. The USGS will do investigations, as requested by USEPA, to help fulfill the goals of the Superfund Program. Activities by the USGS may include borehole logging, surface geophysical surveys, aquifer testing, and hydrologic analysis of Superfund sites.

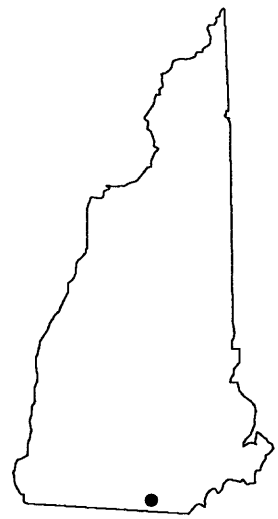
PROGRESS: At the Gilson Road, Nashua, New Hampshire site, one continuous and five non-continuous streamgages were operated. For the Keyes Well, Milford, New Hampshire site, a Water-Resources Investigations Report received colleague review. For the OK Tool (Savage Well), Milford, New Hampshire site, an Open-File Report is nearly complete. Plans are being finalized for additional ground-water-flow modeling. For the New Hampshire Plating, Merrimack, New Hampshire site, an administrative report and a journal article received colleague review. For the Country Pond, Kingston, New Hampshire site, an administrative report was drafted to report well installation and ground-water sampling results.

PLANS NEXT YEAR: Continue review of documents as requested by USEPA. Continue streamgaging at Gilson Road. Continue water quality sampling at Country Pond. Continue geophysical and ground-water-flow investigations at OK Tool. Begin geophysical and surface-water monitoring work at Pine Street Canal site in Burlington, Vermont.

Geohydrology of the Flints Pond Aquifer, Hollis, New Hampshire

PROJECT CHIEF:
Joseph D. Ayotte

PERIOD OF PROJECT:
January 1993 to September 1994



COOPERATOR(S): New Hampshire Department of Environmental Services, Water Supply and Pollution Control Division, Biology Bureau

PROBLEM: Flints Pond in Hollis, New Hampshire, has been subject to accelerated eutrophication as a result of shoreline and watershed development and associated nutrient loading over the past 60 years. Dense growth of milfoil and other aquatic plants have greatly reduced the recreational usability of the pond. The Biology Bureau of New Hampshire's Department of Environmental Services, Water Supply and Pollution Control Division is proposing to conduct a nutrient budget study as an initial step toward establishment of a remediation plan designed to improve the pond's trophic status. Because the pond is fed primarily from groundwater sources, the Bureau has sought the assistance of the U.S. Geological Survey, New Hampshire/Vermont District, in quantifying the ground-water flow regime in the vicinity of the pond. The District has previously undertaken stratified-drift aquifer assessment and mapping in the area.

OBJECTIVE: Characterize the ground-water flow system in the stratified-drift deposits in the vicinity of Flints Pond.

APPROACH: Depth to bedrock and thickness of stratified-drift will be determined by conducting ground-penetrating radar (GPR) surveys across the valley at seven locations. Bedrock, water table, wetland deposits, and thickness of bottom sediments will be mapped using GPR. Thickness of wetland sediments will be determined by probing, through ice cover, when necessary. Water-level measurements will be obtained from about 24 wells to be installed in a grid pattern near the GPR surveys. Staff gages will also be installed in the pond and at the culverts on Pine Hill Road and Broad Street. The altitude of all wells and gages will be surveyed to a common datum. Grain-size distribution of materials within the stratified-drift deposits will be determined by analyzing split-spoon samples obtained from the test holes at 16 shallow well sites and from the five deep test holes drilled to refusal. Transmissive characteristics of the deposits will be determined by two methods: hydraulic conductivity values assigned based on the grain-size analyses and hydraulic conductivity values calculated from slug tests in both the shallow and deep wells.

PROGRESS: Over five miles of GPR data collection were completed. More than 20 wells (or borings) were installed. Elevations of all wells were determined and water levels were monitored. Slug tests were performed at all wells. Approximately 50 percent of report has been completed. An abstract was approved for publication in a proceedings to a 1994 symposium.

PLANS NEXT YEAR: Complete the report titled "Geohydrology of the Flints Pond Aquifer, Hollis, New Hampshire," by J.D. Ayotte and T.H. Dorgan. Write and receive Director's approval for journal article for proceedings to 1994 Symposium on the Application of Geophysics to Engineering and Environmental Problems, March 1994, Boston, Massachusetts.

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