UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WATER-RESOURCES INVESTIGATIONS IN NORTH DAKOTA--FISCAL YEAR 1984

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March 1984

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WATER-RESOURCES INVESTIGATIONS

IN NORTH DAKOTA--1984

INTRODUCTION

The U.S. Geological Survey, through its Water Resources Division, investigates the occurrence, quantity, quality, distribution, and movement of the surface and underground water that composes the Nation's water resources. This publication contains a brief description of the ongoing investigations of the North Dakota District.

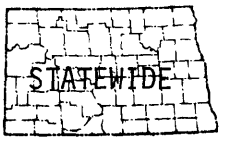
Much of the Geological Survey program is conducted in cooperation with other Federal agencies and several state agencies. The publications resulting from the program are listed periodically in a miscellaneous release titled, "Water Resources Investigations of the U.S. Geological Survey, 19XX." The last such release was issued in 1982. They are also listed in a monthly nationwide release titled, "New Publications of the Geological Survey, List XXX--Publications issued in month 19XX."

DATA-COLLECTION PROJECTS

The U.S. Geological Survey continually records stage, discharge, quality of water, sediment concentrations, and groundwater levels at selected sites throughout North Dakota. Some of the sites are operated on a long-term basis to sample trends in the gross water supply, while others are operated for short terms for correlation with long term to gain wider areal coverage or for specific purposes. The information is published annually in water-data reports and stored in computer files for retrieval and processing.

PROJECT TITLE: Surface-Water Stations

LOCATION: Statewide



PERIOD OF PROJECT: Continuous

PROJECT CHIEF: Russell E. Harkness

OBJECTIVES.--To 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) forecasting, (4) disposal of wastes and pollution controls, (5) discharge data to accompany water-quality measurements, (6) compact and legal requirements, and (7) research or special studies. 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, etc., for use in planning and design.

APPROACH.-- 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 IN 1983.--All network (fig. 1) data were collected on schedule and annual water-year records are being prepared for publication. Five continuous-record streamflow stations, including three coal-lease monitoring network stations were discontinued. One streamflow station was converted to a crest-state gage. One streamflow gage and one lake gage were installed late in the year. An electromagnetic flow-meter installation on the Red River of the North at Grand Forks, N. Dak., was completed early in the year.

PLANS FOR 1984.--Continue to operate network. Five coal-lease monitoring stations will be discontinued. One streamflow and one lake gage may be installed. Data recovery and accuracy will be improved with continued control rehabilitation and conversion to the new 12-volt power system. The WATSTORE data will be stored on the new inhouse computer system and the new WRD ADR processing system will be initiated.

REPORT PRODUCTS.--U.S. Geological Survey, Water-resources data, North Dakota, Water year 1983 (planned).

U.S. Geological Survey, 1982, Water-resources data, North Dakota, Water year 1982, U.S. Geological Survey Water-Data Report ND-82-1, 418 p.

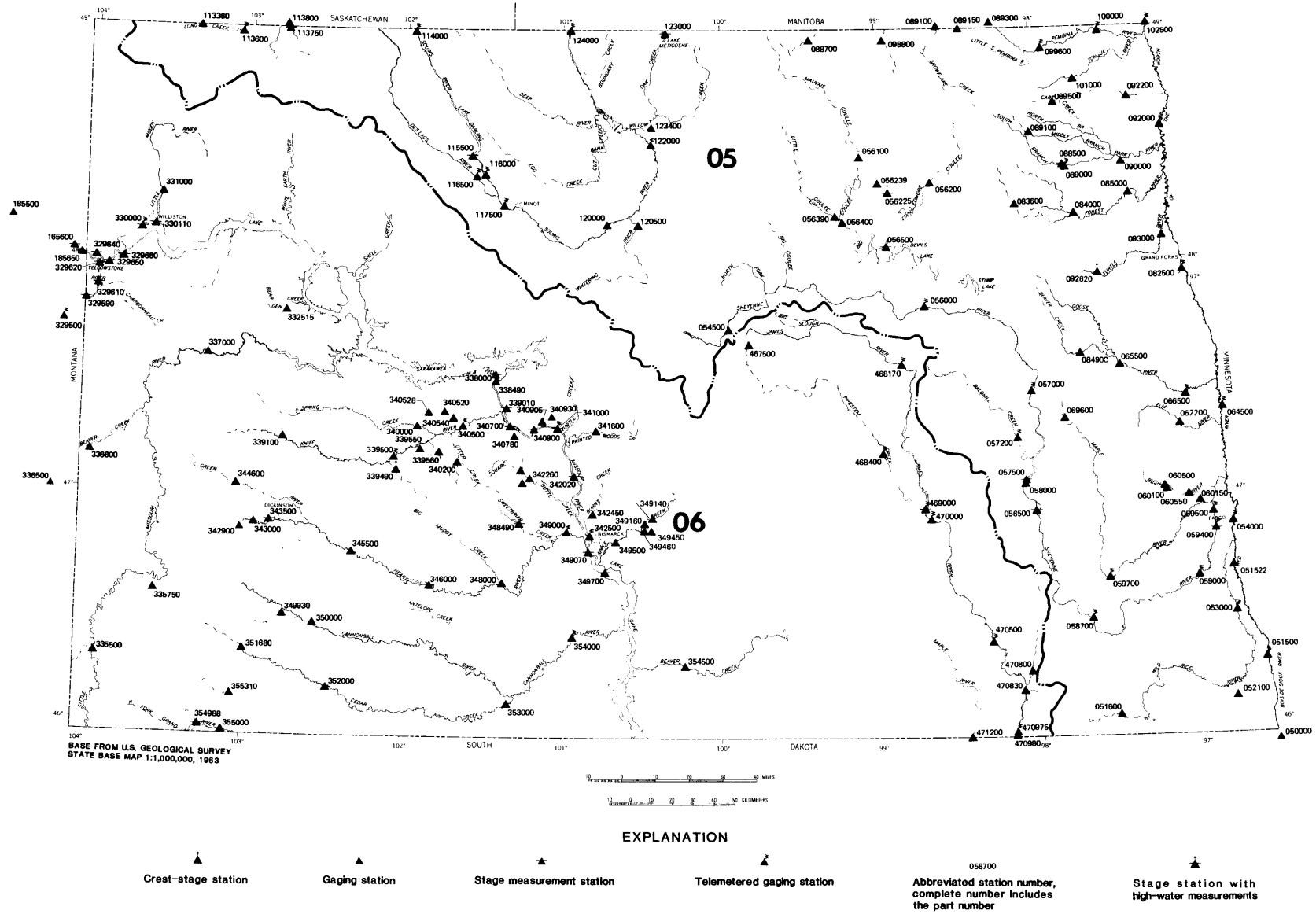


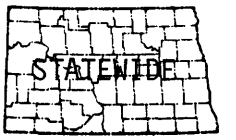
FIGURE 1.—Location of lake, crest-stage and stream-gaging stations.

PROJECT TITLE: Ground-Water Stations

LOCATION: Statewide

PERIOD OF PROJECT: Continuous

PROJECT CHIEF: Russell E. Harkness



OBJECTIVES.--To collect water-level data sufficient to provide a minimum 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 early enough to allow proper planning and management. To 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, (3) detect and define pollution and supply problems, and (4) provide the data base necessary for management of the resources.

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 of observation wells to determine long-term system behavior. This 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.

PROGRESS IN 1983.--All network data were collected on schedule. The data were tabulated and stored in District and WATSTORE files. All water-level data for active network wells was retrieved and computer plotted hydrographs made for the period of record. Examples of hydrographs were published in the report, "Water Resources Data North Dakota, Water Year 1982."

PLANS FOR 1984.--Continue to operate network. Will transfer data to inhouse computer storage if master program is developed by the Division.

REPORT PRODUCTS.--U.S. Geological Survey, 1977, Ground-water levels in the United States, 1972-74, North Central States: U.S. Geological Survey Water-Supply Paper 2163, p. 57-61.

Ground-water data for the basic network (fig. 2) have been and will continue to be published in the annual report series, "U.S. Geological Survey, Water-Resources Data, North Dakota."

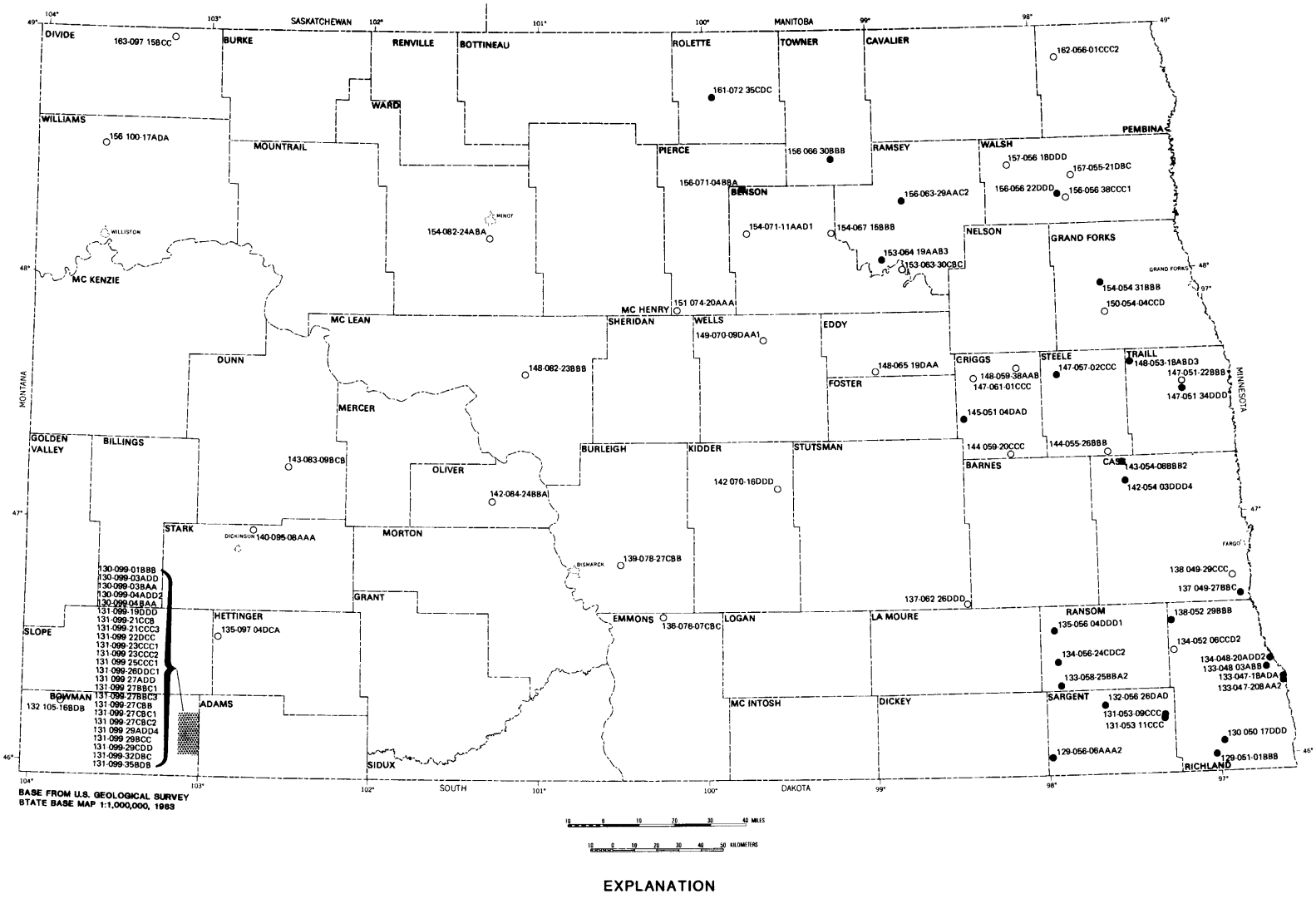


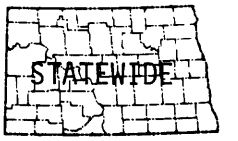
FIGURE 2.—Locations of ground-water observation wells.

PROJECT TITLE: Water-Quality Stations

LOCATION: Statewide

PERIOD OF PROJECT: Continuous

PROJECT CHIEF: Robert L. Houghton



OBJECTIVES.--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 and international waters.

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

PROGRESS IN 1983.--All network (fig. 3) data were collected on schedule and records are being prepared for publication. Three minimonitors were installed in the lower James River basin, two of which record water temperature, specific conductance, and dissolved-oxygen concentrations.

PLANS FOR 1984.--The network will continue to operate with a few cooperator-requested modifications. The number of sampling sites with frequency of sampling greater than semiannual will be reduced from 45 to 30. Samples will be collected at two lakes and four stream sites to monitor planned diversion of New Johns Lake into Painted Woods Creek. Probes to measure pH will be installed on two of the lower James minimonitors as soon as they are approved for use by HIF. Two more minimonitor installations will be made as soon as the FY84 budget is approved.

REPORT PRODUCTS.--U.S. Geological Survey, Water-resources data, North Dakota, Water year 1983 (planned).

U.S. Geological Survey, Water-resources data, North Dakota, Water year 1982, U.S. Geological Survey Water-Data Report ND-82-1, 418 p.

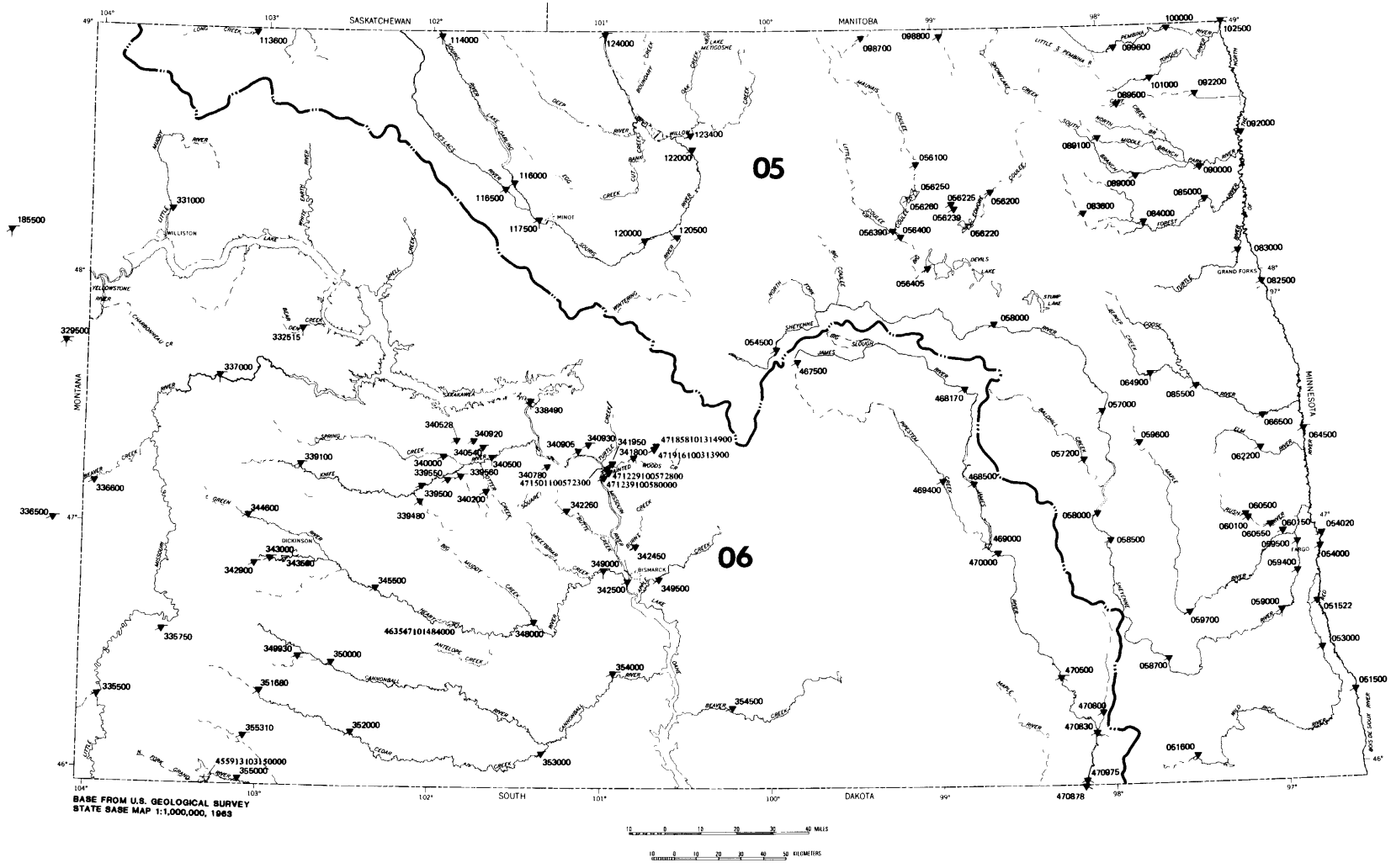


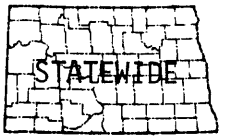
FIGURE 3.—Locations of water-quality stations.

PROJECT TITLE: Sediment Stations

LOCATION: Statewide

PERIOD OF PROJECT: Continuous

PROJECT CHIEF: Russell E. Harkness



OBJECTIVES.--To provide a national bank of sediment data for use in broad Federal and State planning and action programs and to provide data for Federal management of interstate and international waters.

APPROACH.--Establish and operate a network of sediment stations to provide spatial and temporal averages and trends of sediment concentration, sediment discharge, and particle size of sediment being transported by rivers and streams.

PROGRESS IN 1983.--Data were collected and analyzed for 21 partial-record stations (fig. 3). Records are being prepared for publication.

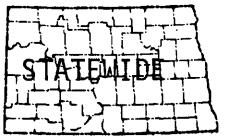
PLANS FOR 1984.--Continue to operate network. Five quarterly sites will be discontinued.

REPORT PRODUCTS.--U.S. Geological Survey, Water-resources data, North Dakota, Water year 1983 (planned).

U.S. Geological Survey, Water-resources data, North Dakota, Water year 1982: U.S. Geological Survey Water-Data Report ND-82-1, 418 p.

PROJECT TITLE: National Trends Network for Atmospheric Deposition

LOCATION: Statewide



PERIOD OF PROJECT: Continuous

PROJECT CHIEF: Robert L. Houghton

OBJECTIVES.--The objective of the project is (1) to establish and operate a nationwide long-term monitoring network to detect and measure levels of atmospheric depostion and (2) to determine variations in atmospheric deposition that occurs on a week to week basis by collection of wet- and dry-deposition products for analysis of elements and constituents that can contribute to the chemical composition of surface waters.

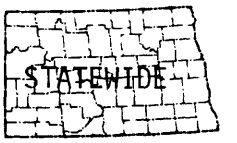
APPROACH.--Monitoring stations are to be set up as part of the National Trends Network. Stations will be maintained, on-site measurements made, samples processed, and samples submitted to the analytical laboratory. Data will be stored in WATSTORE and verified. Results will be reported to the national program coordinator.

PROGRESS FOR 1983.--Two atmospheric deposition stations were installed and data collection began. Record for first year's precipitation and quality is in progress.

PLANS FOR 1984.--Stations will continue to be monitored, will be stored in WATSTORE files.

REPORT PRODUCTS.--Data will be published in annual district report.

PROJECT TITLE: Water-Use Data Acquisition and Dissemination Program



LOCATION: Statewide

PERIOD OF PROJECT: Continuous

PROJECT CHIEF: Jon Patch, North Dakota State Water Commission, and Norman D. Haffield, U.S. Geological Survey

OBJECTIVES.--This study will establish a program to provide water-use information for the optimum utilization and management of the State's water resources. The program will collect, store, and disseminate water-use data to complement data on availability and quality of the State's water resources.

APPROACH.--Withdrawal uses can be evaluated quantitatively because they require removal of the water from the ground, stream, lake, or reservoir. The categories that would be applicable for obtaining the total withdrawals are irrigation, municipal use, industrial self-supply, agricultural (nonirrigation), dewatering, and injection. The total quantity of the water withdrawn can be obtained by adding together the known amounts of withdrawals. Two nonwithdrawal uses that need to be considered are recreation and preservation. For each of these categories, not only the record of withdrawal would be collected but other pertinent information that would be useful in water-use analysis.

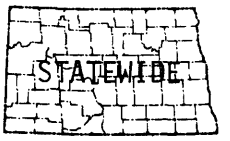
PROGRESS IN 1983.--The major cooperator, North Dakota State Water Commission, continues to collect water-use data and to store these data in their site specific oriented data base. The water-use data are obtained through contact with individuals who have permission to withdraw water for consumptive use. Field investigators were used to verify and supplement the user-supplied data.

PLANS FOR 1984.--(1) The North Dakota State Water Commission will continue to update and maintain the detailed water-use data base. (2) A computerized system that can retrieve the water-use data from the detailed state-level water-use data base and transfer these data to the National Water-Use Data System's (NWUDS) national-level aggregated data base will be developed and implemented. (3) In order to improve data collection, various techniques for obtaining accurate discharge information will be tested.

REPORT PRODUCTS.--Smith, M. L., and Harkness, R. E., 1980, Water use in North Dakota, 1980: North Dakota State Water Commission Information Series No. 31 (map).

Estimated Use of Water for North Dakota, 1982, (in preparation) will be published by North Dakota State Water Commission Information Series.

PROJECT TITLE: Evaluation of the Streamflow Collection Network for North Dakota



LOCATION: Statewide

PERIOD OF PROJECT: October 1983 to September 1985

PROJECT CHIEF: Gerald L. Ryan

OBJECTIVES.--Changes in the streamflow data-collection network are being made in a somewhat indiscriminate manner based on individual agency needs. The changes or cutbacks are necessary due to severe restraints on funds and manpower, and increased cost of operation. The tendency is to collect selective data to meet immediate requirements with little thought to future needs. The purpose of this study is to make a systematic review of the network to determine how best to serve the immediate and long-term Federal and State needs. The specific objectives of the study are to (1) define the purpose of the data collection at each site, (2) make a comparative merit evaluation for all sites, (3) identify alternative ways to supply data requirements and the changes that could be made in the network to effect savings in funds and manpower, and (4) identify requirements for periodic or continuous network evaluation.

APPROACH.--The study would be conducted in two phases. Phase one would be to answer objectives 1 and 2. Phase two would be to answer objectives 3 and 4. A questionnaire will be prepared and distributed to cooperators and other interested agencies to ascertain individual station interest. The data from the questionnaire would be compiled and manipulated to develop a relative merit for each existing station as well as any that might be proposed. Phase two would lend itself to statistical manipulation to effect network efficiency. This can be accomplished by one or more of several methods. A method that might be used effectively in improving data-collection activities and reducing funding and manpower costs is the "Kalman Filter Cost Effective Resource Allocation (K-CERO)".

PROGRESS IN 1983.-- New project. Project proposal and work plan completed.

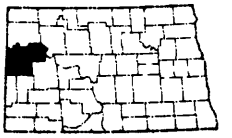
PLANS FOR 1984.--A general questionnaire will be formulated, circulated, and data compiled to develop a relative merit for each station. Report will be prepared containing results of first phase of the investigation. A start will be made on the statistical evaluation of data operation.

REPORT PRODUCTS.--A streamflow network for North Dakota (planned).

COUNTY GROUND-WATER STUDIES

The Geological Survey has for many years had a continuing program in cooperation with state and other Federal agencies to investigate the ground-water resources of the counties in North Dakota. The studies are connected under county or multicounty boundaries and every county has a study completed or in progress (fig. 4).

PROJECT TITLE: Ground-Water Resources of McKenzie County, North Dakota



LOCATION: Western North Dakota

PERIOD OF PROJECT: October 1978 to September 1983

PROJECT CHIEF: Mack G. Croft

OBJECTIVES.--The purpose of the investigation is to determine the quantity and quality of ground water available for municipal, domestic, livestock, industrial, and irrigation uses. Specifically, the objectives are (1) to determine the location, extent, and nature of the major aquifers and confining beds; (2) to evaluate the occurrence and movement of ground water, including the sources of recharge and discharge; (3) to estimate the quantities of water stored in the aquifers; (4) to estimate the potential yields to wells tapping the major aquifers; and (5) to determine the chemical quality of the ground water.

APPROACH.--This is a relatively comprehensive study of the ground-water resources. The methods of study are caategorized by the following activities: (1) Project planning, (2) water records, (3) geologic mapping, (4) test drilling, (5) chemical quality of water sampling and analyses, (6) aquifer tests and special studies, (7) data compilation and analysis, and (8) report preparation.

PROGRESS IN 1983.--Five test holes ranging from 1,600 to 2,100 feet deep have been drilled to the Pierre Shale. Thirty test wells have been drilled to the base of the Tongue River Formation. Glacial channels, some containing gravel, have been outlined in the northern part of the county and about 100 test wells have been drilled into them. The well canvas is complete. About 150 water samples have been collected and analyzed. Basic data report and interpretive report are written but awaiting logs from several test holes and proofing of data.

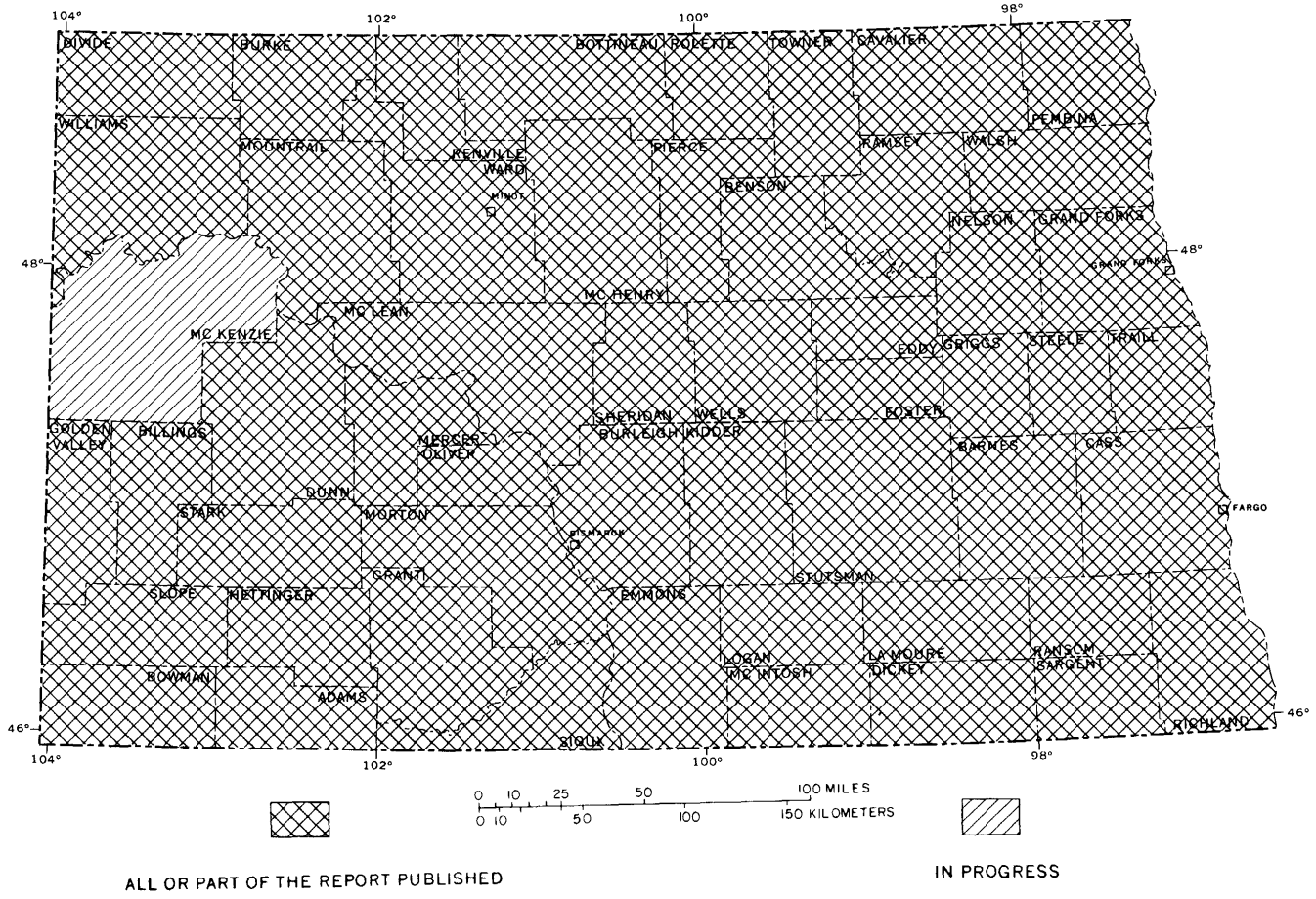


FIGURE 4.—Locations of county ground-water studies.

PLANS FOR 1984.--Plans for 1984 include addition of remaining data to data report and checking of accuracy. An analysis will be made of the remaining data, and the hydrologic report will be completed.

REPORT PRODUCTS.--Geology and ground-water resources of McKenzie County, North Dakota, pt. I, Geology (planned).

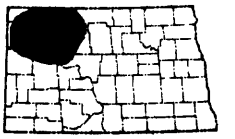
Geology and ground-water resources of McKenzie County, North Dakota, pt. II, Basic data by M. G. Croft (in preparation).

Geology and ground-water resources of McKenzie County, North Dakota, pt. III, Ground-water resources by M. G. Croft (in preparation).

REGIONAL STUDIES

In anticipation of water demands on a scale unlimited by political boundaries or local problems, the Geological Survey is conducting studies of regional ground-water systems. Some of these studies are in cooperation with other agencies. The studies are directed toward definition of the systems and prediction of the effects of stresses that could be imposed by present and future management plans.

PROJECT TITLE: Hydrology of Area 46 Northern Great Plains Coal Province, North Dakota



LOCATION: Northwestern North Dakota

PERIOD OF PROJECT: October 1982 to September 1983

PROJECT CHIEF: Mack G. Croft

OBJECTIVES.--The purpose is to describe the hydrology of Area 46 in a format readily usable by the coal-mining industry, the regulatory agencies, interest groups (such as environmental organizations), and the general public. The specific objectives of the study are to present (1) a description of the area in a hydrologic framework, (2) a quantitative assessment of the occurrence and availability of water, (3) an assessment of the present quality of available water, and (4) an identification of current and planned utilization of water.

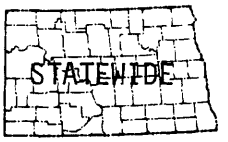
APPROACH.--A topic outline will be developed based on previous reports. Only existing data will be utilized to establish an information framework for the study area. All available data will be used to prepare graphs, maps, and text to fulfill the objectives of the study. The report will be prepared in accordance with the STOP (Sequential Thematic Organization of Publications) format.

PROGRESS IN 1983.--Work on ground-water and surface-water sections was completed. Illustrations and text completed. In-house review of report nearly complete.

PLANS FOR 1984.--Complete reviews and obtain Director's approval for publication.

REPORT PRODUCTS.--Hydrology of Area 46, Northern Great Plains coal province, North Dakota (report in preliminary form).

PROJECT TITLE: Changes in Precipitation Chemistry Resulting from Coal-Fired Energy Conversion Plants in North Dakota



LOCATION: North Dakota

PERIOD OF PROJECT: October 1981 to September 1984

PROJECT CHIEF: Robert L. Houghton

OBJECTIVES.--Detailed geochemical investigations will be made to (1) determine baseline concentrations of certain elements in aerosol, precipitation, soil, and water prior to large-scale development of fuel resources; (2) examine this baseline data for evidence of current influences by coal-fired generating facilities; (3) determine the variation in composition of atmospheric precipitation both temporally and spatially; (4) identify and evaluate mechanisms by which elements transfer within the ecosystem among atmosphere, water, and soil components; and (5) determine the impact of changes in precipitation chemistry on surface- and ground-water quality. The results of these studies should provide the necessary basis to (1) develop a conceptual model of the processes controlling the composition of atmospheric deposition, (2) follow with a mathematical model for quantitative predictions of future changes in precipitation quality and network design required to determine long-term changes in the quality of precipitation.

APPROACH.--Representative receptor locations will be chosen within and downwind of the energy development area in western North Dakota. Meteorological data and chemical data for wetand dry-deposition collected at each receptor location will be statistically evaluated to determine the covariance of properties measured. Parameters indicative of differing types of energy development will be identified and monitored on an event or weekly basis. Stable isotopes will be monitored periodically to determine the proportion of acidic substances in precipitation contributed by biogenic processes and fossil-fuel combustion. A mass balance-flux type model will be used to evaluate the effects of changing precipitation composition on the hydrologic system. An atmospheric model developed by the North Dakota State Health Department may be used to evaluate the effects of powerplant emissions on precipitation quality and predict future impacts. The composition of streams and lakes in the vicinity of precipitation stations will be monitored to measure the effects of precipitation chemistry on local surface waters. If impacts of degraded atmospheric deposition are recognized in local surface waters, regional surface- and ground-water quality data collected as part of the statewide network will be evaluated to determine the extent of these impacts.

PROGRESS IN 1983.--The quality of water in potholes adjacent to precipitation-collection stations at Canfield Lake and Woodworth and a small-basin headwater stream near Dunn Center was determined monthly to determine the hydrologic consequences of changing precipitation chemistry. During snowmelt, these surface-water quality determinations were supplemented by daily samplings and snow cores to identify snowmelt enrichments in the volatile trace metals. An area of apparent acidification in the Turtle Mountains of northern North Dakota was identified and added to surface-water quality investigations in midyear. Due to funding constraints, the Canfield Lake precipitation chemistry station was not operated in 1983; however, the North Dakota State Health Department continued to operate stations at Dunn Center and Woodworth. In September, this network was supplemented by installation of National Trends Network stations at Woodworth and Icelandic State Park.

PLANS FOR 1984.--Monitoring of pothole quality on a monthly basis will be continued in Canfield Lake Pothole No. 1 and Woodworth Pothole No. 14. These samplings will be supplemented by a daily monitoring during initial snowmelt and snow cores. Canfield Lake precipitation-collection station will be operated on a weekly basis.

REPORT PRODUCTS.--Houghton, R. L., 1983, Composition of atmospheric deposition in western North Dakota: Proceedings, 75th Annual Meeting of the North Dakota Academy of Science, Grand Forks, N. Dak., April 28-30, 1983, p. 59.

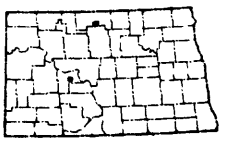
Houghton, R. L., 1983, Acidification of North Dakota surface water: Proceedings, Symposium on Acid Rain in Western Canadian Provinces, Regina, Saskatchewan, May 26-27, 1983, p. 16.

Houghton, R. L., Berger, M. E., Zander, N., and Dutchuk, S. K., 1984, Atmospheric deposition: Sample handling, storage, and analytical procedures for chemical characterization of event-based samples in North Dakota: U.S. Geological Survey Water Resources Investigations 83-4205, 136 p.

SPECIAL INVESTIGATIONS

Special hydrologic investigations are often needed to supplement the ongoing program. These special investigations include water-supply problems, drainage problems, ground-water and surface-water relationships, ground-water recharge, and water management. The objective is to assist State and Federal agencies in solving water-resources problems on short notice.

PROJECT TITLE: Feasibility of Aerial Snow Surveys to Determine the Variation of Snow Cover on Snow Courses of 1 Mile or Less on the Northern Plains of North Dakota



LOCATION: North-Central North Dakota

PERIOD OF PROJECT: October 1980 to September 1982

PROJECT CHIEF: Douglas G. Emerson

OBJECTIVES.--The objectives of the investigation are (1) to combine aerial snow survey and ground snow survey techniques to determine snow water equivalents on selected land use/terrain type units, and (2) reducing operating length of the aerial sensing path into segments sufficiently short to quantify areal variation in snow water equivalents.

APPROACH.--Two methods of making snow surveys will be used to obtain the objectives of the study. The first method is a ground snow survey using a terrain type land-use method as outlined by Steppuhn and Dyck1/. Pastures, cultivated fields, sloughs, brush, etc., within the same climatic region tend to accumulate snow according to recurring patterns unique to specific terrain type and land use. Therefore, snow samples are collected within similar areal units resulting in a ready, but statistically valid, method of estimating true snow-water equivalents. The second method is an airborne snow survey system based on the attenuation of natural terrestrial gamma radiation due to snow cover. The operational program serves primarily National Weather Service River Forecast Centers in the upper Midwest. The delineation of the airborne snow survey data into smaller segments to determine the variation of snow cover will be examined.

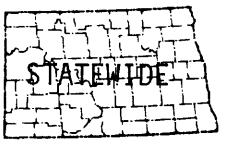
1/Stepphun, H., and Dyck, G. E., 1974, Estimating true basin snow cover; Proceedings of Symposium on Advanced Concepts and Techniques in the Study of Snow and Ice Resources: U.S. National Academy of Sciences, Washington, D.C., p. 314-324.

PROGRESS IN 1983.--Colleague review has been completed.

PLANS FOR 1984.--Plans for 1984 are to complete the review for the interpretive report and obtain Director's approval for publication.

REPORT PRODUCTS.--"Feasibility of Aerial Snow Surveys to Snow Cover on Snow Courses of 1 Mile or Less on the Northern Plains of North Dakota" by Emerson, D. G., Carroll, T. R., and Steppuhn, H. (in preparation).

PROJECT TITLE: Pumping Techniques Bias in Chemistry of Ground-Water Samples



LOCATION: Statewide

PERIOD OF PROJECT: October 1980 to September 1982

PROJECT CHIEF: Robert L. Houghton

OBJECTIVES.--The objective of this investigation is to determine the nature and magnitude of chemical biases introduced during the sampling of ground water by several different common pumping methods. Pumps being investigated include air-lift, gas-squeeze, gas-driven reciprocating, peristaltic, and submersible centrifugal pumps and Kemmerer-type and conventional bailers. Analyses of ground water sampled by these techniques should provide a basis for evaluating historical ground-water data and determining preferred methods for future sampling.

APPROACH.--In phase 1 of the project, only wells of similar construction were studied, thus minimizing water-quality alteration due to well conditions. During phase 2, randomly selected wells were sampled without regard to construction design, but only water from wells of similar construction and composition were considered in each statistical group. To fully assess the affected properties, deep, intermediate, and shallow wells were included. To assure applicability of the results to all water types, wells yielding sulfate-, bicarbonate-, and chloride-type waters were studied. Additionally, adjacent wells to the same aquifer depth but cased in different materials were sampled to evaluate the effect of well construction on apparent ground-water quality.

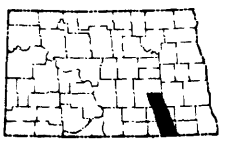
PROGRESS IN 1983.--The draft report was completed and started into the review process.

PLANS FOR 1984.--Final publication of the report is anticipated in 1984.

REPORT PRODUCTS.--Houghton, R. L., and Berger, M. E., 1984 Effect of sampling method on apparent quality of ground water (in progress).

Houghton, R. L., and Berger, M. E., 1984, Effects of well-casing composition and sampling method on apparent quality of ground water: Proceedings of the National Water Well Association's Fourth National Symposium and Exposition on Aquifer Restoration and Ground-Water Monitoring, Columbus, Ohio (in progress).

PROJECT TITLE: Hydrology of the Lower James River Basin in North Dakota



LOCATION: Southeastern North Dakota

PERIOD OF PROJECT: October 1981 to September 1984

PROJECT CHIEF: Jeffrey E. Miller and Paul K. Christensen

OBJECTIVES.--The objectives of this study are to (1) define the hydrology of the ground-water and surface-water system and (2) develop quantitative capabilities for the evaluation of water-use impacts.

APPROACH.--The project is being done in a series of stages over a 3-year period. The ground-water and surface-water system will be defined as far as possible with currently available data. Based on this definition, a data-collection procedure will be designed so that the system can be redefined in detail. Ground-water levels, flow data, and ground-water and surface-water quality differences will be used to define the system. A preliminary report will be prepared. Additional data needs again will be determined and the data collected before the final system definition is completed. Based on the system and approach, a model will be developed, tested, and described in the final report.

PROGRESS IN 1983.--Based on the results of over 40,000 feet of drilling and the development of 230 monitoring wells, a significantly updated conceptual model of the ground-water and surface-water system is being developed. A seepage run under ice was completed which clearly showed the reaches of ground-water contribution. The digital modeling system for simulating the ground-water and surface-water system has been designed, programed, and tested. The system is based on the U. S. Geological Survey modular ground-water model. A progress report was prepared but will not be published.

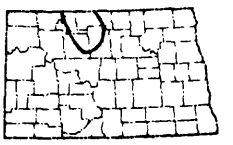
PLANS FOR 1984.--The data report will be prepared. Final data development for the digital ground-water and surface-water model will be completed and the modeling system will be calibrated and simulation runs made. The final report will be completed.

REPORT PRODUCTS.--Progress report for the cooperator on the ground-water and surface-water system of the lower James River basin, North Dakota by P. K. Christensen and J. E. Miller (not published).

Ground-water and surface-water data for the lower James River basin, North Dakota (planned).

The ground-water and surface-water system of the lower James River basin, North Dakota (planned).

PROJECT TITLE: Water-Quality Assessment of the Souris River within North Dakota



LOCATION: Souris River within North Dakota

PERIOD OF PROJECT: October 1981 to September 1984

PROJECT CHIEF: Edwin A. Wesolowski

OBJECTIVES.--(1) To define the hydrologic system and the current water-quality problems. (2) To determine time-of-travel, dispersion, and reaeration characteristics. (3) To quantitatively evaluate water-quality processes. (4) To develop conceptual and digital models to evaluate the waste load and water-quality relationships and to predict the effect of waste discharges on the river at various flows and at selected reaches of the river.

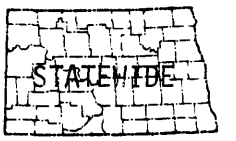
APPROACH.--Existing data will be used to identify seasonal water-quality and hydrologic trends and conditions when the river is susceptible to degradation. At these critical periods additional data will be collected to isolate the processes that degrade the stream. A one-dimensional, steady-state, water-quality model will evaluate these processes using the new data and field determined times-of-travel and dispersion and reaeration coefficients.

PROGRESS IN 1983.--Initial calibration of the steady-state water-quality model was performed. Data storage and retrieval for 1982 data has been accomplished. Some data reduction has also been accomplished, mostly determining BOD decay rates and ultimate BOD's. All planned 1983 fieldwork was accomplished which consisted of: dye and gas tracer studies to determine time-of-travel and reaeration characteristics in five subreaches of a 180-mile reach, and collecting one set of synoptic water-quality samples from 12 river sites and three lagoon sites to verify the steady-state water-quality model.

PLANS FOR 1984.--Reduce and analyze all data collected, finish calibrating and verifying steady-state water-quality model, and write report.

REPORT PRODUCTS.--Water quality of the Souris River (planned).

PROJECT TITLE: Inventory and Analysis of Information for Flood Plain Management in North Dakota



LOCATION: Statewide

PERIOD OF PROJECT: October 1982 to September 1983

PROJECT CHIEF: Douglas G. Emerson

OBJECTIVES.--The objectives of this study are to (1) determine all data available regarding flood hazards, hydraulics, and hydrology for particular areas; (2) analyze these data to determine their adequacy for flood-plain management purposes; (3) if adequate, present these data in a format usable to local flood plain administrators, and (4) if inadequate, determine the effort necessary to produce "best engineering judgment" flood elevations.

APPROACH.--A systematic and comprehensive data search will be conducted for each site. The data search will include files of the U.S. Geological Survey, other Federal agencies, and the State agencies. Direct contact will be made with governmental units responsible for area under consideration. The data obtained through the systematic search will be analyzed for its adequacy in defining flood information. If found adequate, data will be put into a format that can be used by managers. If the data are found inadequate, an attempt will be made to establish the fieldwork and analytical work necessary to provide at least a minimal base for flood management decisions.

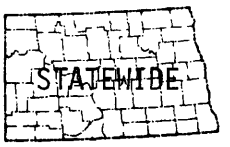
PROGRESS IN 1983.--The compilation of flood data for selected areas has been completed. Flood data report has been prepared.

PLANS FOR 1984.--Plans for 1984 are to obtain Director's approval to publish flood data report.

REPORT PRODUCTS.--Emerson, D. G. and Wald, J. D., 1983: Inventory and analyses of information for flood plain management in North Dakota.

Supplement to published report planned for 1984.

PROJECT TITLE: Evaluation of the Theory and Methodology for Quantifying Recharge and Evapotranspiration for Shallow Glacial Aquifers in North Dakota



LOCATION: Statewide

PERIOD OF PROJECT: October 1982 to September 1983

PROJECT CHIEF: William F. Horak, Jr.

OBJECTIVES.--Several of North Dakota's shallow glacial aquifers have been extensively developed for irrigation and municipal water supplies. Requests for new ground-water use permits for these aquifers are evaluated with regard to the impact of the proposed use on prior appropriators and on the overall water budget of the geohydrologic system. The evaluation procedure, particularly for the aquifers that are already heavily appropriated, generally includes the use of ground-water flow models. The models frequently have given unsatisfactory results, however, because reliable data concerning recharge and evapotranspiration magnitudes for North Dakota aquifers are lacking. This study is designed, therefore, to provide information concerning recharge and evapotranspiration that will strengthen the credibility of aquifer management decisions. Specifically, the study objectives are to (1) review the hydrologic literature dealing with the determination of ground-water recharge and evapotranspiration; (2) review the theory and methodology for the determination and estimation of the critical soil and meteorological parameters; (3) consider the relative merits of a rigorous, data-intensive approach versus an estimation, parametric approach; and (4) review the agronomic research, past and present, in North Dakota for applicability of the research and the data generated to the study of recharge and evapotranspiration.

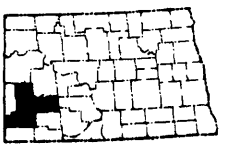
APPROACH.--This study will involve no original data collection. Rather, achievement of the objectives will involve an extensive study of the literature and a canvassing of appropriate scientific agencies and institutions. The study will have application to all shallow glacial aquifers in North Dakota. It is expected that this study provide the background research, preliminary planning, and sound approach for a subsequent project that would actually acquire the data and make the analyses and interpretations necessary for quantifying recharge and evapotranspiration.

PROGRESS IN 1983.--The literature study was completed and agencies having pertinent data were contacted and interviewed. A draft report was about 75 percent completed.

PLANS FOR 1984.--The final report will be completed and submitted for review early in fiscal year 1984.

REPORT PRODUCTS.--"Theory and methodology for quantifying recharge and evapotranspiration for shallow glacial aquifers in North Dakota" will be submitted for publication in the Water-Resources Investigation series of the U.S. Geological Survey.

PROJECT TITLE: Hydrogeochemical Controls on the Mobility of Radiogenic Constituents in Uraniferous Lignite and Ash in North Dakota



LOCATION: Billings, Stark, and Slope Counties, North Dakota

PERIOD OF PROJECT: June 1983 to September 1987

PROJECT CHIEF: Robert L. Houghton

OBJECTIVES.--The objectives are: (1) determination of the physiochemical conditions which promote the mobility of radiogenic, select trace metal, and other potentially hazardous chemical constituents from uraniferous lignite and its ash throughout the hydrologic system; (2) prediction of the mobility of these constituents at each of the abandoned mine sites in western North Dakota; (3) comparison of predicted and observed ground-water, pore-water, and surface-water compositions affected by mine-derived solutes; (4) development of reclamation methods which might limit hazardous waste mobility from the sites; and (5) eval-uation of reclamation practices adopted by the North Dakota State Public Service Commission to restore the sites to maximum safe usefulness.

APPROACH.--The study consists of three phases. Phase 1 is designed to provide the geohydrologic and geohydrochemical data at all eight sites necessary to develop initial reclamation plans. Phase 2 will determine the geochemical processes controlling radiochemical mobility in the hydrologic system. Specifically, one uranium mining and ashing site which intersects the water table, a second uranium mining and ashing site remote from the water table, and a kiln processing site will be selected for extensive study. Phase 3 will determine the transference value of information gathered in phase 2 to the remaining phase 1 sites. Proof of transference is requisite before the simulation can be utilized to help develop standards for reclamation of mine sites.

PROGRESS IN 1983.--All existing hydrogeologic data in the vicinity of the mine sites have been evaluated to look for evidence of mobility of radiogenic constituents from the sites. Seepage surveys were conducted on area streams and samples of baseflow and stream sediments taken for analysis for radiogenic and selected trace-element components. Domestic- and livestock-supply wells in the vicinity of mine sites were sampled and the collected ground water analyzed for the same constituents as surface water. Aerial photographs of all sites were obtained and converted to topographic maps. Aerial radiogenic surveys were conducted to identify surface exposures of radiogenic constituents in the area and the magnitude of wind-blown dust migration from mine sites to surrounding farmland.

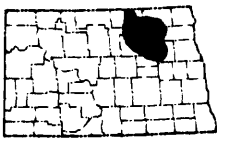
PLANS FOR 1984.--During the fall, ground-water wells, pressure-vacuum lysimeters, and radon etch detectors will be emplaced in and near mine sites. Ground and pore water will be sampled seasonally. Cores obtained during drilling operations will be subjected to leaching and Soxholet extraction experiments to determine the mobility of hazardous constituents occurring in the solid phase. Monthly ground-water levels and drilling information will be used to develop flow models at the phase 2 sites. Solute transport equations may be applied if errors in the flow model are sufficiently low.

REPORT PRODUCTS.--Houghton, R. L., Wald, J. D., and Anderson, Garth, 1984, Hydrogeochemical controls on the mobility of radiogenic constituents in mine spoils and uraniferous lignite ash in southwestern North Dkaota [abs.]: Proceedings of the 1984 Rocky Mountain Ground-Water Conference, Great Falls, Mont. (in progress).

Houghton, R. L., Wald, J. D., and Anderson, Garth, 1984, Hydrogeochemical controls on the mobility of radiogenic constituents at uraniferous lignite mines in southwestern North Dakota [abs.]: Proceedings, 76th Annual Meeting of the North Dakota Academy of Science, Fargo, N. Dak., (in progress).

Houghton, R. L., Wald, J. D., and Anderson, Garth, 1984, Hydrogeochemical controls on the mobility of radiogenic constituents in the coal-bearing Fort Union Formation and in lignite mines of western North Dakota: Proceedings of the 1984 Rocky Mountain Coal Symposium, Bismarck, N. Dak., 47 p. (in progress).

PROJECT TITLE: An Investigation of the Hydrologic and Climatologic Mechanisms Controlling the Water-Surface Elevation of Devils Lake, North Dakota



LOCATION: Northeastern North Dakota

PERIOD OF PROJECT: October 1983 to September 1984

PROJECT CHIEF: Gregg J. Wiche

OBJECTIVES.--The current high water-surface elevations of Devils Lake pose an immediate flood threat to the city of Devils Lake. The U.S. Army Corps of Engineers has developed a draft report detailing a flood control project at Devils Lake. In this plan, four structural and nonstructural flood control plans have been developed to prevent flooding. Implementation of any of these plans should be based on knowledge of the hydrologic and climatologic relationships of the Devils Lake system. The purpose of this study is to gain an understanding of the interaction of the hydrologic and climatologic mechanisms controlling the water-surface elevation of Devils Lake. There are two objectives that will be investigated to meet the purpose of the study. First, a literature review will be conducted to see what previous studies have been completed. The second objective will be to conduct a statistical comparability analysis of Devils Lake basin to other streams and basins.

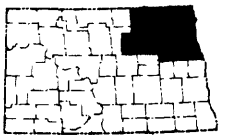
APPROACH.--A literature review will be conducted to see what studies have been undertaken that may provide ideas and methods that can be incorporated in the present study. These findings from previous studies will provide guidelines as to what statistical techniques may show promising results. A statistical analysis of Devils Lake basin and other streams and basins will be conducted using multiple linear regression. In addition, correlations will be made using the climatological indices of temperature and precipitation.

PROGRESS IN 1983.--New project.

PLANS FOR 1984.--Complete project as outlined in objectives and approach and prepare final report.

REPORT PRODUCTS.--Investigation of Devils Lake water-level fluctuations (planned).

PROJECT TITLE: Effects of Fallowed Land on Soil Erosion, Northeastern North Dakota



LOCATION: Northeastern North Dakota

PERIOD OF PROJECT: July 1983 to September 1985

PROJECT CHIEF: Robert L. Houghton

OBJECTIVES.--The objectives are to: (1) make semiquantitative estimates of soil erosion from farmlands managed with differing agricultural practices, (2) determine the effect of land laid fallow on the magnitude of soil erosion, and (3) determine the effect of expected increase in soil erosion on sediment loads in major rivers and their tributaries draining eastern North Dakota.

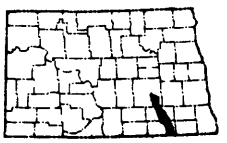
APPROACH.--Low-level aerial photography of fallow fields will be employed before and after the major summer rain period. Soil erosion will be estimated from rill patterns on the photographs and calibrated against ground-truth surveys. Calculated soil losses will be compared to suspended-sediment loads at stations in the small basins being investigated.

PROGRESS IN 1983.--Project-planning phases have been completed. Track lines and areas to be included by the study have been identified by reconnaissance survey.

PLANS FOR 1984.--Tracts identified for survey will be flown and ground-truth measurements taken. Data evaluation will begin in midsummer.

REPORT PRODUCTS.--Aerial determination of soil erosion in northeastern North Dakota (planned).

PROJECT TITLE: Evaluation of Streamflow-Gaging Methods for Application to Rivers with Flat Slopes, North Dakota.



LOCATION: Southeastern North Dakota

PERIOD OF PROJECT: October 1982 to September 1985

PROJECT CHIEF: Gregg J. Wiche

OBJECTIVES.--The objectives of this study area are to (1) test and compare the feasibility, cost effectiveness, and accuracy of acoustical velocity meters, stage-fall-discharge ratings, and unsteady-state flow models for gaging stream discharge and (2) collect adequate field data to develop streamflow records at a site near Hecla, S. Dak.

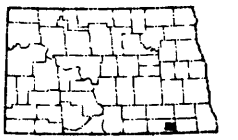
APPROACH.--The stage data, necessary to drive the unsteady flow model, has been collected by constructing and operating three gaging stations. These stage data will be used to develop the unsteady-state flow model for a 4-mile section of the river ending at the downstream site. Discharge will be computed by the flow model at the downstream site. A stage-fall-discharge rating will be developed at the downstream site. Discharge is also being collected using an acoustic velocity flow meter. The accuracy, feasibility, and cost effectiveness of the three methods used to collect discharge will be compared. In addition, a stage-discharge relationship will be developed at the upstream site which is a low-head dam.

PROGRESS IN 1983.--Construction and operation of the three sites has been completed. The acoustical velocity flow meter was installed and there has been a number of operational problems. Twelve discharge measurements have been made at the downstream site and these have been used to start development of the stage-fall-discharge relationship. The necessary cross-section data for the unsteady flow model has been gathered. At the upstream site (low-head dam), 22 discharge measurements have been made and were used to develop a stage-discharge relationship. The discharge record for the 1982 water has been worked at the upstream site.

PLANS FOR 1984.--A new acoustic velocity flow meter will be installed and calibrated at the downstream site. The cross-section data, required as input to the unsteady flow model, will be compiled, and the initial calibration will be conducted. Development of the stage-fall-discharge relationship will continue. Initial comparisons of discharge at the upstream and downstream sites will be undertaken.

REPORT PRODUCTS.--None planned for 1984.

PROJECT TITLE: Application of Unsaturated Zone Monitoring and Modeling Techniques to the Determination of Ground-Water Recharge



LOCATION: Southeastern North Dakota

PERIOD OF PROJECT: October 1983 to September 1986

PROJECT CHIEF: William F. Horak

OBJECTIVES.--A review of the hydrologic literature indicates that little precedent is available for direct, quantitative approaches to studying ground-water recharge and evapotranspiration (ET). Most geohydrologic studies have involved either loosely defined water budgets or water level time series analyses to estimate ground-water recharge or ET or both. Neither of these approaches are suitable for the intensive management of North Dakota's heavily developed glacial-drift aquifers. Attempts to simulate the effects of additional ground-water withdrawals on these aquifers have been frustrated by the lack of data regarding recharge and ET. It is essential to the responsible management of the aquifers, therefore, that reliable estimates of the magnitudes of recharge and ET be made available. The specific objectives are to: (1) measure the hydraulic properties, including the functional relations of hydraulic conductivity and of matric potential to moisture content, for the major soil groups in the study area; (2) evaluate the areal variability of those data; (3) select a physically-based model(s) for simulation of unsaturated or variably saturated flow; (4) use the model to test the sensitivity of the flow system to variations in soil hydraulic properties and assumed boundary conditions; (5) collect the data required for use of the Penman combination method of estimating potential evapotranspiration (PET); and (6) make recommendations as to the optimum manner in which to interface the information output by the recharge and ET process model(s) with the ground-water flow model.

APPROACH.--The important emphasis of this study will be the field collection of soil hydrologic data. Tensiometers and neutron moisture measurements will be used to define the soil-moisture characteristics for the major soils in the study area. The instantaneous profile method of determining unsaturated hydraulic conductivity will also be used. The acquired soil-moisture, moisture potential, and hydraulic conductivity data will be used with an unsaturated or variably saturated flow model to determine probable rates of ground-water recharge. Estimates of ET from the water table will be derived from the PET, moisture content, and moisture potential data.

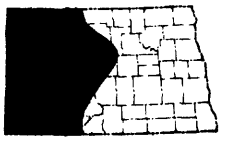
PROGRESS IN 1983.--New project. However, a literature review was completed under a previous project.

PLANS FOR 1984.--Begin collection of data and select an unsaturated or variably saturated model for use on project.

REPORT PRODUCTS.--Preliminary report on field collection methods for recharge determinations (planned).

Determination of recharge and ET for shallow drift aquifers in North Dakota (planned).

PROJECT TITLE: Hydraulic Characteristics of Aquifers and Confining Units in the Fort Union Formation



LOCATION: West-Central North Dakota and Eastern Montana

PERIOD OF PROJECT: October 1983 to September 1985

PROJECT CHIEF: Thomas B. Reed

OBJECTIVES.--Previous studies of the hydrogeology of lignite deposits in North Dakota have generally not provided the areally distributed hydraulic data that are required for use in groundwater flow models. Without this type of data, the areal and temporal distribution of drawdown in the vicinity of a strip mine cannot be accurately projected. Furthermore, without valid, calibrated flow models, solute transport processes cannot be quantitatively modeled. The objectives will be to: (1) evaluate the available methodologies appropriate for the in situ determination of hydraulic conductivity (or transmissivity), specific storage, and specific yield of fractured rock aquifers and for the determination of vertical hydraulic conductivity and specific storage of confining beds; (2) establish and execute a systematic procedure for the collection and analysis of data required for the determination of the hydraulic properties of the lignite and sandstone aquifers and confining beds; (3) examine the data for correlative relationships between lignite hydraulic conductivity and various physical or geologic parameters such as depth of burial or lignite bulk density; and (4) compare values of aquifer hydraulic conductivity derived from slug testing with those derived from pumping tests; to evaluate the validity of the slug test method for fractured rock and granular aquifers.

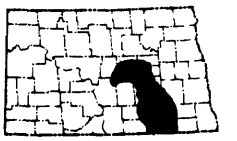
APPROACH.--Accomplishment of the study objectives will require a drilling program that will provide the production and observation wells necessary for the pumping and slug tests. Aquifer testing by pumping methods will require production wells to be drilled in several different locations, each fully penetrating the aquifer and each accompanied by several observation wells placed at varying distances and directions from the production well. Each of the wells completed in aquifer zones will also be used for slug testing. Additional wells will be completed in the confining beds.

PROGRESS IN 1983.--New project. Project proposal and initial literature review completed.

PLANS FOR 1984.--Plan initial field data collection. Drilling test holes and establishing wells for aquifer and confining unit testing. Complete literature review.

REPORT PRODUCTS.--Hydraulic parameters in the Fort Union Formation (planned).

PROJECT TITLE: Data Development and Analysis for Use in the U.S. Bureau of Reclamation Model on the James River



LOCATION: Southeastern North Dakota

PERIOD OF PROJECT: October 1983 to September 1984

PROJECT CHIEF: Gregg J. Wiche

OBJECTIVES.--The James River planning model that will be developed by the U.S. Bureau of Reclamation will require, as input data, the nonregulated and regulated discharges at a number of locations along the James River. A combination of water balance and statistical procedures will be used to synthesize the necessary input data. The purpose of this study will be to compile and analyze the monthly discharge data needed as input to the planning flow model that will be developed by the U.S. Bureau of Reclamation. Specific objectives are to: (1) compute a regulated discharge for the period 1953-82 at the North Dakota-South Dakota State line, (2) compute unregulated discharge for six James River locations, (3) characterize the period of record in terms of the recorded climatological record, and (4) compute revised drainage area figures for the James River basin.

APPROACH.--Two methods will be used to compute the regulated discharge at the North Dakota-South Dakota line. The first method of record reconstruction is the drainage area ratio technique outlined by Hirsch (1979). The second method will be to develop log-log regression between the monthly flows of James River at LaMoure and the monthly flows of James River at Ludden Dam which is within a mile of the North Dakota-South Dakota line. The unregulated flows will be computed by determining the effect of Jamestown and Pipestem Reservoirs and then subtracting or adding the monthly effect to the regulated flows at stations downstream of the reservoirs.

PROGRESS IN 1983.--New project. Project proposal and work plan completed.

PLANS FOR 1984.--Meet the objectives of the project and produce the report.

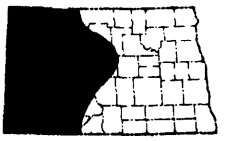
REPORT PRODUCTS.--James River model data (planned).

ENERGY-RELATED STUDIES

The expanding domestic energy demand has resulted in increased coal production and associated development in North Dakota. To meet the requirements for coal leasing and environmental protection, the Geological Survey has developed a program to evaluate the water resources in areas of current and planned development. This program is effected through the cooperation of interested agencies and Geological Survey funds.

PROJECT TITLE: Hydrologic Changes Due to Lignite Mining in North Dakota, Part 1--Reconnaissance of Strippable Lignite Deposits

LOCATION: Western North Dakota



PERIOD OF PROJECT: July 1974 to June 1977

PROJECT CHIEF: William F. Horak, Jr.

OBJECTIVES.--The project objectives are to define for each strippable lignite deposit (as identified in publications of the U.S. Bureau of Mines and the U.S. Geological Survey) the following information: (1) A summary of local geologic conditions; (2) description of the local ground-water flow system; (3) flow characteristics of the streams; (4) chemical quality of water from streams, lakes, and aquifers; (5) stream sediment loads; and (6) recommendations for more intensive hydrologic studies in probable problem areas.

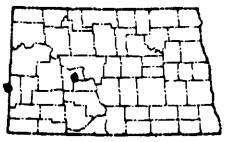
APPROACH.--A field reconnaissance will be made to evaluate the deposit areas in regard to geology, topography, and land use. A literature and data search will be made and all hydrologic and geologic data computerized. Conceptual models will be developed for each site through preliminary analysis and interpretation of available data. Additional data needs will be defined and a program of data collection instituted. These data will then be used to further develop and test the conceptual models. The probable hydrologic changes due to mining will be evaluated for each deposit, and recommendations for areas of future intensive hydrologic study will be made.

PROGRESS IN 1983.--The ground-water aspects of the lignite deposit areas have been completed. These are being incorporated into second generation reports. One area, the Avoca deposit, is being reported on separately.

PLANS FOR 1984.--Complete the review of the report on the Avoca deposit and process through Director's approval.

REPORT PRODUCTS.--Hydrologic reconnaissance of lignite deposit areas in North Dakota, Avoca deposit by W. F. Horak and O. A. Crosby (in preparation).

PROJECT TITLE: Evaluation Through Modeling of Probable Surface-Water Hydrologic Effects of Future Lignite Mining and Reclamation Activities in the Antelope Creek Area, Mercer County, North Dakota, and the Wibaux-Beach Deposit Area, Wibaux County, Montana, and Golden Valley County, North Dakota



LOCATION: Mercer County, North Dakota, and Wibaux County, Montana

PERIOD OF PROJECT: October 1979 to September 1982

PROJECT CHIEF: Douglas E. Emerson

OBJECTIVES.--The objectives of this investigation are (1) to determine premining hydrologic conditions in a small representative drainage basin, (2) to provide historical data with which to compare the magnitude of change with mining, and (3) to develop the capability of making reasonable accurate projections of hydrologic effects resulting from the various land treatments imposed by surface mining.

APPROACH.--This will be a very comprehensive study of two small representative watersheds. A surface-water model will be developed through coupling of snowmelt-rainfall-runoff models. A modular-design program will be used with each element of the hydrologic system being defined by a subroutine. This program has the capability of combining subroutines to best fit a particular problem. A distribution-parameter approach is being used by having the basin partitioned into subunits based on slope, aspect, vegetation type, soil type, and snow distribution. Each subunit will be considered homogeneous with respect to these parameters. Partitioning into subunits will help define the temporal and spatial variations of the hydrologic characteristics, climatic variables, and overall system response.

PROGRESS IN 1983.--The U.S. Geological Survey's Precipitation Runoff Modeling System was calibrated for both watersheds for snowmelt runoff. For the snowmelt period, maximum available water-holding capacity of soil profile, emissivity of dry air, and correction for daily precipitation (SMAX, EAIR, and DSCOR) were parameters which were most sensitive. Several basic delineations were tested and found that for well-defined snow distribution about 36 subunits adequately showed the variability in the basin.

PLANS FOR 1984.--Plans for 1984 are to complete the review of the final report and obtain Director's approval for publication.

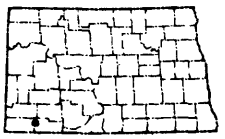
REPORT PRODUCTS.--Emerson, D. G., 1981, Progress report on the effects of surface mining on the surface-water hydrology of the selected basins in the Fort Union coal region, North Dakota and Montana: U.S. Geological Survey Open-File Report 81-678.

Emerson, D. G., 1982, Hydrologic analysis of high flow from snowmelt on small basins in the Fort Union coal region: Proceedings of North Dakota Academy of Science 74th Annual Meeting, Bismarck, N. Dak., April 22-24, 1982, v. 36, p. 42.

Emerson, D. G., Norbeck, S. W., and Boespflug, K. L., 1983: Data from the surface-water hydrologic investigations of the Hay Creek study area, Montana, and the West Branch Antelope Creek study area, North Dakota, October 1976 through April 1982, 273 p.

Hydrologic analyses of Hay Creek, Montana, and West Branch Antelope Creek, North Dakota by D. G. Emerson (in review).

PROJECT TITLE: Geochemistry of the Upper Fort Union Group as Related to Impacts of Strip Mining of Lignite in the Gascoyne Area, North Dakota



LOCATION: Southwestern North Dakota

PERIOD OF PROJECT: October 1979 to September 1984

PROJECT CHIEF: Robert L. Houghton

OBJECTIVES.--The purpose of this investigation is to quantitatively describe major controls on the movement of critical solutes in local and regional ground-water systems within the Fort Union Group affected by surface mining of lignite in western North Dakota. Specific objectives at the Gascoyne site are to define the hydrogeologic and hydrogeochemical character of the shallow ground-water system in the area and to ascertain the source of observed anomalous sulfate concentrations. The effects of discharge of mine-impacted ground water on the surface-water system in the area also are of concern.

APPROACH.--The first phase was to establish a clear and complete understanding of the hydrologic regime. Next, the mineralogy and mineral chemistry of the Fort Union Group was determined. Thirdly, determinations of formation cation-exchange rates and constants were determined. Fourth, oxidation-reduction reactions were defined for important species pairs. Finally, the solute flux from mine to locations of water use must be defined as mining expands.

PROGRESS IN 1983.--Continued monitoring of 20 ground-water wells and one surface-water station on a tributary of Buffalo Creek draining the mine area provided additional data on temporal hydrochemical changes in the vicinity of the Gascoyne mine. Review of the data base to identify which chemical parameters in ground and surface water best indicate mine impact was initiated. Two new cores were obtained in the mine area to provide material for stable and radiogenic carbon analyses in cooperation with D. C. Thorstenson and H. A. Haas, Northeast Region Research staff. This carbon-isotopic data are expected to constrain the number of possible organic reactions involved in water-quality evolution at the site to a small number, permitting refinement of preliminary solute transport simulations.

PLANS FOR 1984.--Monitoring of 20 ground-water wells and one surface-water station will continue. A summary of the existing hydrochemical data will be developed. Work will continue on the reports.

REPORT PRODUCTS.--Houghton, R. L., 1982, Hydrochemistry of shallow ground water from the Fort Union Group near the Peerless lignite strip mine, Gascoyne, southwestern North Dakota [abs.]: Proceedings, 74th Annual Meeting of the North Dakota Academy of Science, Bismarck, N. Dak., p. 40.

Houghton, R. L., and Davison, D., 1982, Stratigraphy and paleoenvironment of the Paleocene Fort Union Group of the Williston basin near Gascoyne, southwestern North Dakota [abs.]: Proceedings, 74th Annual Meeting of the North Dakota Academy of Science, Bismarck, N. Dak., p. 15.

Houghton, R. L., 1982, Hydrogeochemical consequences of strip mining in the Fort Union Group of southwestern North Dakota: Proceedings of the 1982 National Symposium on Surface Mining Hydrology, Sedimentology, and Reclamation, Lexington, Ky, December 6-10, 1982, p. 79-86.

Houghton, R. L., 1982, Weathering of coal scoria--a source for diagenetic silica cements? [abs.]: Proceedings of the U.S. Geological Survey Workshop on Diagenesis, Denver, Colo., March 1982, p. 36.

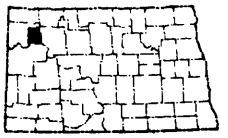
Houghton, R. L., 1982, Trace-element enrichments in waters associated with strip mining of lignite in the Fort Union Group of southwestern North Dakota [abs.]: in Gough, L. P., and Severson, R. C.; eds., Trace Element Mobilization in Western Energy Regions: Colorado School of Mines Research Institute, Golden, Colo., p. 46.

Houghton, R. L., Thorstenson, D. C., Fisher, D. W., and Groenewold, G. H., 1984, Hydrogeochemsitry of the upper part of the Fort Union Group in the Gascoyne lignite strip-mining area, North Dakota: U.S. Geological Survey Open-File Report 84-131, 163 p.

Houghton, R. L., Probable and observed hydrologic consequences of lignite strip mining in the Fort Union Group near Gascoyne in southwestern North Dakota (in progress).

Fisher, D. W., Thorstenson, D. C., and Houghton, R. L., Geochemical processes in the Gascoyne lignite mining area, Bowman County, North Dakota (in progress).

PROJECT TITLE: Evaluation of Probable Hydrologic Effects of Future Lignite Mining and Subsequent Reclamation Activities in the M & M Deposit, Williams County, North Dakota



LOCATION: Northwestern North Dakota

PERIOD OF PROJECT: October 1980 to September 1983

PROJECT CHIEF: William F. Horak, Jr.

OBJECTIVES.--Define the hydrologic regime in the greatest possible detail consistent with the duration of the study and funding. This will include assessment of the ground-water flow system and its chemical characteristics, determination of flow frequencies and magnitude, chemical quality, and sediment concentration and load of the larger streams. Establish a historical data base. Develop the capability for projecting the hydrologic effect of physical treatments imposed by surface mining.

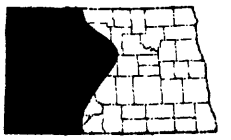
APPROACH.--Data will be assembled and collected for use in conjunction with digital models to define the ground-water flow system. The surface-water system will be defined through available records, data collection, and regionalized equations. Quality of water will be defined through an intensive sampling program. Methods for estimating the hydrologic effects of various land treatments imposed by mining will be developed.

PROGRESS IN 1983.--Interpretations and report writing continued.

PLANS FOR 1984.--Complete report and process through Director's approval.

REPORT PRODUCTS.--Hydrologic characteristics and possible effects of surface mining in the M & M lignite deposit area, North Dakota by O. A. Crosby, W. F. Horak, and P. G. Randich (in preparation).

PROJECT TITLE: Surface-Water Resources, Fort Union Coal Region of Western North Dakota



LOCATION: West-Central North Dakota

PERIOD OF PROJECT: October 1977 to September 1982

PROJECT CHIEF: Norman D. Haffield

OBJECTIVES.--The purpose of the study is to describe the surface-water resources of the Fort Union coal region of western North Dakota in a readily usable format. The specific objectives are (1) to determine the streamflow and water quality characteristics for the streams located in the region and (2) to describe seasonal and areal variations that occur within the various stream systems.

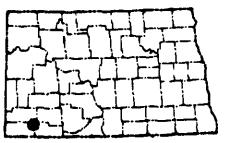
APPROACH.--All existing data will be condensed and analyzed in order to define the characteristics of the various components of the streamflow systems that are located within the region.

PROGRESS IN 1983.--Data from the surface-water gaging stations located within the study area were assembled by basin. Work continued on the data analysis.

PLANS FOR 1984.--The data analysis will be completed. Illustrations will be prepared and the report completed.

REPORT PRODUCTS.--Streamflow and water quality for streams in Fort Union coal region in North Dakota by N. D. Haffield (in progress).

PROJECT TITLE: Evaluation of the Hydrologic System in the New England-Mott Coal Area, Adams and Hettinger Counties, North Dakota



LOCATION: Southwestern North Dakota

PERIOD OF PROJECT: October 1982 to December 1983

PROJECT CHIEF: Mack G. Croft

OBJECTIVES.--The primary objective will be to define the hydrologic regime in the greatest possible detail consistent with the project duration and funding. This will include assessment of the ground-water flow system and chemical characteristics and determination of surface-water flow magnitudes, chemical quality, sediment concentration, and sediment load. By defining the hydrologic regime of the study area, a second objective will be satisfied--the establishment of a historical data base with which to monitor changes in the system as mining proceeds.

APPROACH.--Existing geologic and hydrologic data will be assembled and used to establish an information framework of the study area. Limited surface-runoff, water-level, and quality-of-water information will be collected in the field. Where possible, regionalized information will be used to define the hydrology. The final report will assess the available information and make recommendations as to whether further study is needed for leasing purposes.

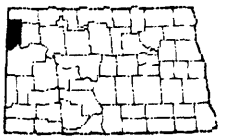
PROGRESS IN 1983.--A detailed project proposal and work plan was prepared. A limited canvas of wells and collection of additional water samples was completed in the area. Data was assembled and illustrations and text prepared.

PLANS FOR 1984.--Complete final report, process reviews and obtain Director's approval for publication.

REPORT PRODUCTS.--Wald, J. D., and Norbeck, S. W., 1983, Ground-water data for selected coal areas in Western North Dakota: U.S. Geological Survey Open-File Report 83-219, 229.

Hydrology of New England-Mott, North Dakota coal area by M. G. Croft (in preparation).

PROJECT TITLE: Evaluation of the Hydrologic System in the Sand Creek-Hanks Coal Area, Williams County, North Dakota



LOCATION: Northwestern North Dakota

PERIOD OF PROJECT: October 1982 to September 1983

PROJECT CHIEF: Clarence A. Armstrong

OBJECTIVES.--The primary objectives will be to define the hydrologic regime in the greatest possible detail consistent with the project duration and funding. This will include assessment of the ground-water flow system and chemical characteristics and determination of surface-water flow magnitudes, chemical quality sediment concentration, and sediment load. By defining the hydrologic regime of the study area, a second objective will be satisfied--the establishment of a historical data base with which to monitor changes in the system as mining proceeds.

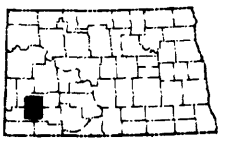
APPROACH.--Existing geologic and hydrologic data will be assembled and used to establish an information framework of the study area. Limited surface-runoff, water-level, and quality-of-water information will be collcted in the field. Where possible, regionalized information will be used to define the hydrology. The final report will assess the available information and make recommendations as to whether further study is needed for leasing purposes.

PROGRESS IN 1983.--The compilation of data from the area is about 75 percent complete and can be found in Open-File Report 83-219. The report is about 15 percent completed.

PLANS FOR 1984.--Finish the data compilation and write the report.

REPORT PRODUCTS.--Hydrology of Sand Creek-Hanks coal area by C. A. Armstrong (in preparation).

PROJECT TITLE: Evaluation of the Hydrologic System in the Dickinson Coal Area, Stark County, North Dakota



LOCATION: Western North Dakota

PERIOD OF PROJECT: October 1982 to September 1983

PROJECT CHIEF: Clarence A. Armstrong

OBJECTIVES.--The primary objective will be to define the hydrologic regime in the greatest possible detail consistent with the project duration and funding. This will include assessment of the ground-water flow system and chemical characteristics and determination of surface-water flow magnitudes, chemical quality, sediment concentration, and sediment load. By defining the hydrologic regime of the study area, a second objective will be satisfied--the establishment of a historical data base with which to monitor changes in the system as mining proceeds.

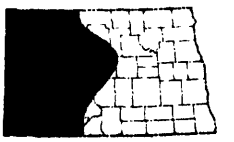
APPROACH.--Existing geologic and hydrologic data will be assembled and used to establish an information framework of the study area. Limited surface-runoff, water-level, and quality-of-water information will be collected in the field. Where possible, regionalized information will be used to define the hydrology. The final report will assess the available information and make recommendations as to whether further study is needed for leasing purposes.

PROGRESS IN 1983.--Data were sufficient to make reasonable correlations of the upper lignite beds. However, the data from the area within a few miles of the drainage divide between the Cannonball and Heart Rivers is of such quality that correlations were made with only a moderately high degree of certainty (about 70 to 75 percent). Report nearly completed.

PLANS FOR 1984.--Complete report processing through Director's approval and publication.

REPORT PRODUCTS.--Hydrology of the Dickinson coal area by C. A. Armstrong (in review).

PROJECT TITLE: Hydrochemical Impacts of Surface Mining of Lignite--The Sulfur Cycle



LOCATION: Fort Union Coal Region, North Dakota

PERIOD OF PROJECT: October 1983 to September 1984

PROJECT CHIEF: Robert L. Houghton

OBJECTIVES.--Detailed geochemical investigations will be made to quantitatively describe the sulfur sources which contribute to ground-water sulfate in strip mines situated in recharge zones and to determine the hydrogeochemical processes which control the sulfur path to the ground water. Isotopic studies will be employed to: (1) trace sulfur transformations among solid and aqueous species present throughout the sulfur cycle, (2) quantify the relative magnitude of each transformation as a contributor to ground-water sulfate concentrations, and (3) determine which transformations are affected by biological activity.

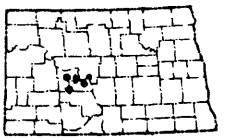
APPROACH.--Cores and ground- and pore-water samples will be obtained from two active strip mines and one potential mine site. Sulfur species present at various depths will be identified and the sulfur isotopic ratios will be used to determine transformation paths. Samples will also be obtained with minimal contamination for determination of the presence and activity of sulfur-metabolizing microorganisms. Comparison of organism distributions and isotopic ratios will be used to determine the stages at which biological activity affects the sulfur cycle. Observations will be simulated in the laboratory as a control check.

PROGRESS IN 1983.--The contract for sulfur-isotope analyses was not processed until May so sampling for the fall, winter, and spring seasons of 1983 was unable to proceed. Ground- and pore-water samples were collected from wells and lysimeters adjacent to lignite strip mines near Gascoyne and Center, N. Dak., and from a potential mine site near Beach, N. Dak., during the summer months. Cores were also obtained adjacent to sampling sites at Gascoyne and Beach. Cores were described and sampled for isotopic analysis of solid phases and mineralogic determinations. Soxholet extractions have begun on remaining core material to simulate accelerated weathering. Sulfur-metabolizing bacteria in water samples have been cultured and growth limiters identified. Experimentation to determine relationship between bacterial activity and sulfur isotopic fractionation is continuing to permit subsequent in situ microbial activity determinations.

PLANS FOR 1984.--Seasonal collection of ground- and pore-water samples at all sites will continue. Core will be recovered from the Center mine site to complete the sampling of solid phases. The contractor will complete isotopic analysis of collected samples while the project chief will complete soxholet and microbiological studies.

REPORT PRODUCTS.--Houghton, R. L., Koob, R. D., and Groenewold, G. H., 1984 Progress Report on the geochemistry of the sulfur cycle in western coal mines (in progress).

PROJECT TITLE: Evaluation of Effects of Ongoing and Future Mining and Reclamation Activities in Western North Dakota



LOCATION: Western North Dakota

PERIOD OF PROJECT: October 1982 to September 1985

PROJECT CHIEF: Douglas G. Emerson

OBJECTIVES.--The purpose of the study is to provide the capability to assess and predict the effects of mining and energy development on the hydrologic system. Specific objectives are (1) to monitor the variations in the quantity and quality of surface below active energy development sites, (2) to use the data collected to augment and refine predictive models presently available, and (3) verify the transferability of a calibrated watershed model.

APPROACH.--The study includes the operation of five river stream-gaging and water-quality sites, one complete weather station, and three precipitation sites. The U.S. Geological Survey's Precipitation-Runoff Modeling System has been selected as the predictive model. The model has not been completely calibrated for the site where the model was developed; this is one of the five sites to be operated under this project. The plans are to collect enough data at the sites to check verification of the model. The present plans are to collect data for 3 years, but it could depend on runoff conditions.

PROGRESS IN 1983.--Data collection of streamflow, chemical quality, and meteorological data has been made. Data report is being prepared.

PLANS FOR 1984.--Collection of streamflow, chemical quality, and meteorological data will continue. Data report will be published.

REPORT PRODUCTS.--Data report of streamflow, chemical quality, and meteorological data (in progress).

PROJECT TITLE: Effects of Energy Development on Trace Element Concentrations in Hydrologic Benchmark Streams

MULTISTATE

LOCATION: Nationwide

PERIOD OF PROJECT: April 1983 to September 1983

PROJECT CHIEF: Robert L. Houghton

OBJECTIVES.--The purpose of this investigation is to evaluate existing hydrochemical data from Hydrologic Benchmark Network sites for evidence of snowmelt enrichments in atmospherically-derived trace constituents. On the basis of the relationship of such enrichments to the hydrograph, it should be possible to develop guidelines for future sampling procedures at these sites which would enhance our ability to monitor snowmelt enrichments.

APPROACH.--Trace-element data from benchmark sites within the snowbelt are evaluated for enrichments during snowmelt periods. Once enrichments are identified with respect to the hydrograph, these enrichments will be statistically quantified relative to the mean concentration for nonsnowmelt periods. Standard statistics for each properties summed over all stations will be used to determine the significance of observed enrichments.

PROGRESS IN 1983.--All data have been identified and statistical evaluations completed. A draft summary of the results has been prepared.

PLANS FOR 1984.--The draft report will continue through the review process for publication during the fiscal year.

REPORT PRODUCTS.--Effects of energy development on trace element concentrations in hydrologic benchmark streams (in preparation).

Houghton, R. L., and Schimke, LeAnn, 1984, Effects of energy development on trace-element concentrations in snowmelt contributions to Hydrologic Benchmark Network streams (in progress).

BOARDS AND COMMISSIONS

PROJECT TITLE: Boards and Commissions

LOCATION: Bismarck, North Dakota

PERIOD OF PROJECT: Continuous

PROJECT CHIEF: L. Grady Moore

OBJECTIVES.--Assure impartial Federal representation on the Yellowstone River Compact Commission and the Souris River Board of Control and supply accurate, unbiased information to boards and commissions.

APPROACH.--Chair the meetings and provide administrative support to the Yellowstone River Compact Commission. Act as alternate member for the United States to the Souris River Board of Control. Furnish information requested by members of the Pembina River Engineering Board and the International Souris-Red River Engineering Board.

PROGRESS IN 1983.--The 1982 Annual Report of the Souris River Board of Control was printed and distributed. Meetings of the Board were held January 27, 1983, and May 20, 1983. Information was routinely furnished to parties concerned with Souris River streamflow.

PLANS FOR 1984.--All meetings of the Souris River Board of Control will be attended. The Annual Report for 1983 will be prepared and distributed.

All meetings of the Yellowstone River Compact Commission and the Administration Committee will be attended. The Annual Report for 1983 will be prepared and distributed.