

## XV. SOURCES OF PUBLISHED (GEOLOGIC AND HYDROLOGIC INFORMATION)

Pertinent 30CFR<sup>1</sup> Sections:

- Description of hydrology and geology.
- Ground-water information.
- Surface-water information.
- Cross sections, maps, and plans.

### 1. U.S. Geological Survey Coal Area Hydrology Reports

Coal-area hydrology reports, published by the U.S. Geological Survey, contain a text with maps, charts, graphs, and other illustrations and provide hydrologic information to describe the hydrology of areas within the coal provinces. The areas represented by each report is shown in figure XV-1-1. The information should be useful to mine owners and operators and to consulting engineers in the preparation of permits and also to regulatory authorities in appraising the adequacy of permit applications. These reports are available at no charge from the U.S. Geological Survey offices listed in table XV-1-1.

A need for hydrologic information and analysis on a scale never before required nationally was recognized when the "Surface Mining Control and Reclamation Act of 1977" was signed into law as Public Law 95-87, August 3, 1977. The hydrologic information presented in, or available through sources identified in, these reports may be used in describing the hydrology of the general area of any proposed mine. However, it is expected that this information will be supplemented by the applicant's site-specific information as well as data from other sources to provide a detailed coverage of the hydrology of the mine and vicinity and the anticipated hydrologic consequences of the proposed mining operation.

The coal area reports include discussions of bedrock geology, water use, hydrologic networks, surface-water information, chemical quality of surface water, ground-water information, chemical quality of ground water, and hydrologic-data-collection stations.

<sup>1</sup>CFR = Code of Federal Regulations

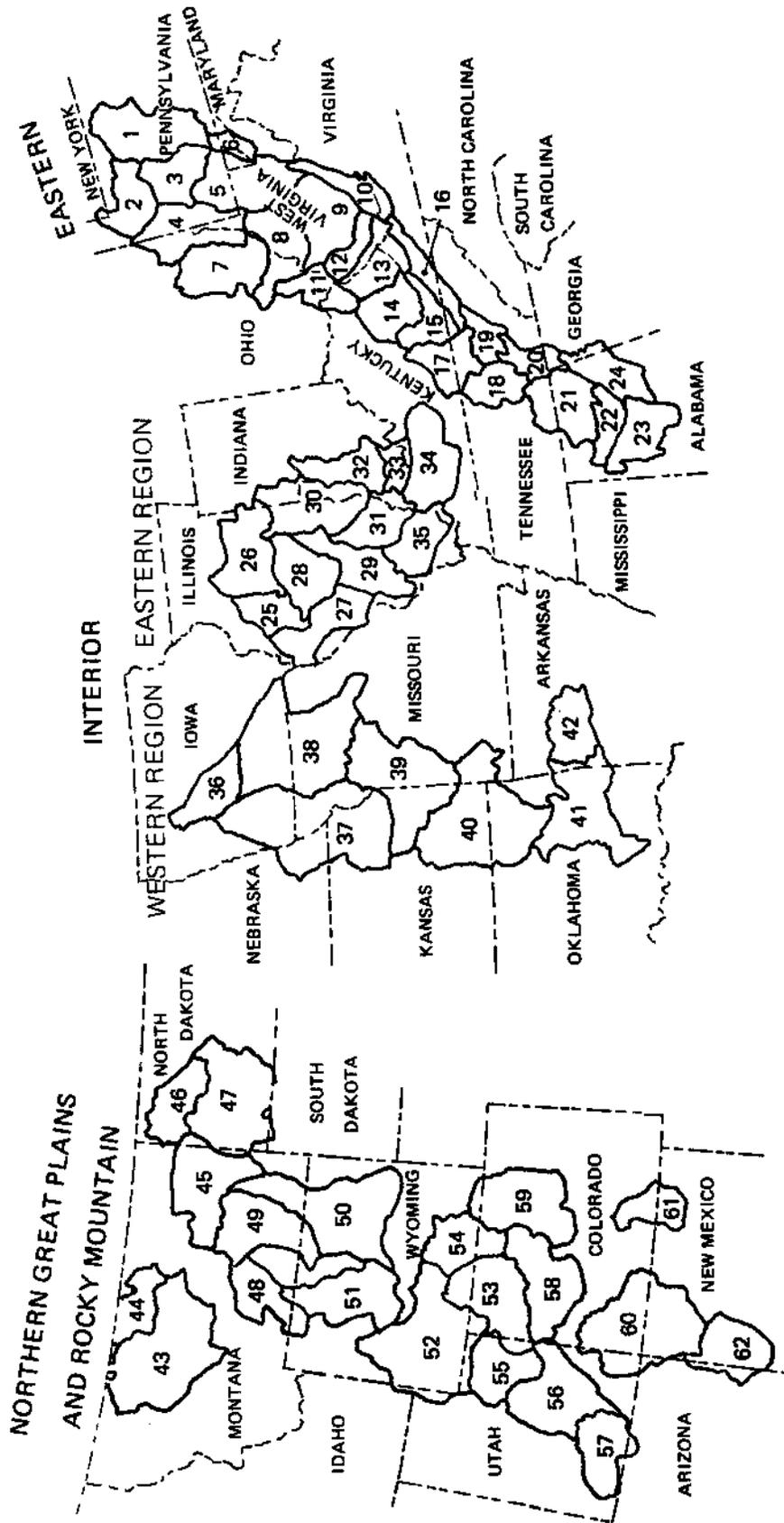


Figure XV-1-1.— Index maps of U.S. Geological Survey coal hydrology reports in Northern Great Plains, Rocky Mountains, Interior, and Eastern Coal Provinces .

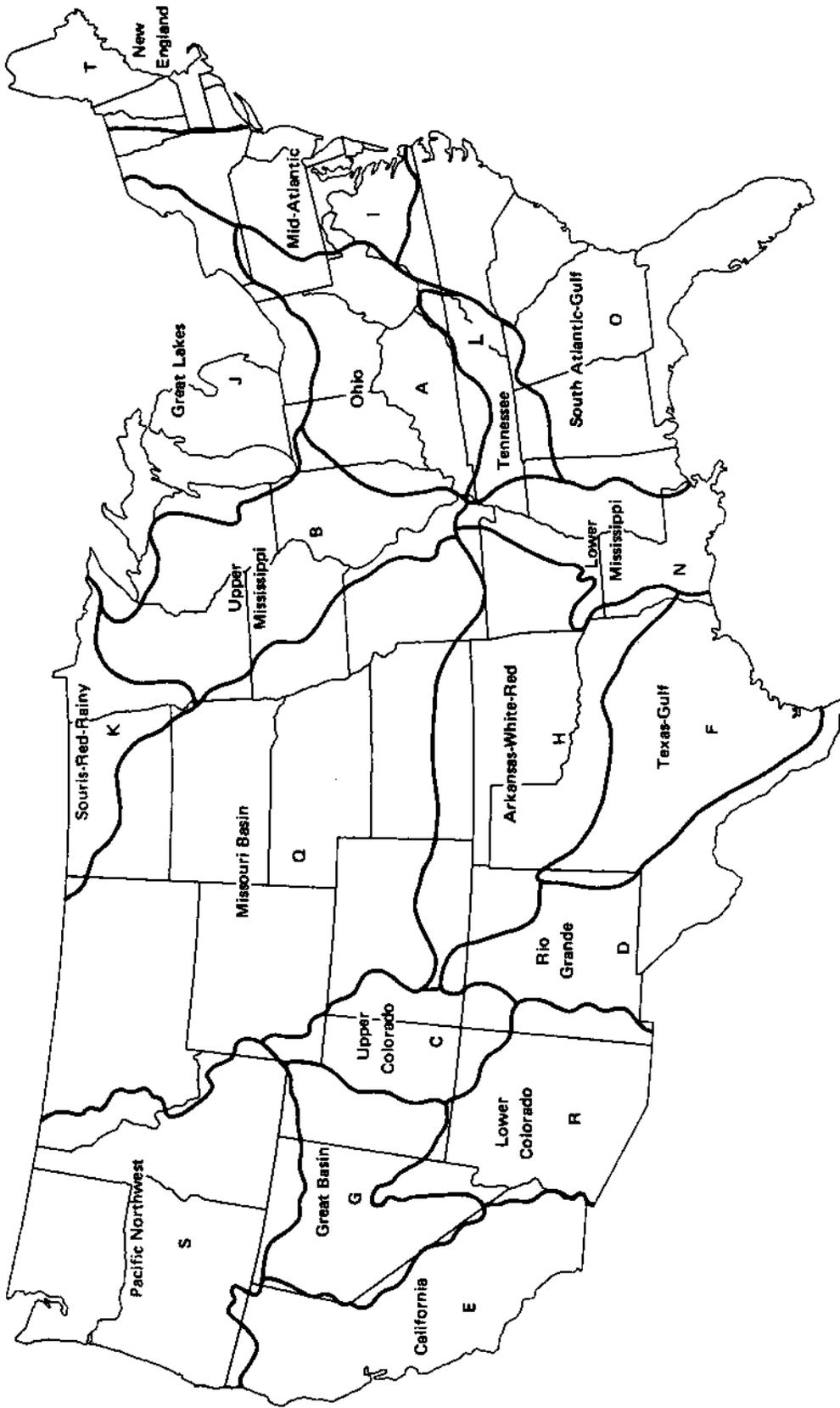


Figure XV-2-1.— Geographic index to the series, U.S. Geological Survey Professional Paper 813, "Summary Appraisals of the Nations Ground-Water Resources. Boundaries shown are those established by the U.S. Water-Resources Council for Water-Resources Regions in the United States. (From Sinnott, 1982)

Table XV 1-1.- COAL AREA HYDROLOGY REPORTS

Can be obtained at no cost from the following U.S. Geological Survey (USGS)

Please write or call: District Chief, USGS, Water Resources Division

U.S. Geological Survey, Water Resources Division

<u>State</u>	<u>Address and Telephone Number (s)</u>	<u>Area Report</u>	<u>Open-file Number</u>
Alabama	5200 19th Avenue	22	81-135
	Tuscaloosa, Alabama 35401	23	80-693
	(Telephone: FTS-229-2957 or (205) 752-8104)	24	81-1113
Arkansas	Room 2301 Federal Office Building	42	82-636
	700 West Capitol Avenue Little Rock, Arkansas 72201 (Telephone: FTS-740-6391 or (501) 378-6391)		
Colorado	Building 53, Denver Federal Center	53	
	Mail Stop 415, Box 25046	58	
	Denver, Colorado 80225	59	
	(Telephone: FTS-234-5092 or (303) 234-5092)	61	83-132
Illinois	Champaign County Bank Plaza	25	81-636
	4th Floor	26	
	102 East Main Street	27	
	Urbana, Illinois 61801	28	
		29	82-858
		30	82-1005
	(Telephone: FTS-958-5353 or (217)398-5353)	31	
Indiana	6023 Guion Road, Suite 201	30	82-1005
	Indianapolis, Indiana 46254	32	81-498
	(Telephone: FTS-336-8640 or (317) 927-8640)	33	81-423
		35	81-403
Iowa	P.O. Box 1230, Roan 269, Federal Building	38	82-1014
	400 South Clinton Street Iowa City, Iowa 52244		
	(Telephone: FTS-863-6251 or (319) 337-4191)		
Kansas	1950 Avenue A, Campus West	40	
	University of Kansas Lawrence, Kansas 66044		
	(Telephone: FTS-75 2-2300 or (913) 864-4321)		
Kentucky	Room 572, Federal Building	14	81-137
	600 Federal Place	15	81-809
	Louisville, Kentucky 40202	34	82-638
	(Telephone: FTS-352-5241 or (502) 582-5241)		
Maryland	208 Carroll Building	6	83-33
	8600 LeSalle Road Towson, Maryland 21204 (Telephone: FTS-922-7872 or(301) 828-1535)		
Missouri	1400 Independence Road	39	
	Mail Stop 200 Rolla, Missouri 65401		
	(Telephone: FTS-277-0824 or (314) 341-0824)		

Table XV 1-1.– (continued)

<u>State</u>	<u>Address and Telephone Number (s)</u>	<u>Area Report</u>	<u>Open-file Number</u>
Montana	Federal Building, Drawer 10076	45	83-527
	Helena, Montana 59626	46	
		47	
	(Telephone: FTS-585-5263 or (406) 449-5263)	48	
		49	
New Mexico	505 Marquette, NW, Room 720	60	83-203
	Western Bank Building	62	
	Albuquerque, New Mexico 87102 (Telephone: FTS-474-2246 or (505) 766-2246)		
North Dakota	821 E. Interstate Avenue Bismarck, North Dakota 58501 (Telephone: FTS-783-4601 or (701) 255-4011)	47	
Ohio	975 West Third Avenue	4	81-343
	Columbus, Ohio 43212	7	81-815
	(Telephone: FTS-943-5553 or (614) 469-5553 )	11	84-233
Oklahoma	Room 621, 215 Dean A. McGee Ave Oklahoma City, Oklahoma 73102 (Telephone: FTS-736-4256 or (405) 231-4256 )	41	
Pennsylvania	Federal Building, 4th Floor	1	82-223
	P.O. Box 1107, 228 Walnut Street	2	82-647
	Harrisburg, Pennsylvania 17108	3	81-537
	(Telephone: FTS-590-5414 or (717) 782-4514 )	5	81-538
Tennessee	A-413 Federal Building	17	81-1118
	U.S Courthouse	18	81-492
	Nashville, Tennessee 37203	19	81-901
		20	82-440
	(Telephone: FTS-852-5424 or (615) 251-5424)	21	82-679
Utah	1016 Administration Building	55	
	1745 West 1700 South	56	83-38
	Salt Lake City, Utah 84104 (Telephone: FTS-588-5663 or (801) 524-5663 )	57	
Virginia	200 W. Grace Street, Room 304 Richmond, Virginia 23220 (Telephone: FTS-925-2427 or (804) 771-2427)	16	81-204
West Virginia	Federal Building and Courthouse, Room 3416	8	
	500 Quarrier Street, East	9	81-803
	Charleston, West Virginia 25301	10	82-864
		12	81-902
	(Telephone: FTS-924-1300 or (304) 343-6181, ext. 310)	13	82-505
Wyoming	P.O. Box 1125	50	
	Cheyenne, Wyoming 82003	51	83-146
	(Telephone: FTS-328-2153 or (307) 778-2220)	52	
		54	

2. U.S. Geological Survey Professional Paper 813  
"Summary Appraisals for Nation's Ground-Water Resources"

The U.S. Geological Survey Professional Paper 813 consists of 21 chapters, each of which summarizes the ground-water resources of part of the United States - a river basin, a part of a major river basin, or a State. A geographic index map for this publication series (chapters A through U) is shown in figure XV-2. The listing of the bibliographic references for each chapter for the coal-bearing states is presented in table XV 2-1.

The analyses of ground-water resources presented in these reports describes:

- (1) the significance of the ground-water resources in relation to the regional water supply;
- (2) identification of the regional aquifers, including their geologic framework and aquifer characteristics;
- (3) estimated quantity of ground water available;
- (4) chemical quality of ground water;
- (5) existing and potential problems associated with ground-water use; and
- (6) the relationship between streamflow and ground-water flow.

Mine-permit applicants can become informed of general geologic and ground-water conditions within a specific area by referring to the applicable report. Any publication within the Series can be purchased from

Superintendent of Documents  
U.S. Government Printing Office  
Washington, D.C. 20402

Copies are also available for inspection at designated Federal document repository libraries at the U.S. Geological Survey Public Inquiries Offices (PIO). Additional information on PIO's may be obtained from

U.S. Geological Survey  
National Center Rm. 1C402, Mail Stop 302  
Reston, VA. 22092  
Phone: (703) 860-6167

There are 10 PIO's in the United States: Anchorage, AK; Dallas, TX; Denver, CO; Los Angeles, CA; Menlo Park, CA; Reston, VA; Salt Lake City, UT; San Francisco, CA; Spokane, WA; and Washington, DC.

Table XV 2-1.— Listing of bibliographic references for U.S. Geological Survey  
Professional Paper 813 Series for conterminous coal-bearing states.

CHAPTER DESIGNATION LETTER	AUTHOR (S)	YEAR OF PUBLICATION	WATER RESOURCES REGION	NUMBER OF PAGES
A	Bloyd, R. M., Jr.	1974	Ohio	41
B	Bloyd, R. M., Jr.	1975	Upper Mississippi	22
C	Price, Don and Arnou, Ted	1974	Upper Colorado	40
D	West, S. W. and Broadhurst, W. L.	1975	Rio Grande	39
E	Thomas, H. E. and Phoenix, D. A	1976	California	51
F	Baker, E. T., Jr. Wall, J. R	1976	Texas-Gulf	29
G	Eakin, T. E. , Price, Don and Harrill, S. R.	1976	Great Basin	37
H	Bedinger, M. S. and Sniegocki, R. T.	1976	Arkansas-White-Red	31
I	Sinnott, Allen and Gushing, E. M.	1978	Mid-Atlantic	32
J	Weist, W. G., Jr.	1978	Great Lakes	30
K	Reader, H. O.	1978	Souris-Red-Rainy	25
L	Zurawski, Ann	1978	Tennessee	35
N	Terry, J. E., Bosnian, R. L., and Bryant, C. T.	1979	Lower Mississippi	41
O	Cederstrom, D. J., Boswell, E. H., and Tarver, G. R.	1979	South Atlantic-Gulf	35
Q	Taylor, O. J.	1978	Missouri Basin	41
R	Davidson, E. S.	1979	Lower Colorado	23
S	Foxworthy, B. L.	1979	Pacific Northwest	39
T	Sinnott, Allen	1982	New England	23

### 3. National Water Data Exchange (N7WDEX)

The following description of NAWDEX is from Roth and Cooper (1984) on coal area 11.

NAWDEX is an national confederation of water-oriented organizations working together to make their data more readily accessible and to facilitate a more efficient exchange of water data.

Services are available through a Program Office located at the U.S. Geological Survey's National Center in Reston, Virginia, and through a nationwide network of Assistance Centers located in 45 States and Puerto Rico, which provide local and convenient access to NAWDEX facilities. (See figure XV3-1). A directory is available on request that provides names of organizations and persons to contact, addresses, telephone numbers, and office hours for each of these locations titled - Directory of Assistance Centers of the National Water Data Exchange (NAWDEX), U.S. Geological Survey Open-File Report 83-262.

NAWDEX can assist any organization or individual in identifying and locating needed water data and referring the requestor to the organization that retains the data required. To accomplish this service, NAWDEX maintains a computerized Master Water Data Index (fig. XV3-2), which identifies sites for which water data are available, the type of data available for each site, and the organization retaining the data. A Water Data Sources Directory (fig. XV.3-3) also is maintained that identifies organizations that are sources of water data and the locations within these organizations from which data may be obtained. In addition, NAWDEX has direct access to some large water-data bases of its members and has reciprocal agreements for the exchange of services with others.

Charges for NAWDEX services are assessed at the option of the organization providing the requested data or data service. Search assistance services are provided free by NAWDEX to the greatest extent possible. Charges are assessed, however, for those requests requiring computer cost, extensive personnel time, duplicating services, or other costs encountered by NAWDEX in the course of providing services. In all cases, charges assessed by NAWDEX Assistance Centers will not exceed the direct costs incurred in responding to the data request. Estimates of cost are provided by NAWDEX upon request and in all cases where costs are anticipated to be substantial.

For additional information concerning the NAWDEX program or its services contact:

Program Office  
National Water Data Exchange (NAWDEX) U.S. Geological Survey  
421 National Center 12201 Sunrise Valley Drive  
Reston, VA 22092  
Telephone: (703) 860-6031  
FTS-938-6031 Hours: 7:45-4:15 Eastern Time

**A PROGRAM TO PROVIDE ACCESS**

**TO WATER DATA**

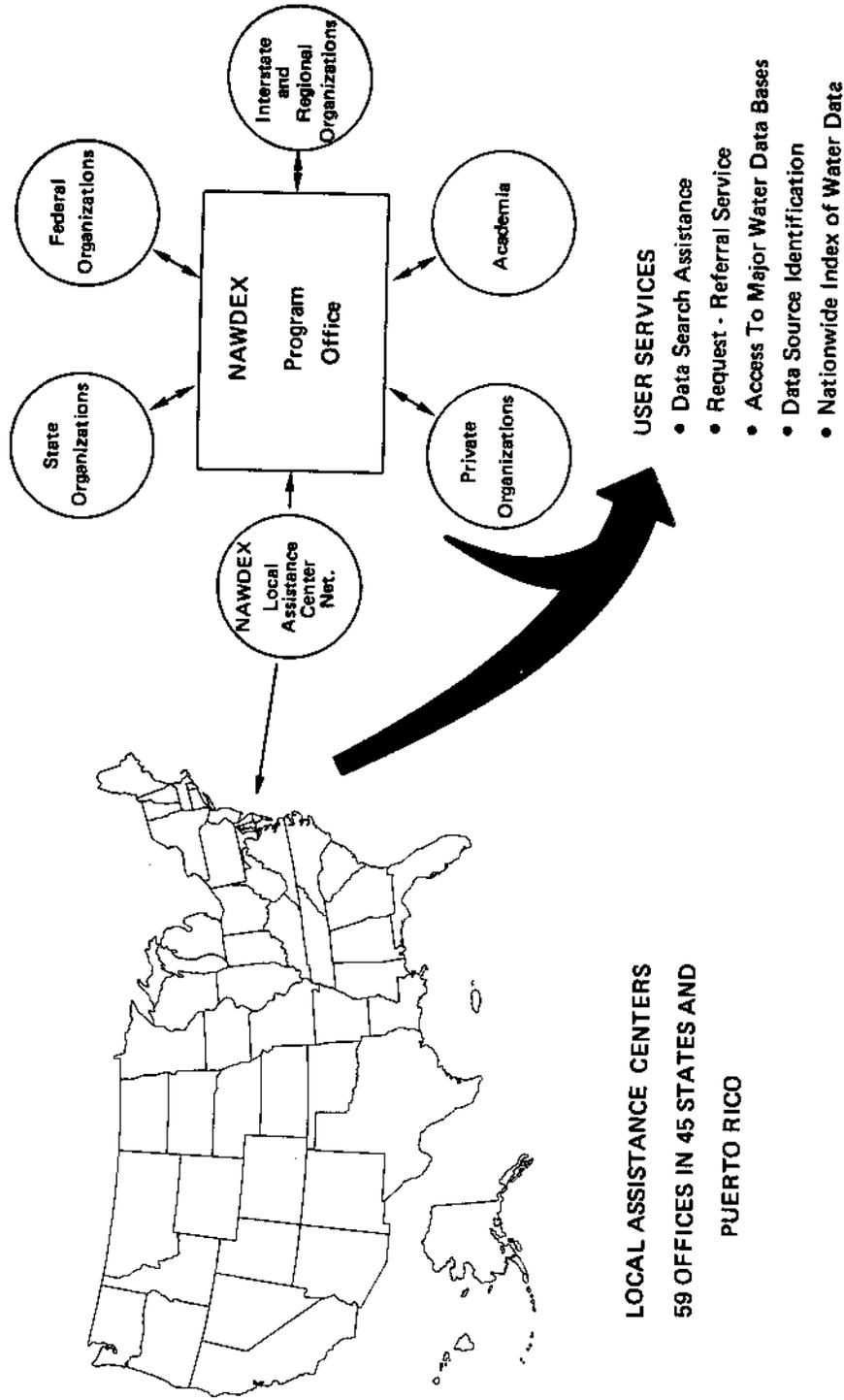


Figure XV-3-1.—Access to water data.

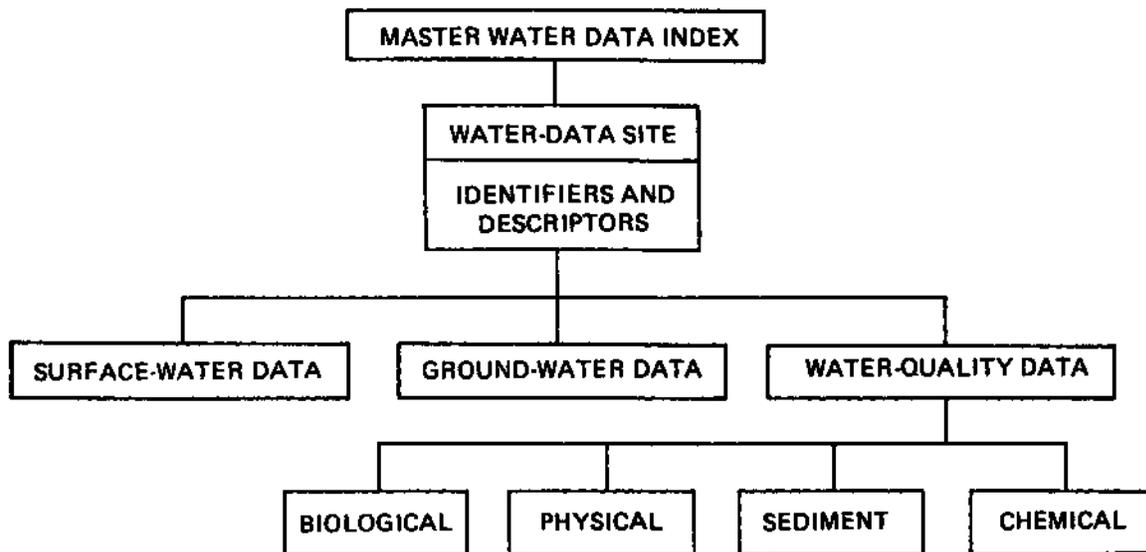


Figure XV-3-2.— Master water-data index

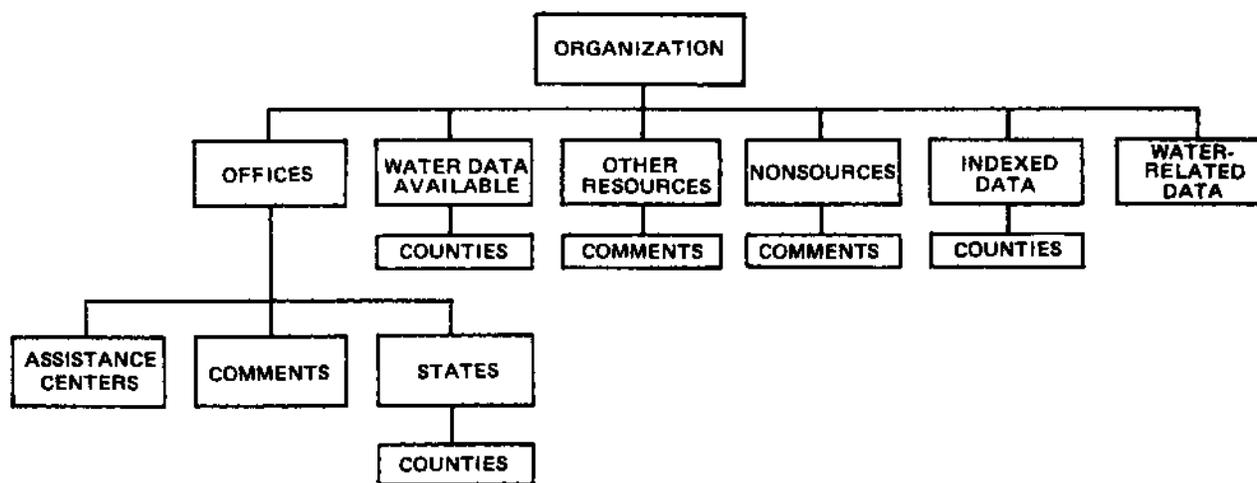


Figure XV-3-3.— Water-data sources directory.

#### 4. National Water Data Storage and Retrieval System (WATSTORE)

The following description of WATSTORE is from Roth and Cooper (1984) report on coal area 11.

The National Water Data Storage and Retrieval System (WATSTORE) was established in November 1971 to computerize the U.S. Geological Survey's existing water-data system and to provide for more effective and efficient management of its data-releasing activities. The system is operated and maintained on the central computer facilities of the Survey at its National Center in Reston, Va.; however, data may be entered into and retrieved from WATSTORE at a number of locations that are part of a nationwide telecommunication network. General inquiries about WATSTORE may be directed to U.S. Geological district office or to:

WATSTORE Program Office  
U.S. Geological Survey  
437 National Center  
Reston, VA 22092

The Geological Survey currently (1983) collects data at approximately 17,000 stage- and discharge-gaging stations, 5,200 surface-water quality stations, 27,000 water-level observations wells, and 7,400 ground-water quality wells. Each year many water-data collection sites are added and others are discontinued; thus, large amounts of diversified data, both current and historical, are amassed by the Survey's data-collected activities.

The WATSTORE system consists of several files in which data are grouped and stored by common characteristics and data-collected frequencies. The system also is designed to allow for the inclusion of additional data files as needed. Currently, files are maintained for the storage of: (1) Surface-water, quality-of-water, and ground-water data measured on a daily or continuous basis; (2) annual peak values for streamflow stations; (3) chemical analyses for surface-and ground-water sites; (4) water parameters measured more frequently than daily; and (5) geologic and inventory data for ground-water sites. In addition, an index file of sites for which data are stored in the systems is also maintained (fig. XV 4-1). A brief description of each file is as follows:

**Station Header File:** All sites for which data are stored in the Daily Values, Peak Flow, Water-Quality, and Unit Values files of WATSTORE are indexed in this file. It contains information pertinent to the identification, location, and physical description of nearly 220,000 sites.

**Daily Values File:** All water-data parameters measured or observed either on a daily or on a continuous basis and numerically reduced to daily values are stored in this file. Instantaneous measurements at fixed-time intervals, daily mean values, and statistics such as daily maximum and minimum values also may be stored. This file currently contains over 200 million daily values including data on streamflow, river stages, reservoir contents, water temperatures, specific-conductance, sediment concentrations, sediment discharges, and ground-water levels.

Peak Flow File: Annual Maximum (peak) streamflow (discharge) and gage height (stage) values at surface-water sites comprise this file, which currently contains over 400,000 peak observations.

Water Quality File: Results of over 1.4 million analyses of water samples that describes the chemical, physical, biological, and radiochemical characteristics of both surface and ground waters are contained in this file. These analyses contain data for 185 different constituents.

Unit Values File: Water parameters measured on a schedule more frequent than daily are stored in this file. Rainfall, stream discharge, and temperature data are examples of the types of data stored in the Unit Values File.

Ground-Water Site-Inventory: This file is maintained within WATSTORE independent of the files discussed above, but it is cross-referenced to the Water-Quality File and the Daily Values File. It contains inventory data about wells, springs, and other sources of ground water. The data included are site location and identification, geohydrologic characteristics, well-construction history, and one-time field measurements such as water temperature. The file is designed to accommodate 225 data elements and currently contains data for nearly 700,000 sites.

Remote Job Entry Sites: Almost all of the Water Resources Division's district offices are equipped with high-speed computer terminals for remote access to the WATSTORE system. These terminals allow each site to put data into or retrieve data from the system within several minutes to overnight, depending upon the priority placed on the request. The number of remote job entry sites is increased as the need arises.

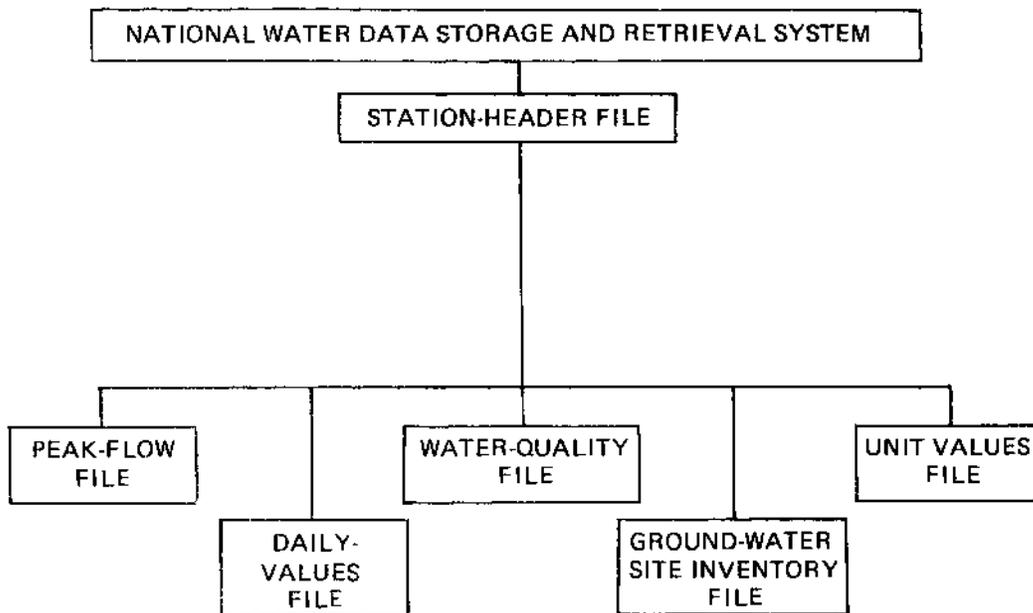


Figure XV-4-1.—index file of stored data (WATSTORE).

**Digital Transmission Sites:** Digital recorders are used at many field locations to record values for parameters such as river stages, conductivity, water temperature, turbidity, wind direction, and chlorides. Data are recorded on 16-channel paper tape, which is removed from the recorder and transmitted over telephone lines to the receiver at Reston, Va. The data are recorded on magnetic tape for use on the central computer. Extensive testing of satellite data collection platform indicates their feasibility for collection real-time hydrologic data on a national scale. Battery-operated radios are used as the communication link to the satellite. About 500 data relay stations are being operated currently (1983) by the Water Resources Division.

**Central Laboratory Systems:** The Water Resources Division's two Welter-quality laboratories, located in Denver, Colorado, and Atlanta, Georgia, analyze more than 150,000 water samples per year. These laboratories are equipped to automatically perform chemical analyses ranging from determinations of simple inorganic compounds, such as chloride, to complex organic compounds, such as pesticides. As each analysis is completed, the results are verified by laboratory personnel and transmitted via a computer terminal to the central to the central computer facilities to be stored in the Water -Quality of File of WATSTORE.

**Computer-Printed Tables:** Users most often request data from WATSTORE in the form of tables printed by the computer. These tables may contain lists of actual data or condensed indexes that indicate the availability of data stored in the files. A variety of formats is available to display the many types of data.

**Computer-Printed Graphs:** Computer-printed graphs for the rapid analysis or display of data are another capability of WATSTORE. Computer programs are available to produce bar graphs (histograms), line graphs, frequency distribution curves, X-Y point plots, site-location map plots, and other similar items by means of line printers.

**Statistical Analyses:** WATSTORE interfaces with a proprietary statistical package called the Statistical Analysis System (SAS)<sup>1</sup> (SAS Institute, 1982) to provide extensive analyses of data such as regression analyses, the analysis of variance, transformations, and correlations.

**Digital Plotting:** WATSTORE also make use of software systems that prepare data for digital plotting on peripheral offline plotters available at the central computer site. Plots that can be obtained include hydrographs, frequency-distribution curves, X-Y point plots, contour plots, and three-dimensional plots.

**Data in Machine-Readable Form:** Data stored in WATSTORE can be obtained in machine-readable form for use on other computers or for use as input to user-written computer programs. These data are available in the standard format of the WATSTORE system or in the form of punched cards or card images on magnetic tape.

<sup>1</sup> The use of trade names in this report is for identification purposes only and does not imply endorsement by the U. S. Geological Survey.

## 5. Index to Water-Data Activities in Coal Provinces

The following description of the "Index to Water-Data Activities" is from Roth and Cooper (1984) report of coal area 11.

The "Index to Water-Data Activities in Coal Provinces of the United States" was prepared to assist those involved in developing, managing, and regulating the Nation's coal resources by providing information on the availability of water-resources data in the major coal provinces of the United States. It is derived from the "Catalog of Information on Water Data" which is a computerized information file about water-data acquisition activities in the United States, and its territories and possessions, with some international activities included.

This special index consists of five volumes (figure XV5-1) Volume 1, Eastern Coal province; volume II, Interior Coal province, volume III, Northern Great Plains and Rocky Mountain Coal provinces; volume IV, Gulf Coast Coal provinces; and volume V, Pacific Coast and Alaska Coal provinces. The information presented will aid the user in obtaining data for evaluating the effects of coal mining on water resources and in developing plans for meeting additional water-data needs. The report does not contain the actual data; rather, it provides information that will enable the user to determine if needed data are available.

Each volume of this special index consists of four parts; Part A, Streamflow and Stage Stations; Part B, Quality of Surface-Water Stations; Part C, Quality of Ground-Water Stations; and Part D, Areal Investigations and Miscellaneous Activities. Information given for each activity in Parts A-C includes: (1) The identification and location of the station, (2) the major types of data collected, (3) the frequency of data collection, (4) the form in which the data are stored, and (5) the agency or organization reporting the activity. Part D summarizes areal hydrologic investigations and water-data activities not included in the other parts of the index. The agencies that submitted the information, agency codes, and the number of activities reported by type are shown in a table.

Those who need additional information from the Catalog file or who need assistance in obtaining water data should contact the National Water Data Exchange(NAWDEX). (See chapter XV. 3)

Further information on the index volumes and their availability may be obtained from:

Office of Water Data Coordination  
U.S. Geological Survey  
National Center Mail Stop 417  
Reston, Virginia 22092  
Telephone: (703) 860-6931

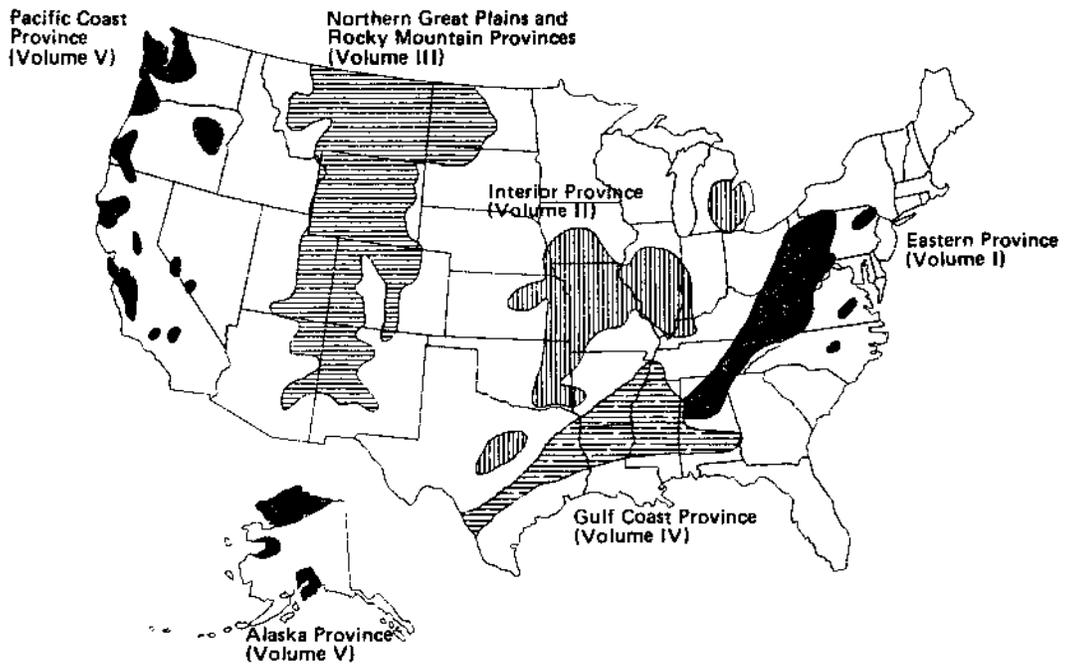


Figure XV-5-1.—Index volumes to water-data activities in coal provinces.

## 6. U.S. Geological Survey Annual Water Resources Reports

Records of discharge and stage of streams and contents or stage of lakes and reservoirs were first published in a series of U.S. Geological Survey water-supply papers titled "Surface Water Supply of the United States." Through September 30, 1960, these water-supply papers were published in an annual series and then during 1961–65 and 1966–70 in a 5-year series. Records of chemical quality, water temperatures, and suspended sediment were published from 1941 thru 1970 in an annual series of water-supply papers titled, "Quality of Surface Waters of the United States." Records of ground-water levels were published from 1944 thru 1973 in a series of water-supply papers entitled, "Ground-Water Levels in the United States."

Since the 1961 water year the U.S. Geological Survey has released streamflow data on a State-boundary basis, in annual reports in a series titled "Water Resources Data for (state)". Water-quality records beginning with the 1964 water year and ground-water data since the 1971 water year have been similarly released either in separate volumes or in conjunction with streamflow records. These reports provide rapid release of preliminary water data shortly after the end of the water year. The final data are then released in the water-supply paper series mentioned above.

Since the 1975 water year, water data have been released on a State-boundary basis in final form and are not republished in the water-supply paper series. These reports make up an annual series that carry an identification number consisting of the two-letter State abbreviation and the last two digits of the water year.

Reports in the annual series contain records of stage, discharge, and water quality of streams; stage and volume of lakes; and water levels and water quality of wells and springs. They also include daily discharge records for stream-gaging stations; stage and (or) volume of lakes and reservoirs; and data for crest-stage and low-flow partial-record stations. They also include water-quality data from National Stream Quality Accounting Network Stations (NASQAN) and coal-hydrology stations. Some reports in the series may contain daily temperatures records, daily specific conductance, and miscellaneous temperature and specific conductance determinations for special purpose (project) stations. Suspended sediment data for some special study stations are also given. Ground-water levels and, for some States, data on the quality of ground water, are published in separate reports. These data represent that part of the National Water Data Systems operated by the U. S. Geological Survey and cooperating State and Federal agencies.

These reports are for sale to the public for a nominal fee from the National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161.

## 7. Regional Aquifer Systems Analyses (RASA)

Regional Aquifer System Analyses (RASA) have been formed to examine the hydrology of the major aquifer systems of the United States on a regional scale. These studies develop quantitative appraisals of the major ground-water systems through the use of digital computer modeling. The areal extent of the RASA studies is shown on figure XV-7-1. Coal-permit areas within these RASA areas therefore have additional hydrologic data available for analysis and inclusion in permit applications.

Digital ground-water computer models are constructed to provide information on the nature of ground-water systems, how they function, and how they respond to hydraulic or chemical stresses, and to identify the need for additional data. The models are constructed by defining the limit of the aquifer system, the spatial variation of aquifer properties, and the stresses to be imposed.

As stated by the U.S. Water Resources Council (1980), the principal data requirements for ground-water analysis and modeling (table XV-7-1) include:

- (1) physical framework: the time and space variation of the aquifer characteristics—transmissivity, storativity (storage coefficient), and specific yield (chapter X), and definition of the hydrologic boundaries (chapter X-2.7);
- (2) hydrologic stresses: the time and space variation of the flow rates (discharges and recharges) to the aquifer system—ground-water pumpage, precipitation, infiltration from precipitation, evapotranspiration, induced streamflow infiltration, and ground-water discharge as base flow (chapters VII, XI); and,
- (3) model calibration: the time and space variation of water levels (chapter IX) in the aquifer, which are used to test and to calibrate, the components of the model.

Compilations of these data for the RASA studies are available to the public.

The reliability of the model output, such as predicted water-level declines due to projected surface-mining operations, depends directly upon the quantity and quality of the hydrologic data input to the model.

Additional information on available ground-water models can be obtained from the Clearinghouse for Ground-Water Models, Holcomb Research Institute, Butler University, Indianapolis Indiana 46208. Information on the Clearing House and its services may be obtained from the Director of the Institute.

In 1984, the U.S. Geological Survey published a report titled "A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model", Open File Report 83-875. Copies can be purchased from:

Open-File Services Section  
Western Distribution Branch  
Box 25425, Federal Center  
Denver, Colorado 80225  
Telephone: (303) 234-5888

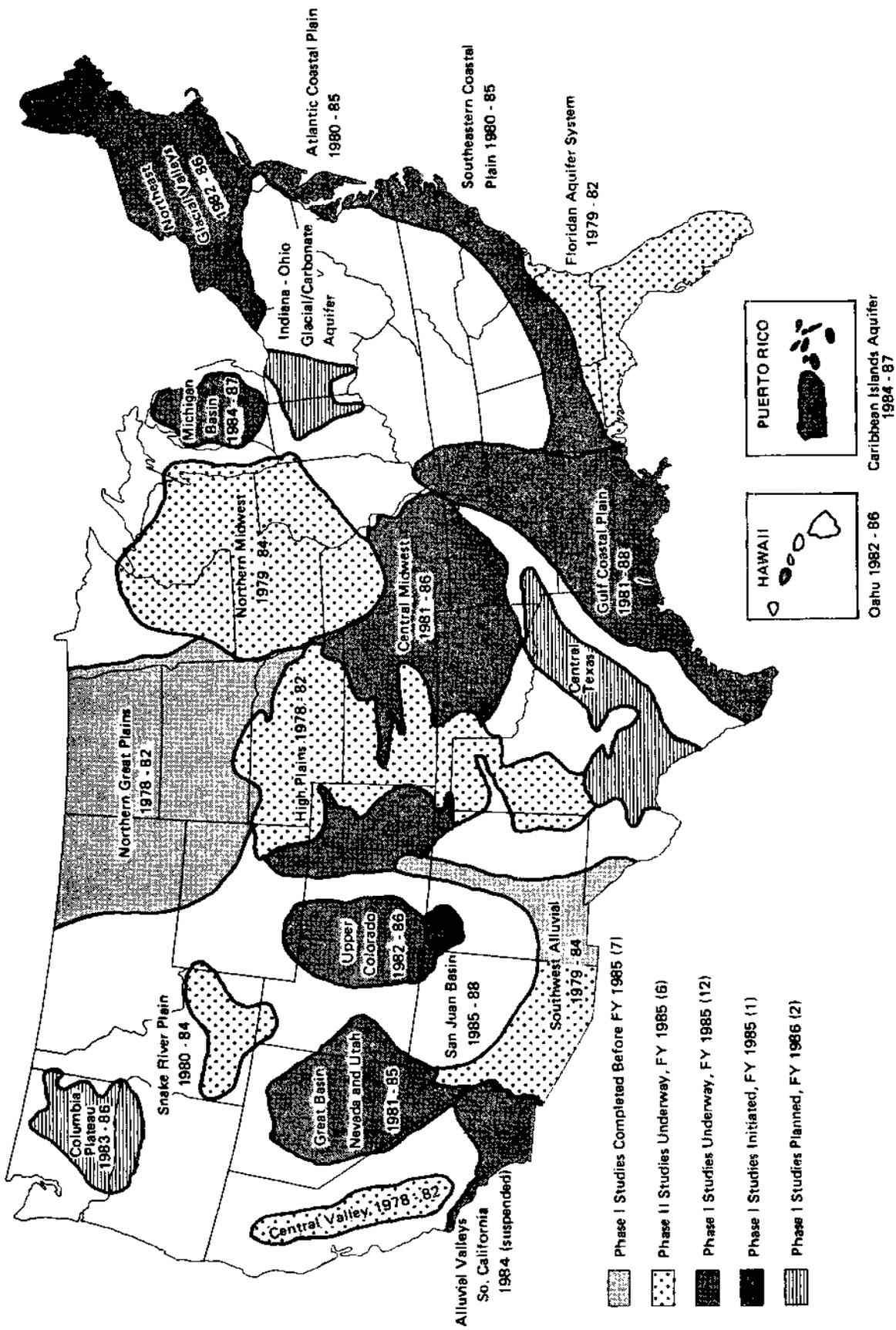


Figure XV-7-1.— Areal extent of regional aquifer-system analyses.  
 (From U.S. Geological Survey, Ground-Water Branch, personal communication)

Table XV 7-1.– Principal data requirements for ground-water analysis and modeling  
(From U.S. Water Resources Council, 1980, p. 21.)

Physical Framework	<p>Hydrogeologic maps showing extent and boundaries of all aquifers and non -water -bearing rocks.</p> <p>Topographic map showing surface-water bodies and land forms.</p> <p>Water-table, bedrock-configuration, and saturated-thickness maps.</p> <p>Transmissivity maps showing aquifers and boundaries.</p> <p>Map showing variations in storage coefficient.</p> <p>Relation of saturated thickness to transmissivity.</p> <p>Hydraulic connection of streams to aquifers .</p>
Hydrologic Stresses	<p>Type and extent of recharge areas (irrigated areas, recharge basins, recharge wells, natural recharge areas).</p> <p>Surface-water diversions.</p> <p>Ground-water pumpage (distribution in time and space).</p> <p>Precipitation.</p> <p>Areal distribution of water quality in aquifer.</p> <p>Streamflow quality (distribution in time and space).</p> <p>Geochemical and hydraulic relations of rocks, natural water, and artificially introduced water or waste liquids.</p>
Model Calibration	<p>Water-level change maps and hydrographs.</p> <p>Streamflow, including gain and loss measurements.</p> <p>History of pumping rates and distribution of pumpage.</p>
Prediction and Optimization Analysis	<p>Economic information on water supply and demand.</p> <p>Legal and administrative rules.</p> <p>Environmental factors.</p> <p>Other social considerations.</p>