FUNCTIONAL REQUIREMENTS OF COMPUTER SYSTEMS FOR THE U.S. GEOLOGICAL SURVEY, WATER RESOURCES DIVISION, 1988-97

By R. Michael Hathaway and Jesse M. McNellis

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ABSTRACT

Investigating the occurrence, quantity, quality, distribution, and movement of the Nation's water resources is the principal mission of the U.S. Geological Survey's Water Resources Division. Reports of these investigations are published and available to the public. To accomplish this mission, the Division requires substantial computer technology to process, store, and analyze data from more than 57,000 hydrologic sites. The Division's computer resources are organized through the Distributed Information System Program Office that manages the nationwide network of computers. The contract that provides the major computer components for the Water Resources Division's Distributed Information System expires in 1991. Five work groups were organized to collect the information needed to procure a new generation of computer systems for the U.S. Geological Survey, Water Resources Division. Each group was assigned a major Division activity and asked to describe its functional requirements of computer systems for the next decade. The work groups and major activities are: (1) hydrologic information, (2) hydrologic applications, (3) geographic information systems, (4) reports and electronic publishing, and (5) administrative.

The work groups identified 42 functions and described their functional requirements for 1988, 1992, and 1997. A few new functions such as Decision Support Systems and Executive Information Systems, were identified, but most are the same as performed today. Although the number of functions will remain about the same, steady growth in the size, complexity, and frequency of many functions is predicted for the next decade. No compensating increase in the Division's staff is anticipated during this period.

To handle the increased workload and perform these functions, new approaches will be developed that use advanced computer technology. The advanced technology is required in a unified, tightly coupled system that will support all functions simultaneously. The new approaches and expanded use of computers will require substantial increases in the quantity and sophistication of the Division's computer resources. The requirements presented in this report will be used to develop technical specifications that describe the computer resources needed during the 1990's.

INTRODUCTION

The U.S. Geological Survey, Water Resources Division (WRD), is the principal Federal water-data agency. Its mission is to investigate the occurrence, quantity, quality, distribution, and movement of the Nation's water resources. Reports of these investigations are published and available to the public. To accomplish this mission, the Division collects hydrologic information at more than 57,000 sites and processes more than 1,000,000 pieces of water data daily (Condes de la Torre, 1987). To process, store, and analyze this much data requires substantial computer technology. Since 1982 the Division's computer technology has been organized through the Distributed Information System (DIS) Program Office that manages the nationwide network of computers. A contract with PR1ME Computers[1] was signed in 1982 to provide the major computer components for the DIS. This contract expires in 1991 and, prior to that time, all available capacity of the present DIS will be in use. In addition, the demand to update the current DIS environment with new technology and to provide additional features continues to grow.

[1]The use of brand, trade, or firm names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

Purpose and Scope

To make a considered and smooth transition to a new generation of computer technology requires substantial planning. Requirements need to be well defined, economic and personnel considerations weighed, and technology carefully considered. To obtain the new computer resources, the DIS Program Office organized the Distributed Information System-II (DIS-II) project. The objectives of the project were: (1) determine the Division's computer requirements, (2) develop technical specifications that meet the requirements, and (3) obtain the computer resources. The Information Management and Computer Utilization Advisory Committee (IMACUAC) and the Technical Advisory Committee (TAC), which are the management and technical advisory committees of the Division's Office of the Assistant Chief Hydrologist for Scientific Information Management (SIM), endorsed the establishment of five work groups to analyze the Division's major activities and determine the functional requirements for future computer systems. Functional requirements are the tasks that must be performed to meet the mission of the Division, many of which require computer support. The purpose of this report is to present the functional requirements to be supported by DIS-II as described by the five work groups.

The five work groups and the major activities of the Division addressed by the work groups are:

- Hydrologic Information: The acquisition, computation, storage, and distribution of hydrologic information.
- Hydrologic Applications: The manipulation, analysis, and interpretation of hydrologic information.
- Geographic Information Systems: The acquisition, storage, sharing, and presentation of spatial information.
- Reports and Electronic Publishing: The processing, storage, and distribution of published reports, maps, and scientific documents.
- Administrative: The processing, storage, and distribution of administrative information.

The scope of this report encompasses the descriptions of the functional requirements derived from the analysis of these activities.

The five work groups consisted of representatives from the Water Resources Division, Geologic Division, National Mapping Division, Information Systems Division, and Administrative Division. Each work group, which consisted of six or seven members expert in the activity, prepared descriptions of current functional requirements and those anticipated in the 1990's. The names of work group members and their respective Survey organizational unit are listed in table 1. Supplementary Data SD-1 through Supplementary Data SD-V contain the activity descriptions prepared by each work group. The authors wish to acknowledge the long hours and hard work of each member without which this report would not be possible.

Work Group Approach

The work groups had the charge to identify and describe the functions within their activity that require computer support in the 1988, 1992, and 1997 time horizons. Each work group independently designed its approach for determining the functional requirements and organization of its reports. A common format, the Functional Requirements Form, was used by the work groups as a guide in reporting the information. All work groups first met to determine the tasks to be investigated, and assigned one or more tasks to an individual or group to develop information about the function. Each work group reconvened to discuss and compile its results. The work group report was compiled, usually by the chairman, and distributed to each member for review. The chairmen met with the project coordinators to present their reports, discuss the results, and resolve any discrepancies.

The five work group reports were then compiled and analyzed by the authors of this report. The aggregate functional requirements for computer systems derived from the five reports were further analyzed for potential overlap. Overlapping functional requirements were noticed and stress the importance of those requirements by their presence in multiple activities.

Table 1.—Work group members

[WRD, Water Resources Division; ISD, Information Systems Division; NMD, National Mapping Division; GD, Geologic Division; AD, Administrative Division]

Work group members	Division	Organizational unit
	Hydrologic Information	
Daniel P. Bauer, Chair	WRD	Missouri District
S. Ernest Dreyer	WRD	Branch of Instrumentation
Oliver Feist	WRD	Branch of Analytical Services
Joe B. Gillespie, Jr.	WRD	Kansas District
Mark Kutsco	ISD	Reston, Va.
Jonathon Scott	WRD	Oklahoma District
William B. Garrett	WRD	Arizona District
	Hydrologic Applications	
Alan M. Lumb, Chair	WRD	Office of Surface Water
Larry R. Bohman	WRD	South Carolina District
Ralph T. Cheng	WRD	Western Region
Mary M. Chepiga	WRD	New Jersey District
Dennis Helsel	WRD	Branch of Systems Analysis
Jeffrey E. Miller	WRD	Central Region
Bill Sikonia	WRD	Pacific Northwest District
	Geographic Information Systems	
Mark A. Ayers, Chair	WRD	New Jersey District
James M. Bettandorff	WRD	Kentucky District
Frederick J. Heimes	WRD	California District
John M. Kernodle	WRD	New Mexico District
Kenneth J. Lanfear	WRD	Branch of National Water Summary
Brent Lowell	NMD	Reston, Va.
	Reports and Electronic Publishing	
Gregory J. Allord, Chair	WRD	Wisconsin District
Darwin F. Alt	WRD	Publications Planning Unit
Jackie Durham	GD	Reston, Va.
Sherron D. Flagg	WRD	Florida District
Kerie J. Hitt	WRD	Branch of National Water Summary
Robert S. Roberts	WRD	Montana District
Richard E. Smith	WRD	Western Region
	Administrative	
Robert D. Hudson, Chair	WRD	Southeastern Region
Clara L. Chambliss	WRD	Branch of Accounting Services
Eliot Christian	AD	Reston, Va.
Mark S. Gerl	WRD	Montana District
Elaine Gockel	WRD	California District
Robert F. Middelburg, Jr.	WRD	Colorado District

The Functional Requirements Form provided to the work groups also included software and hardware items that are properly technical specifications and are not used nor explicitly discussed in this report. However, the work groups' descriptions of software and hardware are valuable in the development of the DIS-II technical specifications.

DISTRIBUTED INFORMATION SYSTEMS-II (DIS-II) FUNCTIONAL REQUIREMENTS FORM

The following questions are designed to collect detailed information about what activities are performed, where, and how often. You will need to describe linkages to external activities such as the Administrative Division, Geologic Division, Environmental Protection Agency, cooperators, universities, and consultants. Also you will need to describe each activity for the 1988, 1992, and 1997 periods. Use your best estimates about what applications will be developed, what new work you feel will be important, and how it will be accomplished.

Please complete a questionnaire for each activity and year. For example, an activity might be payroll, therefore individual forms will be completed describing payroll in 1988, 1992, and 1997. If you need more space to describe the activity, use additional pages. If you wish to include any printed documents, tables, or charts, please attach them to the form.

(1) Please identify the major activities performed.

(2) Please describe each identified activity and why it is needed. Use a separate form for each period (1988, 1992, 1997) that this activity will occur.

(3) Please describe the flow of information in this activity.

(4) How many locations do this activity?

(5) How many times per year is this activity done?

(6) How many people per year do this activity?

(7) How many hours per person per year are spent doing this activity?

(8) Are there any special requirements for this activity?

(9) Please describe any software requirements for this activity. You may list functions of the software or a specific product.

(9a) Data-base manager -

(9b) Editor software -

(9c) Graphics -

(9d) Programming languages -

(9e) Statistics software -

(9f) Spreadsheet software -

(9g) Utility software -

(10) Please describe any equipment requirements for this activity.

(10a) Display/Keyboard -

(10b) Processor -

(10c) Storage unit -

(10d) Printer/Plotter -

(10e) Communications -

HISTORY OF THE DISTRIBUTED INFORMATION SYSTEM

The Recent Past

The Division has used its Distribution Information System since 1982. Prior to DIS, the Division relied on remote job entry (RJE) to mainframe computers at headquarters in Reston, Va., and at other locations to do most of its computing.

The DIS resulted in part from an extensive effort that began in 1976 when Jesse McNellis of the Kansas District of the U.S. Geological Survey made a comprehensive study and determined that to conduct business more effectively, the Division would require about 80 minicomputers located in Division field offices. On the basis of that study, prototype minicomputers were installed in the Kansas and New Mexico Districts and in the Northeast Regional Research Office at headquarters. A report "The Use of Minicomputers in a Distributed Information Processing System--A Feasibility Study" (Longwill and others, 1980) described the use of minicomputers at the two district offices, presented a cost-benefit analysis, and discussed the effects that distributed processing had on Division activities. The following observations, which are pertinent to the DIS today, are taken from that report.

"The effects of distributed processing in Kansas and New Mexico are many and varied particularly since all levels of personnel are involved in using the computers. Use of distributed processing has transferred computing activities to the locations where data originate and are used. By doing this, certain important efficiencies have resulted that have benefited operations in both districts.

"These include increased user control, utilization and participation, increased responsiveness, faster turnaround, quicker access to local data bases, more accurate data capture, and faster error correction. Other economic benefits include lower costs for manpower and communication, and the ability to relate data processing costs to function.

"The daily business of WRD offices requires heavy computer use. This requirement continues to grow each year. Water data and their analysis and interpretation are essential to the national management of water resources. The data bases become more extensive, the modeling activity becomes more critical to decision making, and the need for faster access to computer-based information increases.

"Therefore, it is recommended that the Water Resources Division implement an integrated information system and procure for district use minicomputers that have the following features:

Conventional data processing in batch, interactive, and remote job entry modes.

Word and text processing.

Report preparation capability, including interface to typesetting equipment.

Support of a Data Base Management System (DBMS) package.

The capability of communicating with any other integrated information system to allow teleconferencing, electronic mail service, and the sharing of system and application programs.

The capability of being interfaced to data gathering devices both in the field and in the office. Such devices include laboratory instruments, portable point of entry, data logging, and data conversion equipment.

Each integrated information system must be capable of running all tasks described above concurrently.

Each system must be capable of being assembled from a large family of compatible processors and peripherals to meet the needs and budget restrictions of each WRD district and subdistrict operation."

The Present

Before the DIS, there probably were less than 300 computer literate users in the Division. Today, the number is closer to the number of employees, or about 4,000. The DIS has made this improved literacy possible by providing an easy to use, uniform system available to every employee. The DIS is composed of many components built on a foundation of computers and associated software modeled on the recommendations listed in the feasibility study (Longwill and others, 1980).

What are the components of the DIS that make it successful?

<u>Computers</u> that run efficiently for long periods of time; when a problem exists, the maintenance personnel do an outstanding job. The distribution of computers is shown in table 2.

<u>The DIS network</u> that links the Division's computers and the Division together with electronic mail, a file-transfer service, and virtual terminals. The location of DIS network sites is shown in figure 1.

<u>Common models of terminals and peripheral equipment</u> that provide a consistent base for developing new skills. This equipment is shown in table 3.

<u>A common body of commercial software</u> that includes word processors, editors, graphics generators, programming languages, utilities, and statistical packages. This software is shown in table 4.

Table 2. – **Location, model, and capacity of Distributed Information System computers**

[MB, megabytes]

Location	Model	Central Processing Unit memory (MB)	Disk memory (MB)
Albany, N.Y.	9955-II	8	1,500
Albuquerque, N. Mex.	9955-II	16	2,400
Anchorage, Alaska	750	8	1,675
Arvada, Colo.	850	6	1,200
Arvada, Colo.	850	10	1,200
Atlanta, Ga.	750	4	600
Austin, Tex.	9955-II	12	2,400
Austin, Tex.	9955	14	1,975
Baton Rouge, La.	750	4	1,800
Bay St. Louis, Miss.	750	6	600
Bay St. Louis, Miss.	750	4	600
Bismarck, N. Dak.	750	8	1,200
Boise, Idaho	9955-II	8	1,200
Boston, Mass.	750	8	900
Boston, Mass.	9955-II	14	1,800
Carson City, Nev.	9955-II	16	1,975
Charleston, S.C.	750	6	980
Cheyenne, Wyo.	750	6	2,400
Columbia, S.C.	9955	8	3,350
Columbus, Ohio	750	6	1,200
Doraville, Ga.	9955-II	16	2,400
Harrisburg, Pa.	9955-II	12	1,500
Helena, Mont.	750	8	1,500
Honolulu, Hawaii	750	8	1,200
Huron, S. Dak.	750	6	1,200
Indianapolis, Ind.	750	6	1,500
Indianapolis, Ind.	750	4	1,200
Iowa City, Iowa	750	6	980
Jackson, Miss.	9955-II	12	3,180
Lakewood, Colo.	9955-II	10	3,000
Lakewood, Colo.	9955	16	3,000
Lakewood, Colo.	9955	14	3,175
Lakewood, Colo.	9955-II	14	1,800

Table 2.—**Location, model, and capacity of Distributed Information System computers**--Continued

[MB, megabytes]

Location	Model	Central Processing Unit memory (MB)	Disk memory (MB)
Lincoln, Nebr.	750	6	1,200
Little Rock, Ark.	9955-II	12	1,580
Louisville, Ky.	9955-II	16	1,500
Madison, Wis.	9955-II	8	2,400
Menlo Park, Calif.	9955-II	16	2,400
Miami, Fla.	9955-II	12	1,800
Nashville, Tenn.	9955-II	8	1,800
Oklahoma City, Okla.	9955-II	16	1,500
Orlando, Fla.	750	8	1,800
Portland, Oreg.	9955-II	8	1,200
Raleigh, N.C.	9955	8	1,800
Reston, Va.	9955	16	3,600
Reston, Va.	9955-II	16	3,173
Reston, Va.	850	8	2,400
Reston, Va.	850	8	3,600
Reston, Va.	2250	2	180
Reston, Va.	9955-II	16	3,968
Richmond, Va.	750	6	1,800
Rolla, Mo.	750	8	1,975
Sacramento, Calif.	9955-II	16	1,800
Sacramento, Calif.	9950	6	1,200
St. Paul, Minn.	750	4	1,200
Salt Lake City, Utah	9955-II	8	1,500
San Juan, P.R.	9955-II	12	1,580
Syosset, N.Y.	9955-II	8	1,500
Tacoma, Wash.	750	8	2,100
Tacoma, Wash.	9955	10	0
Tallahassee, Fla.	750	8	1,800
Tampa, Fla.	9955-II	12	1,800
Towson, Md.	9955-II	8	1,800
Trenton, N.J.	9955-II	8	1,200
Trenton, N.J.	9955	18	1,200
Tucson, Ariz.	9955	16	2,400
Tuscaloosa, Ala.	750	6	1,200

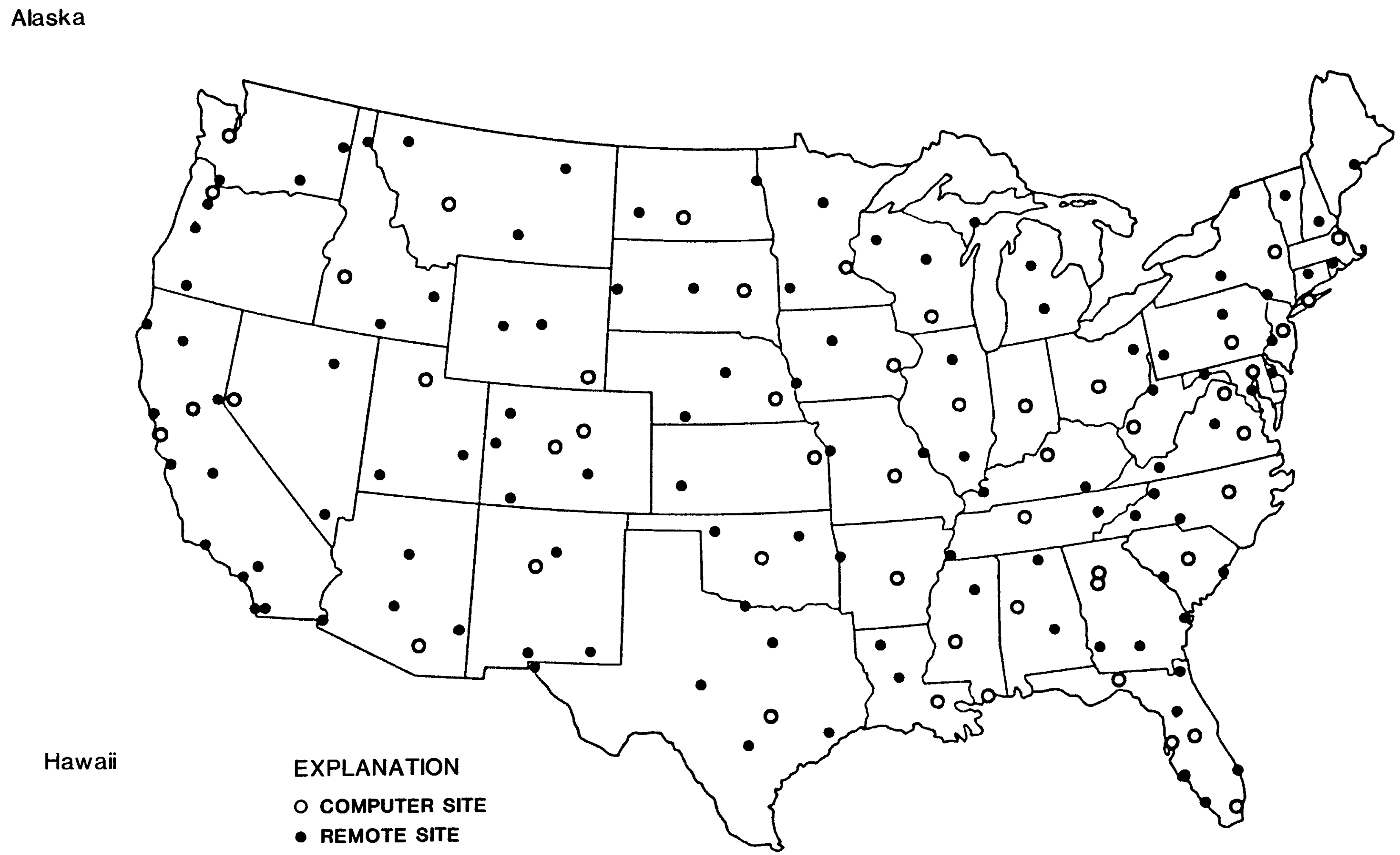

Figure 1.--Distributed Information System sites.

Table 3.—**Water Resources Division peripheral equipment**

Equipment type	Number
Terminals	2,921
Printers	621
Plotters	90
Microcomputers	424

Table 4.—**Water Resources Division commercial software**

Software	Type	Approximate number of sites
PRIMOS	Systems	70
PRIMENET	Communications	70
X.25/FTS	Communications	70
BASIC/VM	Programming	70
MIDASPLUS	Data base	70
FORTRAN	Programming	70
F77	Programming	70
ED	Editing	70
EMACS & RUNOFF	Editing	70
Source Level Debugger	Utility	70
COBOL	Programming	70
PL1	Programming	70
INFO	Data base	70
IMSL	Statistical	70
PSTAT	Statistical	70
CUECHART	Graphical	70
DISSPLA	Graphical	70
TELLAGRAF	Graphical	70
20/20	Statistical	70
WordMARC	Editing	54
ARC/INFO	GIS	44
DATAGRAF	Graphical	3

A common body of in-house software that includes storage, retrieval, computation, and manipulation of ground water, surface water, and quality of water information as well as the digital simulations of hydrologic systems, and administrative data processing.

A comprehensive training program covering the software and hardware that includes vendor training, training at the Division training center, regional offices, and training by Division personnel at field sites.

The Division's employees using the computer for most, if not all, of their work.

The computers, software, and other components complement each other and make each other better. For example, the communications network improves the effectiveness of the word processing software by allowing faster review and preparation of reports. The Division requires no less interrelationship among the new components of DIS-II.

The Near Future

The work groups predict a significant increase in the amount of work to be accomplished within the Division from 1988 to 1997 with no increase in personnel. The work groups expect the use of computer technology to provide the increased productivity. Their descriptions of the functional requirements continue the Division's past and present direction of distributing computer technology to the employee. The work groups' descriptions also show that the computer technology needs to be a tightly coupled system handling all functions simultaneously. To meet these needs, powerful, easy-to-use software, running on general purpose computers which are linked together in a network, are required.

MAJOR ACTIVITIES AND FUNCTIONAL REQUIREMENTS OF THE U.S. GEOLOGICAL SURVEY, WATER RESOURCES DIVISION

Each work group identified issues and made assumptions in describing their activities and functional requirements. These are presented with the following abbreviated descriptions of each major activity and their functional requirements. A complete description of each is presented in Supplementary Data I through Supplementary Data V.

Hydrologic Information

The requirements for hydrologic information are presented in nine sections. These sections encompass the four general areas involved in processing hydrologic data: acquisition, computation, file maintenance, and retrieval. The requirements in each section are reported for three Water Resource Division groups: District (including all district, State, subdistrict, project, and field offices), Research and Headquarters, and Analytical Service Laboratory. This breakdown was used because of the current and projected differences in the mode and operational characteristics of each group. Three types of hydrologic information processed by these groups are: (1) time dependent, (2) spatial, and (3) narrative information.

Several assumptions were made in the analysis, including: continued existence of a national hydrologic data base, large changes in the amount and types of data, and continued expansion of real-time data. The national data base will be a periodic aggregation of the distributed data bases and is needed for large nationwide retrievals. The need for data collection platforms and direct readout ground stations are expected to continue at an accelerated pace. Significant changes are expected as the Analytical Services Laboratory changes from manual to automated data entry into the Division's data bases.

The work group perceives a continuing critical requirement for maximum support of an efficient high speed network for inter- and intra-office communications. Some of the projected large data transfers include: real-time data transfers, at least through 1992 time horizon, uploading and support of national data bases, transfer of spatial data, report processing, and a large increase in requests for retrievals from local and national data bases.

The work group members determined that automated procedures are needed to check data to assure its validity.

Hydrologic information residing in paper files and cabinets are of little value to the user community. Procedures are required for digital entry and retrieval of all forms of numeric and narrative data.

Spatial data bases are thought to be primarily the responsibility of the National Mapping Division (NMD). The Division's data bases will contain only specific spatial data as related to project needs. Therefore, carefully designed linkages between the Division's and NMD data bases are required for easy efficient use of spatial data.

The Hydrologic Information activity includes the acquisition, computation, storage, and distribution of hydrologic information and has the following functional requirements.

1. Acquisition of manually entered data.--The manual entry of data from notes, graphs, maps, and figures into a digital format using terminals and digitizers.
2. Acquisition of automatically entered data.--The automated entry of data into a digital format using devices attached to a digital computer interface.
3. Standard computation of data.--This task includes instrument calibration, reformatting, unit conversion, calculation, and reduction of data elements.
4. Data synthesis.--The generation of synthetic hydrologic data from several hydrologic data elements using statistical, graphical, and other comparative methods.
5. Data validation.--Validation of hydrologic data includes checking for internal consistency, checking against known values, comparing data elements, and correlation analysis.
6. Data-base maintenance.--Structural maintenance includes definition and modification of data elements, testing the integrity of the data, recovery from catastrophic system failures, and setting data-base security. Content maintenance includes backing up the data base, calculating file statistics, and reorganizing data files.
7. Data archiving.--This task archives data into a national or historical data base.
8. Facilitating access to data.--This task provides an interface to non-Survey users to access the Division's data.
9. Retrieval of data.--This task provides retrievals and retrieval methods to all internal and external users and the public.

Hydrologic Applications

The requirements for hydrologic applications are presented in 11 sections. Initially, the committee had a brainstorming session to identify all possible computer activities in Hydrologic Applications. From that list, the final 11 sections were organized. Overlap in the various sections exists, but is considered useful and helps stress the importance of some of the requirements. Hydrologic applications included district projects, research projects at the regional centers and districts, and projects at headquarters. The full range of activities from data collection, through data analysis, to report production, were considered.

Several issues and themes emerged during the discussions. These are highlighted in the following paragraphs.

Larger computer memories, faster processors, and more disk space are required by hydrologic applications. Most all models are structured to handle more time steps and greater spatial resolution, but applications are currently limited because of inadequate disk space, memory, and turnaround time. Additional limits are preprocessing time and effort required to create and check model input, but these limits are rapidly vanishing with improved software to handle spatial data, advances in data loggers, and improved software to handle time series information.

Higher resolution graphics, graphic standards and improved integration of graphics with data handling, modeling, and statistical programs are required. Interactive graphics is the key to preprocessing for developing input for models.

Visualization systems are required. Hydrologic processes and models are very dynamic, and as such, graphics animation becomes a powerful tool for understanding hydrology and model output. Strong consideration should be given to software and hardware necessary for animation.

Desktop publishing is required and must include capabilities for complex equations and integration of text and graphics. Editors are required to have software development features.

Supercomputer power is needed, but much of the need is and will be coupled with the need for interactive graphics. Thus, high volumes of data must pass between the workstation and supercomputer. Some of the hydrologic models can use parallel processing.

Portable software is very important. Most of the hydrologic modeling software and much of the statistics applications are shared with other agencies, universities, cooperators, and consultants. Supported software languages and tools must adhere to American National Standards Institute (ANSI) standards.

Hydrologic applications process large quantities of data. Some is input data and some is output data. Optical disk technology will play an important role in hydrologic applications as a source of input data and to archive project data.

The Hydrologic Applications activity includes the manipulation, analysis, and interpretation of hydrologic information and has the following functional requirements.

10. Editing environment.--The editing environment tasks consist of creating and editing data files, reports, correspondence, and software development.
11. Communications.--Communications involve the internal and external transfer of program and graphics software, data, report text, graphics, and mail which support the other major Hydrologic Application activities.
12. Data handling.--Data handling includes collecting data in the field or laboratory, transmitting data to the office, processing data for input to an application, processing data generated by the application, and may also include acquisition of data from local and external data bases.
13. Spatial data processing.--Spatial data processing is the compilation and analysis of remotely sensed or field collected data, which in addition to having variable values (such as water levels and constituent concentrations), also has at minimum two-dimensional spatial characteristics (latitude-longitude) and often a third dimension of either depth or time.
14. Graphics.--Graphics involve the display of information in symbolic form, and are essential for the display and analysis of input data and output results associated with hydrologic applications.
15. Statistical analysis of data.--This task applies statistical methods to the presentation, analysis, and interpretation of hydrologic data.
16. Surface-water modeling.--Surface-water models reproduce hypothetical or real-world surface-water flow problems by solving a set of governing nonlinear equations.
17. Ground-water modeling.--Ground-water models reproduce measured and conceptualized movement of ground water through an aquifer by solving a set of finite difference or finite element equations.
18. Other modeling.--Other disciplines modeled alone or as an extension of surface water or ground water include solute and sediment transport and geomorphology, chemistry, geochemistry, and ecology.
19. Real-time applications.--This task involves collecting, transmitting, processing, and immediately interpreting hydrologic data in a hydrologic application.
20. Decision support systems.--Decision support systems are the integration of hydrologic models and data management directed toward specific resources management decisions.

Geographic Information Systems

The requirements for geographic information systems (GIS) are presented in six sections. GIS is a spatial data management and analytical tool offering tremendous potential gains in power and efficiency for the Division. To make full use of GIS, requires a commitment toward application development, research into advanced GIS technology, training, and providing better ways to document and distribute GIS applications.

Digital line graph data (1:100,000 scale) for hydrography, transportation, public land survey systems, political boundaries, and topography are needed.

Distributed processing with improved network technology linking systems and equipment is required. Existing linkages to computerized data have too much manual intervention; automated procedures are required. Software to easily place, move, and edit text on maps and other graphics is required. An improved data base management system (DBMS) to effectively manage GIS data including quality assurance and quality controls, security protection, data base dictionary, and transactional reports is required.

Visualization procedures capable of three dimensional animation and video media output are required. This type of visualization requires supercomputer processing power. New technologies (such as compact disk-read only memory (CD-ROM) and video-cassette recorder (VCR) tapes) are required for storing and distributing data. Scanners are required to eliminate considerable manual operations.

Research into alternative GIS data structures and advanced GIS concepts such as object oriented structures is required to better represent spatial and hydrologic data and for development of advanced hydrologic models. A knowledge based GIS (KBGIS) is required to achieve greater efficiency and reduce errors, particularly in querying and data entry operations. Specialized expertise is required for these research activities.

By 1992, the DIS will require a powerful DBMS, including some level of artificial intelligence (AI), to provide easy and transparent access to spatial, time series, and textual data. GIS will require optimization procedures and unification with numerical and statistical models. Increased use of GIS will require additional national base data layers such as geology, land use, and soils. The Division's new products and how they are delivered will require new technologies.

The type of GIS applications expected to mature during 1992-97 will not change appreciably beyond 1997. However, the scope of these applications will increase to include modeling and analysis of natural phenomena on large, even global scales or at fine detailed scales, and will require much faster computers. The GIS environment is required to be AI assisted with integrated raster-vector, image processing, surface-volume modeling, and statistical analysis capabilities. This environment is required to be fully integrated into the DIS-II for efficient sharing of information and processing power. As a result of research into alternate data structures, it is possible that an entirely different GIS software structure will exist by the year 1997.

The geographic information systems activity includes the acquisition, storage, sharing, and presentation of spatial information and has the following functional requirements.

21. Data automation.--This task involves the digital capture of analog data for GIS, the transformation of existing digital data into GIS, and the editing and updating of GIS data.
22. GIS data manipulation.--Manipulation involves data redefinition, data restructuring, and coordinate transformation of GIS data.
23. GIS data-base management.--This task includes development, storage, management, manipulation, query, and retrieval of GIS map layers or coverages contained in data bases.
24. GIS applications and analysis.--This task involves GIS as a pre- and post-processor for other hydrologic applications and as an aid to information processing, reformatting, and dissemination.
25. GIS output and publications.--This task involves the output of data, graphics, and text for use in review, analysis, and publication of GIS related products.
26. Advanced GIS analysis.--This task is defined as the research and development of new and improved software systems for managing and analyzing GIS data.

Reports and Electronic Publishing

The requirements for reports and electronic publishing are presented in eight sections. These sections were organized by the seven work group members to encompass the complete reports processing activity. The requirements determined by the work group are as described below.

A general purpose word processing package is required that meets the Division's scientific publishing standards. It must provide two levels of sophistication: A basic level to be used for text processing that is fast, simplistic, and uses an icon and menu-driven operating system, and an advanced level for special functions and advanced editing or layout. This package is required to import and export files between all common word processing packages while retaining all special formats. Eventually, the word processing software is required to be an integral part of a publishing software system. Publishing files are required to be sent through the network to any DIS system.

A general purpose graphics package is required that meets the Division's scientific illustrations standards. The graphics package must provide full screen editing of an image along with integration of the graphic into the text processing package. Graphic files are required to be sent through the network to any DIS system. By 1997, text processing and graphic processing are required to be fully integrated as part of an overall Division package. All text and graphic products, from any software package, must be capable of being manipulated by this sytem.

The basic word processing and graphic processing packages, while able to create text and graphics for informal series reports, are required to transfer files to higher resolution graphic and text processing systems. These specialized systems are required to have complete text and graphic manipulation capabilities for final formatting and transmittal to full format film devices. Initially, this will be for reports that require multicolor or high resolution output.

A reports tracking system is required that is fully compatible between all field locations and headquarters. It must be capable of processing information about project, report preparation, and publications activities. It is required to transfer to and from any system, graphics, editing notations, revisions to reports, and generate status reports. This system is required to be eventually linked to other bibliographic data bases.

Special editing and correcting software is required by editors to change an author's text to conform to Division standards during the review cycles. It is required to be compatible with the general purpose word processing software, and must also be able to edit images from the Division graphics software.

A technical review and approval package is required. It must provide the ability for a reviewer to comment on a report's text and graphics without physically altering the report contents. It is required to be able to show review comments by different reviewers as specific annotations. All comments are required to be kept in a master file for future reference.

A specialized archival and retrieval system is required. It must provide citation information for management and planning purposes, retrieval of original text or graphics for reference or inclusion in reports, and retrieval for distribution of hard copy.

It is intended that, to the maximum extent possible, all required software is developed and maintained by the prepress and publishing industry. Some special enhancements will have to be developed through special software development, such as reports tracking or technical review and approval.

The Reports and Electronic Publishing activity includes the processing, storage, and distribution of published reports, maps, and scientific documents and has the following functional requirements.

27. Word processing.--This task includes general purpose word processing to create and modify text for use in reports and other scientific documents.

28. Graphic processing.--This process starts with the origination of a design for an illustration, continues through the drafting and review cycles, and ends when the draft illustration is approved for publication.

29. Reports tracking.--Reports tracking is a mechanism to effectively and efficiently track and project the progress of report preparation.

30. Editing and correcting.--Editing and correcting are processes that consist of changing the author's copy of a manuscript to agree with report standards.

31. Technical review and approval.--Technical review is a process where technically competent and unbiased individuals carefully examine and comment on the content of newly written reports.

32. High resolution graphics preparation.--A cartographer or illustrator takes an approved graphic, revises it for conformance to Division publication policy, manipulates the image for design changes, and generates a final copy on a high-resolution film output device.

33. Publishing.--Publishing consists of two principal activities, page layout and printing.

34. Distribution and archiving.--This task consists of storage, retrieval, and distribution of reports.

Administrative

The requirements for Administrative activities are presented in eight sections. The eight sections describe the entire Division's administrative processing activity and requirements for DIS-II. In summary the requirements are as follows.

All employees are required to have access to an electronic system with sufficient processing and input output capability to perform tasks quickly.

Easy control of multiple concurrent information management processes is required. All software is required to operate within a multiple processing environment where background tasks operate concurrently with the foreground task. The environment is required to have a user-friendly graphical interface incorporating windows and icons on a high resolution display and with a pointing input device in addition to a standard keyboard.

The capability to quickly exchange information in many forms with other facilities both locally and remotely is required. Provision must be made for reliable transmission of all information including text, tables, graphs, and other images.

Integration of subsystems is required such that performing administrative and management tasks across subsystem boundaries are transparent to the user.

An efficient text-string search capability is required for those data base queries and retrievals.

Scanners are required to transcribe paper documents to electronic storage.

Electronic signatures are required that meet legal and management standards.

Expert systems are required by 1992 in order to cope with the task of correlating multiple information sources, such as the Personnel Action System (PAS) and Federal Financial System (FFS).

The Administrative activity includes the processing, storage, and distribution of administrative information and has the following functional requirements.

35. Payroll.--Payroll is the process of collecting employee time and attendance information, calculating costs for benefits and salary, and certifying and forwarding payroll records to the Department payroll system.

36. Financial management.--Financial management covers budgeting, funding, and expenditure activities of the Division at all levels of the organization.

37. Procurement.--Procurement covers acquisition of all supplies, equipment, and contractual services needed to support the Division's mission.

38. Personnel.--This task includes employee recruitment and placement, training, and career development planning.

39. Office automation.--Office automation includes inter- and intra- office communication, electronic message transfer using electronic mail, filing of correspondence, and information directories.

40. Executive Information System.--Field, region, and headquarters project management needs are included in the Executive Information System.

41. Travel.--This task is the process of authorizing and paying for official travel.

42. General services.--General services are a group of mandatory tasks including but not limited to the management of property, vehicles, and space.

Table 5 is a summary list of the 42 functional requirements. Table 6 is a matrix of the potential overlap of the functional requirements described by the work groups. The amount of overlap among functional requirements indicates the relative significance of that requirement. For example, the GIS output and publications requirement overlaps with 10 other functional requirements. Table 7 is a matrix of the software and hardware requirements for each functional requirement.

Table 5. – **Distributed Information System II functional requirements**

[GIS, Geographic Information System; MIS, Management Information System; EIS, Executive Information System]

Activity	Functional requirements
Hydrologic Information	Acquisition of manually entered data Acquisition of automatically entered data Standard computation of data Data synthesis Data validation Data base maintenance Data archiving Facilitating access to data Retrieval of data
Hydrologic Applications	Editing environment Communications Data handling Spatial data processing Graphics Statistical analysis of data Surface-water modeling Ground-water modeling Other modeling Real-time applications Decision support systems
Geographic Information Systems	GIS data automation GIS data manipulation GIS data base management GIS applications and analysis GIS output and publications Advanced GIS analysis
Reports and Electronic Publishing	Word processing Graphic processing Reports tracking Editing and correcting Technical review and approval High resolution graphics Publishing Distribution and archiving
Administrative	Payroll Financial management Procurement and contracts Personnel Office automation MIS and EIS planning Travel General services

Table 6.--Matrix of potential overlap of functional requirements among major activities

[GIS, Geographic Information Systems; MIS, Management Information System; EIS, Executive Information System]

Computer activity	Functional requirement No.	Hydrologic Information									Hydrologic Applications											Geographic Information Systems (GIS)						Reports and Electronic Publishing								Administrative							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
Hydrologic Information	1										X		X		X													X	X														
	2																			X																							
	3												X							X																							
	4																X	X	X	X					X																		
	5															X																											
	6												X											X																			
	7												X													X									X								
	8											X								X															X								
	9												X								X				X	X									X								
Hydrologic Applications	10	X																										X	X			X											
	11								X																			X	X			X								X			
	12	X		X			X	X		X																																	
	13																					X	X	X	X	X																	
	14	X																											X			X											
	15					X																																					
	16				X																				X	X																	
	17				X																				X	X																	
	18				X																				X	X																	
	19		X	X	X				X																																		
	20									X																	X														X		
Geographic Information Systems (GIS)	21													X																													
	22													X																													
	23						X							X																													
	24				X					X				X			X	X	X																								
	25							X		X				X			X	X	X													X	X	X	X								
	26																				X																						
Reports and Electronic Publishing	27	X									X	X																												X			
	28	X									X	X			X																												
	29																																								X		
	30																																										
	31										X	X			X											X																	
	32																									X																	
	33																									X																	
	34							X	X	X																X																	
Administrative	35																																										
	36																																										
	37																																										
	38																																										
	39											X																X															
	40																				X									X													
	41																																										
	42																																										

Functional requirement numbers:

1 = Acquisition of manually entered data
2 = Acquisition of automatically entered data
3 = Standard computation of data
4 = Data synthesis
5 = Data validation
6 = Data base maintenance
7 = Data archiving
8 = Facilitating access to data
9 = Retrieval of data

10 = Editing environment
11 = Communications
12 = Data handling
13 = Spatial data processing
14 = Graphics
15 = Statistical analysis of data
16 = Surface-water modeling
17 = Ground-water modeling
18 = Other modeling
19 = Real-time applications
20 = Decision support systems

21 = GIS data automation
22 = GIS data manipulation
23 = GIS data base management
24 = GIS applications and analysis
25 = GIS output and publications
26 = Advanced GIS analysis

27 = Word processing
28 = Graphic processing
29 = Reports tracking
30 = Editing and correcting
31 = Technical review and approval
32 = High resolution graphics
33 = Publishing
34 = Distribution and archiving

35 = Payroll
36 = Financial management
37 = Procurement and contracts
38 = Personnel
39 = Office automation
40 = MIS and EIS planning
41 = Travel
42 = General services

Table 7.--Matrix of described software and hardware

[GIS, Geographic Information Systems; MIS, Management Information System; EIS, Executive Information System]

Data base software:

1 - Relational
2 - Text
3 - Graphical
4 - Object oriented
5 - Indexed access method
6 - Other specific

Graphical software:

1 - Interactive
2 - Subroutine library
3 - Animation
4 - Real-time
5 - Computer assisted design
6 - Graphical line annotation

Programming software:

1 - Command language
2 - FORTRAN 77
3 - C
4 - Object oriented
5 - PL/1
6 - PASCAL
7 - LISP and PROLOG

Editing software:

1 - Line editor
2 - Screen editor
3 - Word processor
4 - Electronic publishing

Statistical software:

1 - Interactive
2 - Subroutine library
3 - Spreadsheet software

Functional requirement No.	Functional requirement	Data-base software						Editing software				Graphical software						Programming software							Statistical software		
		1	2	3	4	5	6	1	2	3	4	1	2	3	4	5	6	1	2	3	4	5	6	7	1	2	3
1	Acquisition of manually entered data	X						X	X	X	X							X	X	X							
2	Acquisition of automatically entered data	X																X	X	X							
3	Standard computation of data	X											X					X	X	X						X	
4	Data synthesis	X						X	X		X		X					X	X	X				X	X	X	
5	Data validation	X						X	X		X	X	X					X	X	X				X	X	X	
6	Data-base maintenance	X																X	X	X							
7	Data archiving	X						X	X									X	X	X							
8	Facilitating access to data	X						X	X		X		X					X	X	X					X	X	
9	Retrieval of data	X						X	X		X		X					X	X	X				X	X	X	
10	Editing environment							X	X	X	X				X		X	X									
11	Communications																	X									
12	Data handling	X						X	X			X	X					X	X	X							
13	Spatial data processing	X						X	X			X	X		X			X	X	X				X			
14	Graphics											X	X	X	X			X	X	X			X				
15	Statistical analysis of data											X	X					X							X	X	
16	Surface-water modeling	X						X	X			X	X					X	X						X	X	
17	Ground-water modeling	X						X	X			X	X					X	X						X	X	
18	Other modeling	X						X	X			X	X					X	X						X	X	
19	Real-time applications																	X	X	X							
20	Decision support systems											X	X					X	X	X				X			
21	GIS data automation	X		X	X		X	X	X	X	X	X	X					X	X	X	X			X	X	X	X
22	GIS data manipulation	X		X	X		X	X	X	X	X	X	X					X	X	X	X			X	X	X	X
23	GIS data-base management	X		X	X		X	X	X	X	X	X	X					X	X	X	X			X	X	X	X
24	GIS applications and analysis	X		X	X		X	X	X	X	X	X	X	X				X	X	X	X			X	X	X	X
25	GIS output and publications	X		X	X		X	X	X	X	X	X	X	X			X	X	X	X	X			X	X	X	X
26	Advanced GIS analysis	X		X	X		X	X	X	X	X	X	X	X				X	X	X	X			X	X	X	X
27	Word processing									X		X						X						X	X		
28	Graphic processing										X	X	X		X			X	X						X		X
29	Reports tracking	X									X	X						X							X		X
30	Editing and correcting										X	X			X			X							X		
31	Technical review and approval										X	X			X			X							X		
32	High resolution graphics										X	X	X		X	X		X									
33	Publishing	X									X	X	X		X	X		X							X		X
34	Distribution and archiving		X									X						X									X
35	Payroll	X				X	X	X										X							X	X	
36	Financial management																	X							X	X	
37	Procurement and contracts	X	X				X			X						X		X							X	X	
38	Personnel		X						X									X									
39	Office automation																	X									
40	MIS and EIS planning	X	X						X			X						X							X	X	
41	Travel									X																	
42	General services														X												

Table 7.--Matrix of described software and hardware--Continued

[GIS, Geographic Information Systems; MIS, Management Information System; EIS, Executive Information System]

Utility software:

1 - Spooler
2 - Reformatting packages
3 - Debugger
4 - Math matrix library
5 - Sort and merge
6 - Expert system

Communication software:

1 - Electronic mail
2 - File transfer
3 - Terminal emulation
4 - Remote Job Entry (RJE)
5 - External data base access

System software:

1 - Windowing
2 - Personal Computer (PC) operating systems support
3 - Computer resource accounting
4 - Real-time processing
5 - Audio processing

GIS software:

1 - Vector
2 - Raster

Input hardware:

1 - VT100
2 - Pointing devices
3 - Digitizer
4 - Scanner
5 - Bar code
6 - Voice input

Functional requirement No.	Functional requirement	Utility software						Communication software					System software					GIS software		Input hardware					
		1	2	3	4	5	6	1	2	3	4	5	1	2	3	4	5	1	2	1	2	3	4	5	6
1	Acquisition of manually entered data																			X					
2	Acquisition of automatically entered data																			X					
3	Standard computation of data					X														X					
4	Data synthesis					X														X					
5	Data validation																			X					
6	Data-base maintenance																			X					
7	Data archiving																			X					
8	Facilitating access to data														X					X					
9	Retrieval of data					X														X					
10	Editing environment	X													X					X					
11	Communications	X						X	X		X	X			X					X			X		
12	Data handling	X	X	X		X							X		X					X	X				
13	Spatial data processing	X		X			X						X		X			X		X	X				
14	Graphics	X		X									X		X					X	X				
15	Statistical analysis of data	X			X										X					X					
16	Surface-water modeling	X		X	X						X				X					X					
17	Ground-water modeling	X		X	X						X				X					X					
18	Other modeling	X		X	X						X				X					X					
19	Real-time applications	X		X											X	X				X					
20	Decision support systems	X		X			X						X		X					X	X				
21	GIS data automation		X				X		X					X				X	X		X	X	X		X
22	GIS data manipulation		X				X		X					X				X	X		X	X	X		X
23	GIS data-base management		X				X		X					X				X	X	X	X	X	X		X
24	GIS applications and analysis		X				X		X					X				X	X		X	X	X		X
25	GIS output and publications		X				X		X				X	X				X	X		X	X	X		X
26	Advanced GIS analysis		X				X		X					X				X	X		X	X	X		X
27	Word processing																					X	X		X
28	Graphic processing									X												X	X		
29	Reports tracking																								X
30	Editing and correcting																					X	X		X
31	Technical review and approval																					X	X		
32	High resolution graphics																				X	X	X		
33	Publishing	X																							
34	Distribution and archiving																			X		X	X		
35	Payroll						X		X	X	X		X	X			X			X	X		X		X
36	Financial management						X			X		X	X	X			X			X	X		X		X
37	Procurement and contracts						X			X		X	X	X			X			X	X		X		X
38	Personnel						X			X		X	X	X			X			X	X		X		X
39	Office automation						X	X		X			X	X			X			X	X		X		X
40	MIS and EIS planning						X			X			X	X			X			X	X		X		X
41	Travel						X			X		X	X				X			X	X		X		X
42	General services						X			X			X							X	X		X	X	X

Table 7.--Matrix of described software and hardware--Continued

[GIS, Geographic Information Systems; MIS, Management Information System; EIS, Executive Information System]

Display hardware:

1 - Medium resolution color
2 - High resolution color
3 - Greek and math
4 - Large screen
5 - Video projector

CPU; Central Processing Unit hardware:

1 - Multi-tasking

Storage hardware:

1 - Temporary
2 - Permanent archival
3 - High capacity
4 - Magnetic tape
5 - Diskette

Output hardware:

1 - Line printer
2 - Letter quality
3 - Color graphics printer
4 - Vector plotter
5 - Film recorder and typesetter
6 - Video
7 - Microfilm recorder
8 - Special forms handling
9 - Holographics

Communication hardware:

1 - Wide area network
2 - Local area network
3 - Asynchronous
4 - Synchronous
5 - Other

Functional requirement No.	Functional requirement	Display hardware					CPU	Storage hardware					Output hardware									Communication hardware				
		1	2	3	4	5	1	1	2	3	4	5	1	2	3	4	5	6	7	8	9	1	2	3	4	5
1	Acquisition of manually entered data	X																					X			X
2	Acquisition of automatically entered data	X																					X			X
3	Standard computation of data	X											X		X	X							X			X
4	Data synthesis	X											X		X	X										
5	Data validation	X											X		X	X										
6	Data-base maintenance	X													X	X										
7	Data archiving	X							X		X												X			X
8	Facilitating access to data	X							X		X												X		X	X
9	Retrieval of data	X											X		X	X										
10	Editing environment			X			X							X									X	X		
11	Communications						X															X	X	X	X	
12	Data handling	X					X								X	X							X	X		
13	Spatial data processing		X				X								X	X							X	X		
14	Graphics		X			X	X								X	X	X	X					X	X		
15	Statistical analysis of data		X				X								X	X							X	X		
16	Surface-water modeling	X					X						X		X	X							X	X	X	
17	Ground-water modeling	X					X						X		X	X							X	X	X	
18	Other modeling	X					X						X		X	X							X	X	X	
19	Real-time applications	X					X									X							X	X	X	
20	Decision support systems	X	X				X						X		X	X							X	X		
21	GIS data automation	X	X			X			X	X	X	X	X		X	X	X	X			X	X	X			
22	GIS data manipulation	X	X			X			X	X	X	X	X		X	X	X	X			X	X	X			
23	GIS data-base management	X	X			X			X	X	X	X	X	X	X	X	X	X			X	X	X			
24	GIS applications and analysis	X	X			X			X	X	X	X	X		X	X	X	X			X	X	X			
25	GIS output and publications	X	X		X	X			X	X	X	X	X		X	X	X	X			X	X	X			
26	Advanced GIS analysis	X	X			X			X	X	X	X	X		X	X	X	X			X	X	X			
27	Word processing		X	X											X		X			X		X				
28	Graphic processing		X	X										X	X							X	X			
29	Reports tracking		X											X								X	X			
30	Editing and correcting		X	X										X												
31	Technical review and approval		X	X										X												
32	High resolution graphics		X				X							X	X		X									
33	Publishing		X	X										X			X									
34	Distribution and archiving													X								X	X	X		
35	Payroll	X								X			X		X			X		X		X	X			
36	Financial management	X					X			X				X	X			X		X		X	X			
37	Procurement and contracts		X				X			X			X	X				X		X		X	X			
38	Personnel									X			X			X		X		X		X	X			
39	Office automation	X			X					X				X	X			X				X	X			
40	MIS and EIS planning		X							X				X				X			X	X	X			
41	Travel									X			X									X	X			
42	General services									X			X									X	X			

SUMMARY

The daily business of the Division is to investigate the Nation's water resources. The use of computer technology is crucial to collecting, studying, and managing water data, and to the support services of the Division. The DIS is the Division's principal computer resource. The contract that provides the major components of the DIS expires in 1991, and to provide new computer technology beyond 1991, the DIS Program Office organized the DIS-II project. The DIS-II project will determine the Division's computer requirements, develop the technical specifications that meet the requirements, and obtain the computer resources. This report presents the functional requirements to be supported by DIS-II.

Work groups described the Division's major activities and identified 42 functional requirements. These descriptions predict a substantial increase in the amount of work to be accomplished within the Division over the next decade. With no compensating increase in personnel, computer technology is expected to provide the improved productivity to accomplish the work. An analysis of the descriptions shows that the required computer technology should be provided in a tightly coupled system capable of handling all functions simultaneously. This report is the first step in providing that technology.

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SUPPLEMENTARY DATA I.--Hydrologic Information Work Group

TABLES

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SUPPLEMENTARY DATA I. – HYDROLOGIC INFORMATION WORK GROUP

Introduction

Hydrologic information is a very important part of the past, present, and future operation of the Water Resources Division of the U.S. Geological Survey as noted by Harbaugh (1986), "Data management accounts for 50 percent of the computational workload because of hydrologic data collected in all 50 States, Puerto Rico, and the Trust Territories. Streamflow is measured at about 11,000 locations, water levels are measured in 39,000 wells, and water quality is sampled at over 14,000 locations. An extensive program to collect water-use data has also been established." Based on current analysis, the hydrologic information (HI) task group finds this extensive hydrologic data effort ongoing and with strong expansion possibilities in the future. The expansion is based on a larger national emphasis on hydrologic information and the increase in the types and complexity of data collected. Another recent addition is the collection and use of "real time" hydrologic information. This is made possible through efficient satellite data transmission, dedicated land line telephone systems, or short-range radio frequency.

Three general types of hydrologic information are recognized by the HI task group and include: time dependent, spatial, and narrative. The time data can be thought of as discrete or continuous, whereas spatial data are digital representations of map features of points, lines, or areas (polygons). Narrative data are parts of the entire reports, memorandums, or any written presentations. The conceptual design for the National Water Information System (NWIS) as described by Edwards and others (1986) gives the framework for most HI activities. All the data herein closely resemble that presented by Edwards and others (1986) with a greater emphasis on real time, narrative, and spatial data. The HI task group, for example, projects that almost all fixed station hydrologic data will use real-time data transmission capabilities in the near future. In addition, the task group projects a larger amount of narrative data to be entered into the computer system.

The definitions of hydrologic information given by the HI task group are basically the same definitions as those of Edwards and others (1986, p. 20–21). The spatial data, for example, defining "digitized/line data" would also include areal data. Current thinking is that the major digital cartographic data base would remain the responsibility of the National Mapping Division (NMD), but with efficient methods for retrieval and transfer to WRD files when needed. In addition, adequate methods would be developed for the actual WRD map derivation of this data when it is not available from the NMD files. The real-time data will fit the characteristics of both complete and discrete data, in some cases being only one value while in others representing a series of values. The volume of this data in the computer files could amount to significant storage if overall WRD projections are on track.

The narrative data is defined as text and descriptive data by Edwards and others (1986) with only bibliographic and abstract citations included. The HI task group projects this data area to be underestimated with, in some cases, complete reports being entered into the system through the use of digital scanners or other devices. It is further noted that vast amounts of hydrologic information currently reside in nonaccessible areas such as file drawers, cabinets, and so forth. Therefore, new techniques and hardware are needed to bring this data into WRD computer systems for reference and use.

Assumptions

Certain assumptions were initially agreed upon by the HI task group. To help deal with the charge of assessing the current and the 1992 and 1997 time horizons for the hydrologic information needs of the WRD, some assumptions were derived. These assumptions are as follows:

- Existence of a national data base that consists of a periodic aggregation or update of distributed data bases.
- Greatly expanded capability of online storage.
- The data elements of the national data base will be a subset of the distributed data base.
- Division personnel availability will remain constant or decrease.
- Increasing demand for data, especially in machine readable format. Cooperators and general public will have online access to the data.
- Centralized and distributed data-base maintenance and retrieval software will be designed to be similar in characteristics and structure.

- The types and formats of data collected will increase with time.
- All districts that have a need for real-time data will have their own direct readout ground station, as follows: 30-40 percent of districts by 1992, 100 percent of districts by 1997.
- A location can be defined as an office with one or more computers.

These assumptions match fairly well with the basic guidelines given as part of the conceptional design report by Edwards and others (1986, p. 2–3). Within that report there were six objective guidelines. A synopsis of the objective guidelines includes: (1) increased local processing; (2) distributed data system; (3) adequate storage-retrieval system to meet all needs; (4) single flexible and expandable system; (5) standardization and uniformity of data handling; and (6) modular data base and software systems. Based on these stated assumptions, the HI task group agree and support all of these objectives. The task group also agrees with the complete district node definition and the data-base architecture considerations of Edwards and others (1986, p. 9 and p. 15).

A major difference, however, in the current HI work groups is the projected need for a national data base consisting of a periodic aggregated subset of the distributed data bases. This is different from the Edwards and others (1986) report which only requires the maintenance of an index at the National Archives location. The HI task group, in contrast, anticipate a large amount of national and multi-State data retrievals. The polling of each individual district office file would be prohibitive to the GEONET network and overall computation speed. It is noted, however, that the national file would only include a portion of the data at the district level. For example, not included would be narrative project data and selected real-time data. Polling software to maintain the national file will be done automatically at the central location. Current projections would be to update this file on a monthly basis.

The noted assumption dealing with real-time data is based on the premise that the direct ground readout station costs will continue to decrease and additional usage and need will greatly expand. This eventually will result in a perceived need of a majority of offices having their own downlink. This will allow generally less traffic of the real-time data on the GEONET network with additional checks and balances of all of the data received and processed at each WRD office.

The projection of the personnel levels to remain constant or decrease will require wise utilization of the expanded computer hardware and software. Special efforts will have to be made to minimize the personnel time while working with the hydrologic data, but not sacrificing any of the needed quality control and quality assurance procedures. This is especially challenging considering the expected rapid growth and complexity of data. In the past, many of the checks and balances of the data were done manually. Therefore, with the projected limited expected workforce, additional automated procedures will need to be developed for many of the data integrity checks.

Other Considerations

Recently, more emphasis has arisen in WRD for the dissemination of the hydrologic information to a much larger number of people. The people targeted for the use of this information would include all age levels and a large variation in understanding from college graduates to elementary school students. Currently, each office expends, yearly, approximately one person's time in the area of data dissemination. About one-fourth of that time involves computer processing. This amount of available personnel time is not perceived to increase in the future and as a result, new easy-to-understand automated techniques will need to be developed to help in the data dissemination to the general public. It is also thought that very few people know of the existence of this vast amount of hydrologic information. It is projected, however, that this will dramatically change in the future through such things as magazine, newspaper, radio, and TV exposure. In conclusion, the task group projects vast increases in the use of the WRD hydrologic information. Therefore, WRD needs to prepare and develop procedures to accommodate the expanded data dissemination.

Much of the hydrologic information currently collected is part of hydrologic studies within the WRD. Generally, at the completion, the data are either summarized in tables, stored in cabinets, or stored in user derived computer files. In any case, there is little consistency or uniformity from one study to the next. In most cases, much of the data is lost after several years from the end of the project. Since the amount of this data is large and valuable, uniform procedures need to be developed for its storage and use.

Another consideration is better coordination of standardized storage and retrieval techniques by various government agencies. For example, within the U.S. Geological Survey there needs to be standardization of WRD hydrologic data, NMD digital spatial data, and general geologic data. In addition, some discussion should be promoted between the other countries of the world, particularly with the neighboring countries of Canada and Mexico. A good example is the acid rain data which affects both Canada and the United States.

Executive Summary

Results of this section are given for nine major activity areas and include the following: acquisition of manually entered data, acquisition of automatically entered data, standard computation of data, data synthesis, data validation, data-base maintenance, data archiving, facilitating access to data, and retrieval of data. These activities encompass the four general areas of acquisition, computation, file maintenance, and retrieval and are felt to include all major work efforts for hydrologic information.

Based on the HI task group evaluation, three types of HI are recognized and include: time dependent, spatial, and narrative. It is further projected by the group that large changes in the amount and types of these data are certain and will need to be effectively managed by the WRD.

Several assumptions were made in the analysis, with two of the more major assumptions being the need and continued existence of a national data base, and continued expansion of real-time data. The central data base will be a periodic aggregation of the distributed data bases and is foreseen to be needed for large national retrievals. Costs and need for data collection platforms and direct readout ground stations are expected to continue at a very accelerated pace.

Based on HI task group experience, the current validation of data within the national and district computer files needs greater attention. New automated procedures will need to be developed.

Hydrologic information now resides in files and cabinets and is of little value to the large user community. Procedures need to be developed for digital entry and retrieval procedures for all forms of numeric and narrative data.

Spatial data are thought to be primarily the responsibility of the NMD with carefully designed linkages between the WRD and NMD data bases for easy and efficient use. WRD files would, therefore, be assumed to contain only specific spatial data as related to project tasks.

The critical need for continued support of an efficient large volume network is perceived by the HI task group for both "inter" and "intra" office communications. Some of the projected large data transfer are: real-time data, particularly up to the 1992 time horizon; uploading and support of the national data base; spatial data application needs; processing of reports; and a large increase of retrieval requests for both local and national files.

Statistical tabular results for the HI task group were done for three separate areas; namely: district, research and headquarters, and the Analytical Services Laboratory. The method was used primarily because of the current and projected differences in the mode and characteristics of operation of each group. The number of locations for district operations included all district, state, subdistrict, project, and field offices. The total estimated numbers of times per year vary widely due to the number of people involved in task and daily repetitions. Data retrieval requests are projected for huge increases with perceptions of 3,640,000 requests per year by 1997. A large change from manual to automated data entry is perceived for the Analytical Services Laboratory with currently all data being manually entered into the WRD data bases.

Major Activities

Major activities that are involved with hydrologic information include:

1. Aquisition of manually entered data
2. Aquisition of automatically entered data
3. Standard computation of data
4. Data synthesis
5. Data validation
6. Data-base maintenance
7. Data archiving
8. Facilitating access to data
9. Retrieval of data

All of these activities are currently involved in working with hydrologic information and will continue for the 1992 and 1997 time horizons. The techniques, software, and computer hardware will, however, change with future product development. The next pages of this report are a summary of the HI work group for the current activities and those perceived for 1992 and 1997. In cases where the findings are the same for the current, 1992, and 1997 timeframe, the results are given only one time; for example, questions 1 through 3 and 8 through 10. Because of the time constraints for this study, many of the findings were somewhat speculative and approximate. It is, however, thought that the estimates should give good direction for future management planning with regard to the WRD hydrologic information needs.

Results are given tables SD-I-1 through SD-I-9 for three separate areas, namely: district, research and headquarters, and the Analytical Services Laboratory. The results are expressed in this manner primarily because of the current and projected differences in the mode and characteristics of operation. Polling of statistical data, as explained later, was done in such a manner to acquire activity statistics for each of the three work areas.

Question 4: The number of locations expressed for tables SD-I-1 through SD-I-9 were computed based on the number of geographical office locations. For district operations this includes 170 locations for all district, state, subdistrict, project and field offices. For research and headquarters, the number of locations are the four PR1MEs available to this group. One analytical service laboratory was assumed to be at Arvada, Colo. These conditions were additionally assumed to remain constant for activities 1 to 9, and for the 1992 and 1997 time horizons.

Question 5: The total estimated number of times per year each activity is performed is given for each work area, activity, and time horizon. The estimated numbers vary widely due to the number of people involved in task and daily repetitions.

Question 6: An estimate was first made of the number of people that work with hydrologic data in 20 selected districts. The average number of people that work with hydrologic data for the 20 districts was about 75 percent, therefore, it was assumed that 75 percent of the people in all districts work with hydrologic data or 2,400 employees out of a total of 3,200. An estimated total of about 170 people work in the computer sections in the districts and it is assumed that these people do not work on any of the first four activities. For data-base maintenance (table SD-I-6) and facility access to data (table SD-I-8) the number of people involved were estimated based on the number of computers projected for various time horizons. For example, in 1988 WRD would have about 75 systems, and in 1992 The projection is 215 systems, and 1997, 761 systems. For each of these computers one or more people would spend about 10 percent of their time on maintenance and 25 percent on access to data.

Question 7: The hours per person per year that are spent doing each activity are given in each table.

All of the personnel information was derived from the 1987 WRD Personnel Directory.

Acquisition of Manually Entered Data

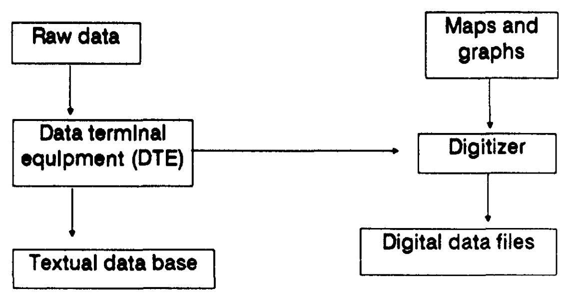
(1) Please identify the major activities performed.

Acquisition of manually entered data.

(2) Please describe each identified activity and why it is needed.

Acquisition of manually entered data (1988, 1992, 1997): The entry of data from notes, graphs, maps, and figures into a digital format using terminals and digitizers. These types of data need to be captured in order to make them widely accessible and usable.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

See table SD-I-1.

Table SD-I-1.—*Statistics for acquisition of manually entered data activity*

Organizational unit	Number of locations	Number of times performed per year	Number of people	Number of hours per person per year
		1988		
District	170	185,540	2,230	330
Research and headquarters	4	11,440	440	110
Analytical Services Laboratory	1	10,740	70	1,230
		1992		
District	170	185,540	2,230	330
Research and headquarters	4	9,200	440	90
Analytical Services Laboratory	1	5,600	70	650
		1997		
District	170	185,540	2,230	165
Research and headquarters	4	6,860	440	70
Analytical Services Laboratory	1	1,820	70	200

(5) How many times per year is this activity done?

See table SD-I-1.

(6) How many people per year do this acitvity?

See table SD-I-1.

(7) How many hours per person per year are spent doing this activity?

See table SD-I-1.

(8) Are there any special requirements for this activity?

Special procedures and methods should be developed for discharge and other field notes.

Input forms and other easy-to-use techniques for entering laboratory data including the capacity to back up and make corrections will be needed. Provision is also needed to transmit and process digital data from contract lab computers to prevent manual re-entry of the contracted data.

Some procedure(s) are needed for narrative data so they can be processed along with numeric data.

Manual re-entry of old data (such as from reports) should no longer be necessary; this data should be available online.

With the imminent vast growth of real-time (and near-real-time) data, there is a need to automate the procedure of stage-discharge measurements and ratings.

(9) Please describe any software requirements for this activity.

A. Data base manager.

Relational data base that will handle:

- Textual and numerical data and allow it to be related to hydrologic data,
- Input forms using "screen painting" supporting a large number of terminal types which meet American National Standards Institute (ANSI) standards,
- One-time query capability,
- Support of structured query language (SQL),
- High language interface for languages FORTRAN 77 and C,
- Concurrent access from one or more central processing units (CPU),
- Data dictionary and directory,
- Transaction processing,
- Recovery in the event of system failure,
- Security at a file, record, and field level,
- Utilities including: online, help, file reorganization, file integrity, and
- Data communication interface to handle one or more telecommunications monitors.

B. Editor software

Screen and line oriented text editor for reviewing and modifying text information associated with hydrologic data.

Must support the Document Interchange Format (DIF).

Must be able to view multiple documents at the same time (windows).

Must provide extensive spelling checker.

Must support most terminals which meet ANSI standards.

Graphics editor for reviewing and modifying graphical data.

C. Graphics software

D. Programming languages

General purpose programming languages such as FORTRAN 77 and C for writing special programs to process manually entered data in cases where off-the-shelf software is not adequate.

Must provide an operating system command procedure language that has the following characteristics:

- Ability to supply responses to command prompts,
- Ability to perform flow control based upon logical decision-making,
- Ability to perform command line parsing, and
- Ability to define, use, and transfer variables.

E. Statistics software

F. Spreadsheet software

G. Utility software

(10) Please describe any equipment requirements for this activity.

A. Display/Keyboard

Terminals that have a QWERTY keyboard, 132-character lines, and the ability to display graphical images.

B. Processor

C. Storage unit

D. Printer/Plotter

E. Communications

Must be able to support asynchronous communications across an RS232C.
Must be able to support ETHERNET

Acquisition of Automatically Entered Data

(1) Please identify the major activities performed.

Acquisition of automatically entered data.

(2) Please describe each identified activity and why it is needed.

Acquisition of automatically entered data (1988, 1992, 1997): The entry of data from electronic devices attached to a digital computer interface, such as paper and magnetic tape readers, devices used to extract data from electronic data recorders, satellite and other telemetry receive sites, scanners, modems, and so forth. These data are transferred to a digital computer in order to increase the usability and accessibility of the data recorded. This transfer mechanism is used to handle large data volumes, to increase data reliablilty, and to decrease the time needed to make these data accessible.

This activity consists of acquiring data from WRD's data collection network and acquiring data that have been collected or generated by others from such media as paper, graphs, magnetic media, and so forth.

A. On-site recordings

- Telemetry systems that automate the entire data-collection process.
- Nontelemetry systems that may automate most of the data-collection process, but still require human intervention in order to complete the process.

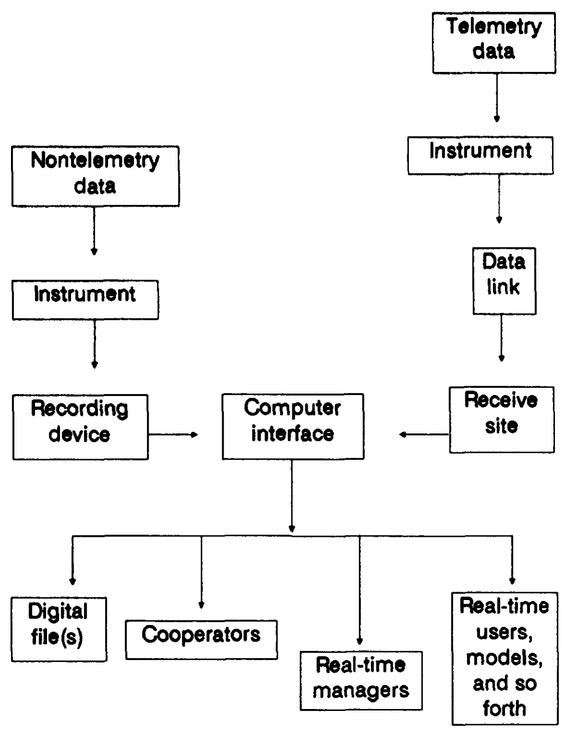
B. Laboratory recordings

It is expected that the majority of laboratory instrumentation will have its own micro-processor (often a personal computer) that will handle the direct control of the instrument. What will be needed is a means of communication which allows a file containing sample information to be sent to the instrument and a similar file, containing analytical results to be sent back and processed into the laboratory data base.

Telemetry systems use on-site automated recorders that are equipped with some form of transmission device capable of automatically transferring the recorded data from the site. The primary telemetry system used by WRD uses Geostationary Operational Earth Satellites (GOES) to transfer data from remote sites. These sites are equipped with special devices called Data Collection Platforms (DCP) that both record data from sensors and transmit the data to a GOES satellite. Data are relayed by the satellite to receive sites which enter the data directly into WRD's computers.

Nontelemetry systems use automated recorders at field sites to record the data at the site. The data must be manually retrieved and then entered into WRD computers by means of a computer interface device that is able to read the data from the media used for recording and enter these data into WRD's computers.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

See table SD-I-2.

(5) How many times per year is this activity done?

See table SD-I-2.

(6) How many people per year do this activity?

See table SD-I-2.

Table SD-I-2.—*Statistics for acquisition of automatically entered data activity*

Organizational unit	Number of locations	Number of times performed per year	Number of people	Number of hours per person per year
		1988		
District	170	69,580	2,230	125
Research and headquarters	4	6,900	440	65
Analytical Services Laboratory	0	0	0	0
		1992		
District	170	81,170	2,230	150
Research and headquarters	4	11,400	440	100
Analytical Services Laboratory	1	5,600	70	650
		1997		
District	170	301,500	2,230	270
Research and headquarters	4	27,460	440	120
Analytical Services Laboratory	1	9,650	70	1,100

(7) How many hours per person per year are spent doing this activity?

See table SD-I-2.

(8) Are there any special requirements for this activity?

The acquisition and processing of telemetered data requires an operating system that supports a multitasking environment with the following three constructs: (1) Dijkstra semaphores, or their equivalent, (2) queued message passing between tasks, and (3) supports real-time processes.

The ability to enter data from documents requires high resolution scanner as well as text and line recognition software. The consensus is that current technology is inadequate at this time to perform this function, but it is hoped that by 1992 or, certainly, by 1997 this will become a significant contributor to the WRD data base.

WRD will need to stay aware of new developments, and the system will need to be flexible enough to allow the incorporation of new technology as it becomes available.

WRD needs to maintain communications throughout the Division so that, as individuals and groups discover and evaluate new techniques and methods, their conclusions and discoveries can become widely available as quickly as possible. Education about, and training in, new techniques also needs to be available (and sometimes, perhaps, even required) so the entire Division can benefit from the new techniques and technologies.

Special software will need to be developed to transfer spatial and geographic data into WRD files.

Relatively easy and straightforward mechanisms are needed to retrieve old data (digital, strip-chart, and such) when needed, although a wholesale rereading of old data is unlikely.

An automated process is needed for the report-reviewing process which allows the text of the report to remain online during, and even after, the review process.

(9) Please describe any software requirements for this activity.

A. Data base manager.

Relational data base that will handle:

- Textual and numerical data,
- Input forms using "screen painting" supporting a large number of terminal types which meet ANSI standards,
- Ad hoc query capability,
- Support of structured query language (SQL),
- High language interface for languages FORTRAN and C,
- Concurrent access from one or more CPU's,
- Data dictionary and directory,
- Transaction processing,
- Recovery in the event of system failure,
- Security at a file, record, and field level,
- Utilities including: online, help, file reorganization, file integrity, and
- Data communication interface to handle one or more telecommunications monitors.

B. Editor software

C. Graphics software

D. Programming languages

General purpose programming languages such as FORTRAN 77 and C for writing special programs to process entered data in cases where off-the-shelf software is not adequate.

Must provide an operating system command procedure language that has the following characteristics:

- Ability to supply responses to command prompts,
- Ability to perform flow control based upon logical decision making,
- Ability to perform command line parsing, and
- Ability to define, use, and transfer variables.

E. Statistics software

F. Spreadsheet software

G. Utility software

(10) Please describe any equipment requirements for this activity.

A. Display/Keyboard

Terminals that have a QWERTY keyboard, 132-character lines, and the ability to display graphical images.

B. Processor:

For sites that connect to a data relay ground station (DRGS), the processor must support the acquisition of satellite transmissions at an average rate of about 2 per minute with peaks of 10 per minute, transmissions range from 40 to 500 bytes long.

C. Storage unit

D. Printer/Plotter

E. Communications

Must have serial communications ports that support asynchronous and synchronous communications using RS232C conventions.

Must provide a user programmable Universal Asynchronous Receive/Transmit (UART) and Universal Synchronous Receive/Transmit (USRT).

Must be able to support ETHERNET.

Standard Computation of Data

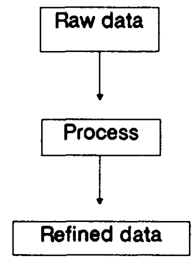
(1) Please identify the major activities performed.

Standard computation of data.

(2) Please describe each identified activity and why it is needed.

Standard computation of data (1988, 1992, 1997): This activity consists of instrument calibration, reformatting, unit conversion, calculation, and reduction of data elements. This is done in order to store, interpret, and correct hydrologic data.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

See table SD-I-3.

(5) How many times per year is this activity done?

See table SD-I-3.

(6) How many people per year do this activity?

See table SD-I-3.

(7) How many hours per person per year are spent doing this activity?

See table SD-I-3.

Table SD-I-3.—*Statistics for standard computation of data activity*

Organizational unit	Number of locations	Number of times performed per year	Number of people	Number of hours per person per year
		1988		
District	170	237,900	2,230	425
Research and headquarters	4	11,400	440	105
Analytical Services Laboratory	1	12,500	70	225
		1992		
District	170	210,100	2,230	350
Research and headquarters	4	10,200	440	100
Analytical Services Laboratory	1	12,500	70	225
		1997		
District	170	196,700	2,230	300
Research and headquarters	4	9,150	440	90
Analytical Services Laboratory	1	12,500	70	225

(8) Are there any special requirements for this activity?

Procedures and processes need adequate testing and review without causing too much delay in implementation.

For the distributed processing, adequate checks and balances need to be included to verify that the computations are valid. Nonstandard variations especially need to be verified before use.

Benchmark testing should include accuracy checks for functions (trigonometric, statistical, and so forth).

WRD needs to maintain communications throughout the division so that, as individuals and groups discover and evaluate new techniques and methods, their conclusions and discoveries can become widely available as quickly as possible. Education about, and training in, new techniques also needs to be available (and sometimes, perhaps, even required) so the entire division can benefit from these new techniques and technologies.

(9) Please describe any software requirements for this activity.

A. Data base manager.

Relational data base that will handle:

- Textual and numerical data,
- Input forms using "screen painting" supporting a large number of terminal types which meet ANSI standards,
- Ad hoc query capability,
- Support of structured query language (SQL),
- High language interface for languages FORTRAN and C,
- Concurrent access from one or more CPU's,
- Data dictionary and directory,
- Transaction processing,
- Recovery in the event of system failure,
- Security at a file, record, and field level,
- Utilities including: online, help, file reorganization, file integrity, and
- Data communication interface to handle one or more telecommunications monitors.

B. Editor software

C. Graphics software with DISSPLA-like graphics products.

D. Programming languages

General purpose programming languages such as FORTRAN 77 and C for writing special programs to process manually entered data in cases where off-the-shelf software is not adequate.

Must provide an operating system command procedure language that has the following characteristics:

- Ability to supply responses to command prompts,
- Ability to perform flow control based upon logical decision-making,
- Ability to perform command line parsing, and
- Ability to define, use, and transfer variables.

E. Statistics software

Subroutine library of statistical software such as IMSL.

F. Spreadsheet software

G. Utility software

Flexible sort and merge utility with a command and subroutine interface.

(10) Please describe any equipment requirements for this activity.

A. Display/Keyboard

Terminals that have a QWERTY keyboard, 132-character lines, and the ability to display graphical images. Must have at least the capabilities of a Tektronix 4207.

B. Processor

C. Storage unit

D. Printer/Plotter

For displaying hydrologic data in tabular and graphical form to aid in analyzing and reviewing standard computations, the following printers and plotters are required:

- Medium volume raster printer capable of printing ASCII characters with true descenders on a 132 column line.
- Medium volume raster printer capable of printing ASCII characters with true decenders on a 132 column line supporting at least 4 colors.
- High volume printer such as fast impact or laser.

- Vector plotter capable of registering preprinted forms at least 36 inches by 48 inches.
- Medium volume printer must be able to be connected to a port on the display terminal and print screen dumps of character and graphical data.

E. Communications

Must have serial communications ports that support asynchronous and synchronous communications using RS232C conventions.

Must provide a user programmable UART and USRT.

Must be able to support ETHERNET.

Data Synthesis

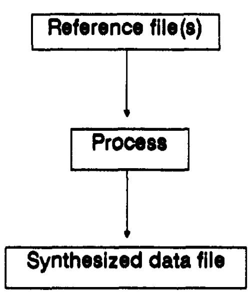
(1) Please identify the major activities performed.

Data synthesis.

(2) Please describe each identified activity and why it is needed.

Data synthesis (1988, 1992, 1997): The generation of synthetic hydrological data by interpolating several hydrologic data elements using statistical, graphical, or other comparative methods. These data are generated in order to complete or extend data records over space or time or provide estimates of unmeasured hydrologic data.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

See table SD-I-4.

(5) How many times per year is this activity done?

See table SD-I-4.

(6) How many people per year do this activity?

See table SD-I-4.

(7) How many hours per person per year are spent doing this activity?

See table SD-I-4.

Table SD-I-4.—*Statistics for data synthesis activity*

Organizational unit	Number of locations	Number of times performed per year	Number of people	Number of hours per person per year
		1988		
District	170	69,600	2,230	125
Research and headquarters	4	9,200	440	85
Analytical Services Laboratory	0	0	0	0
		1992		
District	170	139,150	2,230	125
Research and headquarters	4	18,300	440	90
Analytical Services Laboratory	0	0	0	0
		1997		
District	170	139,150	2,230	125
Research and headquarters	4	22,880	440	95
Analytical Services Laboratory	0	0	0	0

(8) Are there any special requirements for this activity?

WRD needs to maintain communications throughout the Division so that, as individuals and groups discover and evaluate new techniques and methods, their conclusions and discoveries can become widely available as quickly as possible. Education about, and training in, new techniques also needs to be available (and sometimes, perhaps, even required) so the entire Division can benefit from these new techniques and technologies.

(9) Please describe any software requirements for this activity.

A. Data base manager.

Relational data base that will handle:

- Textual and numerical data,
- Input forms using "screen painting" supporting a large number of terminal types which meet ANSI standards,
- Ad hoc query capability,
- Support of structured query language (SQL),
- High language interface for languages FORTRAN and C,

- Concurrent access from one or more CPU's,
- Data dictionary and directory,
- Transaction processing,
- Recovery in the event of system failure,
- Security at a file, record, and field level,
- Utilities including: online, help, file reorganization, file integrity, and
- Data communication interface to handle one or more telecommunications monitors.

B. Editor software

Screen oriented text editor for reviewing and modifying text information associated with hydrologic data.

Graphics editor for reviewing and modifying graphical data.

C. Graphics software

DISSPLA-like graphics products.

D. Programming languages

General purpose programming languages such as FORTRAN 77 and C for writing special programs to process manually entered data in cases where off-the-shelf software is not adequate.

Must provide an operating system command procedure language that has the following characteristics:

- Ability to supply responses to command prompts,
- Ability to perform flow control based upon logical decision-making,
- Ability to perform command line parsing, and
- Ability to define, use, and transfer variables.

Special purpose artificial intelligence language such as LISP or PROLOG. Must interface with the other high-level languages.

E. Statistics software

Subroutine library of statistical software such as IMSL.

Command driven, interactive statistical package which provides flexible data management, including support for character data, missing values. The package should include all statistical procedures in current use by WRD.

F. Spreadsheet software

G. Utility software

Flexible sort/merge utility with a command and subroutine interface.

(10) Please describe any equipment requirements for this activity.

A. Display/Keyboard

Terminals that have a QWERTY keyboard, 132-character lines, and the ability to display graphical images. Must have at least the capabilities of a Tektronix 4207.

B. Processor

C. Storage unit

D. Printer/Plotter

For displaying hydrologic data in tabular and graphical form to aid in analyzing and reviewing data synthesis activities, the following printers and plotters are required:

- Medium volume raster printer capable of printing ASCII characters with true descenders on a 132 column line.
- Medium volume raster printer capable of printing ASCII characters with true descenders on a 132 column line supporting at least 4 colors.
- High volume printer such as fast impact or laser.
- Vector plotter capable of registering preprinted forms at least 36 inches by 48 inches.
- Medium volume printer must be able to be connected to a port on the display terminal and print screen dumps of character and graphical data.

E. Communications

Data Validation

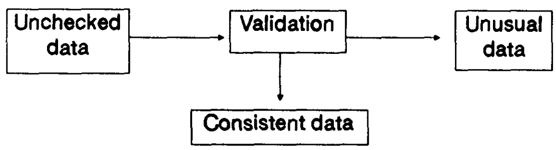
(1) Please identify the major activities performed.

Data validation.

(2) Please describe each identified activity and why it is needed.

Data validation (1988, 1992, 1997): The process of identifying anomalous hydrologic data by: range checking, checking for internal consistency, checking against known values, comparing data elements, sorting, plotting, and correlating. This is done in order to identify potential errors, determine real anomalies, provide quality control, and assure conformity to predefined standards.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

See table SD-I-5.

(5) How many times per year is this activity done?

See table SD-I-5.

(6) How many people per year do this activity?

See table SD-I-5.

(7) How many hours per person per year are spent doing this activity?

See table SD-I-5.

Table SD-I-5.—*Statistics for data validation activity*

Organizational unit	Number of locations	Number of times performed per year	Number of people	Number of hours per person per year
		1988		
District	170	149,800	2,400	245
Research and headquarters	4	11,400	440	115
Analytical Services Laboratory	1	15,500	70	520
		1992		
District	170	324,500	2,400	270
Research and headquarters	4	27,460	440	120
Analytical Services Laboratory	1	15,500	70	520
		1997		
District	170	349,400	2,400	295
Research and headquarters	4	27,460	440	120
Analytical Services Laboratory	1	15,500	70	520

(8) Are there any special requirements for this activity?

WRD needs to maintain communications throughout the Division so that, as individuals and groups discover and evaluate new techniques and methods, their conclusions and discoveries can become widely available as quickly as possible. Education about, and training in, new techniques also needs to be available (and sometimes, perhaps, even required) so the entire Division can benefit from these new techniques and technologies.

Since manpower is likely not to increase, automated procedures will be needed to allow QC and QA of data. Also the previously mentioned increase of volume and complexity of data, such as the Air Force Installation Restoration Program (IRP), will require the development of new techniques of data validation.

The Central Laboratory has unique requirements for data validation, including calculations between and among from two to many different records.

Obtaining data from contract laboratories (some of which comes through the Central Laboratory, and some which do not) needs rigid specifications to ensure its validity. This could include the method of data transmission from the contractor's computer to the appropriate WRD computer.

(9) Please describe any software requirements for this activity.

A. Data base manager.

Relational data base that will handle:

- Textual and numerical data,
- Input forms using "screen painting" supporting a large number of terminal types which meet ANSI standards,
- Ad hoc query capability,
- Support of structured query language (SQL),
- High language interface for languages FORTRAN and C,
- Concurrent access from one or more CPU's,
- Data dictionary and directory,
- Transaction processing,
- Recovery in the event of system failure,
- Security at a file, record, and field level,
- Utilities including: online, help, file reorganization, file integrity, and
- Data communication interface to handle one or more telecommunications monitors.

B. Editor software

Screen oriented text editor for reviewing and modifying text information associated with hydrologic data. Graphics editor for reviewing and modifying graphical data.

C. Graphics software

DISSPLA-like graphics products.

TELLAGRAF-like graphics package.

D. Programming languages

General purpose programming languages such as FORTRAN 77 and C for writing special programs to process entered data in cases where off-the-shelf software is not adequate.

Must provide an operating system command procedure language that has the following characteristics:

- Ability to supply responses to command prompts.
- Ability to perform flow control based upon logical decision-making.
- Ability to perform command line parsing.
- Ability to define, use, and transfer variables. Special purpose artificial intelligence language such as LISP or PROLOG. Must interface with the other high-level languages.

E. Statistics software

Subroutine library of statistical software such as IMSL.

Command driven, interactive statistical package which provides flexible data management, including support for character data, missing values. The package should include all statistical procedures in current use by WRD.

F. Spreadsheet software

G. Utility software

Flexible sort and merge utility with a command and subroutine interface.

(10) Please describe any equipment requirements for this activity.

A. Display/Keyboard

Terminals that have a QWERTY keyboard, 132-character lines, and the ability to display graphical images. Must have at least the capabilities of a Tektronix 4207.

B. Processor

C. Storage unit

D. Printer/Plotter

For displaying hydrologic data in tabular and graphical form to aid in validating hydrologic data, the following printers and plotters are required:

- Medium volume raster printer capable of printing ASCII characters with true descenders on a 132 column line.
- Medium volume raster printer capable of printing ASCII characters with true descenders on a 132 column line supporting at least 4 colors.
- High volume printer such as fast impact or laser.
- Vector plotter capable of registering preprinted forms at least 36 inches by 48 inches.
- Medium volume printer must be able to be connected to a port on the display terminal and print screen dumps of character and graphical data.

E. Communications

Data-Base Maintenance

(1) Please identify the major activities performed.

Data-base maintenance.

(2) Please describe each identified activity and why it is needed.

Data-base maintenance (1988, 1992, 1997): Consists of operations that affect the structure and content of the data base. Structural operations consist of data element definition and modification, as well as testing of the integrity of data files, recovery from catastrophic system failures, and setting data-base security. Operations that affect the content of the data base include backups, calculation of file statistics, and reorganization of data files. These operations are performed in order to store and retrieve hydrologic data, preserve the integrity of the data base, and provide an easily accessible data base to authorized users.

(3) Please describe the flow of information in this activity.

(4) How many locations do this activity?

See table SD-I-6.

(5) How many times per year is this activity done?

See table SD-I-6.

(6) How many people per year do this activity?

See table SD-I-6.

(7) How many hours per person per year are spent doing this activity?

See table SD-I-6.

Table SD-I-6.—*Statistics for data-base maintenance activity*

Organizational unit	Number of locations	Number of times performed per year	Number of people	Number of hours per person per year
		1988		
District	70	18,200	70	200
Research and headquarters	4	1,040	4	200
Analytical Services Laboratory	1	260	1	200
		1992		
District	135	54,600	210	200
Research and headquarters	4	2,600	10	200
Analytical Services Laboratory	1	260	1	200
		1997		
District	170	182,000	700	210
Research and headquarters	4	7,800	30	210
Analytical Services Laboratory	1	260	1	210

(8) Are there any special requirements for this activity?

Special procedures will be needed for project files and data management techniques will be needed for microfilmed data.

(9) Please describe any software requirements for this activity.

A. Data base manager.

Relational data base that will handle:

- Textual and numerical data,
- Input forms using "screen painting" supporting a large number of terminal types which meet ANSI standards,
- Ad hoc query capability,
- Support of structured query language (SQL),
- High language interface for languages FORTRAN and C,
- Concurrent access from one or more CPU's,
- Data dictionary and directory,
- Transaction processing,
- Recovery in the event of system failure,
- Security at a file, record, and field level,
- Utilities including: online, help, file reorganization, file integrity, and
- Data communication interface to handle one or more telecommunications monitors.

B. Editor software

C. Graphics software

D. Programming languages

General purpose programming languages such as FORTRAN 77 and C for writing special programs to process entered data in cases where off-the-shelf software is not adequate.

Must provide an operating system command procedure language that has the following characteristics:

- Ability to supply responses to command prompts.
- Ability to perform flow control based upon logical decision-making.
- Ability to perform command line parsing.
- Ability to define, use, and transfer variables. Special purpose artificial intelligence language such as LISP or PROLOG. Must interface with the other high-level languages.

E. Statistics software

F. Spreadsheet software

G. Utility software

(10) Please describe any equipment requirements for this activity.

A. Display/Keyboard

Terminals that have a QWERTY keyboard, 132-character lines, and the ability to display graphical images.

B. Processor

C. Storage unit

D. Printer/Plotter

For displaying data base statistics in tabular and graphical form to aid in analyzing and reviewing the performance and size of data bases in order to improve the efficiency of the data bases and plan for growth, the following printers and plotters should be available:

- Medium volume raster printer capable of printing ASCII characters with true descenders on a 132 column line.
- Vector plotter

E. Communications

Data Archiving

(1) Please identify the major activities performed.

Data archiving.

(2) Please describe each identified activity and why it is needed.

Data archiving (1988, 1992, 1997): This activity processes data entered manually, automatically, or through standard computations. It provides for the storage of information from paper, film, and digital media for the purpose of maintaining a permanent historical record of hydrological data collection, as well as research and interpretive studies. These data may be stored in a variety of formats, such as: ASCII, binary, vector, or raster. Some of these data will be periodically transferred to a central site and, when aggregated from all the local data bases, will comprise a data base which is national in scope. This activity is performed to provide rapid access to historical data and efficient storage of data.

(3) Please describe the flow of information in this activity.

Data archives will exist at each district office and the central site locations. Data for the central location will be supplied periodically from a portion of the district files.

(4) How many locations do this activity?

See table SD-I–7.

(5) How many times per year is this activity done?

See table SD-I–7.

(6) How many people per year do this activity?

See table SD-I–7.

(7) How many hours per person per year are spent doing this activity?

See table SD-I–7.

(8) Are there any special requirements for this activity?

The ability to enter data from documents requires high resolution scanners as well as text and line recognition software. The current technology does not appear to be adequate for this function at present; however, it is hoped that it will be possible in the future.

Procedures and processes will be needed for archiving data on microfilm, and such.

(9) Please describe any software requirements for this activity.

A. Data base manager.

Relational data base that will handle:

- Textual and numerical data,
- Input forms using "screen painting" supporting a large number of terminal types which meet ANSI standards,
- Ad hoc query capability,
- Support of structured query language (SQL),
- High language interface for languages FORTRAN and C,
- Concurrent access from one or more CPU's,
- Data dictionary and directory,
- Transaction processing,
- Recovery in the event of system failure,
- Security at a file, record, and field level,
- Utilities including: online, help, file reorganization, file integrity, and
- Data communication interface to handle one or more telecommunications monitors.

Table SD-I–7.—*Statistics for data archiving activity*

Organizational unit	Number of locations	Number of times performed per year	Number of people	Number of hours per person per year
		1988		
District	70	2,340	70	85
Research and headquarters	4	8	4	5
Analytical Services Laboratory	0	0	0	0
		1992		
District	135	15,750	210	150
Research and headquarters	4	50	10	10
Analytical Services Laboratory	0	0	0	0
		1997		
District	170	52,500	700	150
Research and headquarters	4	150	30	10
Analytical Services Laboratory	0	0	0	0

B. Editor software

Screen oriented text editor for reviewing and modifying text information associated with hydrologic data.

C. Graphics software

D. Programming languages

General purpose programming languages such as FORTRAN 77 and C for writing special programs to process entered data in cases where off-the-shelf software is not adequate.

Must provide an operating system command procedure language that has the following characteristics:

- Ability to supply responses to command prompts.
- Ability to perform flow control based upon logical decision-making.
- Ability to perform command line parsing.
- Ability to define, use, and transfer variables. Special purpose artificial intelligence language such as LISP or PROLOG. Must interface with the other high-level languages.

E. Statistics software

F. Spreadsheet software

G. Utility software

(10) Please describe any equipment requirements for this activity.

A. Display/Keyboard

Terminals that have a QWERTY keyboard, 132-character lines, and the ability to display graphical images. Must have at least the capabilities of a Tektronix 4207.

B. Processor

C. Storage unit

Nine-track magnetic tape high volume online removable pack (Write Once Read Many (WORM)).

D. Printer/Plotter

None.

E. Communications

Must have serial communications ports that support asynchronous and synchronous communications using RS232C conventions.

Must provide an user programmable UART and USRT.

Must be able to support ETHERNET.

Facilitating Access to Data

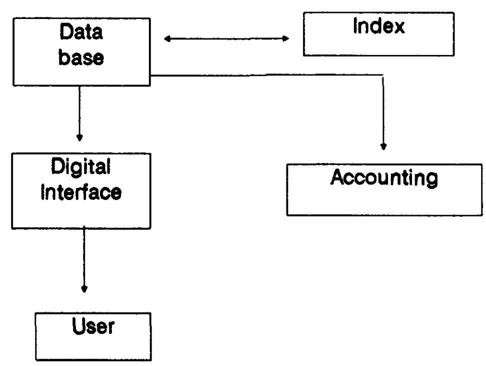
(1) Please identify the major activities performed.

Facilitating access to data.

(2) Please describe each identified activity and why it is needed.

Facilitating access to data (1988, 1992, 1997): Provides an interface to the telephone company voice network using modems. Public access is provided through easy-to-use retrieval software which can be controlled by responding to program queries or via an ad hoc query capability. An index will be maintained for a rapid review of available data. Cost accounting and training will be provided for controlling and facilitating outside access. This access is provided in order to promote better understanding of hydrology, conservation of our natural resources, and informed management planning.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

See table SD-I-8.

(5) How many times per year is this activity done?

See table SD-I-8.

(6) How many people per year do this activity?

See table SD-I-8.

(7) How many hours per person per year are spent doing this activity?

See table SD-I-8.

(8) Are there any special requirements for this activity?

WRD needs to rethink how we provide report information to the general public.

Consideration needs to be given to the expected vast increase in demand for data. Most users will need to be trained to retrieve their own data due to limited personnel available to do it for them.

Consideration needs to be given to specially designed public-access data retrieval systems.

Table SD-I-8. —*Statistics for facilitating access to data activity*

Organizational unit	Number of locations	Number of times performed per year	Number of people	Number of hours per person per year
		1988		
District	70	364,000	70	520
Research and headquarters	4	2,080	4	520
Analytical Services Laboratory	1	520	1	520
		1992		
District	135	109,200	210	520
Research and headquarters	4	5,200	10	520
Analytical Services Laboratory	1	520	1	520
		1997		
District	170	364,000	700	520
Research and headquarters	4	15,600	30	520
Analytical Services Laboratory	1	520	1	520

(9) Please describe any software requirements for this activity.

A. Data base manager.

Relational data base that will handle:

- Textual and numerical data,
- Input forms using "screen painting" supporting a large number of terminal types which meet ANSI standards,
- Ad hoc query capability,
- Support of structured query language (SQL),
- High language interface for languages FORTRAN and C,
- Concurrent access from one or more CPU's,
- Data dictionary and directory,
- Transaction processing,
- Recovery in the event of system failure,
- Security at a file, record, and field level,
- Utilities including: online, help, file reorganization, file integrity, and
- Data communication interface to handle one or more telecommunications monitors.

B. Editor software

Screen oriented text editor for reviewing and modifying text information associated with hydrologic data.

Graphics editor for reviewing and modifying graphical data.

C. Graphics software

DISSPLA-like graphics products.

D. Programming languages

General purpose programming languages such as FORTRAN 77 and C for writing special programs to process entered data in cases where off-the-shelf software is not adequate.

Must provide an operating system command procedure language that has the following characteristics:

- Ability to supply responses to command prompts.
- Ability to perform flow control based upon logical decision-making.
- Ability to perform command line parsing.
- Ability to define, use, and transfer variables. Special purpose artificial intelligence language such as LISP or PROLOG. Must interface with the other high-level languages.

E. Statistics software

Subroutine library of statistical software such as IMSL.

Command driven, interactive statistical package which provides flexible data management, including support for character data, missing values. The package should include all statistical procedures in current use by WRD.

F. Spreadsheet software

G. Utility software

Computer resource accounting is required.

(10) Please describe any equipment requirements for this activity.

A. Display/Keyboard

Terminals that have a QWERTY keyboard, 132-character lines, and the ability to display graphical images. Must have at least the capabilities of a Tektronix 4207.

B. Processor

C. Storage unit

Nine-track magnetic tape

Compact Disk-Read Only Memory (CD-ROM)

D. Printer/Plotter

None

E. Communications

Must have serial communications ports that support asynchronous and synchronous communications using RS232C conventions.

Must provide a user programmable UART and USRT.

Must be able to support ETHERNET.

Must be able to communicate with computers using Job Entry System-2 (JES2) or Houston Automatic Spooling Program (HASP) job entry systems.

Retrieval of Data

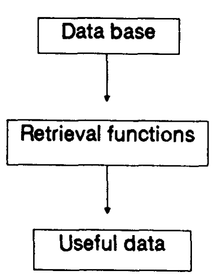
(1) Please identify the major activities performed.

Retrieval of data.

(2) Please describe each identified activity and why it is needed.

Retrieval of data (1988, 1992, 1997): The subsetting, relating, ordering, and formatting of data elements from a data base. This is done in order to retrieve publications, satisfy information requests, monitor gage operations, and provide data for various applications such as statistics, graphics, and models.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

See table SD-I-9.

(5) How many times per year is this activity done?

See table SD-I-9.

(6) How many people per year do this activity?

See table SD-I-9.

(7) How many hours per person per year are spent doing this activity?

See table SD-I-9

Table SD-I-9. – *Statistics for retrieval of data activity*

Organizatoinal unit	Number of locations	Number of times performed per year	Number of people	Number of hours per person per year
		1988		
District	170	600,000	2,400	125
Research and headquarters	4	127,600	440	145
Analytical Services Laboratory	1	140	70	1
		1992		
District	170	1,200,000	2,400	125
Research and headquarters	4	255,200	440	145
Analytical Services Laboratory	1	280	70	1
		1997		
District	170	1,765,000	2,400	125
Research and headqaurters	4	375,300	440	145
Analytical Services Laboratory	1	410	70	1

(8) Are there any special requirements for this activity?

General publications need to be developed to facilitate data requests from the public. That is, to help the general public to formulate their requests in a meaningful and reasonable manner.

(9) Please describe any software requirements for this activity.

A. Data base manager.

Relational data base that will handle:

- Textual and numerical data,
- Input forms using "screen painting" supporting a large number of terminal types which meet ANSI standards,
- Ad hoc query capability,
- Support of structured query language (SQL),
- High language interface for languages FORTRAN and C,
- Concurrent access from one or more CPU's,
- Data dictionary and directory,

- Transaction processing,
- Recovery in the event of system failure,
- Security at a file, record, and field level,
- Utilities including: online, help, file reorganization, file integrity, and
- Data communication interface to handle one or more telecommunications monitors.

B. Editor software

Screen oriented text editor for reviewing and modifying text information associated with hydrologic data.

Graphics editor for reviewing and modifying graphical data.

C. Graphics software

DISSPLA-like graphics products.

D. Programming languages

General purpose programming languages such as FORTRAN 77 and C for writing special programs to process entered data in cases where off-the-shelf software is not adequate.

Must provide an operating system command procedure language that has the following characteristics:

- Ability to supply responses to command prompts.
- Ability to perform flow control based upon logical decision-making.
- Ability to perform command line parsing.
- Ability to define, use, and transfer variables. Special purpose artificial intelligence language such as LISP or PROLOG. Must interface with the other high-level languages.

E. Statistics software

Subroutine library of statistical software such as IMSL.

Command driven, interactive statistical package which provides flexible data management, including support for character data, missing values. The package should include all statistical procedures in current use by WRD.

F. Spreadsheet software

G. Utility software

Flexible sort and merge utility with a command and subroutine interface.

(10) Please describe any equipment requirements for this activity.

A. Display/Keyboard

Terminals with QWERTY keyboards, 132-character lines, and the ability to display graphical images. Must have at least the capabilities of a Tektronix 4207.

B. Processor

C. Storage unit

Will be able to access the data files in a method which is transparent to the users.

D. Printer/Plotter

For displaying hydrologic data in tabular and graphical form to aid in analyzing and reviewing data synthesis activities, the following printers/plotters are required:

- Medium volume raster printer capable of printing ASCII characters with true descenders on a 132 column line.
- Medium volume raster printer capable of printing ASCII characters with true descenders on a 132 column line supporting at least 4 colors.
- High volume printer such as fast impact or laser.
- Vector plotter capable of registering preprinted forms at least 36 inches by 48 inches.
- Medium volume printer must be able to be connected to a port on the display terminal and print screen dumps of character and graphical data.

E. Communications

Must have serial communications ports that support asynchronous and synchronous communications using RS232C conventions.

Must provide a user programmable UART and USRT.

Must be able to support ETHERNET.

Concluding Remarks

For the results expressed in tables SD-I-1 through SD-I-9 the HI task group has tabulated results for three distinct work groups: district, research and headquarters, and the Analytical Services Lab. The HI task group did this for two reasons: variations in work type for each group, and secondly, to give a distinct result of each work group without dilution of an overall combination. The Analytical Services Laboratory data processing procedures as currently depicted are in need of vast improvement on the methods for entering and verifying data (tables SD-I-1 and SD-I-2). The HI task group, therefore, projects a significant change in automation in 1992 and 1997. An additional area of concern for the HI task group is the large expected use of contract analytical laboratories. In these situations, it is strongly recommended that required guidelines be given to each contract analytical laboratory for automatically entering and verifying data into the WRD computer files.

The overall software and equipment needs (questions 9 and 10) of each activity express a conglomerate of what already exists and additionally what the HI task group envisions as obtainable in the near future. The group felt that additional emphasis should be given to acquiring tools that: (1) support industry or de facto standards (that is, text editors that support DIF, data base management systems that support SQL, and such) and (2) facilitate the establishment of data processing standards within WRD (that is, a Data Base Management System that would standardize the access to all WRD hydrologic data bases, software development tools that would provide a standard methodology for designing and documenting software developed in-house, and so forth). The specific amount of equipment to be purchased or vendor to be selected is left for the overall system resource needs appraisal to be determined by members of the Technical Integration Group (TIG), and later to be presented to the WRD senior staff. Projected computer storage needs were briefly discussed by the HI task group with the following results:

Time horizon	Space, gigabytes	Percentage hydrologic data
March 1987	103	70
1988	250	70
1992	500	60
1997	1,000	50

The HI task group bases these projections on the current (1987) conditions and expected rapid storage needs for real time, narrative, and other data types. In addition, a large emphasis is expected for spatial digital data principally as related to GIS type applications with large increases by 1992 and continuing through 1997. The HI task group perception is that the principal national cartographic digital data base will remain the responsibility of NMD with data being retrieved and stored by WRD for various application on a "as needed" basis. This data would, therefore, only reside in our files temporarily until the completion of the project. Even with the limited spatial data, the HI task group projects the temporary spatial storage to be large and is reflected in the lower percentage of file use by hydrologic data in 1992 and 1997.

Overall, the charge that was given to the HI task group was extremely large for the allotted timeframe. The work group members do, however, think they have considered the primary activities that are currently impacting our hydrologic data system and additionally, how these activities are expected to change in 1992 and 1997. These projections were based on the individual work group members' perceptions as to perceived change and, additionally, reflecting on the previous changes that have occurred during the 1982 to 1987 timeframe. We hope these results and conclusions prove useful for future management decisions.

Selected References

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Edwards, M.D., Putnam, A.L., and Hutchison, N.E., 1986, Conceptual design for the National Water Information System: U.S. Geological Survey Open-File Report 86–604, 38 p.

Harbaugh, A.W., 1986, Distributed Information System: U.S. Geological Survey Open-File Report 85–649 (Water Fact Sheet) 2 p.

SUPPLEMENTARY DATA II.--Hydrologic Applications Work Group

TABLES

page 47 follows

SUPPLEMENTARY DATA II. – HYDROLOGIC APPLICATIONS WORK GROUP

Executive Summary

The requirements are presented in 11 sections. Initially, the committee had a brainstorming session to identify all possible computer activities in hydrologic applications. From that list, the final 11 sections were organized. Overlap in the various sections exists, but is considered useful and helps stress the importance of some of the requirements. Hydrologic applications included district projects, research projects at the regional centers and districts, and projects at headquarters. The full range of activities from data collection, through data analysis, to report production were considered.

Several issues and themes emerged during the discussions. These are highlighted in the following paragraphs.

Hydrologic applications can easily use more memory, more "million instructions per second" (MIPS), and more disk space. Most models are structured to handle more time steps and greater spatial resolution, but applications are currently limited because of inadequate disk space, memory, and turn-around time. An additional limit is preprocessing time and effort for model input, but those limits are rapidly vanishing with better software to handle spatial data, Geographic Information Systems (GIS), advances in data loggers, and better software to handle time series.

Higher resolution graphics, graphic standards and better integration of graphics with data handling, models, and statistics are required. Interactive graphics is the key to preprocessing for model input development.

Desk-top publishing must include capabilities for complex equations and integration of text and graphics. Special text editors for software development are needed.

The power of supercomputers is needed, but much of the need is, and will be, coupled with the need for interactive graphics. Thus, high volumes of data must pass between the workstation and the "supercomputer." Some of the hydrologic models can use parallel processing.

Most of the hydrologic modeling software and much of the statistics applications are shared with other agencies, universities, cooperators, and consultants. Thus, portability is very important. Supported software languages and tools must adhere to American National Standards Institute (ANSI) standards.

Hydrologic processes and models are very dynamic. As such, graphics animation becomes a powerful tool for understanding hydrology and model output. Strong consideration should be given to software and hardware necessary for animation.

Hydrologic applications process large quantities of data. Some is input data and some is output data. Optical disk technology will play a very important role in hydrologic application as a source of input data and to archive project data.

Editing Environment

Description of activity

The professional involved in hydrologic applications spends a considerable amount of time planning for future investigations, managing existing projects, and communicating results in the form of a report upon completion of the analyses. Also, a certain amount of correspondence is necessary between colleagues and to fulfill the associated administrative duties required in the course of an investigation. One can, therefore, see the need for high productivity in what may broadly be described as the editing environment. The components of the editing environment activity may be described as follows.

Reports and Correspondence

This is perhaps the most important category. It may be defined as the preparation of text files (word processing) used in report writing, project proposals, electronic mail, and other project management documentation. It includes:

- Writing of simple text,
- Merging of text and graphics on a single page,
- Formatting complex equations (includes math and Greek characters and multiple superscripts and subscripts),
- Spelling and grammar checks, and
- Editing of text, tables, and graphics for compliance with U.S. Geological Survey (USGS) Water Resources Division (WRD) publication standards (1992 and 1997).

Software Development

This category consists of program development in low and high level languages or software such as data handlers, statistical analysis systems, and graphics.

Software development involves the interaction of program files, that are usually developed using an editor, and the compiler or higher level software. In hydrologic applications the user creates the program statements and then goes through a testing procedure to finalize the statements so that they accomplish the intended task. Even though there are standard analysis programs available, the development of the input and analysis of the output from some simulation models may require many specialized or custom analyses to meet the specific purposes of the hydrologic application.

Creating and Editing Data Files

The creation and editing of data files is done routinely to prepare a data set for analysis. Even though the activity is routine, the activity itself often is highly variable. Hydrologic applications require the analysis of data from numerous sources in varied formats to form the basis of many kinds of analyses.

Flow of information

The flow of information is dependent on the purpose of the information being edited but can essentially be viewed as shown below.

Number of locations

All 175 WRD offices.

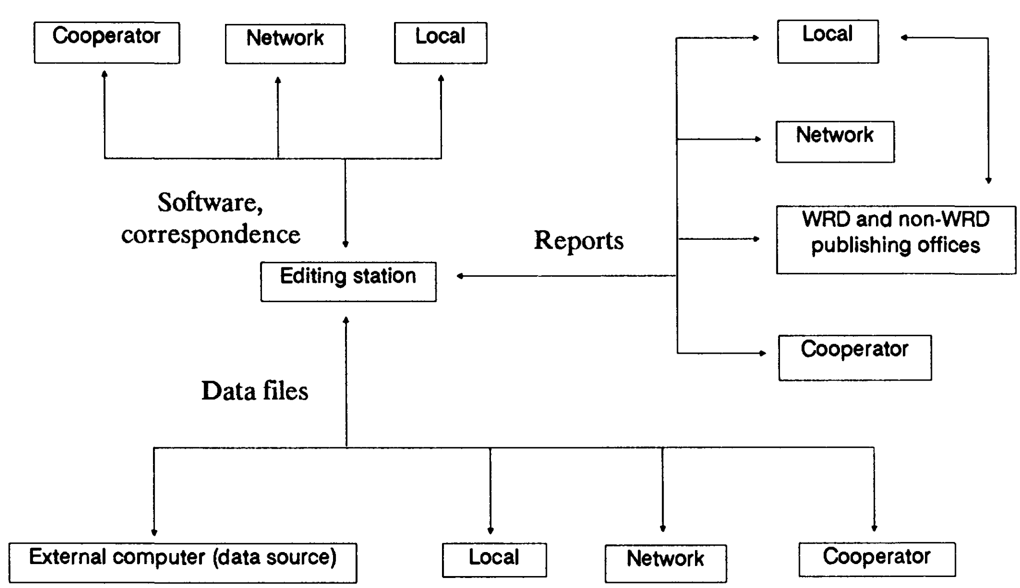
Usage

The editing environment is used routinely by all personnel involved in hydrologic applications. Although the amount of work performed in this activity will increase in 1992 and 1997, advances in editor efficiency will decrease the time necessary to accomplish it. Therefore, the usage per person will drop from 200 hours to 150 hours. The number of project personnel, however, may become greater, requiring more computer processing time for this function than is currently being utilized. The estimates are provided in tables SD-II-1, SD-II-2, and SD-II-3.

Special requirements

An important consideration here is the need for a USGS-wide editor package that is both operational and compatible on the minicomputers and a variety of microcomputers. The ability to change font sizes is necessary to emphasize text concepts and in the development of media such as slides or overhead plates.

The three editing activities require an editing package that has additional capabilities other than word processing. This includes simultaneous multiple file editing, interactive execution of system commands during the editing session, FORTRAN and C programming modes (allowing for the formating of code, compilation and correction of code, and the execution of the



code while in the editing session), and the ability to define and execute macros (long strings of editor commands) multiple times.

Software and hardware requirements

The hardware should be able to support a variety of printers. The three activities of the editing environment sometimes require editing functions which are unique. An advantage to having one software package is that personnel involved in hydrologic analyses will not have to learn to be proficient in more than one editing environment. If one editing package is selected then it should encompass a majority of the functions required by the three editing activities and be flexible enough to allow modifications to meet more detailed needs. However, one package probably will not meet all of the unique requirements of each editing activity. Therefore, if more than one software package is chosen, the editing commands should be similar or compatible.

Communications

Description of activity

Communication is the transfer, both internally and externally, of program and graphics software, data, report texts, graphics, and mail in order to support and facilitate the other major hydrologic application activities and to disseminate information to cooperators, resource managers, and the scientific community. Wide-area, high-speed networking is required to support remote users by providing specialized machines and software for specialized applications. The need for more powerful external (non-USGS) computer processing will be nearly eliminated by 1992 and will be nonexistent by 1997. File transfers and disk-sharing performed between small- and large-capability machines will be done occasionally in 1988 and will become routine by 1992.

In 1988, a limited amount of use will be made of external data bases (such as meteorological, soils, and so forth) in the formation and augmentation of project data bases. This use will become considerable by 1992. These data bases and those of all USGS divisions (including WRD) will be used routinely by 1992.

The size of accessible data sets may be twice as large in 1992 as in 1988. By 1997 the use of an Earth Science Data System (ESDS), composed of the consolidated data bases of all five USGS divisions, may be a reality. The data bases accessible in 1997 may be as much as 10 times larger than those used in 1988.

Cooperators and other public users will have access to a wealth of USGS information by 1997 for use in, or which is a product of, hydrologic applications. Such information might include regional water use, groundwater data, water-quality data, and real-time information.

Little use is made of computer literature search capabilities in 1988 due to the expense and awkward nature of the process. Simple, inexpensive computer literature search capabilities should be available by 1992.

Interactive graphics performed across the network will be limited in 1988 but will increase and become routine by 1992.

There are several "information types" which may be transferred as part of the communication activity, some of which may overlap areas covered in other major hydrologic application activities. These include the transmission of:

- Electronic mail (both inside and outside WRD by 1992),
- Reports (does not include writing and editing functions performed locally),
- Executable code,
- Low level and high level language codes,
- Graphics,
- Data (includes retrieval and update of existing data bases, transmission of satellite or other real-time data, file transmittals to and from locations external to WRD, and archiving processes), and
- Batch jobs to another computer.

Flow of information

The flow of information is dependent on the purpose of each type of communication activity. In general, the communications scheme is shown on the next page.

Number of locations

All 175 WRD offices.

Usage

There will be a somewhat steady flow of communicative transfers from month to month or day to day, with peak usage during business hours. Almost all hydrologic applications personnel transfer one of the information types (excluding real-time data transmissions and batch jobs for modeling) about 100 times per year. The time spent readying these files for transfer or reading and cataloging incoming files is typically 50 hours per person per year.

In 1988, 10 to 30 persons per day are accessing a larger external computer with batch transfers. The number of persons utilizing high-speed external computer processors will decrease; about 2 to 10 persons per day by 1992 and zero by 1997. These persons may make these transfers 1 to 10 times per day and spend 100 to 300 hours per person per year readying batch files or reading and cataloging output receipts.

Real-time data for use in simulation models is covered in the "Real-Time Applications" activity description. A summary of estimates is provided in tables SD-II-1, SD-II-2, and SD-II-3.

Special requirements

A standard operating system that would function at all computing levels within the WRD is needed by 1988.

Productivity should not be hampered by having to learn new operating systems or by user fees.

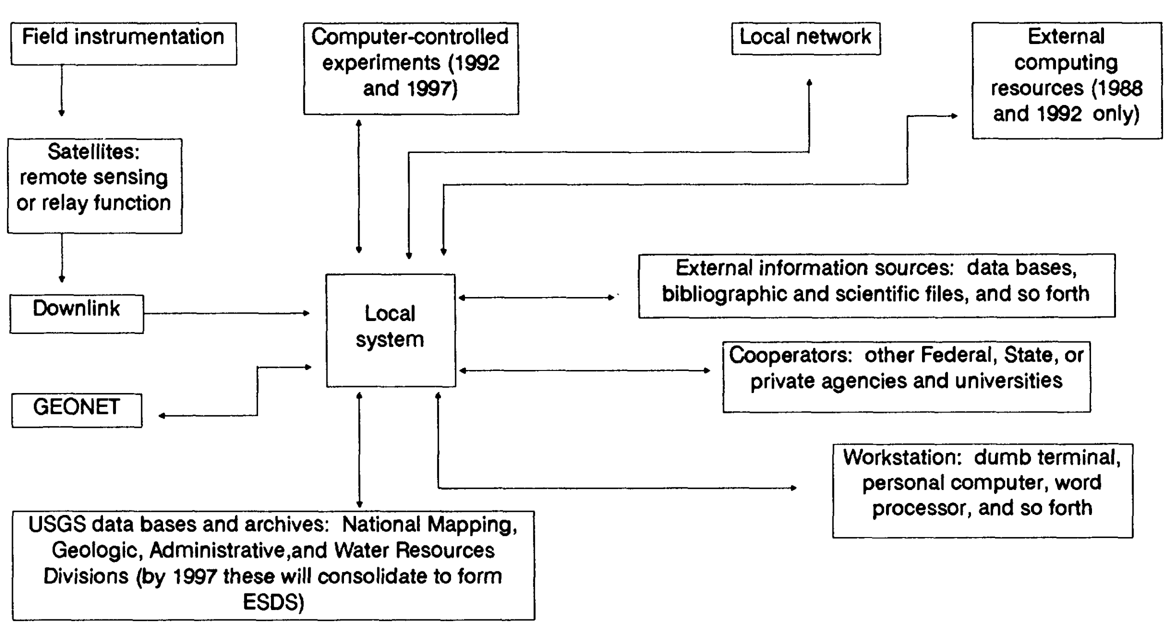
Access to external data bases, scientific and bibliographic information, and high speed processing should not be encumbered due to interfacing difficulties or high costs.

Software and hardware requirements

A high-speed communication link should tie each workstation to a large-scale computer (supercomputer). These larger computers, such as the CRAY, with processing speeds in the 10 to 170 millions of floating point operations per second (MFLOPS) range, will be required as vector processing begins to play a significant role in the reduction of solution times of complex two-dimensional and three-dimensional models. The communications software should link the workstations computing capability to the larger computer so that as much of the load as possible is distributed from the larger computer to the microcomputer. File transfer rates between local systems and microcomputers in 1988 will be on the order of 1 megabyte per second. In order to make CRAY-like computers valuable, the transfer rate between a local system and the CRAY computer should be at least 0.01 megabyte per second in 1988. Both of these transfer rates can be expected to increase by an order of magnitude every 5 years.

Scanners which convert imagery to digital information or convert hardcopy texts consisting of letters and numbers to ASCII computer files will be necessary in 1988.

Hardware necessary to produce the files for writing to compact disk, read-only memory (CD ROMs) for the transfer of massive data files both within the WRD and to cooperators and to others should be possible by 1992. Drives to read from CD ROMs are needed by 1988.



Additional topics and more detailed descriptions of hardware and software requirements can be found in the appropriate Hydrologic Applications activity sections.

Data Handling

Description of activity

Data collection and handling for hydrologic applications includes logging the data in the field or laboratory, transmitting the data to the office, processing the data for input to the model, and processing data generated by the model. Data handling also involves getting data from numerous data bases, local and external, and editing data for input to models. Examples of the volumes of data are:

- Five-minute data for air temperature, rainfall, solar radiation and relative humidity at five sites for a 3-year project period,
- Digital elevation data from NMD for four quad sheets,
- Annual peak flow and 20 basin characteristics for 30 years for 4,000 sites,
- Landsat images for 100 square mile watershed for identification of vegetal cover,
- Concentrations for 5 heavy metals for 12,000 wells and 6,000 stream locations,
- Five parameters at 50,000 nodes, and
- Hourly precipitation from Next Generation Radar (NEXRAD) for a 50,000 square kilometer basin for a 36-hour storm with values on a 2-kilometer grid.

Editing and verifying data is required using graphical presentations and special rules and algorithms. Some data needs to be adjusted automatically. Isolated data points must be located, changed, and stored.

Modeling requires rapid transfer of large chunks of data from a file to memory, perhaps from 2,000 bytes to 1,000,000 bytes. Data files read by FORTRAN programs are often binary direct access files. Thus, the data handling must be able to read large volumes of data rapidly and accommodate editing and graphic functions as well. This is being done by special software written in higher level languages and will likely continue since data base management packages do not meet needs of many modeling applications.

Flow of information

See flow diagrams in Ground-Water-Modeling, Surface-Water Modeling, and Graphics sections.

Number of locations

All 175 WRD offices.

Usage

The number of people working with data handling is estimated to be 1,200 in 1988 and increasing by 100 in 1992 and 1997. The actual time spent by each person will decrease as the software will improve faster than the volumes of data will increase. A summary of the estimates is provided in tables SD-II–1, SD-II–2, and SD-II–3.

Special requirements

None.

Software requirements

Some data will be handled with special software written in FORTRAN or C. Some data could be handled by software that could plot and edit the data as well as run statistical screening. Support for FORTRAN and C and drivers for the Graphical Kernel System (GKS) are required. Any data base manager for statistics must be able to communicate with FORTRAN and C programs and produce files in common data exchange formats.

Hardware requirements

Standard keyboards with a mouse or equivalent and high resolution screen are needed. (See Graphics section.)

Tape drives are needed to read some data. Compact disc drives will be needed for much of the data.

Spatial Data Processing

Description of activity

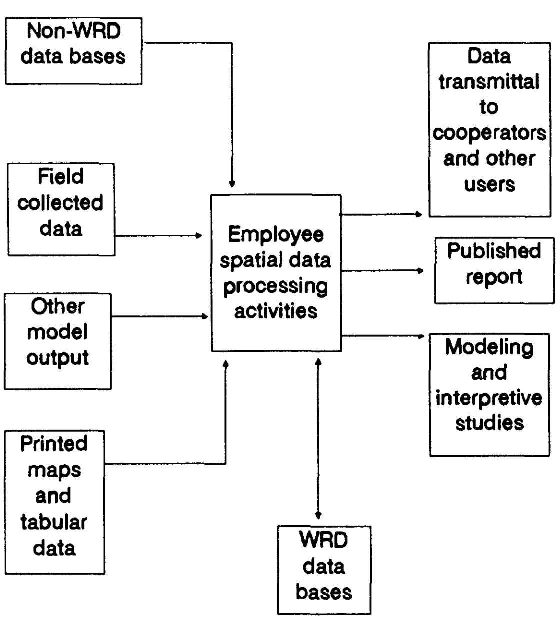
Spatial data processing is the compilation and analysis of remotely sensed or field-collected data, which in addition to having variable values (water levels, constituent concentrations) also has, at minimum, two-dimensional spatial characteristics (latitude and longitude), and often a third dimension of either depth or time. Compilation of spatial data provides a data format which is readily interpretable for hydrologic analysis, efficiently displays large amounts of data, provides a means to verify data for consistency, can be translated into model input data, and can be used in management of water resources.

Analysis of spatial data includes detection of spatial trends and patterns, interpolation of surface contours, and descriptive statistics for subsets of data delineated by spatial groupings. Traditional products have been maps, cross sections, and fence and block diagrams. Spatial data currently being processed within WRD include: model output, water levels, water use, water quality, water-resource hazards, anthropogenic characteristics such as population and land use, and other hydrologic information.

Spatial data processing includes the two- and three-dimensional display of: hydrogeologic characteristics of aquifers and confining units; water levels; water use; soil, air, and water temperature; surface- and ground-water quality; land elevations, slope, and aspect; soil type; surface-geophysical data; precipitation; and locations.

Exploratory data analysis techniques (see statistics section) should be used to summarize data characteristics, check data distributions and interrelations and so forth. Thus, a linkage with the graphics, data handling, and statistics software is required.

Flow of information



Number of locations

In 1988, spatial data processing will be done in 150 of the 175 offices. By 1997, all 175 offices will do spatial data processing.

Usage

All WRD projects include some form of spatial data processing and about 20 percent of non-WRD technical and data requests are answered using some form of spatial data processing. About 800 WRD project personnel now perform spatial data processing approximately 100 times per year. This activity will continue, with the amount of times the activity is performed doubling every 5 years, as the speed of processing increases. A summary of the estimates is provided in tables SD-II–1, SD-II–2, and SD-II–3.

Special requirements

Highly complex and detailed maps may be contoured from as many as 50,000 data values or be derived from a compilation of up to 10 other maps. Computer computational speed capable of processing and displaying highly complex and detailed maps in several minutes is required. The number of data values and types of input data will double by 1997.

By 1992, internal communications among the graphics, data handling, and statistics software will be required for the preparation, editing, and analysis of spatial data. While looking at the graphics display, menus to create subsets of data, do simple statistics and exploratory plots, and display the results in screen windows will be necessary.

Software requirements

Data handler

The data handler must be able to collate, aggregate and disaggregate, compare, and edit files. For the efficient and accurate compilation, verification, and analysis of model input and output data, the data handler must communicate internally with (1) a graphical display routine which allows for graphical identification and editing of data, and (2) with a simple statistical routine which will do summary statistics on selected data sets.

To efficiently handle data from multiple sources into single or multiple maps, the data handler must be able to read and write data in user-defined formats.

To identify data presented in multiple maps with specified areas, the data handler must be able to associate, relate, and translate data from various types of maps into various data set formats. Using the mouse and screen cursor, irregularly shaped regions should be identifiable, and designated as a subset for further study.

For daily preparation or analysis of up to 10 highly complex and detailed maps, the data handler (in communication with a graphics and statistics routine) must read, write, relate, display, statistically summarize, or compare data files with up to 50,000 data values within seconds.

Editor software

For the efficient editing of numerous data files and data management programs, the editor must be able to edit multiple files, run system commands, have a FORTRAN programming mode, and be able to run large editing macros.

Graphics software

The complex graphics software requirements for spatial data processing are those described under the graphics activities of hydrologic applications.

In summary, the graphics software must be able to produce scatter plots, boxplots, bar charts, contour maps, point-data maps, cross sections, multiple-layer maps, and perspective maps. Graphical display is crucial to the presentation and analysis of spatial data, as data files with more than 100 values prohibit interpretation and presentation of data in tabular form. Also, the speed and quality of interpretation of very small data files (5 to 20 values) is greatly enhanced by graphical display.

The graphics software must also communicate internally with the data handling software to allow relatively quick display of spatial data during editing or statistical analysis.

The graphics software must be able to relate various types of maps to produce data and communicate with the data handler to produce user-defined data files.

The graphics software must include a screen graphics editor which can move statistical output such as boxplots or bar graphs from their windows onto the main plot itself. Such modified plots are necessary in the presentation of data, and for interpretive report products.

Programming languages

FORTRAN 77 and C programs for data editing and management, and for custom statistical manipulation, must be usable from within the package.

A knowledge-based programming language (such as PROLOG or LISP) for guided data analysis routines should also be useable from within the software.

Statistics software

Software to do simple statistics to describe, quantify, and compare several model input and output files of up to 50,000 data values in seconds, and that can be utilized by the data handling software, is needed to allow simultaneous statistical analysis of graphically displayed data.

More complex statistical software which can contour point data, perform principal components analysis, test for spatial trends, and perform kriging and other spatial analyses is also needed.

Routines to process data into maps and other graphical presentations are also required.

Utility software

An easily implemented and understandable (FORTRAN) program debugger and standard (FORTRAN) mathematical library (such as International Math and Statistics Library (IMSL)) is required in the writing, modification, and running of data management and analysis programs.

Utility software is required to read data in various formats from computer and communication systems and to transmit graphic displays of spatial data to various types of plotting and printing devices.

Hardware requirements

Display/keyboard

Display of 132 characters and full graphics capability, including multicolor, pan and zoom, and simultaneous viewing of graphics and commands are required for analysis and verification of model input and output data. Graphical display should be of adequate speed to draw highly complex and detailed maps in a few seconds.

A standard QWERTY keyboard as well as mouse control are required for data entry, programming, and editing of data files and graphical displays.

Multiple windows should be available to allow display of statistical summaries at the side of the main graphics display.

Processor

The processor should be suitable to run software and provide immediate response for data entry and several second response for data handling, graphical display, and statistical analysis of several data sets with up to 50,000 values.

Storage

Ten megabytes of storage for each person doing spatial data processing is needed to maintain files required and produced by the data-handling, graphics, and statistics software for data files with less than 50,000 values.

Printer/plotter

A high quality, multicolor laser printer is needed for the preparation of report text and graphics.

High resolution, multicolor electrostatic plotter is required for large numbers of oversize (working-scale), highly complex, and detailed maps and other graphical display of spatial data.

The ability to make slides and transparencies is required for presentation of spatial data at meetings.

High speed printing is required to print 1 megabyte files in several minutes.

Communications

File transfer to and from other WRD and non-WRD locations at a rate of 0.01 megabytes per second are required. Limited interactive processing with other locations is also required for the aquisition of data. Generally, periodic transfer of large amounts of data are required.

File transfer within local computer systems should be at 1 megabyte per second.

Communication rates should increase an order of magnitude every 5 years.

Graphics

Description of activity

Graphics involve the display of information in symbolic form. Graphics are essential to the display of data and output associated with models. The human eye-brain system is very adept at pattern recognition, and graphics presents data in a form to use this facility to advantage. The large data sets and complex output from typical models used by WRD necessitate the use of graphics as an aid in spotting data errors, and in recognizing trends, or anomalies, during analysis of model output.

The amount of information is increasing exponentially with time in nearly all fields of hydrological applications. The only method to deal with such an amount of data flow is through the use of computer graphics. The alternative of scanning long columns of numbers is impractical for all but the smallest data sets and simplest modeling activities.

Computer graphics are no different from traditional methods of displaying data in plots, although the entire process is done by computers. A much greater amount of data can be handled, and it has been demonstrated that computer graphics is an effective method of displaying hydrological information on computer screens (cathode ray tubes (CRT)) for interim use, or on hard copies produced by computer for presentation, or for inclusion in reports.

Computer graphics is considered the most effective method for communication for both administrative and technical writers. The common saying that "A picture is worth a thousand words" certainly holds true in the case of computer graphics for hydrological applications.

Computer graphics are used in many activities in WRD. Only the use of computer graphics in hydrological applications is discussed here. All data analysis, and numerical modeling in all surface-water, ground-water, and water-quality investigations involve computer graphics. Computer graphics are used to show interrelations between various field data, to show properties of input parameters before input to models, and to show results of model outputs.

The role of computer graphics in hydrological applications has changed from helpful tools a few years ago to necessary means of exhibiting data in modern applications. The evolving role of computer graphics is due to the drastic increase in the amount of data flow that WRD handles. Just a few years ago fewer than a thousand nodes were used in numerical models. In 1988, models routinely use 5,000 to 10,000 points, and the largest models in WRD use 50,000 points. Models are expected to increase in size two to four times every 5 years.

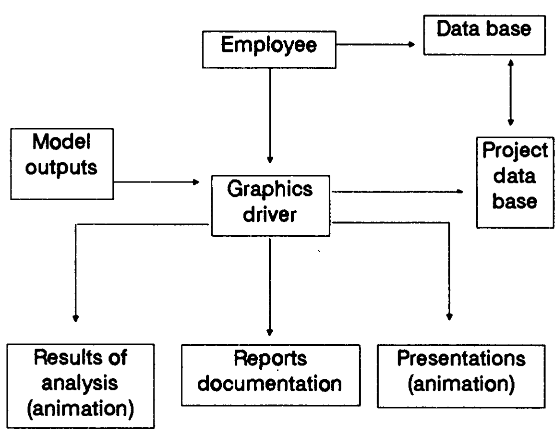
Furthermore, more of the hydrological applications deal with transient processes. Therefore, graphics must show not only the spatial distribution of data, but also its transition in time. The human eye-brain system has great facility in recognizing and interpreting motion. Computer graphics animation provides a way of presenting transient processes in a natural way that makes use of this ability.

Computer graphics in hydrological applications include, but are not limited to, the following examples.

- Bar and pie charts, and box plots.
- Typical x-y plots, or x-y plots of several parameters.

- Two-dimensional and three-dimensional contour plots to show functional dependence of 2 to 3 variables. These tasks can be further enhanced by the use of color graphics.
- Two-dimensional and three-dimensional color separation plots.
- Maps showing water-resources parameters superimposed over area maps.
- Continuous tone graphics in two and three dimensions.
- Interactive graphics.
- Computer graphics used directly in presentations.
- Computer graphics animation.

Flow of information



Number of locations

All 175 WRD offices.

Usage

Nearly all employees who use computers have applications for computer graphics. The heaviest use is by numerical modelers and model applications are also the most complex. At any given time, an estimated 40 percent of projects within the Water Resources Division are engaged in applying or developing computer models. This estimate includes individual employees who may devote entire careers, essentially full time, to surface-water modeling, as well as others who may engage in modeling from time to time in carrying out their professional duties. Perhaps 10 percent of the hours devoted to modeling projects involves the use of graphics. A summary of the estimates is provided in tables SD-II-1, SD-II-2, and SD-II-3.

Special requirements

The complexity of the models being developed and used by WRD causes a dependence on graphics to sort out the mass of data and results. A high resolution color CRT graphics display is needed for immediate interaction with the model under development or use. This display allows immediate pictures to construct and verify input data. Typical uses are to present three-dimensional representations of river channels, channel cross sections, or plots of input discharge hydrographs. The same CRT is needed for immediate access to model output. Typical output results would be graphs showing water-surface elevations or river surface profiles during a flood.

High resolution is needed to show sufficient detail to distinguish individual features in graphical displays such as complex finite element grids. Color is also needed to code subsets of the display so they are easily distinguished by the human eye. An example would be the use of different colors to distinguish a computed stage hydrograph from a measured one that is being used for model verification.

Hard copies of graphics seen on the CRT screen are needed throughout the modeling effort. Thus the picture seen on the screen should be available for output to a laser printer, for example, without the need to rerun either the model, or even the graphics display program. The models in particular, and sometimes the graphics programs, often are long-running so that rerunning them simply to change the plot output device is impractical and wasteful of resources.

A device-independent graphics metafile as output allows directing the same plot to a variety of graphics output devices in an efficient manner using device drivers specific to particular machines. Metafiles should follow the GKS standard. Apparently no United States graphics standard exists at the moment, but the GKS is probably the closest to being such a standard, and GKS has been accepted as standard in Europe.

Color laser printers should be included in the array of output devices as they become available.

Graphics packages should allow such features as the easy labeling of axes and easy insertion of notation on plots.

Graphics packages should be specialized, by special contract with the software developer or otherwise, to allow easy construction of illustrations that satisfy U.S. Geological Survey publication requirements.

Many of the processes being modeled in WRD are dynamic. The model representation of the real-world situation evolves in time. A natural presentation of this time-dependent process is through the use of animation. Because of the slow speeds of graphics display devices up to now, use of this form of output has been limited. However, it is certainly possible with existing hardware to output a sequence of snapshots of output from a surface-water model to movie film. The movie so produced might show, for example, the evolution in time of a computer-modeled dambreak. The movie can either be shown directly, or transferred by commercially available processes to video tape for showing on standard television sets. Further development of animation should be pursued because it is such a natural way of presenting dynamic situations. Animated displays directly on the CRT screen would be highly desirable, since putting together a movie as just described is hardly an immediate, interactive-style interplay between modeler and computer program. However, direct animation to the CRT screen will certainly require orders of magnitude faster communication rates between processor and screen than the 9,600 bit-per-second rates that are typically available now.

Direct memory access should be made available for rapid data transfer.

Software requirements

Graphics software should in general consist of subroutines from which the modeler can choose to create his plots. Subroutines should be usable from user programs written in FORTRAN 77, and perhaps C and Pascal as well. These subroutines should allow the modeler to easily create x-y plots, bar graphs, pie charts, histograms, scatter plots, contour plots, three-dimensional views, and three-dimensional stacked plots. If subroutines originate with different plotting packages, care should be taken that ones from different packages are compatible and will work together in the same graphics program.

Easy labeling of axes and insertion of notations on plots should be provided. True zoom, that recomputes images for close-up views so lines do not broaden, and pan should be available. Continuous tone graphics from a palette of 256 colors should be possible.

It should be possible to easily produce plots that satisfy U.S. Geological Survey publication standards. Capability for generating graphics with animation should be provided. Output should be to a GKS-standard metafile for portability. Graphics drivers for a variety of output devices should be available for viewing and plotting the metafile without rerunning either the model or the main plot program.

Merging and manipulating graphics and text within the same output page should be possible.

It may be convenient for some standalone graphics packages, such as for contouring, computer-aided design, or geographic information system applications, to be part of the suite of graphics software available.

There should be a graphics editor.

Hardware requirements

CRT graphics screen output is necessary for interactive display of information during model development and use. Because of the complexity of model data, high resolution and color are needed to distinguish various parts of the plots. Resolution should be at least 640 by 480. A palette of 256 colors should be available. Some higher resolution displays should also be made available immediately. In 1992, standard graphics displays should be 1,280 by 1,024, and they should be supplemented with still higher resolution displays.

Communication to remote processors for graphics purposes should be at least 9,600 bits per second. Efforts should be made to boost this speed higher, if possible, using technology such as local area networks. Graphics displays that are connected at desktop to the processor provide a perhaps simpler avenue for achieving high-speed communication between processor and screen.

Hard copy graphics output should be provided by laserjet printers. Color laserjets should be obtained as they become available. The graphics output from the laserjets should be camera-ready quality for U.S. Geological Survey publications.

Pen plotters such as the Calcomp 36-inch drum plotters are still required for some applications such as large plots, or plotting on mylar.

Care should be taken to ensure that graphics hardcopy devices are available for output from all workstations within a local area network.

Laser printers and associated software drivers should be capable of reproducing exactly what is seen on the workstation display "what you see is what you get" (WYSIWYG).

In nearly all projects, there are needs for high resolution digitizers, as well as for encoders that can convert from photographic images or video images to digital information for further processing. Other input devices such as light pens or mouses are required.

At most cost centers, there should be capability to project graphics imagery directly onto presentation screens. This may require interfacing an encoder to convert from digital red-green-blue (RGB) signals to analog National Television Standard Codes (NTSC).

High capacity devices such as compact disks should be provided to store graphics images.

Statistical Analysis of Data

Description of activity

Statistics is the science of data analysis, providing objective and quantifiable interpretations. These interpretations lead to understanding of the nondeterministic processes of hydrology, and provide information and design criteria to water resources managers and engineers. Products of the analyses are numerical and graphical summaries of data, with emphases on contrasting characteristics of subsets of data, and on depicting trends over space and time.

Data Manipulation

The package must be capable of reading data having a variety of formats; sort, merge and edit data files, create new variables by power transformations and evaluation of equations, and replace variables with their ranks.

1992

Software must completely interface with the GIS software in common use, so that data spatially identified as a group (same color for example) within GIS can be described, boxplots produced, and so forth while still in the GIS software. Exploratory data analysis graphics should be available in optional windows while in GIS.

Exploratory Data Analysis

Exploratory data analysis (EDA) uses graphical inspection to summarize data and perceive patterns. Plots including boxplots, histograms, stem and leaf plots, probability plots, quantile-quantile plots, and scatterplots with superimposed smoothed curves are necessary, both on data and on their power transformations such as logarithms, square roots, cubes, inverse, etc. Graphical output must be of SASGraph or TELAGRAF quality, not limited to business graphics capabilities, and should meet all USGS publication standards. Scatterplots of data in three dimensions should be possible, with axis rotation and generation of subsets possible. Single points or groups of data should be interactively identifiable using a pointer on-screen, and attributes of those data presented on-screen, as with MacSpin (by Macintosh) or S (by Unix).

1992

All screens, laser printers, and graphics software should support color displays. Software should be capable of inspection of multivariate data with a scatterplot matrix, using brushing and conditioning operations (Becker and Cleveland, 1987).

Statistical Tests and Model Building

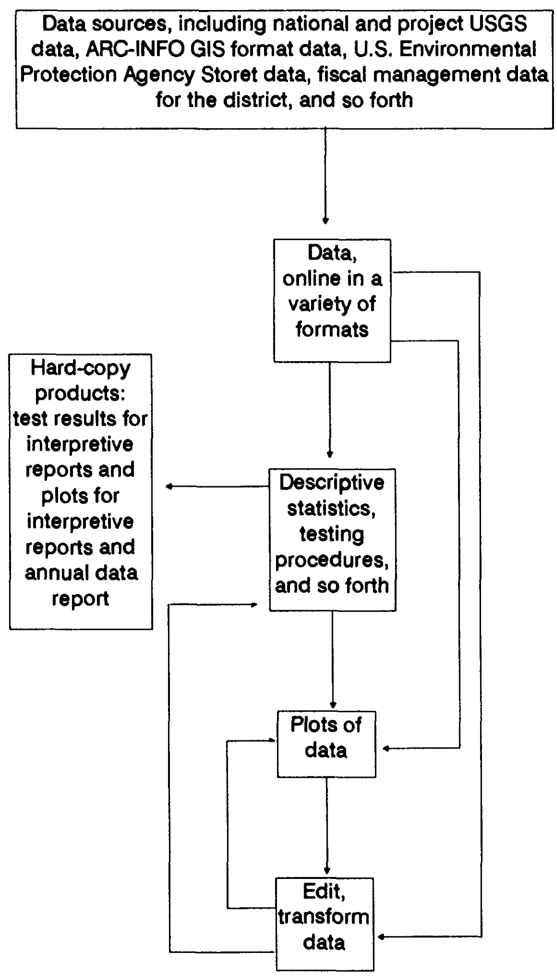
Hypothesis tests, both parametric and nonparametric, are required to compare two or more groups of data (such as t-tests, analysis of variance on both balanced and unbalanced data, Mann-Whitney rank sum test, Kruskal-Wallis and Friedman's tests), to compare a data set to a known distribution such as the normal, to compare categorical data (such as contingency tables), to build regression models (will run all possible regressions for up to 20 variables, similar to SAS Proc Rsquare), compute influence statistics such as variance inflation factor, dfbetas, PRESS, and Mallow's Cp, and produce partial leverage plots for multiple regression, and perform logit regression. Tests are also required for equality of variance (such as Bartlett's and square ranks tests), multiple comparison tests (such as Tukey's HSD, Fisher's LSD, and Ryan-Einot-Gabriel-Welch tests), correlation coefficients (Kendall, Spearman and Pearson), analysis of covariance, and multivariate procedures such as discriminant analysis, cluster analysis, and principal components analysis (with optional subsequent orthogonal and oblique rotation). Finally, 'macros' written in FORTRAN or other languages must be usable from within, and fully compatible with, the package.

Flow of information

See flow chart on next page.

1992

Video recordings of EDA graphs, and plots of data trends over space and time, for display at scientific conferences, cooperator meetings, and so forth will be needed.



Number of locations

Initially, 150 offices would do statistical analysis and increase to 160 in 1992 and 175 in 1997.

Usage

Statistical analysis will be performed by every professional, by many technicians and by some of management personnel. Use by project professionals will be minimal during startup and early data collection phases, but will increase to approximately one-third of their time during later phases of data collection, and during report writing phases. Use by technicians will be minimal for 8 months, but will total approximately 1/10 time during the 4 months prior to publication of the annual State data report.

Management will perform analyses during project review and cooperator presentation periods, largely to manipulate fiscal figures, and overall will spend 1/30 of their year's activities doing statistical analyses.

Project professionals will require access to all capabilities, as 80 percent will use all capabilities at some point. Technicians and management will generally not require multivariate techniques, logistic regression, or macro capabilities, but will require the graphics, hypothesis test and regression (including diagnostics) capabilities listed above.

A summary of the estimates of usage is provided in tables SD-II-1, SD-II-2, and SD-II-3.

Special requirements

None.

Software requirements

See "Description of Activity," above. All software should be dynamic and interactive, such as a graphically oriented editor similar to S which allows the user to point to observations, or groups of observations, on the screen and have a listing of variable values show on the screen. The data input, statistical testing, and graphic output software should have compatible data formats at minimum, and be integrated into the same program at best, subject to the technical requirements and restraints listed above. It is preferable to have separate but compatible software for each of these three activities which meet all technical requirements than to have one integrated package which will not perform some of the necessary functions.

1992

Software must completely interface with the GIS software in common use, so that data spatially identified as a group (same color for example) within GIS can be described, boxplots produced, and so forth while still in the GIS software. EDA graphics should be available in optional windows while in GIS.

Hardware requirements

High-resolution graphics screens are needed with immediate access to 20x5,000 data points (20 water-quality variables by 5,000 observations for a region over some time period, for example). Mouse-directed cursor is required to locate single or groups of points. Graphics output will be to a graphics laser printer capable of reproducing the high-resolution screen display, or better, such as the Apple LaserWriter or equivalent.

1992

All output devices should fully support color. Alternate output is to a video recorder with resolution capabilities to reproduce the screen display accurately. Sufficient speed to compute all possible (2 K) regressions for up to k=20 variables within 2 minutes is also required.

Surface-Water Modeling

Description of activity

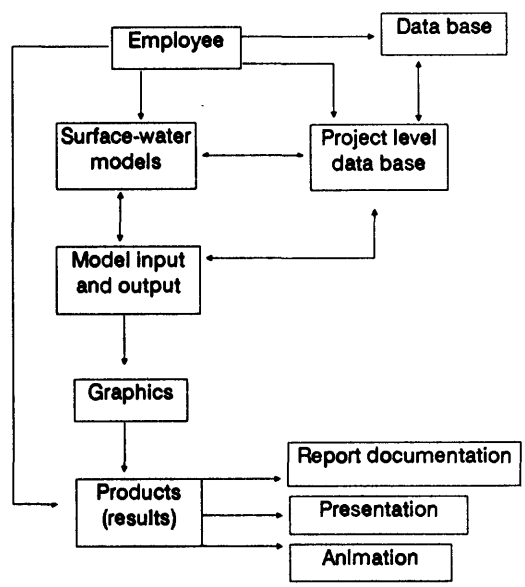
Surface-water models describe real-world surface-water flow problems by the solution of a set of governing nonlinear equations. The solutions of these governing equations are obtained numerically on a computer. Numerical models, when calibrated and verified, have been shown to replicate the essential behavior of hydrological systems. Simple numerical models are currently being further developed to represent more complex situations.

Surface-water models are used to describe streamflow in a variety of specialized contexts. Rainfall-runoff models relate streamflow to incident precipitation. Flood routing and dambreak models predict water-surface elevations for events that would be damaging to life and property. Water-quality models provide estimates of the transport of contaminants by surface water. Sediment transport models describe the interaction between streambed aggradation or degradation and sediment carried by the streamflow. Estuarine models describe and predict tides and tidal circulations in estuaries and coastal embayments.

In general, these surface-water modeling activities have been increasing geometrically with time, and this trend continues. Surface-water models are considered integral parts of comprehensive water-resources investigations. Typically, such investigations include preliminary information gathering, field data collection, numerical model development, model calibration, and model verification. Finally, in some cases, the numerical models have been used for prediction of future conditions. Predictions may involve only natural processes or may, in addition, be used to test the effects of human intervention in the form of levees, dams, urbanization, and so on. Numerical models are used as research tools to provide insights into physical processes. Models are also used as a method for interpolation of field data that is sparse in space and time.

We live in a four-dimensional world (the fourth dimension is time). When referring to the dimensionality of a model, common terminology usually refers only to the number of space dimensions. Any dynamic model operates mathematically in one higher dimension than the stated space dimensionality. Due to limited computing resources, early surface-water computer models were only one-dimensional, representing steady-state conditions in time. The need for more detailed approximations has driven the development of higher dimensional models. In 1988, many one-dimensional dynamic surface-water models can be considered operational, and some two-dimensional dynamic models are becoming operational. In 1992, two-dimensional models will be used more routinely, and development of three-dimensional models will be underway. In 1997, two- and three-dimensional models will be used frequently in modeling activities.

Flow of information



Number of locations

Initially, 150 offices would do surface water modeling and this will increase to 160 in 1992 and 175 in 1997.

Usage

Many models were developed in the projects of the National Research Program, and other models have been acquired from other sources. At least 1/3 of the professionals in the surface-water discipline have been either exposed to, or are actively engaged in, modeling. This estimate includes individuals who may devote entire careers, essentially full time, to surface-water modeling, as well as others who may engage in modeling from time to time in carrying out their professional duties. As the trend of increased model usage continues, by 1992 nearly half of the surface-water professionals will be either conducting or have been exposed to numerical modeling. By 1997, it is estimated that at least half of the surface-water projects will be modeling projects in nature.

A summary of estimates of usage is provided in tables SD-II-1, SD-II-2, and SD-II-3.

Special requirements

Surface-water models involve the solution of nonlinear equations. These equations are discretized by spatial cross sections or nodes and time nodes in order to transform the equations into a form amenable to computer solution. The nonlinear system is solved by successive approximation with a linear matrix equation. The size of the matrix equation depends on the resolution of the spatial discretization, as well as the number of processes such as sediment transport that are being modeled simultaneously with the surface-water flow. The size of the linear system also depends on whether a one-, two-, or three-dimensional mathematical approximation is being used. Typical NxN sizes for the matrix equation range from N equals a few hundred to N equals tens of thousands.

The bandwidth of such a system depends on the number of near-neighbors to a given spatial node, and can range from a tridiagonal system to a bandwidth of a few hundred. Each such linear system must be iteratively solved at each time step to obtain the true nonlinear solution. This process must be repeated for each time step, where the time increment delta-t between steps can range from fractions of a second to several days. Often the model simulation is run for multiyear periods, and thus the linear system must typically be solved thousands to tens of thousands of times during a run. The repeated solution of this large matrix equation places severe demands on computer power.

Extrapolating from the trend of the previous few years, the size of the models is expected to increase two to fourfold every 5 years. As the spatial grid is refined, increasing the NxN dimensionality, and the temporal increment delta-t is reduced, overall computing power demand is expected to increase by ten to fortyfold every 5 years.

The use of very fast computers and vector processing are essential in order to keep the solution time for the linear system within reasonable bounds. As a general rule, computer run times longer than 1 hour are impractically long for routine operation of any model. During model development, computer run times for meaningful, but size-limited test data sets should be no more than minutes.

Software requirements

A standard scientific higher-level programming language with a good debug program is required. Compilers for vector processors should provide automatic vectorization of inner do-loops, to allow easy conversion of existing programs to a parallel processing environment (using FORTRAN 77 or CFT – Cray FORTRAN).

Well documented and supported mathematical and statistical utilities (such as IMSL) are needed.

A standard set of matrix routines for manipulating and solving linear systems, including those with symmetric and nonsymmetric matrices of the banded, profile, and full-dimensioned types is required. The routines should be optimized for vector use (such as Floating Point Systems' Fast Matrix Subroutine Library (FMSLIB).

Extensive graphics capability is required (see section on graphics).

A robust operating system that is common to, or at least allows easy communication between, the various computers in the Distributed Information System is needed. It would be desirable that the operating system for all levels of computers (microcomputers, minicomputers, and supercomputers) share the same operating system.

Data-handling packages for manipulating massive amounts of data are required. Surface-water models must link directly to project-level data bases specific to the needs of the particular application. The models must also be able to access data from larger, more general data bases for calibration and verification. Access to these more general data bases can be either directly or indirectly through data retrieved from the larger data bases into the project data base. Data handling packages should provide statistical analyses of data, as well as the ability to view and manipulate the data graphically. Ability to interact with the graphical representation of the data is essential, so that, for example, contours can be moved visually, and the result reflected in the underlying data base. Ability to smooth data should be provided. Ability to output the binary and ASCII files needed for input to the surface-water models is required. A program such as SAS for statistics and a GIS with facility in treating representations of continuous surfaces for the graphics manipulator is needed.

A high quality screen editor is required. The editor should allow the simultaneous editing of multiple files using a split CRT screen, should allow the use of macros to combine commands, should provide for easy entry of source code, and should allow system commands and software commands to be executed from within the editor (such as with EMACS).

Good documentation of all software, both online and printed, is required (San Diego Supercomputer Center system of online documentation, for example).

Hardware requirements

An active modeler uses about one-half to one-quarter of a PR1ME 9955–II's capacity with the models of 1988, and computer power requirements are expected to increase by ten to fortyfold every 5 years. Computers with very fast processing of sequential operations are necessary because some of the operations of data manipulation, and operations involved in forming the large linear system, are difficult to vectorize. Speed in the 2 to 8 MFLOPS per second range is needed (such as the Amdahl and the Cray operating in a nonvectorized mode).

Sequential speed of fast present-day computers cannot be much improved upon because of light speed restrictions within the computer itself. Vector processing thus becomes the only option for speed increases to treat more complex problems. The solution of the large linear system that is the core of surface-water modeling can be easily vectorized. Vector speed begins to play a significant role in reduction of the solution time as the effective bandwidth of this system increases. This happens as the dimensionality of the problem increases, or as simultaneous processes such as sediment transport are introduced. Speed in the 10 to 170 MFLOPS range is needed (such as the Cray operating vectorially).

The solution of large models having large systems of equations to solve requires large amounts of central memory. This memory must be real memory; virtual memory cannot be used to provide the space necessary to the core manipulations because page-thrashing between central memory and disks will result. Central memory of 16 to 58 megabytes is needed (such as Cray).

Large data bases and heavy use of graphics require large amounts of disk storage. Fifty to one hundred fifty megabytes of online storage is required. This amount of storage is needed for the surface-water modeling project underway at any given time. However, typically, WRD modelers will work on a succession of projects, each with an associated project data base of this size. Access to the data of older projects is still needed for some period of time as reports make their way through the review process, for example. Programs and data already used in other projects may also prove useful in current project. A need exists for providing easy access to this historical data, while at the same time maintaining a sufficient reservoir of fast online storage for the current modeling effort. Therefore, a system is needed for creating an extremely large, virtually unlimited reservoir of readily accessible, but not necessarily online storage. The data storage system should allow transfers from the less accessible mass storage to fast online storage with the entry of a simple one-line computer command. Such transfers might take a few seconds if the data happens to be of recent enough origin to be on disk, to a few minutes if the data is old enough to have been migrated to cartridge or whatever. A catalog to track data is required. It is essential that large amounts of fast online storage always be available (such as the San Diego Supercomputer Center system of storage).

The surface-water modeler must interact very directly with the computer system during model development and application. Communication with the model and data base is provided through a workstation. Because of the extensive interaction necessary to develop models, or to run them to simulate complex physical situations, high quality microcomputer workstations are required. Each workstation should have a standard keyboard, fast hard disk, floppy diskette, text and high resolution graphics display, and a graphics display interaction device such as a mouse. The workstation should have a local compiler, word processing software, and graphics software. A high-speed communication link should tie the workstation to larger scale computers. The communication software should link the workstation's computing capability to the larger computer, rather than merely using it as a dumb terminal. As much of the load as possible should be distributed from the larger computer to the microcomputer station. Communication to remotely located computers should be at least 2,400 bits per second. Local area network communication should be in the megabit per second range. Graphics resolution should be at least 640 by 480, preferably 720 by 512, with 256 simultaneous colors (such as an IBM PC-AT using CTSSLINK to communicate with a CRAY at San Diego Supercomputer Center).

Hard copies of graphics and text are required throughout model development and application. Laser printers, color laser printers, multipen plotters, and associated software drivers should be capable of reproducing exactly what is seen on the workstation display—WYSIWYG. Merging and manipulating graphics and text within the same output page should be possible (such as with Hewlett Packard Laserjet Plus, Apple Macintosh, and Graphic Software Systems' device drivers).

Ground-Water Modeling

Description of activity

Ground-water modeling is the mathematical reproduction of measured and conceptualized field conditions relating to the movement and quality of ground water. Ground-water modeling provides:

- A quantitative analysis of ground-water movement and quality, and of the factors affecting ground-water movement and quality;
- Insights into the cause-and-effect relations of hydrologic processes;
- More detailed spatial and temporal resolution in the representation of the hydrogeologic framework and the distribution of water levels and contaminants;
- A tool for the prediction of future ground-water flow and quality conditions;
- A guide for future data collection by indicating the types, amounts, and locations of needed hydrologic data; and
- A means of estimating data needed by other hydrologic models.

Therefore, modeling is a necessary part of analyzing data on water levels, water use, and water quality; of assessing water resources; and understanding the impact of human activities and natural phenomena on hydrologic systems.

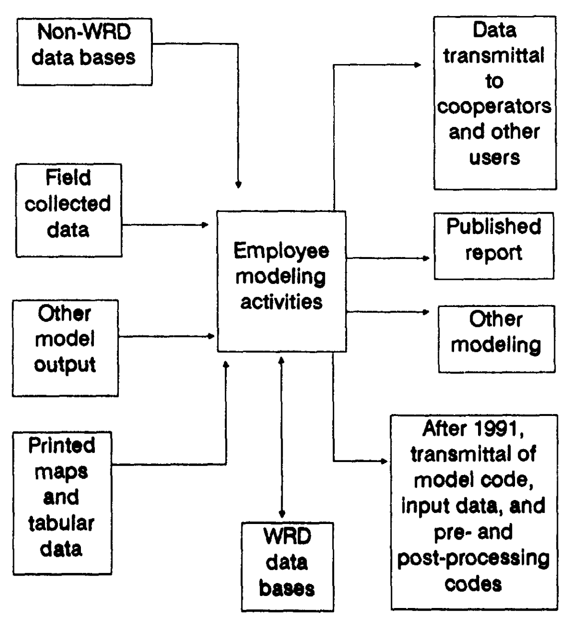
Generally, the mathematical model is one or more partial differential equations with initial and boundary conditions. The equation(s) is solved analytically in the most simple problems and by a finite-difference or finite-element numerical approximation in more complex problems. The finite-difference and finite-element numerical approximations to the continuous partial-differential equation(s) lead to a system of algebraic equations that are solved by a matrix solution technique.

In 1988, the simulation of ground-water flow is done for one-, two-, and three-dimensional hypothetical and field problems for confined and unconfined aquifers. The simulation of solute transport in ground-water systems is done primarily for one- and two-dimensional problems and may include advection, dispersion, diffusion, adsorption, and decay transport processes. The simulation of three-dimensional solute transport and multispecies transport is limited.

Simulation of ground-water flow and solute transport is done for steady-state and transient problems of local and regional nature. Such problems include the simulation of: contaminant movement near landfills, holding ponds, or waste-water injection points; ground-water flow in porous and fractured-rock aquifers; ground-water and surface-water interactions; dewatering operations; radio-nuclide transport near radioactive waste storage sites; and saltwater intrusion.

After 1991, the simulation of solute transport will commonly be done for three-dimensional and multispecies problems. Also, studies including flow and transport modeling will include increasingly more predictive simulations.

Flow of information



Number of locations

Initially, 150 offices would do ground-water modeling with increases to 160 in 1992 and 175 in 1997.

Usage

In 1988, about 20 percent of all WRD projects will include some aspect of ground-water modeling. There will be about 150 ground-water flow modeling projects and about 20 solute-transport modeling projects in the WRD. There will be about 350 people doing ground-water modeling for these projects. Each person will spend about 300 hours per year doing ground-water modeling. Simple analytical or one-dimensional simulations will be made about 25,000 times per year, whereas complex two- and three-dimensional simulations will be made about 45,000 times per year.

In 1991, about 35 percent of all WRD projects will include some aspect of ground-water modeling. There will be about 250 ground-water flow modeling projects and about 40 solute-transport modeling projects in the WRD. There will be about 400 people doing ground-water modeling for these projects. Each person will spend about 300 hours per year doing ground-water modeling. Simple analytical or one-dimensional simulations will be made about 40,000 times per year, whereas complex two- and three-dimensional simulations will be made about 60,000 times per year.

In 1997, about 50 percent of all WRD projects will include some aspect of ground-water modeling. There will be about 450 ground-water flow modeling projects and about 150 solute-transport modeling projects in the WRD. There will be about 600 people doing ground-water modeling for these projects. Each person will spend about 300 hours per year doing ground-water modeling. Simple analytical or one-dimensional simulations will be made about 80,000 times per year, whereas complex two- and three-dimensional simulations will be made about 120,000 times per year.

A summary of the estimates of usage is provided in tables SD-II-1, SD-II-2, and SD-II-3.

Special requirements

The number of calculations needed to solve the numerical approximation of the partial-differential equation which describes a particular problem depends on the spatial and temporal discretization used to define the model input data, as well as the solution technique itself. By 1988, large-size models will include spatial discretization of up to 50,000 nodes or elements and temporal discretizations of hundreds of time steps. Computer computational speed capable of having a matrix solution technique solve for 50,000 unknowns several hundred times in 3 to 5 hours is required. Large-size models will have up to 75,000 nodes by 1991 and 100,000 nodes by 1997.

In 1988, large-size ground-water models may require up to 20 different types of data input and may produce 10 types of data output for each node or element and for each time step. Internal communication among the data handling, graphics, and statistics software is required for the verification and analysis of up to a hundred-million data values (100 megabytes) comprising the model input and output data of each simulation.

After 1991, large-size ground-water models may require up to 30 different types of data input and may produce 20 types of data output for each node or element and for each time step. Integrated data handling, graphics, and statistics software is required for the verification and analysis of up to several-billion data values (over 200 megabytes) comprising the model input and output data of each simulation. For interpretation of large output data sets, animation ability to quickly display hundreds of plots in a time series is required.

Software requirements

Data handler

The data handler must be able to collate, aggregate, compare, and edit files. For the efficient and accurate compilation, verification, and analysis of model input and output data, the data handler must communicate internally with (1) a graphical display routine which allows for graphical identification and editing of data, and (2) with a simple statistical routine which will do summary statistics on selected data sets. To efficiently handle data from multiple sources and prepare them as input to model programs, the data handler must be able to read and write data in user-defined formats and translate contour maps into discretized model input data sets based on a user-defined variable grid spacing. For daily preparation or analysis of moderate-sized (10,000 node) simulations and 2 to 3 day preparation or analysis of large-size (50,000 node) simulations, the data handler (in communication with a graphics and statistics routine) must read, write, discretize, display, statistically summarize, or compare data files with up to 50,000 data values within seconds.

After 1991, the data handler must be directly integrated with the graphics and statistical software for required speed in processing large and numerous data files. Moderate-sized models will have 20,000 nodes by 1991, and 30,000 nodes by 1997. Large-sized models will have 75,000 nodes in 1991, and 100,000 nodes by 1997.

Editor software

For the efficient editing of numerous model input and output files and programs, the editor must be able to edit multiple files, run system commands, have a FORTRAN programming mode, and be able to be run by large editing macros.

Graphics software

The complex graphics software requirements for ground-water modeling are those described under the graphics activities of hydrologic applications. In summary, the graphics software must be able to produce and screen rotate scatter plots, line and bar graphs, contour maps, point-data maps, cross sections, multiple-layer maps, and perspective maps.

Graphical display is crucial to the presentation and analysis of model input and output data as model data files with more than 1,000 values prohibit interpretation of line printer output.

The graphics software must also communicate internally with the data handling software to allow relatively quick display of model input or output files during editing or statistical analysis.

The graphics software must be able to translate a contoured surface into a discretized data set using a user-defined variable grid spacing.

The graphics software must include a graphics editor to modify previously created plots of model input and output files. Such modified plots are necessary in the presentation of data in reports and as the source for revising model input data.

Programming languages: FORTRAN 77.

Statistics software

Software to do simple statistics to describe, quantify, and compare several model input and output files of up to 50,000 data values in seconds, and that can be utilized by the data handling software, is needed to allow simultaneous statistical analysis of graphically displayed data. More complex statistical software which can contour point data, adjust contoured data to include additional point and nonpoint data, and estimate errors in contour plots of point data is needed for the analysis, interpretation, and preparation of data-base and field-collected data into model input data. Data files will include up to 75,000 values in 1991, and 100,000 values in 1997.

Utility software

An easily implemented and understandable program debugger is required in the writing, modification, and running of many pre- and post-data-processing programs and of the flow and solute-transport model codes. A standard FORTRAN numerical library (such as IMSL) is required by the many pre- and post-processing programs and by the flow and solute-transport codes. Utility software is required to read data from various types of computer and communication systems and to transmit graphic display of spatial data to various types of plotting and printing devices.

Hardware requirements

Display/keyboard

Display of 132 characters and full graphics capability, including multicolor, pan and zoom, and simultaneous viewing of graphics and commands are required for screen analysis and verification of model input and output data.

Graphical display should be of adequate speed to draw highly complex and detailed maps in a few seconds.

A standard QWERTY keyboard as well as mouse control are required for data entry, programming, and editing of data files and graphical displays.

Processor

The processor must be suitable to run software and provide immediate response for data entry and several second response for data handling, graphical display, and statistical analysis of several data sets with up to 50,000 values in 1988, 75,000 values in 1991, and 100,000 values in 1997.

Storage

In 1988, 75 megabytes of storage for each ground-water modeling project is needed to maintain files required by the model program, and data-handling, graphics, and statistics software for models with less than 50,000 nodes.

In 1992, 100 megabytes of storage is required for each ground-water modeling project with models less than 75,000 nodes.

In 1997, 150 megabytes of storage is required for each ground-water modeling project with models less than 100,000 nodes. Ten percent of the modeling projects with extremely large models will require 100 megabytes of storage in 1988, and 200 megabytes of storage after 1991.

Printer/plotter

A high quality, multicolor laser printer is needed for the preparation of modeling report text and graphics.

A high resolution, multicolor electrostatic plotter is required for large numbers of oversize (working-scale), highly complex, and detailed plots of model data.

The ability to make slides, transparencies, and videos is required for presentation of model data at meetings.

High speed printing is required to print 10 megabyte files in several minutes.

Communications

File transfer to and from other WRD and non-WRD locations is required. Limited interactive processing with other locations is also required for the acquisition of data.

Generally, periodic transfer of large amounts of data. A local file transfer rate of 1 megabyte per second is needed in 1988. A file transfer rate to offsite locations at 0.01 megabytes per second is needed in 1988. These transfer rates should increase an order of magnitude every 5 years.

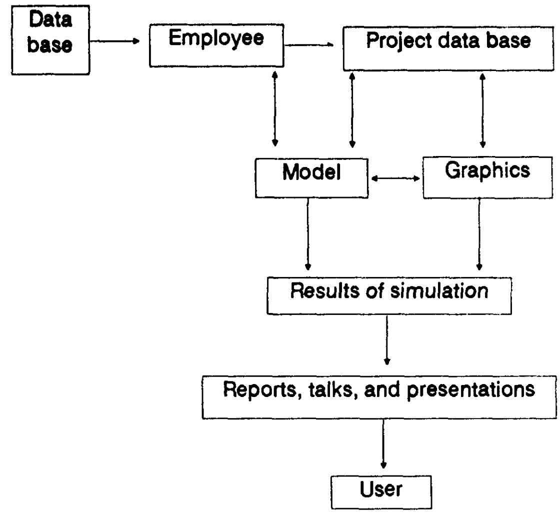
Other Modeling

Description of activity

The two major categories of modeling activity within WRD are surface- and ground-water modeling. Within the research program are four other areas of investigation. These are water chemistry, geochemistry, sediment transport and geomorphology, and ecology. In most cases modeling within these other disciplines is an extension of either surface-water or ground-water modeling. Modeling focuses on the complexities introduced in surface- or ground-water models by consideration of additional processes. Thus, sediment transport models add the complication of the movement of sediment and channel geometry changes to surface-water models. Water chemistry adds organic and inorganic pollutants to surface- or ground-water flow. Geochemistry examines how mineralogical and geological conditions affect surface or ground water. Ecology studies biological and microbiological factors that affect solute transport.

Flow of information

See flow chart.



Number of locations

Initially, 120 offices would do other modeling with increases to 140 in 1992 and 150 in 1997.

Usage

A summary of estimates of usage for other modeling is provided in tables SD-II-1, SD-II-2, and SD-II-3.

Special requirements

Modeling within the four disciplines grouped together under this "other modeling" category can usually be considered an extension of either surface-water or ground-water modeling. As such, all the computer hardware and software requirements of the base water model apply. The additional complexity introduced in the models by the focus of these special disciplines places even more severe demands on computer power.

Models that treat surface-water solute transport must not only be capable of solving the streamflow problem, but must also track a number of organic or inorganic constituents throughout the river system as well. In many cases, little feedback will exist between the additional focus, such as solute transport, and the water flow. In this case, it may be most efficient to simply run a surface- or ground-water model first, and use the resultant surface- or ground-water picture to drive the additional process such as transport. In other cases, such as with sediment transport, too much interaction between the flow and transport may exist to allow such sequential processing. In the case of sediment transport, for example, degradation and aggradation can cause channel modification that significantly affect water flow.

In those cases that have more feedback to the underlying surface or ground-water models, a more intimate tie between the processes must be built into the computer program that treats the augmented process. Often such processes are treated by iterating within each time step between the new process and the base surface or ground-water process. The ultimate interaction is to combine the equations of the new process together with those for the water flow into one set of master equations, and to solve this whole system simultaneously. Demands on computer resources become more severe as the feedback between the additional process and the underlying water flow increases.

Software requirements

At least those of the underlying surface- or ground-water model.

Hardware requirements

At least those of the underlying surface- or ground-water model.

Real-Time Applications

Description of activity

The real-time data technology can be described as the transmission of data from local instrumentation or from remote field facilities (via satellite) directly to a computer system where it is then processed and stored. A distinction is necessary here to differentiate its use from that described by the Hydrologic Information work group. At present, real-time applications are primarily tools for eliminating the need for routine service at gaging sites and as alert systems for cooperators. Existing laboratory applications are mainly computer controlled chemical analyses or direct relay of experimental data to a computer for processing, storage, and subsequent use in modeling efforts. These are considered hydrologic information functions. Hydrologic applications have only recently been proposed and are of two principal types:

(a) Hydrologic data collected at remote field locations and transmitted via satellite to local computers for immediate interpretation through the use of various models, and

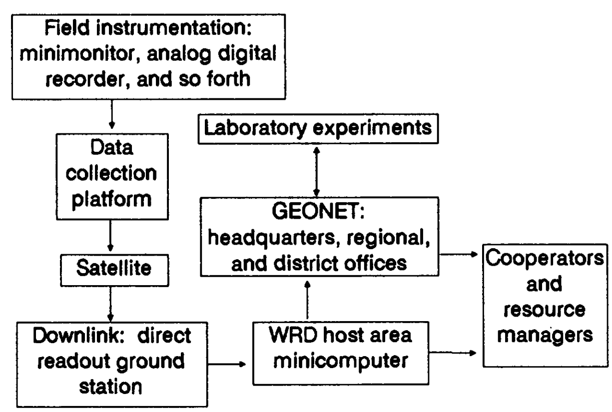
(b) Data from laboratory experiments which is immediately processed for use in simulating the process under investigation or controlling subsequent phases of the experiment.

The perceived value of real-time data collection in hydrologic applications will be tools to cooperators and resource managers in reservoir, water-quality, estuarine, and municipal system management as well as flood forecasting. The most probable types of surface-water models which might lend themselves to real-time data are the BRANCH model, CONROUT, and rainfall and runoff models like HSPF and PRMS. Those models without water-quality capabilities may link further to solute transport models (such as the LaGrangian transport model) or sediment transport models.

An example of real-time data use in future hydrologic applications might be NEXRAD. Through a network of U.S. Weather Bureau radar precipitation stations, spatially distributed data for 1-hour time steps or longer can be obtained and used immediately or stored and used to supplement or replace project precipitation data. Data for approximately 50,000 square miles for a 1-hour time period (or 200,000 bits) could be relayed. The transfer rate for this data would have to be 5 minutes or less in order for the data to be processed and input into a model in a timely manner. These data might be saved for an entire year on a CD ROM for possible subsequent use.

Ground-water uses will be very limited since timely (same day) decisions are seldom required in this discipline. Computer-monitored lab experiments or field instrument malfunction warning systems (important in collecting data for evapotranspiration studies) will be used in ground-water investigations but, again, this is more in the realm of hydrologic information rather than hydrologic application.

Flow of information



Number of locations

There will be no models driven by the real-time data system within WRD in 1988. In 1992 there may be 10 models in 8 locations which are maintained by WRD. In 1997 there may be 20 models in 20 locations.

Usage

In 1988, the real-time system will function chiefly in a hydrologic information capacity. Although proposals for such systems will be marketed to cooperators, WRD operated and maintained models driven by the real-time system will not exist. Hydrologic applications will continue to be performed with real-time data by cooperators using their own models.

In 1992 and 1997, the real-time system will still function chiefly in a hydrologic information capacity. Hydrologic applications will continue to be performed with real-time data by cooperators using their own models. The amount of time spent at a terminal by each of the WRD modelers or cooperators making adjustments to the model and interpreting results will average 100 hours per person per year.

A summary of the estimates of usage is provided in tables SD-II-1, SD-II-2, and SD-II-3.

Special requirements

In order to meet the responsibilities of the managing (cooperative) agency, the downtime for all communication network linkages and system processors will have to be minimal.

In 1988, there may be as much as an hour delay in the relay and processing data. In 1992 and 1997 there may be a requirement for "real" real-time data which is processed from the field in seconds rather than several minutes to an hour.

Some models may need processing times 10 to 100 times faster in order for their predictive abilities to be timely, efficient management tools. Custom data handlers may be necessary for some applications. The need for a variety of graphics capabilities as an aid in interpretation of model results will increase, especially as two-dimensional and three-dimensional models come into use.

The acquisition and processing of real-time data by models requires an operating system that supports a multi-tasking environment with the following three constructs:

- Dijkstra semaphores, or their equivalent,
- queued message passing between tasks, and
- real-time processes.

(Note: 'real-time processes' are processes that can respond to external events within a time period that is sufficient to process the event 100 percent of the time.)

Software requirements

General purpose programming languages such as FORTRAN 77 and C are needed to write special programs for processing real- time data.

Hardware requirements

Processor must support the processing of satellite transmissions at an average rate of about 2 per minute with peaks of 10 per minute. Transmissions range from 40 to 500 bytes long. Serial communications ports that support asynchronous and synchronous communications using RS232C conventions are needed.

User programmable Universal Asynchronous Receive/Transmit (UART) and Universal Synchronous Receive/Transmit (USRT) is required.

Support for ETHERNET is required.

Decision Support Systems

Description of activity

Decision support systems are the integration of hydrologic models and data management directed towards specific resource management decisions. Examples of decisions include evaluation of permits for surface mining, waste discharges, registration of pesticides, building permits, timber harvesting, and wetland modifications. In each case, the models can be comprehensive and data bases large, but the users experience and training is low. To bridge the gap, concepts of artificial intelligence (AI), specifically expert systems, interactive graphics, icons and windows are needed. Tools from geographic information systems (GIS) are needed for storage, retrieval, and association of spatial data.

In decision support systems, the user communicates the needs through a series of menus or commands. Eventually, natural language parts of AI may be used. GIS and interactive graphics are used to get locations of interest from the user and to translate those locations to input for the model and to display the results.

The decision support system activity involves the development of the system and an application as well as use of the system. Since many of the systems will be developed for cooperators and other Federal agencies, and will be used by utilities and consultants, specific hardware and expensive software systems cannot be required. Most agencies are locked into specific hardware and software systems. Many agencies require a specific data base or GIS to be used.

Flow of information

All information for the use of a decision support system will be contained on the local system with the exception of systems for real-time operations. For the development of such systems, the information flow is the same as specified in the modeling activity. For decision support systems for real-time operations, the information flow is the same as specified in the real-time activity.

Table SD-II-1.—*Estimates of hydrologic application usage for 1988*

Hydrologic application	Number of locations	Number of times performed per year	Number of people	Number of hours per person per year
Editing environment	175	560,000	1,400	200
Communications	175	120,000	1,200	50
Data handling	175	360,000	1,200	300
Spatial data processing	150	80,000	800	100
Graphics	175	480,000	1,200	200
Statistical analysis	150	100,000	1,600	100
Surface-water modeling	150	50,000	250	300
Ground-water modeling	150	70,000	350	300
Other modeling	120	40,000	200	300
Real-time applications	0	0	0	0
Decision support systems	1	100	2	200

Table SD-II-2.—*Estimates of hydrologic application usage for 1992*

Hydrologic application	Number of locations	Number of times performed per year	Number of people	Number of hours per person per year
Editing environment	175	600,000	1,500	175
Communications	175	130,000	1,300	50
Data handling	175	325,000	1,300	250
Spatial data processing	175	160,000	1,000	150
Graphics	175	650,000	1,300	250
Statistical analysis	160	120,000	1,800	100
Surface-water modeling	160	75,000	300	300
Ground-water modeling	160	100,000	400	300
Other modeling	140	40,000	200	300
Real-time applications	8	3,750	50	100
Decision support systems	20	2,500	25	250

Table SD-II-3.—*Estimates of hydrologic application usage for 1997*

Hydrologic application	Number of locations	Number of times performed per year	Number of people	Number of hours per person per year
Editing environment	175	720,000	1,600	150
Communications	175	140,000	1,400	50
Data handling	175	280,000	1,400	250
Spatial data processing	175	320,000	1,200	150
Graphics	175	840,000	1,400	300
Statistical analysis	175	140,000	2,000	100
Surface-water modeling	175	125,000	450	300
Ground-water modeling	175	200,000	600	300
Other modeling	150	60,000	300	300
Real-time applications	20	20,000	200	100
Decision support systems	100	90,000	300	300

Number of locations

Decision support systems will eventually occur in all district, State, and project offices as well as research laboratories and offices. In 1988, there will be only 1 site and with expansion to 20 sites by 1992 and 100 sites by 1997.

Usage

Initially, only one site will work developing decision support systems. By 1992, 25 persons will be using or developing decision support systems and the number should greatly expand to 300 by 1997.

A summary of the estimates of usage is provided in tables SD-II-1, SD-II-2, and SD-II-3.

Special requirements

None.

Software requirements

The systems will be developed using language standards for portability. That would include FORTRAN C and possibly AI languages such as LISP. An expert system shell may be needed for system development. GKS will be required. Windows and icons would be used.

Hardware requirements

Same as modeling activities.

Reference

Becker, R.A., and Cleveland, W.S., 1987, Brushing scatterplots: Technometrics, v. 29, p. 127–142.

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SUPPLEMENTARY DATA III.--Geographic Information Systems (GIS) Work Group

TABLES

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SUPPLEMENTARY DATA III.–GEOGRAPHIC INFORMATION SYSTEMS (GIS) WORK GROUP

Geographical Information Systems (GIS) are spatial data management and analytical tools offering tremendous potential gains in power and efficiency for the Water Resources Division's (WRD) information management and data analysis applications. However, the current GIS software package is encumbered by inefficiencies in accessing and handling National Water Information System (NWIS) and other existing data bases, by the general unavailability of critical digital data, and by the lack of certain software and hardware capabilities that always lag with a burgeoning technology.

The GIS work group has identified certain technological improvements attainable in the very near future and have a reasonably clear perspective on where the WRD should be headed. By 1992, GIS technology should be fully embedded in a highly integrated set of Distributed Information System (DIS) software. The GIS needs beyond 1992 are highly speculative and reflect general desires in direction rather than necessarily attainable goals. The monetary commitments to hardware and software, no doubt, will be sizable, but there must be equal commitment toward GIS-WRD training, application development, research into Artificial Intelligence (AI) and alternate Data Base Management Systems (DBMS) for GIS structures, and in providing better ways to document and disseminate an application when it's developed – that is, if the WRD is to maintain its role as a major player in the hydrologic information and analysis game in the 1990's.

The GIS work group envisions a continuum of improvements in the GIS technology and increased application of GIS tools over the next 4 years. We see large improvements in processing and screen painting through the accession of powerful single- and multiple-user workstations (such as the SUN 3/380 or Tektronix 4300 series) that will allow WRD applications to become more GIS oriented, particularly in modeling activities. There is at least one caveat, again, in that the expertise must be developed through rigorous training, specifically tailored for WRD applications, if the efficient use of the GIS software is to be gained.

The more powerful systems (hardware and software) will become the impetus for changes in WRD approaches to processing data, modeling, and otherwise analyzing hydrologic systems. There is a current need for improvements and new approaches will in turn demand even more improvements in WRD specific software, in communications, and in linking with other data bases for quick and efficient access and exchange of hydrologic information.

Currently, WRD's GIS software package has a rather weak relational data base system with much room for improvement. This data management and manipulation need is shared by essentially all WRD activities. It is both obvious and imperative that the DIS should have a more highly integrated software system, which by 1992, should have a powerful data management interface that allows users easy and transparent access to data and software tools. The result is an ability to carry out any number and type of tasks without having to be a computer wizard, whether those tasks be in GIS, hydrologic information, hydrologic applications, reports, or administration. Hence, GIS is only another tool, albeit important, in the DIS toolbox. That ability almost implies that some level of artificial intelligence software (and probably hardware) will be applied, particularly for more routine tasks of data base browsing and retrieval and some types of analyses.

Unless the mission of the U.S. Geological Survey (USGS) and specifically the WRD is changed, the type of GIS applications expected to mature during 1992–97 will not appreciably change beyond 1997. However, the scope of these applications may increase to include modeling and analysis of natural phenomenon on a very large, even global scale or at a very detailed and intricate scale. The software to support these applications must operate in spherical as well as cartesian coordinates, while the hardware needs to be of supercomputer-type speed and capable of fully three-dimensional visualizations. The system is conceptualized as being an AI assisted, integrated raster-vector, image processing, surface-volume modeling, statistical analysis, GIS package, fully integrated in the DIS operating system-DBMS and communications network for efficient sharing of information and processing power.

To handle the description of needs, the GIS activities were divided into six identifiable, but interrelated, activities. The six activities are:

- GIS data automation
- GIS data manipulation
- GIS data base management
- GIS applications and analysis

- GIS output and publications
- Advanced GIS analysis

Each of these are introduced separately and followed by a detailed description on the recommended DIS II functional requirements forms. Not every year (1988, 1992, 1997) is necessarily discussed separately, some of the activities did not lend themselves to this, but all years are covered one way or another. The software and hardware requirements overlapped and they are handled, for most activities, by the tables and discussion below. It is also important to acknowledge the document "Functional Components for Geographic Information Systems" by the Interior Digital Cartography Coordination Committee, GIS Working Group, January 28, 1987. It was used as a guide.

In preparation of the various GIS work group topics it became obvious that the software and hardware requirements were overlapping between the functional categories. This section is our attempt to isolate the software and hardware requirements and consists of two parts. The first (tables SD-III-1 and SD-III-2) lays out the products either by brand name or capability by year. The second (tables SD-III-3, SD-III-4, and SD-III-5) lays out quantities and capabilities required by year.

The approach taken reflects a belief that almost all existing equipment will be phased out by the 1992 time-frame and replaced with higher capacity components and that the same type of transition will also occur between 1992 and 1997 due to technology and price and performance changes. Much of the general purpose hardware would be common to that proposed by other work groups and, therefore, would probably not be totally dedicated to GIS related work. On the other hand, the workstation hardware would probably be devoted almost entirely to GIS and modeling applications in the early years of its acquisition.

Data Automation

(1) Please identify the major activities performed.

Data automation is the process of assembling spatial data in a format that can be easily processed by a geographic information system (GIS). In 1988 and 1992, for all practical purposes that GIS equates to the ARC/INFO system. Three separate tasks are identified within the data automation process:

- Digitizing and scanning
- Conversion and linking
- Editing and updating

All three are critical in providing the basis for the application of GIS techniques within the WRD, for without GIS data there can be no further analysis. Descriptions and needs are defined below.

Digitizing and Scanning

(2) Please describe each identified activity and why it is needed.

Digitizing and scanning involves the capture of analog source data (such as, printed maps, map manuscripts, map separates, photography, and model output) utilizing a digitizer or scanner for input into the ARC/INFO system. In addition, the process includes attribute tagging and topological structuring of spatial data to permit analysis within the GIS. Needless to say, this process is a necessary first step in the application of GIS and often is a very time consuming effort. The whole process can be made easier and more efficient with the proper hardware and software.

Digitizers are the common means, currently, to input map and other data into digital format, scanners are expensive and not generally available, but because they potentially could eliminate considerable manual operations, scanners will be more popular when equipment costs become more reasonable. The current software is reasonably easy to use, but gains can be made through improvements in automatic validity and topologic checks, autosnapping, autogeneration of polygons, and other automated features for digitizing and, especially, for scanning operations.

(3) Please describe the flow of information in this activity.

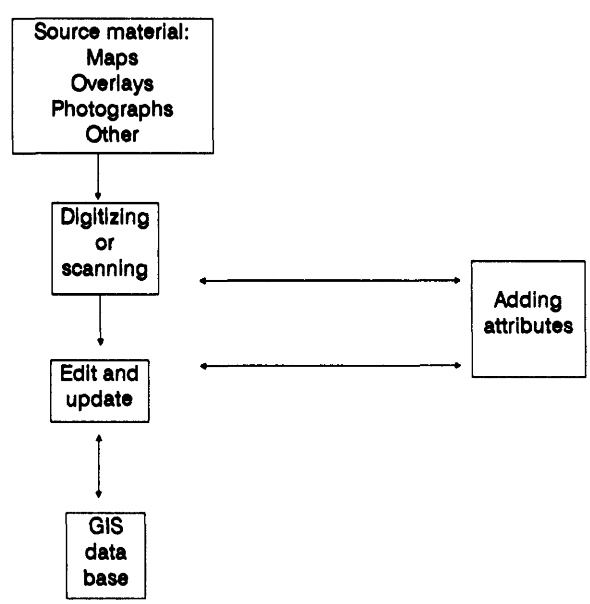


Table SD-III-1.—*Summary of geographic information systems (GIS) software requirements, 1988, 1992, and 1997*

[The information in this table equates to question 9. Refer to tables SD-III-3, SD-III-4, and SD-III-5 for detail]

Current	1988	1992	1997
		A. Data base	
INFO, DB III Oracle, P-STAT	INFO, DB III, Oracle, P-STAT, quad tree Better GIS-DBMS	General DBMS-GIS, quad tree, oct tree, object oriented	Umbrella DBMS, quad tree, oct tree, object oriented
		B. Editors	
ED, EMACS WordMARC	ED, WordMARC EMACS, VI(UNIX)	Full screen text Integrated text and graphics Desk-top publishing	Integrated text and graphics including desk-top publishing (only one editor package)
		C. Graphics	
DISSPLA, P-STAT TELLAGRAF Vendor specific drivers, ARC/INFO	DISSPLA, TELLAGRAF Vendor specific drivers Graphics standard P-STAT, ARC/INFO	General raster-vector capability Interactive graphics generation Vendor specific drivers, graphics standard, visualization	General raster-vector capability. Interactive graphics generation. Vendor specific drivers, graphics standard, visualization
		D. Program language	
FORTRAN CPL, INFO, P-STAT	FORTRAN, CPL INFO/AML, P-STAT Prolog/Lisp	FORTRAN, C, AI, DBMS language, object oriented, AML equivalent	FORTRAN, C, AI, object oriented, DBMS language, AML equivalent
		E. Statistics	
P-STAT Minitab IMSL, SAS	P-STAT, Minitab Better data-handling IMSL, SAS	DIS integrated batch-interactive statistics package with AI beginnings	DIS integrated batch-interactive statistics package with AI capabilities
		F. Spreadsheet	
Lotus, 20/20	Lotus, 20/20	New integrated package with text editor	Integrated package with text editor
		G. Utility software	
	All years: provide standard operating system utilities (transparent).		
		H. GIS software	
ARC, Network TIN, GRID	ARC, Network, MOSS LAS/TAE, TIN/GRID Raster interface	ARC SYSTEM, AI assisted GIS MOSS. LAS/TAE Integrated raster-vector	AI assisted integrated raster-vector IP, GIS, and statistical surface-volume analysis package
		I. Image processing software	
ERDAS, IDIMS ELAS, ERAS	ERDAS, IDIMS LAS/TAE, ELAS	Integrated IP and GIS AI assisted IP	Same requirements as for GIS software
		J. Surface generation	
Surface II, ISM TIN, Kriging	Surface II ISM, TIN, Kriging	Statistical surface analysis package, ISM, TIN	Same requirements as for GIS software
		K. Format conversion	
Numerous home grown	Numerous home grown Begin division-supported package	Division-supported conversion supported packages from standard inputs to supported GIS and other software	Division-supported conversion package to data base and application package
		L. File transfer format	
FTS	FTS, TCP/IP, others	FTS, TCP/IP, others	TCP/IP or other industry supported standard
		M. Operating systems	
PRIMOS, PC OS	PRIMOS, UNIX, PC OS	PRIMOS, UNIX, PC OS	UNIX or other industry standard

Table SD-III-2. —*Summary of geographic information systems (GIS) hardware requirements, 1988, 1992, and 1997*

[The information in this table equates to category 10 from the questionnaire]

Current	1988	1992	1997
		A. Displays	
Tek 41xx	Tek 41xx	Tek 42xx	Tek 43xx/SUN's
Tek 42xx	Tek 42xx	Tek 43xx/SUN's	Flat screen
PC/T-GRAF	Tek 43xx/SUN's	Combined vector-raster	Combined vector-raster
	PC/T-GRAF	2048X2048	2048x2048
		Flat screen	4096x4096
		Fully three-dimensional	Fully three-dimensional
		B. Processors	
PR1ME 750	PR1ME 750	PR1ME 9955	20 MIPS processor
PR1ME 850	PR1ME 850	6 MIPS processor	200 MIPS processor
PR1ME 9955	PR1ME 9955	20 MIPS processor	20 MIPS workstation
	20 MIPS workstation	20 MIPS workstation	100 MIPS workstation
	PC's	100 MIPS processor	1000 MIPS workstation all fully networked for optimum CPU sharing
		100 MIPS workstation	
		PC's all networked	
		C. Storage	
600MB disk	0.496-1 GB disk	1GB disk	4GB disk
Tape drives	Tape drives	Magnetic tape	Magnetic tape
Floppy disk	Floppy disk	CD-ROM	CD-ROM
	CD-ROM	Optical disk	Optical disk
	WORM	WORM/WMRM	WORM/WMRM
		Chip memory	Chip memory
		D. Output devices	
Line printer	Line printer	Line print equivalent	Line print equivalent
36-inch 4-8 pen	36-inch 4-8 pen	36-inch 8-pen	36-inch 8-pen
Table 4-pen	Table 4-pen	Color screen dump	Color screen dump
Color inkjet	Color inkjet	Color electrostatic	Color electrostatic
Production plotter	44-inch electrostatic	Production plotter	Production plotter
	Production plotter	Color laser	Color laser
	Film output	Film output	Film output
	Video capture	Video capture	Video capture
			High resolution electrostatic
		E. Networks	
Primenet	Primenet	Wide area 56KB	Wide area T1
Ethernet	Ethernet		
Geonet 9.6KB	Geonet 19.2KB		
		F. Digitizer-scanner	
Table 0.005"	Table 0.003"	Table 0.003" resolution	Table 0.003" resolution
Scitex scan	Scitex scanner	Scitex scanner	Scitex scanner
	Tek 4991 scan	Tek or equal scan	Tek or equal scanner
	Optical 4096x4096	Optical 4096x4096	Optical 4096x4096
		Color separate	Color separate scan
		Text scanner	Text scanner
		G. Personal interface	
Mouse	Mouse	Mouse	Heads up-voice activated
Joystick-Pad	Joystick-Pad	Joystick-pad	
Trackball	Trackball	Trackball	
		Voice activated	

Table SD-III-3. – *Geographic information systems (GIS) hardware and software projections for 1988*

Hardware or software	Remarks
PR1ME 750 & 850	No change.
PR1ME 9955	Add some disk capacity.
20 MIPS workstation	Obtain 20 workstations. Each workstation should have at least 4 GBytes of disk, 16 MBytes of real memory, one 1600/6250 bpi tape drive (or network access), Ethernet local area network, one high resolution color display (1024x1024), three medium resolution color displays (640x480), some type of graphic output and access via network to high resolution plotter, ARC software coupled to a relational data base, easy-to-use full screen editor, FORTRAN compiler, network software compatible with existing PR1MEs and their capabilities.
Text editors	Obtain prototype easy-to-use full screen combined text and graphics editors for installation on either the PR1ME systems or workstations.
CD-ROM (reader)	Begin to evaluate the technology and install about 10 prototype systems to evaluate off-loading reasonably static data sets from the PR1MEs to extend the existing PR1ME storage capacity.
Optical disk-WORM	Begin to evaluate the technology and install about five prototype systems to evaluate their usage to extend the existing PR1ME online storage capacity cost effectively into the terabyte range.
GIS software	Begin to implement raster capabilities by installing LAS/TAE, ERDAS or other software on new workstations where projects require a raster capability. Start to research DBMS software for better GIS application.
Output devices	Install screen dump plotters with all workstations. Replace line printers only with high-speed graphics devices. All sites with workstations should also have either an eight-pen or electrostatic wide carriage plotting capability (400 dots per inch). Start to obtain color electrostatic.
Camera	Install film generation capability at the regional level for production of slides or other types of film output and Polaroid Palettes at the field level.
Digitizers	Install only digitizing tables with a 0.003" resolution.
Scanners	Install scanners in all regional offices and other sites having large volumes of data to automate.
Data base	Continue to use INFO but utilize a better Relational Data Base (RDB) on new workstations and begin to add quad-tree capabilities where applicable.
Graphics	Begin evaluation of emerging graphics standards and software, using them to eventually replace older stand-alone packages.
Spreadsheet	Continue support for existing Lotus and 20/20 capability. Possibly consider moving this function to PC's or later integrating this capability into text-processing package.
Surface generation	Continue use of Surface II, TIN, and ISM but extend the capabilities to more locations. Begin to investigate three-dimensional software for solids modeling.

Table SD-III-4. – *Geographic information systems (GIS) hardware and software projections for 1992*

Hardware or software	Remarks
PR1ME 750 & 850	Phased out.
PR1ME 9955	No changes or augmentations.
6 MIPS processor	General purpose processors as replacement for 750's and 850's for general use and some GIS applications. Thirty of this size machine will be required. Peripherals will consist of high-speed graphics device, one 1600/6250 bpi tape drive, 4 GBytes of disk, Ethernet LAN, at least 16 MBytes of real memory and the capability to run the types of software noted in table SD-III-1.
20 MIPS processor	General purpose processors for larger districts or replacement for 850 with generally the same capabilities as for the 6 MIPS machine above. Twenty of this type of machine are anticipated.
20 MIPS workstation	Add 20 additional workstations of the type described in 1988.
100 MIPS workstation	Install 20 workstations. Some of these would replace the 20 MIPS machines installed in 1988 allowing the 20 MIPS machines to be moved to other sites. These machines would have generally the same components as the 20 MIPS machines but would have at least 32 MBytes of real memory, 8 GBytes of disk and at least two high resolution color displays and eight medium resolution displays.
Text editors	All machines would be equipped with full screen text editors which allow combining text and graphics. Begin to implement desk-top publishing capability at many sites.
CD-ROM (reader)	Complete equipping all sites with this capability for storing all archival data and for use with other types of data the USGS will be distributing on a regular basis.

Table SD-III-4. – *Geographic information systems (GIS) hardware and software projections for 1992* – Continued

Hardware or software	Remarks
GIS software	Begin to implement integrated raster-vector software and display capability. Also begin use of artificial intelligence (AI) front-ended GIS software. Implement improved DBMS within GIS.
Output devices	Install screen dump plotters with all workstations. All sites with workstations should also have either an eight-pen or electrostatic wide carriage plotting capability (400 dots per inch). Install laser printers where necessary to support sites with desk-top publishing.
Scanners	Install additional scanners to facilitate entry of map data for projects where volume warrants, a few text scanners for entry of published data and text.
Data base	Complete transition away from earlier generation data bases to new general relational data base (RDB) technology capable of use across all facets of site operation. Continue installation of quad-tree based data bases and begin evaluation of oct-tree and object oriented data base structures and software.
Graphics	Implement software conforming to graphics standards and allowing interactive manipulation and revision of plot files and allowing combined raster and vector data within the files.
Statistics	Implement new statistics software which better serves the Division needs for interface to existing operational data bases, GIS systems, and graphics. This software should be capable of running in either batch or interactive modes.
Optical disk	Begin installation of either or both "write once read many" (WORM) or "write many read many" (WMRM) optical disk technology for use along with high speed conventional disk storage.
Surface generation	Continued use from 1988 but expanded to include all sites.

Table SD-III-5. – *Geographic information systems (GIS) hardware and software projections for 1997*

Hardware or software	Remarks
20 MIPS processor	The number of these machines will not be changed from 1992 but they may have been relocated when higher capacity machines were installed. These machines would replace the older 6 MIPS processors.
200 MIPS processor	General purpose processors for larger sites replacing older 6 and 20 MIPS processors. Thirty of this type of machine are anticipated. These machines would have the same range of peripherals as noted earlier except main memory will be in the 4 GByte range and disk storage will be at least 16 GBytes. These machines may require some optical disk depending on the types of work.
20 MIPS workstation	Add 10 additional workstations of the type described in 1988.
100 MIPS workstation	Add 10 additional workstations of the type described in 1992.
1000 MIPS workstation	Install 30 workstations. Some of these would replace the 20 MIPS machines installed previously allowing them to be moved to other sites. These machines would have the same components as the 20 MIPS workstations but would have at least 4 GBytes of main memory, 8 GBytes of disk storage and 100 GBytes of optical disk, up to 10 high resolution displays and 20 medium resolution displays for general use, and at least one 2048x2048 and at least one 4096x4096 display.
Text editors	A single text-processing package combining all full-screen alphanumeric, integrated text and image, and desk top publishing capabilities. This package should also be capable of interfacing with any other site text processing done on PC's and to the data base and spreadsheet.
CD-ROM	Continued support on all systems but no new equipment anticipated.
GIS software	Fully integrated AI-raster-vector-DBMS GIS-IP software installed on all workstations.
Output devices	All sites equipped with 400 dot per inch state-of-the- art electrostatic color plotters as well as eight- pen vector plotters. Continued support of screen dump plotters including ones to handle higher resolution displays. Technology in this area may have developed far enough to begin to install holographic image plotting systems for display of three dimensional product outputs.
Digitizers	Procure and install, as required, as most sites will already have access to 0.003 resolution equipment.
Scanners	Procure and install, as required, as most sites will already have access to this type of equipment.
Data base	Continued support for the software put in place in 1992.
Graphics	Continued support for the software put in place in 1992.
Statistics	Continued support for the software put in place in 1992.
Optical disk	At least one drive installed on all systems and more than one on workstations.
Surface generation	Fully integrated into the GIS software by this point in time.

(4) How many locations do this activity?

High resolution scanning, with associated hardware, software, and training, is one of several GIS related operations that are currently somewhat expensive. However, note that Digital Data Research Laboratories (DDRL) are anticipated to be in place at three sites in 1988. In later time periods, capital costs are expected to decrease and the number of sites doing the activity will increase.

	1988	1992	1997
Digitizing	42 ARC sites	65 sites	65 sites
Scanning	3 sites (DDRL's)	10 sites (DDRL's or large districts)	65 sites

(5) How many times per year is this activity done?

	1988	1992	1997
Digitizing	30,000	25,000	1,300
Scanning	1,200	5,000	10,000

(6) How many people per year do this activity?

	1988	1992	1997
Digitizing	300	500	65
Scanning	6	25	100

(7) How many hours per person per year are spent doing this activity?

	1988	1992	1997
Digitizing	100 hours	50	20
Scanning	200 hours	200	100

(8) Are there any special requirements for this activity?

USGS standards should be developed and special training for the scanning will be needed.

(9) Please describe any software requirements for this activity.

See summary tables above.

(10) Please describe any equipment requirements for this activity.

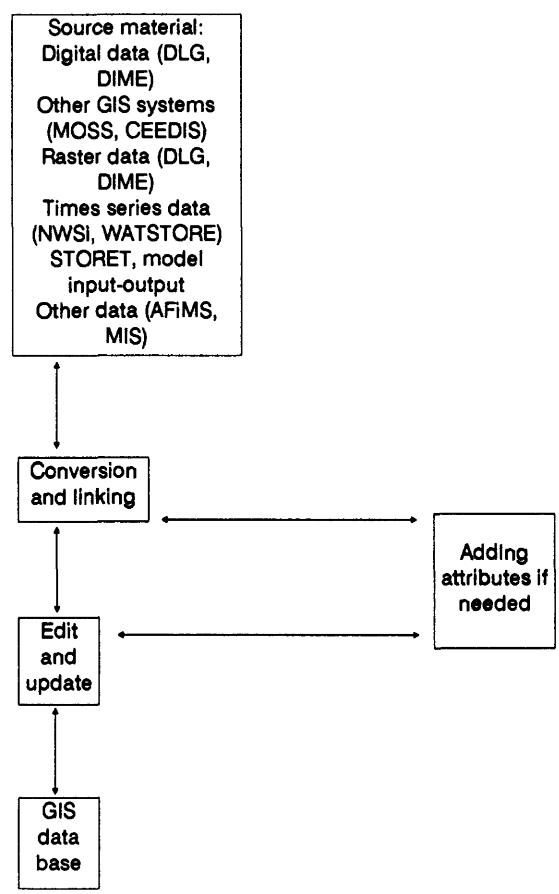
See summary tables above.

Conversion and Linking

(2) Please describe each identified activity and why it is needed.

Conversion and linking involves the transformation of existing digital data (such as, USGS data line graph (DLG) coverages and U.S. Census Bureau DIME Files) from existing digital data bases into the ARC/INFO system, the conversion and interchange of data between different geographic information systems (such as, ARC/INFO, MOSS, and CEEDIS), the conversion and interfacing with raster formatted data (such as, Landsat, SPOT, and other remotely sensed image data), and the linking and interfacing of spatially indexed time-series and point data (such as, NWIS, WATSTORE, STORET, MIS, AFiMS, FMS, FFS, model input-output data bases, population, and other data bases) for use within the ARC/INFO system. In addition, this process may include attribute tagging and topological structuring of spatial data if it does not exist on the transferred coverage. This process provides for the access of data already existing in a computerized format. Current linkages, however, are not efficient and require considerable familiarity and manual intervention. The goal here is to reduce the amount of time spent on obtaining other data and make the process considerably more transparent to the GIS user.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

	1988	1992	1997
Conversion	10	25	65
Linking	42	65	175

Software should be partially integrated by 1992 and fully integrated by 1997.

(5) How many times per year is this activity done?

	1988	1992	1997
Conversion	500	938	1,625
Linking	5,000	11,250	15,000

(6) How many people per year do this activity?

	1988	1992	1997
Conversion	10	25	65
Linking	50	150	300

(7) How many hours per person per year are spent doing this activity?

	1988	1992	1997
Conversion	100	75	50
Linking	100	75	50

(8) Are there any special requirements for this activity?

Standards should be developed and special training for the scanning will be needed.

(9) Please describe any software requirements for this activity.

See summary tables above.

(10) Please describe any equipment requirements for this activity.

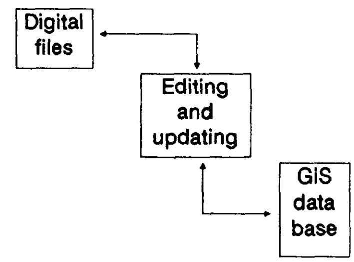
See summary tables above.

Editing and Updating

(2) Please describe each identified activity and why it is needed.

Following the initial entry of data into the GIS data base, the process of data automation often requires that the initial data is then edited to insert, delete, and change attribute and spatial elements in order to correct and update the data. Editing within ARC/INFO is not always efficient, many users do most of their editing in external editors (such as ED, EMACS, or WordMARC). However, the editing process could be more efficient if a good text editor were part of the interactive environment of the GIS system. Needless to say, considerable time is spent on the process of cleaning data files and some efficiencies of operation can be gained with improvements of software.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

	1988	1992	1997
Editing	42	65	175
Updating	42	65	175

(5) How many times per year is this activity done?

	1988	1992	1997
Editing	30,000	25,000	20,000
Updating	4,200	3,250	3,000

(6) How many people per year do this activity?

	1988	1992	1997
Editing	300	500	500
Updating	42	65	175

(7) How many hours per person per year are spent doing this activity?

	1988	1992	1997
Editing	100	50	40
Updating	100	50	20

(8) Are there any special requirements for this activity?

Standards should be developed and special training for the scanning will be needed.

(9) Please describe any software requirements for this activity.

See summary tables above.

(10) Please describe any equipment requirements for this activity.

See summary tables above.

Data Manipulation

(1) Please identify the major activities performed.

The GIS Data Manipulation activity involves the processing of data after it has been placed in digital format and edited within the GIS. This activity includes the three following definable functions:

- Data redefinition
- Data restructuring
- Coordinate transformation

Because of the overlap of these functions, they will be treated as a single activity for estimating needs.

Data Redefinition, Restructuring, and Coordinate Transformation

(2) Please describe each identified activity and why it is needed.

Data manipulation is data alteration not specifically directed towards analysis or data correction and includes redefinition, restructuring, and coordinate transformation. These tasks are inherent to the movement of a data base layer into an active project environment.

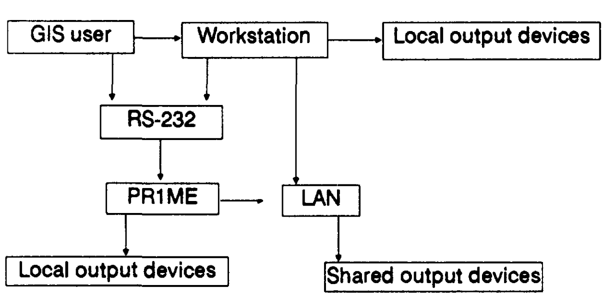
Data redefinition is the selective extraction of a subset(s) of data or the construction of a superset(s) of data by specification of spatial parameters and selected sets of attributes or values for the purpose of concatenation, edge matching, and merging of adjacent data or layers.

Data restructuring is the conversion between data representations and the structure associated with them, such as the converting of raster to vector, vector to raster, or gridded elevation form to triangular irregular network or contoured vector form.

Coordinate transformation involves projection changes, such as converting between latitude-longitude and various map projections, and involves the mathematical adjustment of coordinates based on control points, such as rubber sheeting, polynomial, and least-squares adjustment. These generally are computationally intensive operations as well.

For the most part, these capabilities are currently available in ARC/INFO, but improvement to routines for more automatic manipulation is needed. ARC/INFO also needs to eliminate array restrictions and fixed file length requirements. A future expected need is for support of analysis within spherical as well as cartesian coordinate reference frame.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

All locations will eventually need this capability.

1988 = 42
1992 = 65
1997 = 175

(5) How many times per year is this activity done?

These are ongoing activities for most users at all sites. Frequency of need is a function of whether a user is a full-time or project-oriented GIS user, and by the phase of the project.

1988 = 20,000
1992 = 37,500
1997 = 25,000

(6) How many people per year do this activity?

Many users at every site will be involved in this activity but less than the number that will be editing.

1988 = 200 users
1992 = 500 users
1997 = 500 users

(7) How many hours per person per year are spent doing this activity?

1988 = 100
1992 = 75
1997 = 50

(8) Are there any special requirements for this activity?

Training is an important requirement.

(9) Please describe any software requirements for this activity.

See summary tables above.

(10) Please describe any equipment requirements for this activity.

See summary tables above.

Data Base Management

(1) Please identify the major activities performed.

The GIS data base management activity covers the functions associated with the storage, manipulation, and retrieval of GIS map layers or coverages contained in national, regional, district, and some project level data bases. This activity does not deal with how spatial and attribute data are structured or manipulated with respect to an individual GIS map layer. These internal structures and functions of the GIS are discussed as part of other activities. Three functions were defined as part of the GIS data base management activity:

- Base data development
- Storage and management
- Query and retrieval

Base data development deals with the development of standardized base data GIS coverages for the entire United States at a scale suitable for use in most GIS applications.

Storage and management deals with the functions of developing and maintaining a data base of GIS coverages for general use.

Query and retrieval deals with the functions associated with locating and accessing data from a data base of GIS coverages.

Base Data Development

1988

(2) Please describe each identified activity and why it is needed.

Digital base data layers are required for virtually all GIS projects. Base map information provides the framework for reference and presentation of basic and interpretative spatial data generated as part of a GIS project. Although each project application has specific requirements (types of data layers, scale, and so forth) for their base map information, certain data layers are required by the majority of WRD projects using GIS. Additionally, the majority of the projects using GIS tend to be regional in nature.

The cost, both in time and resources, for each project to develop and automate their own base data is frequently prohibitive, especially for smaller projects of short duration. This "each project for itself" approach to development of base data often results in spatial and informational incompatibility for the same data layers developed by different projects.

This activity involves the development of selected base data layers in ARC/INFO format for all WRD district offices. Each of these data layers would be developed as a national data set to insure spatial and informational consistency between individual map sheets (quads) and between districts.

The following base data layers have been identified as high priority for district GIS applications:

- Hydrography – reference National Mapping Division (NMD) 1:100,000 DLG data descriptions for feature categories.
- Transportation – same as above.
- Public land survey systems—township, range, section
- Boundaries
- Topography – Digital elevation model (DEM) data as gridded elevation or contour data.

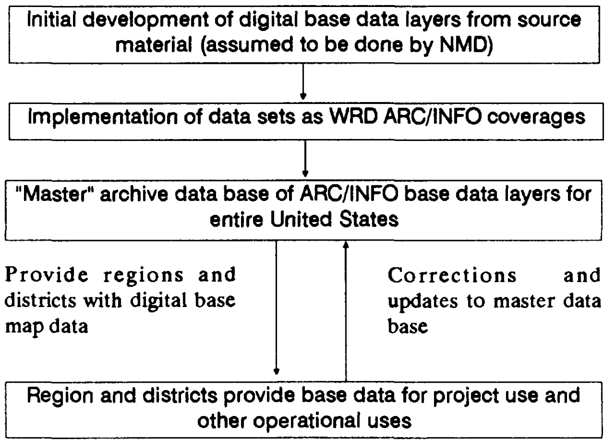
Data for hydrography and transportation are already available from NMD for the entire United States. The remaining data layers listed above are being considered for inclusion into the 1:100,000 DLG series by NMD.

There is an immediate requirement for these data in most region and district offices. Consequently, conversion of existing DLG data layers to ARC/INFO coverages with attributes suitable for WRD applications should begin immediately and WRD should negotiate with NMD to establish priorities, formats, and so forth for development of subsequent data layers. Considerable effort and resources are required to create spatially consistent ARC/INFO coverages with WRD defined attributes for the entire United States using the existing 1:100,000 DLG data.

For the purposes of estimating resources required in the following sections, the assumption is made that digital data for the base data layers has been or will be developed by NMD in a format and of a quality similar to existing 1:100,000 DLG data. The initial creation of the DLG data layers from source material is not addressed in attempting to define the allocation of resources. The assumption is made that WRD will convert the DLG data to ARC/INFO coverages suitable for their needs.

It is essential that the processing of the base map data to create ARC/INFO coverages be done by a single group to assure consistency. Once the data are fully processed and ready for use, an archive master copy would be maintained at a single location and working copies for regional and district areas (initially containing the same features and attributes as the master) would be downloaded to the regions (DDRL's) and districts for maintenance, use, and update as necessary to meet their needs. The master copy should continue to be maintained and updated at regular intervals to assure the availability of a consistent data set nationwide, because each region and district will most likely modify to some extent their copies of the base data to meet specific needs.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

Development of ARC/INFO coverages is done at one or two locations. Maintenance and update of master data base are at each location. Regional and district offices provide feedback on updates to master data base, and manage base data layers at each office.

Use two sites for estimate, assuming two will take the lead.

(5) How many times per year is this activity done?

Development of ARC/INFO base data layers covering the entire United States will most likely be an ongoing effort for at least the next 3 to 5 years, possibly longer, depending on the allocation of resources and the time required to establish procedures for development of interdivisional shared data bases in a standard format.

Maintenance of the master data base will be an ongoing activity. Updates to the master data base may be conducted quarterly, biannually, or annually depending on storage media, and the amount and frequency of updates required.

Maintenance, update, and operation of the regional and district level data bases will be an ongoing activity. Periodic corrections or update of base data layers will be provided for incorporation in the master data base as discussed above.

Estimate 1988 times at 9,000.

(6) How many people per year do this activity?

Development of ARC/INFO coverages from existing DLG data is estimated to require an average of about four people 3/4 time to produce one base data layer per year with all quads edgematched and a selected set of attributes defined and tagged to meet WRD needs for base data. This is only a rough estimate and resource requirements may vary greatly depending on the format, content, and so forth, of each data layer and its location in the United States. Additionally, the rate of development of ARC/INFO base data layers will probably be much slower than the above estimate initially, and then increase as software and procedures are refined to expedite the process.

Two people, half time, should be able to maintain and update the master and regional data bases assuming the frequency of updates discussed previously and the majority of data base transactions being conducted at the district level.

The combined 42 sites will require the equivalent of 2 people to incorporate these master updates.

Estimate is six persons are needed for this.

(7) How many hours per person per year are spent doing this activity?

About 1,500 per person.

(8) Are there any special requirements for this activity?

The core group converting the DLG format data to ARC/INFO coverages will have to be proficient in the use of ARC/INFO software, understand the DLG structure, have programming capability, and have a good working knowledge of cartographic standards and procedures. Well defined and implemented quality assurance (QA) and quality control (QC) procedures will be essential.

Data base management personnel must be proficient in the use of ARC/INFO software, data base design, and data base management. Some programming capability will be required. Well defined QA and QC procedures will be essential. Security of the data bases will also be an important factor.

(9) Please describe any software requirements for this activity.

(a) Data base manager

Data base management software that is thoroughly integrated with ARC/INFO will be mandatory for management of the master and district data bases and will most likely be useful in the process of developing ARC/INFO coverages from DLG type data.

(b) Editor software

All aspects of this activity will require a full function editor, word processing software, and other spatial and attribute editing capabilities such as those contained in ARC/INFO's ARCEDITOR and in the INFO relational data base software.

(c) Graphics software

GIS and related graphics software will be required for all aspects of this activity.

(d) Programming languages

FORTRAN, CPL or equivalent, ARC/INFO's AML language, INFO or equivalent relational data base programming language.

(e) Statistics software

Some use of standard statistical software that is integrated with the GIS software will be required.

(f) Spreadsheet software

(g) Utility software

Input forms for attribute coding, conversion, or lookup tables associated software.

See software and hardware summary tables for additional information.

(10) Please describe any equipment requirements for this activity.

(a) Display/Keyboard

Several ARC/INFO compatible high resolution color graphics workstations with fast vector drawing and screen refresh capability, hardware pan and zoom, mouse, programmable function keys, and so forth, will be required for implementation of DLG data as edgematched and fully attributed ARC/INFO coverages suitable for inclusion in the master and district data bases. Medium to high resolution multipurpose color graphics terminals with mouse, hardware pan and zoom, programmable function keys, and so forth will be needed for most aspects of management of base data layers for the master, regional, and district data bases.

(b) Processor

The graphics workstations described in 10 (a) should be fully compatible with the ARC/INFO software. Refer to the software and hardware summary tables for additional information.

(c) Storage unit

Refer to the software and hardware summary tables for additional information on storage requirements.

Storage at the district level will vary according to district size and GIS activity.

(d) Printer/Plotter

A 36-inch color electrostatic and a 36-inch color pen plotter will be required for implementation of DLG data as ARC/INFO coverages. Each regional and district office, and the group managing the master data base will also require 36-inch color pen plotter capability.

(e) Communications

This activity will require frequent use of network capabilities for remote interaction and frequent file transfers of relatively longer data sets; 1 to 4 MB per 1:100,000 map sheet. Refer to the software and hardware summary tables for additional information.

Base data development

1992 and 1997

(2) Please describe each identified activity and why it is needed.

Same as 1988 for this activity, plus the following.

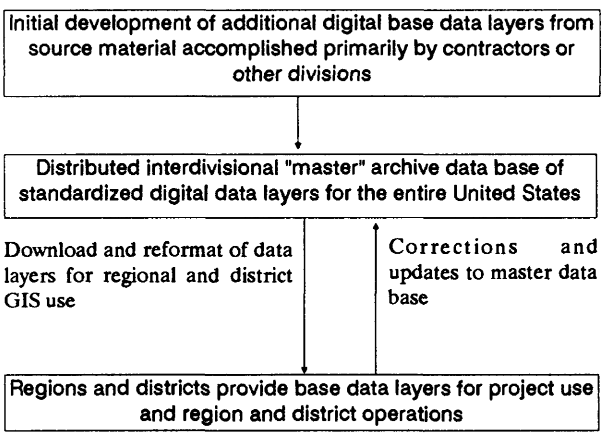
It is anticipated that increased use of GIS technology during the 1992–97 time period will result in the development of a variety of additional national level base data layers (such as geology, land use, soils, and so forth) at 1:100,000 or equivalent scale. During the 1992–97 time period the assumption is made that NMD or outside contractors will be creating these data sets in formats that facilitate incorporation of the spatial and attribute data into WRD district GIS data bases with little manipulation or processing required.

It is envisioned that the need will still exist to maintain regional and district level working copies of the base data layers in order to meet varied needs.

The national level master data base should be maintained as an interdivisional data base, that would most likely be distributed among divisions, but with common formats and standards. NMD would probably maintain base data layers commonly used by all divisions, while WRD and GD might maintain base data layers that are generally unique to their applications. The overall result is that the processing requirements for WRD to develop additional base data layers for regional and district use should decline significantly from the 1988 requirement.

Storage requirements may increase slightly for storage on national level master data bases (this depends on how much data is maintained by each division) and will steadily increase at the regional and district level as additional base data layers are added.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

Reformatting of archive "master" data to GIS format is done by each region or district as part of the retrieval process from the "master" (national level) archive data base, about 65 sites for 1992 and 1997.

(5) How many times per year is this activity done?

Development of standardized interdivisional national level "master" data bases will be an ongoing activity but the downloading and reformatting of data for regional and district data bases will essentially be a one-time occurrence for each data layer for each location. About 6,500 times in 1992, 3,250 in 1997.

(6) How many people per year do this activity?

The requirement for reformatting data for input to ARC/INFO coverages for WRD use will have been reduced significantly by development of a standardized, interdivisional format for digital base map data that is suitable for GIS applications. The personnel requirements for this function will be transferred to the regional and district data base managers and will be accomplished primarily through automated procedures.

WRD's personnel requirement for maintenance and update of the "master" data base will depend on how many base data layers are maintained by WRD. This function should still require no more than one person full time, assuming WRD maintains only base data layers unique to their operations.

About 65 people will be involved in 1992 and 1997, essentially one for each region and district. 1988 comments regarding district size and level of GIS activity will still apply.

(7) How many hours per person per year are spent doing this activity?

Estimate about 100 hours per person in 1992 and 50 hours per person in 1997.

(8) Are there any special requirements for this activity?

Same as 1988 for this activity, except the DLG data structure will be replaced by the new standardized data structure.

(9) Please describe any software requirements for this activity.

(a) Data base manager

Same as 1988 for this activity, except delete requirement for converting DLG data to ARC/INFO coverages.

(b) Editor software

Same as 1988 for this activity, except product names will most likely be different and technology may provide for automation of many interactive editing requirements through incorporation of more sophisticated algorithms and AI.

(c) Graphics software

Refer to discussions of GIS graphics capabilities for this time period under the function category "Publication and Output".

(d) Programming languages

Same as 1988 for this activity, but include AI languages (such as LISP and PROLOG).

(e) Statistics software

Full function statistical software should be integral component of the data base management environment.

(f) Spreadsheet software

(g) Utility software

Same as 1988 for this activity, plus inclusion of reformatting software for interchanging data between "master" archive data bases and district level data bases. Refer to software and hardware summary tables for more specific information.

(10) Please describe any equipment requirements for this activity.

(a) Display/Keyboard

Same as 1988 for this activity, but with increased performance. Refer to software and hardware summary for more specific information.

Master, regional, and larger district data base operations may require special purpose graphic workstations.

(b) Processors

Graphics workstations: refer to software and hardware summary for more specific information.

(c) Storage unit

Will be proportional to the number and sophistication of base data layers stored. It is estimated that by 1992 the average regional and district office will maintain at least five base data layers at 1:100,000 scale with complete statewide coverage. By 1997 the average will be at least eight base data layers at 1:100,000 scale with complete statewide coverage. Refer to software and hardware summary tables for more specific information.

(d) Printer/Plotter

Same as 1988 for this activity.

(e) Communications

Same as 1988 for this activity but more network file transfers. File servers will be needed for local district operations.

Storage and Management

1988

(2) Please describe each identified activity and why it is needed.

Storage and management of GIS data bases encompasses various levels of sophistication and detail ranging from development and management of project-level, working data bases to creation and management of district, regional, or national level, multi-user, archive-type data bases which provide read only access to all except the data managers.

Specific functions include:

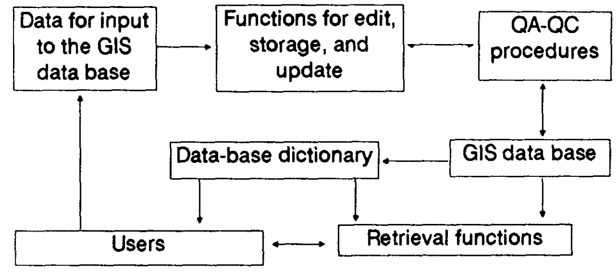
- Data base structural design and implementation;
- Data storage, manipulation, and update;
- QA and QC controls;
- Security protection of data base;
- Development and maintenance of a data base dictionary; and
- Transactional records and status reports.

Development and implementation of a data base management system is desirable for effectively managing GIS data for many projects and is essential for managing GIS data bases at the district, regional, and national level. The structure and functions of the GIS data base management system should work equally well for project working level data bases or large "read only", archive type, national, regional, and district level data bases. In all but the smallest of GIS projects, maps are constantly being manipulated, updated, modified, and so forth, with individual coverages in varying stages of development.

Frequently, a number of people are involved in development, manipulation, and analysis of GIS maps for an individual GIS project. Without some form of data base management structure, it is virtually impossible to efficiently integrate all of these activities. Lack of data management capabilities and functions can result in extra work, lost time, and costly mistakes.

An efficient, well designed data management system is essential for maintaining large GIS data bases, especially those with multi-user access for retrieval of data. Security, quality control, logical data base structure, and user friendly search and retrieval functions are all necessary to provide an effective, high quality data base to support district, regional and national level GIS activities.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

About 42 sites in 1988. Regional and national level data base would most likely be maintained by the DDRL's.

(5) How many times per year is this activity done?

Ongoing; probably daily at the district and regional levels, but will be less frequent (weekly or monthly) at the national level. About 10,000 times in 1988.

(6) How many people per year do this activity?

About 100 total; approximately 60 for management of district, regional, and national level data bases, and 40 for project or program level working data bases.

(7) How many hours per person per year are spent doing this activity?

About 100 hours per person: This will be highly variable depending on location, level of GIS activity, and type and size of data bases being managed. People managing large multi-user data bases will be full time while people managing smaller project level data bases will require only a small amount of time.

(8) Are there any special requirements for this activity?

- Personnel trained in GIS and data base management techniques and software.
- Well defined QA, QC, and data base security procedures, especially for multi-user data bases.
- Large amounts of online data storage required for data bases at national, regional, and some district levels.

(9) Please describe any software requirements for this activity.

(a) Data base manager

Data Base Management System (DBMS) software must be fully integrated with the ARC/INFO GIS package. It must include, at the minimum, the following capabilities.

A data base dictionary and cataloging that provides full documentation of map and attributes contained in the on-line data base and data stored off-line on tape or other storage device. The software should automatically enter or update selected directory information by interpretation of file contents and attribute structures.

The dictionary also should provide information on the history, quality, and availability of each map layer contained in the data base.

The software should be flexible enough to support a variety of formats for organizing thematic map layers (such as hydrography) and spatial structure (such as quadrangles or study areas) within the data base. It should be able to store complete or partial data layers without restrictions of size, areal coverage, scale, and so forth. It should provide the capability of adding data layers to the data base, automatically partitioning them into the thematic map layers and spatial structure established for the data base. It should also provide an easy mechanism for download to tape or other storage device of seldom used data layers with complete referencing and capability to easily reload the data into the on-line data base when needed.

The software should support sequential, direct, and keyed access to data files and direct access to specific features. It should allow selected retrieval of data by spatial or attribute components. Update and reinsertion of selected components of the data base should be accomplished without requiring manipulation of related spatial or attribute features that are not part of the update process. The software should also provide the capability for redefinition of data base content (addition of attributes, tables, and so forth) without requiring the reloading of the entire data layer.

The software should provide a standard set of QA and QC functional checks on the data as part of the data storage procedure and should be flexible enough to allow incorporation of additional site specific QA-QC procedures.

The software should include provisions for maintaining security of the data base and the software, independent of the host computer system.

The software should provide the data base manager a record of transactions on the data base and status reports of contents.

(b) Editor software

Line editor, word-processing software, relational data base editor, and, if required, a special DBMS editor.

(c) Graphics software

GIS graphics software and short, graph capabilities such as those provided in TELLAGRAF and DISSPLA.

(d) Programming languages

FORTRAN 77, CPL, AML, INFO, or other relational data base programming language.

(e) Statistics software

Standard statistical software package (Minitab, P-STAT, and such) integrated with GIS and DBMS software.

(f) Spreadsheet software

Standard spreadsheet software (such as 20/20) for status reporting and transactional summaries.

(g) Utility software

Interfaces to graphics terminals, plotters, and printers (line and letter quality). Software to reformat data retrievals for tape transfer network file transfer, and so forth.

Refer to software and hardware summary tables for additional information.

(10) Please describe any equipment requirements for this activity.

(a) Display/Keyboard

Full function medium to high resolution color graphics terminals with mouse, hardware pan and zoom, programmable function keys, and so forth. For project data base applications terminals will be used for a full range of GIS and other activities. In applications for larger data bases, terminals will be used more for data management and display versus other GIS applications.

(b) Processors

Workstations will be needed for project data management and other GIS applications for some large GIS projects. Some workstations may also be used for management of selected national, regional, and district data bases, especially where the workstation serves other functions. Most data base operations will use existing minicomputer capabilities.

(c) Storage unit

Workstation environments will most likely need their own hard disk storage devices for project-level data base management. The remainder of the storage for data base management activities can be grouped into three categories.

- Large capacity, CD ROM or WORM storage for approved archive data layers, especially master data layers maintained in national and regional level data bases.
- Large capacity, medium speed access storage (such as optical disk) devices for data layers that are changed and accessed at infrequent intervals and where speed of retrieval may not be critical.
- On-line, rapid access, magnetic disk for storage and manipulation of regularly used GIS data layers. Storage space requirements would be for actual data storage and for workspace associated with data base management.

(d) Printer/Plotter

Color pen plotters, several color electrostatic plotters for larger operations, and line and letter-quality printers.

(e) Communications

Local Area Network (LAN) is essential for larger GIS operations with multiple computing resources, extensive local file transfer, limited to moderate network file transfers and interactive processing, and limited to moderate tape Input/Output (I/O) requirements.

(f) Other equipment.

- CD readers for selected sites.
- Digitizers at all sites (may be multifunctional not just for data management).
- Electromechanical and optical scanners for selected locations such as DDRL's.

See software and hardware summary tables for additional information and specifications.

Storage and Management

1992

(2) Please describe each identified activity and why it is needed.

Same as 1988 plus the following:

As indicated in the Conversion and Linking section of the data automation activity above, there should be capability to easily access other WRD data bases (such as NWIS and water use) and provide software to exchange data between each of these data bases and the GIS data base. There should be the capability to temporarily attach to and execute functions in other WRD data base management systems (NWIS, water use, and other GIS DBMS's) without actually leaving the original DBMS.

By 1992, transfer of data between various WRD data bases and the GIS data structure should be routine in order to take full advantage of all available hydrologic data for use in GIS applications. Data base management systems will most likely still be separate packages for most of the various WRD data bases, but because transfer of data between the various data bases will be a relatively routine occurrence, the individual data base management systems for GIS, NWIS, water use, and so forth will need to begin to be integrated from the standpoint of standardization of functions, structures, cross referencing of data, and such.

(3) Please describe the flow of information in this activity.

Same as for this activity in 1988, except the GIS and other DBMS's should have similar structure and flow of information.

(4) How many locations do this activity?

About 65 sites in 1992.

(5) How many times per year is this activity done?

About 11,250 in 1992.

(6) How many people per year do this activity?

About 150 total: approximately 80 for management and administration of GIS data bases at national, regional and district levels; the remainder using the GIS DBMS software package to manage data for larger GIS applications projects.

(7) How many hours per person per year are spent doing this activity?

About 75 hours per person, same types of distribution as discussed for this activity in 1988.

(8) Are there any special requirements for this activity?

Same as 1988 plus:

Efficient data formatting and conversion software packages. Data base management personnel must have working knowledge of a variety of WRD data base structures and operations. There should be coordination among data base managers and development of common standards for data base operations and functions whenever possible.

(9) Please describe any software requirements for this activity.

(a) Data base manager

Same as 1988 for this activity but with the following additions and enhancements:

Incorporation of some expert systems technology to automate and simplify data management functions. More automation of standardized functions, especially for:

- Development of dictionary contents and cataloging.
- QA-QC functions, error checking, and so forth.
- Transaction records and status reports.
- Improved data storage structures and faster and more sophisticated manipulation, retrieval, and update functions.

(b) Editor software

Same as 1988 for this activity, assuming incorporation of new software capabilities and packages as they become available and affordable.

(c) Graphics software

Same as 1988 for this activity, assuming incorporation of new software capabilities and packages as they become available and affordable.

(d) Programming languages

Same as 1988 for this activity, assuming incorporation of new software capabilities and packages as they become available and affordable.

(e) Statistics software

Same as 1988 for this activity, assuming incorporation of new software capabilities and packages as they become available and affordable.

(f) Spreadsheet software

Same as 1988 for this activity, assuming incorporation of new software capabilities and packages as they become available and affordable.

(g) Utility software

Same as 1988 for this activity, but with the addition of a series of user friendly, automated data conversion packages to reformat various hydrologic data for use with the GIS and vice versa.

(10) Please describe any equipment requirements for this activity.

(a) Display/Keyboard

Same as 1988 for this activity, but with a larger percentage of high resolution color graphics terminals.

(b) Processor

Same as 1988 for this activity, but with a larger percentage of workstations.

(c) Storage unit

Same types of categories of data storage as listed in 1988 for this activity, but with much larger data storage volumes in all categories as GIS applications and data bases continue to grow rapidly. New technologies for data storage may shift the balance of data storage among the categories listed (for instance, technology and cost may allow more on-line data).

(d) Printer/Plotter

Same as 1988 for this activity, but taking advantage of new technology available for input and output devices.

(e) Communications

Same as 1988 for this activity, but with larger volumes of data for all functions and increased use of shared computing storage and I/O resources for all levels of operations.

Storage and Management

1997

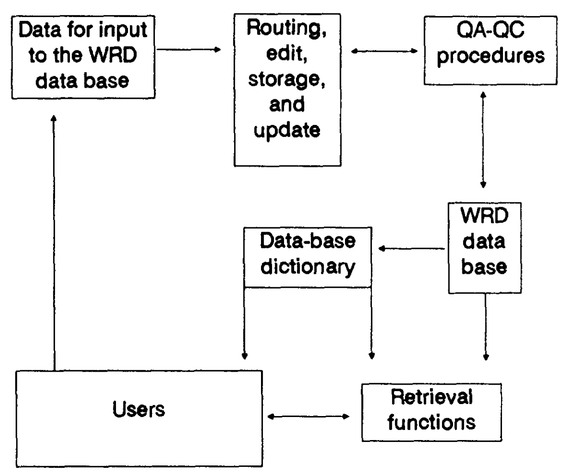
(2) Please describe each identified activity and why it is needed.

Same requirements for data storage and management as in previous years, however, by this date it should be feasible to manage virtually all of WRD's data bases with a single set of DBMS tools.

The requirements and justifications for data storage and management of GIS data are the same as those discussed in 1988 and 1992, however, by this date most hydrologic applications should regularly be using GIS technology requiring a variety of hydrologic and related data. WRD data sets that were treated as individual data bases in 1988 and 1992 will most likely have overlapped to such an extent in 1997 that they would frequently tend to merge into one another if treated separately.

The various types of data maintained by WRD will probably still require different structures for storage and manipulation. However, it should be feasible by this date to have developed a single DBMS package for managing the majority of WRD's data bases, and to maintain much of that data in a common format that would combine the advantages of GIS with those other hydrologic and related data base structures currently being used. The majority of the data stored and manipulated by WRD is spatially oriented, so the integration and merger of GIS technology and other data base structures would provide added functionality for management and application of these data.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

About 175 sites in 1997.

(5) How many times per year is this activity done?

About 10,000.

(6) How many people per year do this activity?

About 200 total; approximately 150 for management and administration of WRD data bases at national, regional and district levels; the remainder would be managing project level data bases for larger projects. Note: These figures are estimates for management of most WRD data bases under the structure in number 3 above. Since it is anticipated that most WRD hydrologic and related data bases will have a spatial (GIS) component, it is not realistic to try to identify spatial data as a unique category of "GIS" data in the scenario posed for 1997. Most all hydrologic data will, in a sense, be GIS data.

(7) How many hours per person per year are spent doing this activity?

About 50 hours per person, same types of distribution as discussed for 1988.

(8) Are there any special requirements for this activity?

Same as for previous years. Data base management teams with expertise in various types of data and data management functions will be required for national, regional, and most district data base management.

(9) Please describe any software requirements for this activity.

(a) Data base manager

Many of the same software requirements as in previous years, but now a single data base management system will be managing the majority of WRD hydrologic and related data as opposed to the DBMS managing "GIS" data in previous years.

There should be general incorporation of export systems technology in many of the DBMS functions.

There will be continued automation of more and more routine DBMS functions.

(b-f)

Same as 1992 for these activities, with respect to spatial data components. Other software packages are, undoubtedly, required for management of other components of hydrologic and related data.

(g) Utility software

See software and hardware summary tables for additional information and specifications.

(10) Please describe any equipment requirements for this activity.

With the assumed merger and integration of what is now referred to as GIS data into most of WRD's hydrologic and related data bases, it will become almost impossible to separate out hardware requirements for storage and management of spatial data. For estimates of hardware requirements for GIS activities in 1997 refer to the software and hardware summary tables.

Query and Retrieval

1988

(2) Please describe each identified activity and why it is needed.

This activity addresses the functions associated with the query and subsequent retrieval of data from GIS data bases using the data base management system (DBMS) structure that was proposed as part of the storage and management activity of the GIS data base management activity. Consequently, frequent reference will be made to functions and capabilities discussed as part of the storage and management function.

The query and retrieval activity is principally a "user" function involving identification of data in the GIS data bases, selection of specific data from the data base, and subsequent retrieval of that data for use. The discussions for this activity will pertain primarily to national, regional, and district level GIS data bases which are generally managed as read only, protected data bases from the user perspective. However, many of the functions and capabilities discussed here could pertain to large project level data bases.

(3) Please describe the flow of information in this activity.

See item number 3 of the 1988 storage and management activity.

(4) How many locations do this activity?

There will be 42 WRD locations with computer facilities and access to data bases.

(5) How many times per year is this activity done?

Estimate 40,000.

(6) How many people per year do this activity?

Approximately 200 (assumes that data bases are only partially populated and not fully functional for the next several years).

(7) How many hours per person per year are spent doing this activity?

About 50 hours per person

(8) Are there any special requirements for this activity?

- Knowledge of GIS data structures and use.
- Read only access, security protected data base.

- Interactive query and moderately fast retrieval capabilities.

(9) Please describe any software requirements for this activity.

(a) Data base manager

Refer to item 9a of storage and management activity discussions of:

- Data base dictionary
- Data base structures
- File access methods

Data dictionary should provide capability to view the contents of the data base from a variety of perspectives (area of coverage, layer type, attributes, feature types, and so forth) and at varying levels of detail (ranging from summary overviews to detailed coverage information such as attribute definitions, coverage status, history files, and so forth). The dictionary should be user friendly, menu driven, and allow direct access to more detailed levels in the tree structure for experienced data base users.

The software should provide the capability of logging selected aspects of the dictionary data for use in developing reports of data contents or a "command file" for subsequent retrieval of data. The dictionary software should have the capability of providing graphics for displaying the data base structure and contents.

Some graphics and more interface capability should be provided such as allowing retrieval of information for data layers by pointing to the area on a map of the "files" contained in the data base.

The software should provide the capability to retrieve data by any combination of the following: map layers, spatial features, areas, attributes, and other selected categories defined in the data base structure. Relational data base query functions should be part of this retrieval capability.

Data retrievals should be available in a variety of formats; download to workspace in GIS format, reformatted "export" type files for tape transfer, hardcopy output, and so forth. Attributes must be able to be retrieved and manipulated independently of spatial data files if desired.

(b-g)

Refer to items 9b through 9g of 1988 storage and management activity and the software and hardware tables.

(10) Please describe any equipment requirements for this activity.

Refer to item 10 of 1988 storage and management activity and the software and hardware tables.

Query and Retrieval

1992

(2) Please describe each identified activity and why it is needed.

Same as 1988 for this activity. Also refer to 1992 storage and management activity, item 2. The query and retrieval activity will still pertain primarily to the GIS DBMS activity in 1992. However, there should be standardization of functions and structure between the GIS DBMS and other WRD DBMS's so that from the users perspective the query and retrieval process is similar for most of the hydrologic and related data bases. Also, there should be some incorporation of AI in query and retrieval activities.

(3) Please describe the flow of information in this activity.

See item 3 of the 1992 storage and management activity.

(4) How many locations do this activity?

About 65 sites in 1992.

(5) How many times per year is this activity done?

Estimate 96,000 times.

(6) How many people per year do this activity?

Approximately 600.

(7) How many hours per person per year are spent doing this activity?

About 40 hours per person – highly variable, some people much more time and some considerably less. This estimate assumes easy, rapid access of data from a well populated data base containing a variety of base map and other GIS data.

(8) Are there any special requirements for this activity?

Same as 1988 for this activity, plus the capability to easily reformat and transfer data between the GIS and other hydrologic data structures. Also, by this date, there should be considerable standardization among data bases and DBMS's for the various WRD hydrologic and related data bases in order to simplify data query and retrieval.

(9) Please describe any software requirements for this activity.

Same as 1988 for this activity, plus the dictionary capabilities should provide some information about data contained in other WRD data bases.

(10) Please describe any equipment requirements for this activity.

Refer to item 10 of 1988 storage and management activity and the software and hardware tables.

Query and Retrieval

1997

(2) Please describe each identified activity and why it is needed.

Same as 1988 for this activity. Also, refer to item 2 for 1997 storage and management activity. Integration of WRD data bases under a single DBMS will result in a set of query and retrieval functions for a variety of WRD hydrologic and related data bases, many of which have a GIS component.

Refer to discussions of this activity for previous years, and to item 2 for the 1997 storage and management activity which describes the integrated DBMS scenario. The integration of the majority of WRD's data bases under a single DBMS framework would allow the user to conduct query and retrieval of a variety of data using a single system with integrated and standardized functions. The integrated DBMS would allow the user to obtain information about and selectively retrieve a variety of hydrologic and related data in a range of formats (such as GIS, tabular, hardcopy, file transfer, summaries, and so forth). All of the query and retrieval capabilities discussed for previous years would be available, plus any additional capabilities provided by new data structures, hardware, software, and so forth. It is anticipated that AI would be part of many of the DBMS functions along with extensive use of graphics for query and retrieval activities.

(3) Please describe the flow of information in this activity.

See item 3 of the 1997 storage and management activity for the diagram of information flow.

(4) How many locations do this activity?

175 sites by 1997.

(5) How many times per year is this activity done?

About 80,000 times.

(6) How many people per year do this activity?

About 1,000 WRD personnel, especially those involved in projects, basic data, publications, and computer operations.

(7) How many hours per person per year are spent doing this activity?

About 20 hours per person, with the same variability as discussed for item 7 of this activity in 1992.

(8) Are there any special requirements for this activity?

Refer to discussions for item 8 of this activity in 1992 and item 8 of the storage and management activity for all years.

(9) Please describe any software requirements for this activity.

Refer to item 9 of 1997 storage and management activity, the software and hardware tables, and discussions in item 2 of this activity.

(10) Please describe any equipment requirements for this activity.

Refer to item 10 of 1997 storage and management activity and the software and hardware tables.

Applications and Analysis

(1) Please identify the major activities performed.

The USGS currently is in the unusual position of being both a novice and an expert in the field of GIS analytical techniques: at one extreme, insufficient training is pervasive resulting in a lack of application of GIS technology in areas of information processing, reformatting, and dissemination (generally the primary application of GIS in the private sector); and, at the other extreme, a few pioneers have developed complex interfaces to transport information to and from the GIS topological processor and complex numerical and statistical models, often via intermediate processes which are used to smooth, filter, or interpolate the information. Descriptions and needs are defined below.

1988

(2) Please describe each identified activity and why it is needed.

Between the current time and 1992, the use of GIS as a pre- and post-processor for other applications will surge with most of the increase occurring by 1990 as specialized training peaks in 1987-88 (refer to Hydrologic Applications work group). The more classical use of GIS in information processing, reformatting, and dissemination will develop less rapidly because of a lack of online data storage facilities, a significant lack of flexibility to convert DBMS, the failure of the current GIS to effortlessly incorporate time-series data, and lack of training. The use of GIS to present the results of investigations will show a steady increase as GIS applications reach maturity (refer to Reports work group). GIS applications in the areas of management and administration will be initiated in the near future.

The current GIS software capabilities are (these are not the USGS functional applications listed later):

- GIS modeling
  - Continuous-surface analysis, slope, aspect, and slope areas
  - Volumetric analysis
  - Cross sections, profiles, and traverses
  - Discrete feature analysis of points, arcs, and polygons
  - Buffering and fuzzy-data analysis
  - Networking
- Boolean operations on spatial and attribute information
- Relational operations with other data files
- Topological operations between spatial GIS coverages
- Utility and elementary mathematical operations on the attribute data base
- Graphic presentation
- Image processing

These GIS capabilities are currently sufficient to allow the GIS to perform some USGS functional tasks without additional software support (at least, other than provided under the major headings of Data Automation, Data Base Management, Data Manipulation, and Output and Publication):

1. Runoff, recharge, and evapotranspiration determinations
2. Thematic map preparation
3. Drainage area delineation and determination
4. Data reduction for management decisions
5. Network analysis and optimization
6. Flow routing and time of travel
7. Resource and facility design, inventory and management
8. Cadastral analysis
9. Geomorphic analysis
10. Relational conditions and probabilities.

The above applications exemplify those which are currently the least utilized but show the greatest potential for steady expansion. User and resource involvement will expand systematically as these applications come into common use over the period 1988–92.

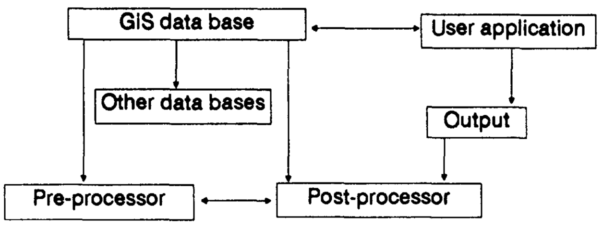
Other applications currently use GIS, as a pre- and post-processor to prepare data for further processing by complex numerical and statistical models, thereby taking advantage of the GIS's inherent analytical and mapping abilities to manipulate spatial data. These other applications include:

11. Ground-water flow numerical models
12. Surface-water flow numerical models
13. Statistical models.

Often, the conversion process includes filtering and smoothing of data through other software programs. Afterwards, the results of the models are often reintegrated with the GIS for further analysis and illustration production. This process often involves contouring of the model results prior to automated entry into the GIS. These satellite applications (filtering, modeling, and contouring) show the highest level of sophistication but usually have a very convoluted relation with the GIS. Currently scheduled training will rapidly desiminate these GIS-to-satellite skills to a wide audience of professionals, quickly expanding GIS usage and, therefore, both CPU and data storage requirements.

The GIS has also been loosely linked with other data bases (NWIS) and software packages (ISM, Surface II, P-STAT, and SAS). Use of these capabilities currently is limited but will expand as GIS-based modeling efforts increase (see the section on Data Automation).

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

All GIS sites, 42 in 1988, carry out one or more of these activities.

(5) How many times per year is this activity done?

Each site will have someone online all the time, see composite table SD-III–6.

(6) How many people per year do this activity?

See composite table SD-III–6.

(7) How many hours per person per year are spent doing this activity?

See composite table SD-III–6.

(8) Are there any special requirements for this activity?

(9) Please describe any software requirements for this activity.

See tables SD-III–1 through SD-III–5.

(10) Please describe any equipment requirements for this activity.

See tables SD-III–1 through SD-III–5.

1992

(2) Please describe each identified activity and why it is needed.

The functional applications for GIS during the period 1992–97 should be very similar to the previous period but the use of the GIS to fulfill these applications will be widespread and at all skill and technical levels. The goals for GIS capabilities should include direct incorporation of sophisticated optimization procedures in the GIS, unification of the GIS with complex numerical and statistical models, integration of all spatial data files into the GIS, and the ability of the GIS to incorporate time-series in its relational data structure. Finally, the GIS should be under a very powerful umbrella DBMS which can channel into any of the functional activities of the USGS (refer to the section Data Base Management).

Because not all public and private concerns use the same GIS, it is imperative that a comprehensive national standard for exchange of digital spatial data be enforced by this time period.

Hardware procurements for online data storage should be made with the anticipation of the conversion and linking of all current "flat" water data bases (SWUDS or IRIS, ADAPS, NWIS, WATSTORE, and RTSYS) to the GIS and the acquisition of massive digital data bases (thematic maps, DEMs, and DLGs) from other sources. Because the number and size of GIS coverages will increase dramatically, CPU and memory procurements must accommodate a minimum two-order and probable four-order of magnitude increase in processing requirements for topological functions (building coverages, intersections, unions, and so forth) which are very CPU intensive and normally require temporary work space areas that are three to four times the size of the original coverage.

During this timeframe, remarkable increases in use of GIS to perform virtually all of the previously listed USGS functions can be expected. Some functions should show remarkable increases:

2. Thematic map preparation
7. Resource and facility design, inventory and management
9. Geomorphic analysis
10. Relational conditions and probabilities
11. Ground-water flow numerical models
12. Surface-water flow numerical models
13. Statistical models

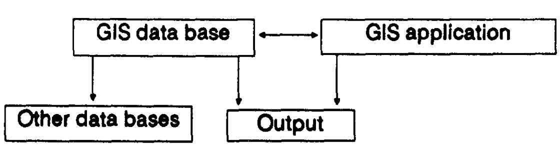
Emphasis must be placed on the evolution of the GIS tool into an integrated system guided by knowledge-based programming and supported by object-oriented data structures (see the section Advanced GIS Applications). This structure will allow the GIS to function as a background process to perform such tasks as interfacing data and models, cataloging and reporting on information availability, and providing information for management and administrative decisions.

Table SD-III-6. – *Composite table of manpower estimates for applications and analysis, 1988-97*

[Individuals may be included under several categories]

Application	Number of locations			Number of times performed per year			Number of people			Number of hours per person per year		
	1988	1992	1997	1988	1992	1997	1988	1992	1997	1988	1992	1997
Runoff, recharge and evapotranspiration determinations	15	40	100	750	1,600	3,000	15	40	100	100	80	60
Thematic map preparation	42	65	175	10,000	15,000	20,000	100	300	400	200	100	100
Drainage area delineation and determination	42	65	175	840	1,300	1,750	42	65	175	10	10	5
Data reduction for management decisions	42	65	175	1,680	8,000	14,000	42	100	175	20	40	40
Network analysis and optimization	15	20	40	750	750	1,000	15	20	40	100	75	50
Flow routing and time of travel	10	20	40	500	1,000	2,000	10	20	40	100	100	100
Resource and facility design, inventory, and management	10	40	50	1,000	4,000	5,000	10	40	50	100	100	100
Cadastral analysis	10	20	20	400	2,000	2,000	10	20	20	40	100	100
Geomorphic analysis	30	65	175	1,500	5,000	10,000	30	100	200	100	100	100
Relational conditions and probabilities	42	65	100	2,100	6,000	6,000	42	120	150	100	100	80
Ground-water flow numerical models	20	65	100	3,000	13,500	20,000	60	300	500	100	90	80
Surface-water flow numerical models	10	50	65	500	2,250	4,000	10	50	100	100	90	80
Statistical models	15	65	65	1,500	5,200	8,000	15	65	100	100	80	80

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

See table SD-III-6 in 1988 form.

(5) How many times per year is this activity done?

See table SD-III-6 in 1988 form.

(6) How many people per year do this activity?

See table SD-III-6 in 1988 form.

(7) How many hours per person per year are spent doing this activity?

See table SD-III-6 in 1988 form.

(8) Are there any special requirements for this activity?

(9) Please describe any software requirements for this activity.

See tables SD-III-1 through SD-III-5.

(10) Please describe any equipment requirements for this activity.

See tables SD-III-1 through SD-III-5.

1997

(2) Please describe each identified activity and why it is needed.

Unless the mission of the Survey, and specifically the WRD, is changed, the list of GIS applications, expected to mature during 1992-97, will not appreciably change beyond 1997. However, the scope of these applications may increase to include modeling and analysis of natural phenomenon on a very large or even global scale. The software to support these applications must operate in spherical as well as cartesian coordinates, while the hardware needs to be of a CRAY-type speed (1,000 MIPS) and capable of fully three-dimensional visualizations.

(3) Please describe the flow of information in this activity.

Same as for 1992.

(4) How many locations do this activity?

See table SD-III-6 in 1988 form.

(5) How many times per year is this activity done?

See table SD-III-6 in 1988 form.

(6) How many people per year do this activity?

See table SD-III-6 in 1988 form.

(7) How many hours per person per year are spent doing this activity?

See table SD-III-6 in 1988 form.

(8) Are there any special requirements for this activity?

(9) Please describe any software requirements for this activity.

See tables SD-III-1 through SD-III-5.

(10) Please describe any equipment requirements for this activity.

See tables SD-III-1 through SD-III-5.

Output and Publication

(1) Please identify the major activities performed.

The GIS output and publication activities involve the output of data, graphics, and text for use in review, analysis, and publication of GIS related products. Outputs are in the form of printouts, plots, screen displays, magnetic media, CD-ROM, or perhaps even video. There are five definable elements within the GIS output activity:

- Generation of working products
- Text and graphics integration and graphics labeling
- Generation of publication quality products
- Generation of data products
- Visualization

Generation of Working Products

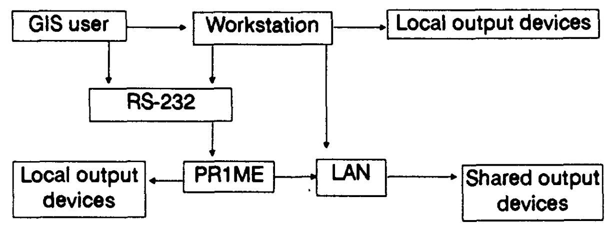
(2) Please describe each identified activity and why it is needed.

Efficient and rapid generation of high resolution, color graphics, either plots or screen displays, is a requirement at the working level of all GIS activities. Color working copies or displays are necessary for the review of data and analysis, for keeping track of progress in data input and analysis activities, and for quickly evaluating data analysis and presentation strategies. Page size screen dump plotters are now available at reasonable cost. However, when available at a reasonable cost, implementation of color electrostatic plotters will add to efficiency.

In the next few years, considerable efficiencies can be gained by moving into the workstation environment, particularly in screen resolution and response.

Improvements in the quality of our technical and interpretive products will occur if outputs of iterative processes can be sped up, that is if the time between generation and review is fairly immediate.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

All locations will need working copy outputs, the number of workstations and newer devices at each location will increase with time.

1988 = 42
1992 = 65
1997 = 175

(5) How many times per year is this activity done?

Generating working copies and displays is an ongoing activity for all users at all sites. Frequency of need is a function of whether a user is a full-time or project-oriented GIS user, and by the phase of the project. At sites with one full-time GIS user and five or more intensive project users (modelers), this activity will probably require redundancy of output devices and some sort of LAN to link users and workstations with devices.

1988 = 96,000
1992 = 160,000
1997 = 156,000

By 1992, workstations and LAN's should be common place, allowing more sharing and efficiency of output. 1997?

(6) How many people per year do this activity?

Most users at every site will be involved in this activity.

1988 = 300
1992 = 1,000
1997 = 1,300

(7) How many hours per person per year are spent doing this activity?

1988 = 1.0 hour per day x 80 days per year = 80 hours per person per year

1992 = 0.5 hour per day x 80 days per year = 40 hours per person per year

1997 = 0.5 hour per day x 60 days per year = 30 hours per person per year

(8) Are there any special requirements for this activity?

Training on the use of equipment and on the software to drive it will be an ongoing and important requirement. The development of LAN technology and its application for linking systems and equipment could be a limiting factor in the progress in this area, through 1992. Beyond?

(9) Please describe any software requirements for this activity.

See tables SD-III-1 through SD-III-5.

(10) Please describe any equipment requirements for this activity.

See tables SD-III-1 through SD-III-5.

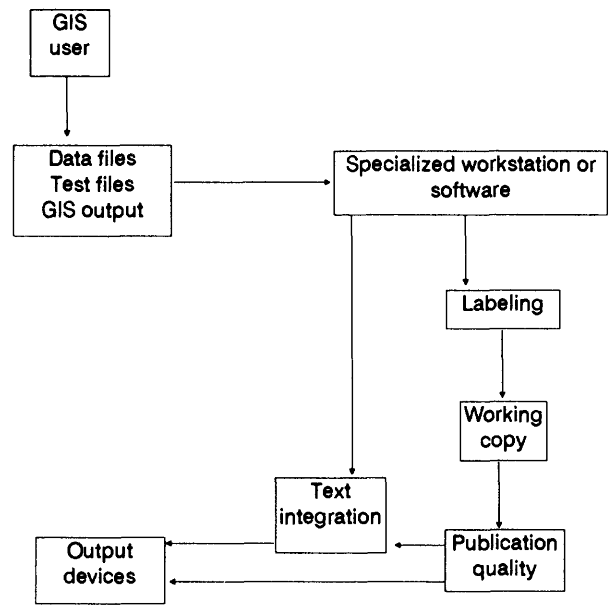
Text and Graphics Integration and Graphics Labeling

(2) Please describe each identified activity and why it is needed.

Efficient and rapid processing of graphics in order to provide labeling or to integrate text with graphics is a current need of most GIS operations. Existing labeling procedures are cumbersome and time consuming, whereas, the computerized integration of text with graphics is a technology that is essentially non-existent in the WRD field offices. Improvements in either or both will speed review and publication activities.

There is an immediate need for a software routine, preferably within the interactive environment of ARC/INFO, that allows for more efficient placement, movement, and editing of textual materials on maps and other graphics outputs. Text integration with graphics, although desirable, is something that will take 3 to 4 years before it becomes commonplace. Beyond 1992 it is difficult to say anything more than improved efficiency by automation and reduction of trial and error is a must if GIS users are to have more time to do analyses, instead of clerical tasks.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

All locations will need improved labeling procedures for all years.

1988 = 42
1992 = 65
1997 = 175

Text integration, on the other hand, is a more specialized duty of publications units at each site and we will see a gradual movement to this technology.

1988 = 10
1992 = 30
1997 = 65

(5) How many times per year is this activity done?

Labeling tasks currently occupy about 1 hour per day while in session (day). However, with an efficient labeling package that time probably could be cut in half.

Estimates are:

1988 = 300 users x 2 times per day x 40 days = 24,000 times per year

1992 = 1,000 users x 2 times per day x 30 days = 60,000 times per year

1997 = 1,300 users x 2 times per day x 20 days = 52,000 times per year

Text integration with graphics is a function of the number of publications per site per year and the extent to which the sites go to this technology. The use is best defined by number of reports using this technology.

1988 = 200 reports x 10 times per report = 2,000 times per year

1992 = 500 reports x 10 times per report = 5,000 times per year

1997 = 800 reports x 10 times per report = 8,000 times per year

(6) How many people per year do this activity?

All users at every site will be involved in the labeling activity.

1988 = 300 users
1992 = 1,000 users
1997 = 1,300 users

Text integration with graphics will have considerably fewer users.

1988 = 10 users
1992 = 50 users
1997 = 80 users

(7) How many hours per person per year are spent doing this activity?

Labeling estimates:

1988 = 1.0 hour per day x 40 days per year = 40 hours per person per year

1992 = 0.5 hour per day x 30 days per year = 15 hours per person per year

1997 = 0.5 hour per day x 20 days per year = 10 hours per person per year

Text integration estimates:

1988 = 200 hours
1992 = 100 hours
1997 = 100 hours

(8) Are there any special requirements for this activity?

There may be a need for specialized equipment, such as page size screens for text integration and for development or integration of a specialized labeling package in ARC/INFO over the next few years. Beyond 1992 these will be common, but perhaps knowledge-based programming will make this less specialized and speed this activity.

(9) Please describe any software requirements for this activity.

See tables SD-III-1 through SD-III-5.

(10) Please describe any equipment requirements for this activity.

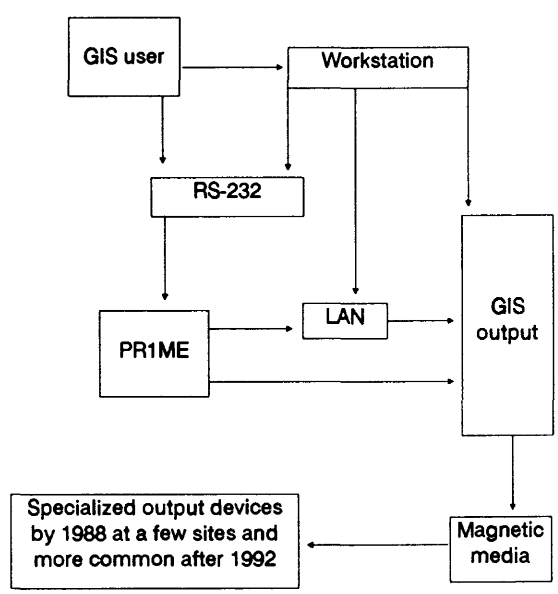
See tables SD-III-1 through SD-III-5.

Generation of Publication Quality Products

(2) Please describe each identified activity and why it is needed.

Published reports and maps are the WRD's principle products and are the key means by which the WRD scientists communicate what was learned from data collection and analysis. GIS not only is the new tool offering efficiencies in these tasks, but also allows for the production of publication quality maps and graphics directly from the GIS and bypassing traditional, manpower intensive drafting. It also may allow for a shortening of the time it takes to get our products into print.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

1988 = 4 sites
1992 = 10 sites
1997 = 25 sites

(5) How many times per year is this activity done?

Generating publication quality products is limited at this point by a general lack of expertise and the high cost of equipment. The technology or know-how will filter down. The number of times this will be done is a function of cost effectiveness of producing maps and plates, and is likely reserved for a few years to reports with a large number of maps and for Hydrologic Atlas type products. As the experience level increases and cost of equipment decreases, more demand for the technology and equipment will result.

1988 = 2,000 times
1992 = 10,000 times
1997 = 25,000 times

(6) How many people per year do this activity?

1988 = 10 users
1992 = 100 users
1997 = 500 users

(7) How many hours per person per year are spent doing this activity?

1988 = 200 hours per person per year
1992 = 100 hours per person per year
1997 = 50 hours per person per year

(8) Are there any special requirements for this activity?

Training on the use of equipment and on the software to drive it will be an ongoing and important requirement. The development of LAN technology and its application for linking systems and equipment could be a limiting factor in the progress in this area in the 1990's. Beyond?

(9) Please describe any software requirements for this activity.

See tables SD-III-1 through SD-III-5.

(10) Please describe any equipment requirements for this activity.

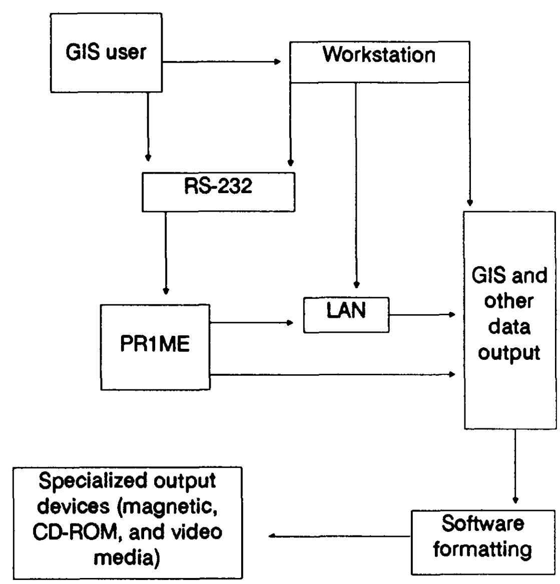
See tables SD-III-1 through SD-III-5.

Generation of Data Products

(2) Please describe each identified activity and why it is needed.

Historically, data products of the WRD have been in the form of tables in paper reports. More recently, magnetic media (tapes and floppies) have been used to provide large data sets to computer oriented users upon request. Newer technologies (CD-ROM's and high-density floppies) should be investigated for their cost effectiveness and potential low cost of distributing data to the public. Video media also shows promise for transfer of modeling and other time-series graphical outputs to higher level users (other scientists and water managers, see Visualization activities). The whole concept of how WRD delivers products needs to be re-evaluated in view of some of these new technologies and is covered more by the Reports work group report.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

1988 = CD-ROM contract or at two sites for other media for data reports

10 or more sites have floppy distribution for data requests

1992 = 10 sites for data reports

50 sites for data requests

1997 = 25 sites for data reports

65 sites for data requests

(5) How many times per year is this activity done?

Frequency of generating data products will depend upon the number of data reports and the number of data requests per year. The use of floppies is probably feasible in 1988, but not likely to occur divisionwide. By 1992, some divisionwide distribution technique will be used, likely CD-ROM. All major data requests should be answered by use of some magnetic media by all sites by 1992, if not sooner as the technology and need is there.

1988 = 1,000 times for reports
600 times for requests
1992 = 3,000 times for reports
2,000 times for requests
1997 = 5,000 times for reports
2,600 times for requests

(6) How many people per year do this activity?

1988 = 5 for data reports, 15 for data requests
1992 = 15 for data reports, 50 for data requests
1997 = 25 for data reports, 65 for data requests

(7) How many hours per person per year are spent doing this activity?

1988 = 200 for reports, 10 for requests
1992 = 200 for reports, 10 for requests
1997 = 200 for reports, 10 for requests

(8) Are there any special requirements for this activity?

Training on the use of equipment and on the software to drive it will be an ongoing and important requirement. May need a contract for CD-ROM for 1989+. Data formats for these digital media reports will have to be developed and adopted in order to standardize output for contract or otherwise. Use of these specialized and new media will require research for economic and timeliness of distribution.

(9) Please describe any software requirements for this activity.

See tables SD-III-1 through SD-III-5.

(10) Please describe any equipment requirements for this activity.

See tables SD-III-1 through SD-III-5.

Visualization

(2) Please describe each identified activity and why it is needed.

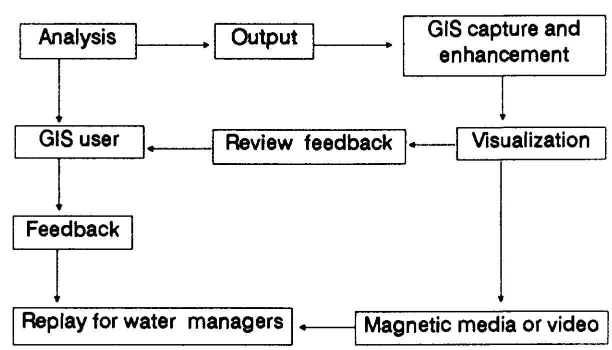
Visualization is the process of capturing and displaying GIS output, either single-image or time-stepped multi-image outputs, in order to enhance the users ability to review, interpret, analyze or to more efficiently pass on information of an interpretive nature to the water resources managers.

A single image application might involve the use of a draping feature to add an existing coverage to an ongoing analysis of another coverage. For instance, to be capable of interactively adding the stream network and basin boundaries or land cover characteristics to a three-dimensional perspective of land surface on a high resolution, color graphics monitor, and then; quickly refresh for another angle of perspective for further review of the same information. The multi-image application would be useful for quickly analyzing the time-series output of a hydrologic model by rapidly displaying each time-step output in a movie-like fashion for the modeler or water manager to actually see the consequences of various model calibration adjustments or model scenarios.

Although the high-resolution monitors are currently available, larger sizes (on the order of 2x3 feet or 3x4 feet) are probably necessary to display the detail needed for many of the modeling efforts.

The software is not yet there, at least not completely, in order to implement these tasks within the interactive environment of ARC/INFO. Hopefully, this concept will become commonplace by 1992 or shortly thereafter.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

1988 = 10 sites
1992 = 25 sites
1997 = 65 sites

(5) How many times per year is this activity done?

Visualization would be used by higher level GIS users and modelers on an intermittent basis. The use of single frame perspectives with draping would be more commonplace, whereas the building of multiple frames for playback would be less common and would be more specific to time-series modeling.

1988 = 2,000 times per year
1992 = 20,000 times per year
1992 = 40,000 times per year

(6) How many people per year do this activity?

1988 = 10
1992 = 200
1997 = 500

(7) How many hours per person per year are spent doing this activity?

1988 = 100 hours per year
1992 = 50 hours per year
1997 = 40 hours per year

(8) Are there any special requirements for this activity?

Visualization will require development of specialized software routines. Draping is available to some degree on the Integrated Surface Model (ISM), but not in ARC/INFO, whereas the multiple time-steps outputs from ARC/INFO need to be downloaded to a micro system (PC with Enhanced Graphics Adapter (EGA) board) where the screen bit map (PIC files) is captured, stored, and a command file to read and refresh multiple frames is built for display. In either case, considerable manual intervention is needed and may be limiting the practicality of common use.

Software to streamline the process is needed. A workstation environment (like the SUN supermicrocomputer with high resolution color graphics) is probably where this activity would find the power for more applications. Also, as the size and resolution of color graphic monitors increases, or the use of windows or dual monitors to gain detail for subareas of the full model area increases, the use of visualization will give the detail necessary for certain modeling efforts and thereby increase its popularity. This is potentially a highly useful tool, more for the 1990's than for current applications.

(9) Please describe any software requirements for this activity.

See tables SD-III-1 through SD-III-5.

(10) Please describe any equipment requirements for this activity.

See tables SD-III-1 through SD-III-5.

Advanced Geographic Information Systems (GIS) Analysis

(1) Please identify the major activities performed.

Advanced GIS analysis is the activity defined here as the research and development of newer and improved software systems for managing and analyzing GIS data. The activity is oriented towards the feedback process between high level GIS users and vendor and university communities, whereby, needs and techniques are communicated, improved upon, and later implemented through revisions of and linkages with appropriate software systems. There are two arenas currently identified within the advanced GIS analysis activity:

- Knowledge-based GIS (KBGIS)
- Alternative GIS data structures

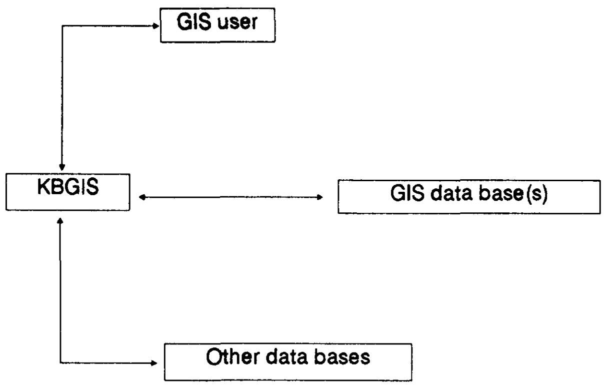
Both activities are critical in providing for the more efficient application of GIS techniques in the future. Descriptions and needs are defined below.

Knowledge-Based Geographic Information Systems (KBGIS)

(2) Please describe each identified activity and why it is needed.

Knowledge-based GIS (KBGIS) is the application of expert rules to the analysis of spatial data. It is necessary to achieve greater efficiency and reduce errors, particularly in operations that involve querying another data base or entering data into a data base. In 1988, KBGIS still will be very much in the development stages. Some expert systems, currently available on PC-type computers, could be applied to small GIS problems. Larger KBGIS applications will likely require dedicated artificial intelligence computers running LISP or PROLOG languages and are probably beyond WRD current expertise. By 1992, there will probably be a number of practical KBGIS applications within the workstation environment, but it is uncertain whether KBGIS software will be a stand alone package or integrated into the existing GIS software. By 1997, KBGIS will probably move out of the advanced and into the operational GIS analysis activity.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

1988 = 5
1992 = 25
1997 = 25

(5) How many times per year is this activity done?

Activities are done on an intermittent basis where KBGIS software are being developed and implemented. Once implemented, however, frequency will be much more continuous.

1988 = 500
1992 = 1,250
1997 = 1,250

(6) How many people per year do this activity?

This research activity is probably limited to a select number of highly computer oriented GIS users, that is, as long as it is an advanced GIS activity.

1988 = 10
1992 = 50
1997 = 50

(7) How many hours per person per year are spent doing this activity?

1988 = 200
1992 = 100
1997 = 100

(8) Are there any special requirements for this activity?

Specialized software and, perhaps, hardware are needed. Also, specialized expertise needs to be developed or acquired for these activities.

(9) Please describe any software requirements for this activity.

See tables SD-III–1 through SD-III–5.

(10) Please describe any equipment requirements for this activity.

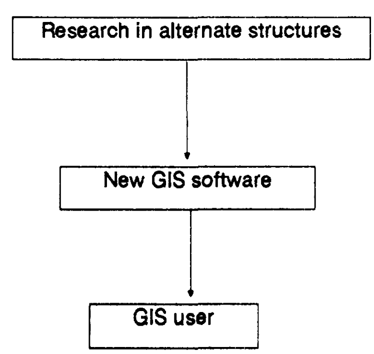
See tables SD-III–1 through SD-III–5.

Alternative Geographic Information Systems (GIS) Data Structures

(2) Please describe each identified activity and why it is needed.

Alternative GIS data structures is a research activity exploring the use of artificial intelligence and newer GIS concepts (such as object-oriented structures) in order to more effectively represent spatial hydrologic data and permit the development of more advanced hydrologic models. Not much activity is expected until the 1990's and will be centered around a few research level hydrologic modelers and the academic and vendor research community. By 1992, some modeling projects will be experimenting with these concepts and by 1997, more common applications will filter down to the GIS operations. As a result of this research, it is quite possible by 1997 that we will see an entirely different GIS software structure than we see in 1988.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

1988 = 2
1992 = 6
1997 = 25

(5) How many times per year is this activity done?

Activity will be very intermittent and isolated to a few researchers, probably until the mid-1990's, when several researchers will be almost continuously active and more common usage will filter down to GIS applications.

1988 = 100
1992 = 500
1997 = 2,500

(6) How many people per year do this activity?

1988 = 2
1992 = 10
1997 = 100

(7) How many hours per person per year are spent doing this activity?

1988 = 200
1992 = 200
1997 = 100

(8) Are there any special requirements for this activity?

Specialized expertise needs to be developed or acquired for these activities.

(9) Please describe any software requirements for this activity.

See tables SD-III–1 through SD-III–5.

(10) Please describe any equipment requirements for this activity.

See tables SD-III–1 through SD-III–5.

SUPPLEMENTARY DATA IV.--Reports and Electronic Publishing Work Group

page 107 follows

Manuscript Preparation and Text Processing

(1) Please identify the major activities performed.

Manuscript preparation and text processing

(2) Please describe each identified activity and why it is needed in 1988, 1992, and 1997.

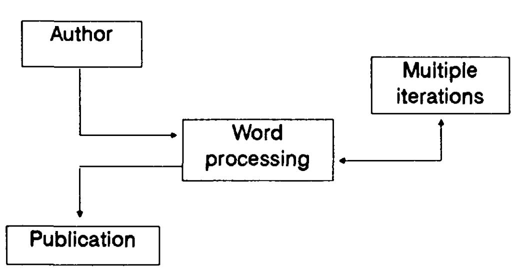
The mission of the U.S. Geological Survey (USGS) is to provide geologic, topographic, and hydrologic information that contributes to the wise management of the Nation's natural resources and that promotes the health, safety, and well-being of the people (U.S. Geological Survey, 1986). An essential part of accomplishing this mission is publishing reports and maps, establishing earth-science data bases, and disseminating earth-science data and information.

One of the goals of the USGS (U.S. Geological Survey, 1986) is to improve dissemination of the knowledge developed by Survey programs so as to enhance timely public and private sector access in ways that are responsive to changing needs.

Manuscript preparation and text processing is one of the first steps toward publication of Survey knowledge and is the thread that holds the other pieces together. As such, it must be solid, workable, accessible, and dynamic.

Manuscript preparation and text processing needs are historic and will continue until the USGS mandate changes. Water Resources Division (WRD) personnel levels have been static for some time and little change is expected in the next decade. The way manuscripts are prepared and text processed will change during the next decade. It is expected that 2 percent more reports will be published annually.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

An average of 230 which includes all WRD locations plus cooperators and affiliates.

(5) How many times per year is this activity done?

Word processing is done continuously as part of the report preparation process.

2,200 authors x 130 days =	286,000
200 editors x 260 days =	52,000
	338,000

This is constant through all periods.

(6) How many people per year do this activity?

The Water Resources Division approves for publication 800 reports and 700 abstracts each year. Several assumptions are made: 800 reports and 700 abstracts is equivalent (for word processing) to 900 full reports; each report may have multiple authors for which the number is unknown; each report is considered to have the full-time equivalent of one author; each equivalent report per year has a comparable full-time author. These assumptions should allow for the fact that the authors have multiple reports, that some authors do not produce a report per year due to the long-term nature of projects; some authors, especially researchers, produce multiple reports and articles per year.

Any one of WRD's 4,000 employees could be the author of a report and therefore could be involved in word processing. However, most field personnel involved in word processing would be those in certain fields such as reports, hydrology, computer science, and other technical areas.

Editors	200
Scientific-technical personnel	2,200
People doing word processing each year	2,400

(7) How many hours per person per year are spent doing this activity?

Authors:	142 hours
Editors:	696 hours

This is constant through all periods.

(8) Are there any special requirements for this activity?

1988

A. Need two levels of access and implementation:

- A basic level that is fast, simplistic, and icon and menu driven
- An advanced level that has all format functions for editing and layout

B. Must be machine independent for output device

C. Must be able to receive and transmit files from and to other, varied sources (Geologic Division (GD), cooperators, and so forth) using a neutral format.

D. Must be able to create a genealogy of all documents (who changed and when) and location (path) of each generation of the report. Must be able to preserve the integrity of the original while preserving any changes.

E. Ergonomics: Contrast and brightness of screens must be user-controllable. Position (tilt and working height) of screens, and keyboards must be user-controllable. Glare protectors and different screen combinations must be available to suit user comfort needs. Screens must meet minimum Occupational Safety and Health Administration (OSHA) standards for emissions.

1992

Same as for 1988 with the addition of:

- Need multilayered levels of access and implementation, from the most basic (simple) to the most advanced. User can choose the level of difficulty or sophistication that best suits his needs.
- Need to create a WRD standard character set with extended math and Greek that can be used on all WRD systems.
- Bibliographic searches of Georef and CSIN bibliographic data bases with insertion of complete reference.

1997

Same as for 1988 and 1992.

(9) Please describe any software requirements for this activity.

1988

Text processing software requirements

Ability to define and relate certain variables. Such as if a page number, table number, or reference is mentioned in text more than once, and that number or reference changes, all occurrences of that number or reference will automatically be changed.

Cursor Movement

Separate cursor keys (not numeric pad)
Numeric pad is usable (unaffected by downloaded functions)
Beginning of file or end of file
Character right or left
End of line or beginning of line
Find backwards (reverse find)
Go to page number
Page up or page down
Screen up or screen down
Top of screen or bottom of screen
Word right or left
Delete, Move, and Copy
Block
Character at cursor
Character left of cursor
Column or rectangle
Cursor to end of line
Cursor to end of page
Cursor to start of line
Line
Word
Paragraph
Page

Print time formatting

Change to new page number
Change font
Support horizontal and vertical motion index (HMI and VMI)
Include text with page number
Justify proportionally spaced text
Support many printers
Margins: top, bottom, page length
Page number placement
Proportional spacing
Set starting page number
Single sheet or continuous paper
Start and stop print any page
Change spacing at print time with automatic reformat of page

On-screen formatting

Bold
Center line
Center block
Center page top and bottom
Decimal columns
Delete formatting codes
Document comments (text, not printed)
Find formatting codes
Flush right, ragged left
Hanging indent
Hard page-end
Hard space
Hyphenation (auto or manual)
Hyphenation (dictionary)
Import graphics
Indent left and right margins (temporary)

Insert code to print date and time
Justify or nonjustify
Line spacing 1-3 (including halves)
List generation (illustrations, tables, or headings)
Margin release, left
Overstrike
Protect block (from page breaks)
Redline
Reformat all text to new margins, (automatically)
Remove redline and strikeout text
Search & replace (auto and manual)
Search & replace (forward or backward)
Search & replace, case sensitive on or off
Set tabs
Set lines per inch (LPI) at 6, 8, variable
Set margins left, right
Set characters per inch (CPI) at 10, 12, 17, or condensed
Show formatting codes
Strikeout
Style sheets
Super and subscript
Table of contents
Thesaurus
Underline any or all characters
Underline tabs and spaces on or off
Underline style, double or single
Undo deletions
Widow and orphan control
Windows and split screen (different documents)
Windows and split screen (same document)
Word wrap at end of line

Miscellaneous features

Align characters for decimal columns
Advance line 1/2 up or down
ASCII import and export
Case change
Color monitor support
Create directory
Dictionary (standard)
Dictionary (personalized)
Document descriptions
Edit while printing
File and directory management
Find and replace (forward)
Foreign alphabets
Go to operating system
Header and footer
Header and footer, alternating
Header and footer, alternating with variable text
Help (full on-line screens)
Index
Insert or typeover toggle
Insert file from disk
Keyboard, define keys to other characters
Line draw
Line numbering
Lock documents (password)
Mailing list and form letter (mail-merge)
Math (columns, horizontal, calculator)
Other file conversion
Outline numbering
Paragraph numbering
Preview document (as printed)
Print from screen
Print block
Print multiple documents (queue)
Printer commands, insert
Repeat command
Sheet feeder support
Sorting
Word count
WordMARC high resolution conversion
Macro definition and support
Full equation capabilities: multitiered with ability to use all alternate characters and oversized Greek and math.
Column layout function requirements for table formatting
Must be able to access without exiting file
Create word (text) columns
Create number columns
User does not have to determine spaces between columns
User does not have to determine where to set tabs
Centered columns
Flush right columns
Flush left columns
Decimally aligned columns
Headings centered over column
Word wrap in text columns
Automatic adjustment of tabs with changes
Automatic adjustment of spaces between columns with changes
Lined-up text tables (paragraphs in one column always begin on same line as paragraphs in another column) with word wrap
Delete or add entries within a column
Replace an entry within a column
Add an entire column to table

Copy or move a column within a table
Copy or move a column into another table
Adjust space between columns
Delete an entire column from table
View a portion of a large table (windowing)
Use any function (delete, copy, add, move) without affecting the position of other columns

Statistics package

Compute n
Compute mean
Compute median
Can be accessed without exiting file
Allow insertion of product into text

Math package

Add, subtract, multiply, divide
Percentages
Use math constant not in text
Can be accessed without exiting file
Allow insertion of total into text
Check totals in a column
Check totals in a row (horizontal)
Use as calculator

Math and statistics packages should be able to cross reference and update products automatically (that is, if it appears more than once in document).

1992

Text processing software requirements

Same as for 1988 with the addition of:

Change fonts within a file, page, line, or word
Headers and footers with alternate and special characters
Headers and footers with proportional spacing
Hyphenation (personalized and WRD)
Proportional spacing with centering
Proportional spacing in tables
Search and replace alternate and special characters
Set lines per inch at 6, 8, variable (user defined)
Set CPI 10, 12, 17, condensed, variable (user defined)
Two-column text
Two-column word wrap
WRD spelling dictionary (geographic terms)
WRD spelling dictionary (geologic names)
Scaling

1997

Text processing software requirements

Same as for 1988 and 1992 with the addition of artificial intelligence (AI) spelling checker; WRD spelling dictionary for geographic and geologic terms that will produce a reference (authority citation).

B. Data base manager:

1988, 1992, and 1997

Not applicable.

C. Editor software:

1988

All peripheral information must be generated by the software: table of contents, list of figures, list of tables, list of references, index, and glossary.

1992

Same as 1988 with the addition of:

Ability to change from one journal style and format to another (user defined).

Must produce list of cited references then interact with bibliographic search (such as Georef) to produce full reference.

Must do bibliographic searches of Georef and CSIN with insertion of complete reference.

1997

Same as 1988 and 1992 plus: must do bibliographic searches of major libraries.

D. Graphics software:

1988, 1992, and 1997

Must be integrated with word processing.

E. Programming languages:

1988, 1992, and 1997

Not applicable

F. Statistics software:

1988, 1992, and 1997

Need simple statistics and math as part of text processing software. Do not need separate statistics software.

G. Spreadsheet software:

1988, 1992, and 1997

Not applicable

H. Utility software:

1988, 1992, and 1997

Not applicable

(10) Please describe any equipment requirements for this activity.

A. Display: Need a WRD standard, high-resolution color terminal with ability to display all special characters: one in each office.

B. Keyboard: Must support all special characters, one in each office. Voice input, in addition to keyboard input, will be gradually phased into the system.

Voice input:

1988

Not obtained except for some trial units

1992

One for each section or unit in every office

1997

Functional part of every machine used for word processing

C. Scanner: Optical scanners capable of reading all common typewriter faces as well as fonts from laser or typesetting systems.

1988

One in each office

1992

One for each section or unit in every office

1997

An average of two for each section or unit in every office

D. Processor and Storage unit:

1988

Regular reports:

1 page = 4,800 characters (60 lines by 80 characters per line) assume half of characters are white space, hence:

1 page = 80 x 60 x 0.5 = 2,400 characters per page
800 reports with 100 pages per report equals 80,000 pages
1 copy each report = 80,000 x 2,400 = 192,000,000 characters or 192 MegaBytes (MB)
first draft through publication = 8 versions of each report, thus storage required = 8 x 192 = 1,536 MB

State data reports:

1 page = 132 columns by 100 lines x 0.5 = 6,600 characters
80 reports with 600 pages per report equals 48,000 pages
1 copy each report = 48,000 x 6,600 = 317,000,000 characters or 317 MB
2 versions of each report, thus storage required = 2 x 317 = 634 MB
Total: 1,536 + 634 = 2,170 MB

1992

2 percent increase per year = 2,350 MB

1997

2 percent increase per year = 2,600 MB

E. Printer/Plotter:

Must have the ability to print all special characters. Must be able to output to labels and envelopes. Must have adequate resolution for a data report in 1988 and equivalent to typesetting in 1997.

1988

One for each office

1992

One for each each section or unit in each office

1997

One for each two persons.

F. Communications:

1988

Must be able to communicate with all USGS (WRD, National Mapping Division (NMD), and GD) equipment. Must be interactive with certain other WRD systems, such as the Management Information System (MIS) and Report Tracking System (RTS). Must be integrated with all other USGS systems.

1992

Must be interactive with other WRD systems to the point of automatically triggering actions (such as press releases, update of RTS, update of bibliographies, transmittal of memos).

1997

Must be able to communicate with all USGS (WRD, NMD, and GD) equipment and any other equipment that uses industry standards.

Graphics Processing

(1) Please identify the major activities performed.

Graphics processing

(2) Please describe each identified activity and why it is needed.

Graphics processing is the act of conceptualizing, drafting, and reviewing illustrations for USGS reports. Graphics processing begins when the author originates a design for an illustration, continues as the draft illustration goes through the review cycle, and ends once the draft illustration receives approval for publication. At that point, preparation of camera ready copy begins. (See High Resolution Graphics Preparation section.)

Graphics processing is an integral part of the report writing activity because illustrations are used to convey technical information in ways that words alone cannot. Depending on the subject of the report, an illustration can range from a simple line drawing to a complex hydrologic or geologic map. USGS publications contain color and black and white charts and graphs, maps, photographs, and drawings. The size of the various types of graphics can be anywhere from that of a postage stamp to that of an atlas sheet. Graphics are used not only to display information, but also to analyze and manage data by showing relationships and trends not apparent in text or tables.

Review copies of illustrations are needed to check the technical information and design of the work before it goes into production of camera-ready art to minimize expensive and time-consuming changes in the final art. Thus, the graphics processing activity must ensure that the illustrations are clear and accurate so that final drafting is not encumbered by the artists having to interpret and redesign the illustrations.

Here are the graphics processing scenarios envisioned

1988

Word processing and graphics processing would start to be integrated, but would not be fully integrated at all sites. Some sites would have fully integrated desk-top publishing systems. WRD would have all of the graphics packages (such as DISSPLA, TELLAGRAF, CUECHART, ARCPLOT, ISM) that it has today. Most likely these packages would be running on a host minicomputer. These packages would create most draft scientific illustrations because of their graphing and mapping capabilities. WRD also would have new microcomputer-based packages coming on-line. The microcomputer-based packages would be icon-driven drawing and painting programs with pop-up menus and windows, such as those on the Macintosh. Authors and graphics artists would be able to make free-form illustrations on the microcomputer. Another function of the micro-based graphics packages would be full-screen graphics editing and integration of text and graphics via desk-top publishing systems. Links between the host and the microcomputer would allow capturing and downloading graphics generated on the host and bringing them up in the full screen graphics editor or desk-top publishing system for further processing. The same links would then upload the products for transmission across the network.

1992

At most WRD sites, text processing and graphics processing would be fully integrated in a two-tiered system that would allow manipulation of text and graphics together. This system would have a basic level and an advanced level. Authors would use the basic level to create draft illustrations. At this level, little training would be required to produce illustrations. Graphics artists would use the advanced level to produce enhanced illustrations. Some specialized training would be needed to use the advanced level. Authors also would have the option to take this training.

This integrated package would have the capabilities of all the graphics packages now running and would create all the draft scientific illustrations with its graphing and mapping capabilities. The integrated package would include icon-driven drawing and painting programs with pop-up menus and windows. Authors and graphics artists would be able to make free-form illustrations as well as regular maps and charts using the package. Another function would be full-screen graphics editing and integration of text and graphics. Links between computers would allow transmitting graphics files across the network.

In 1992, WRD would be moving towards full integration of the Data Base Management System (DBMS), Geographic Information System (GIS), statistical package, and spreadsheet software with the graphics and text processing systems.

1997

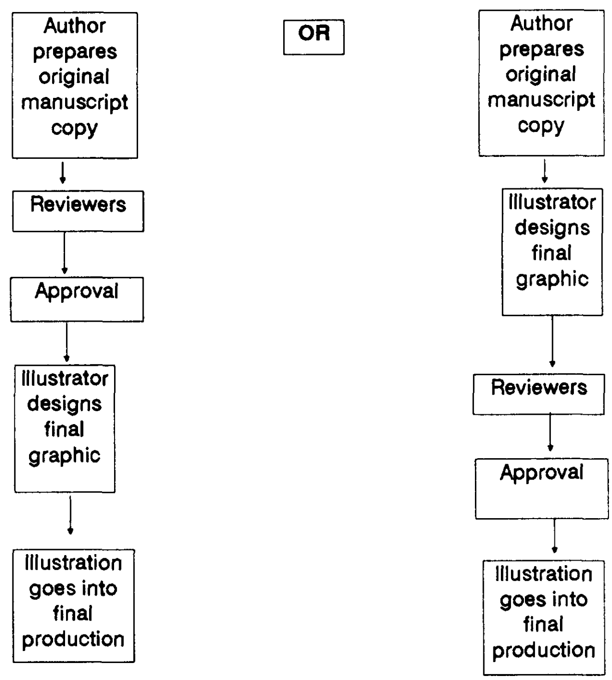
At all WRD sites, text processing and graphics processing would be fully integrated as part of an all encompassing WRD computer package. The graphics software would have links to the DBMS, GIS, statistical, and spreadsheet parts of the system so that data could be input, analyzed, and published without having to jump from package to package. AI or expert systems would be in place.

The graphics part of the system still would be coupled with text processing in a two-tiered system as in 1992. This system still would have a basic level and an advanced level. Users could produce graphics at whatever level of complexity they find comfortable. Graphics artists and others who undergo the special training to use the advanced tier would continue to produce enhanced figures.

This integrated package would have all of the capabilities of the graphics package running in 1992 plus enhancements.

In 1997, WRD will have achieved full integration of the DBMS, GIS, statistical package, and spreadsheet software with the graphics and text processing systems.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

An average of 230 which includes all WRD locations plus cooperators and affiliates.

(5) How many times per year is this activity done?

Graphics processing is done continuously as part of the reports preparation process.

Assume WRD publishes 800 reports in 1988, with an average of 15 illustrations per report.

Total illustrations published, assuming a 2 percent annual increase

12,000 in 1988
13,000 in 1992
14,350 in 1997

Assume that for every illustration published, 4 illustrations are drafted and discarded.

Intermediate graphics drafted

48,000 in 1988
52,000 in 1992
57,400 in 1997

In 1988, assume 1/3 of all graphics are computer-generated.

In 1992, assume 7/10 of all graphics are computer-generated.

In 1997, assume all graphics are computer-generated.

Total illustrations published assisted by computer technology

4,000 in 1988
9,100 in 1992
14,350 in 1997

Intermediate graphics drafted assisted by computer technology

16,000 in 1988
36,400 in 1992
57,400 in 1997

times two sessions per illustration =

40,000 in 1988
91,000 in 1992
143,500 in 1997

(6) How many people per year do this activity?

Any one of WRD's 4,000 employees could be the author of a report and therefore could be involved in graphics processing. However most people involved in graphics processing would be those in certain fields such as reports, hydrology, computer science, and other technical areas:

Cartographic personnel	150
Scientific-technical personnel	2,200
Total doing graphics processing per year	2,350

(7) How many hours per person per year are spent doing this activity?

Author spends 8 hours on each published illustration in 1988, 6 hours in 1992, and 4 hours in 1997. Author spends 2 hours on each draft illustration.

1988

4,000 x 8 = 32,000 hours spent on published graphics
16,000 x 2 = 32,000 hours spent on draft graphics
64,000 hours total per 2,200 authors = 30 hours per author per year

1992

9,100 x 6 = 54,600 hours spent on published graphics
36,400 x 2 = 72,800 hours spent on draft graphics
127,400 hours total per 2,200 authors = 58 hours per author per year

1997

14,350 x 4 = 57,400 hours spent on published graphics
57,400 x 2 = 114,800 hours spent on draft graphics
172,000 hours total per 2,200 authors = 78 hours per author per year

These changes reflect the productivity gains shown by the cartographic personnel

Cartographic personnel:

Cartographic personnel are to be involved only for the final illustrations and therefore should be spending approximately 8 hours on each illustration in 1988, 6 hours in 1992, and 4 hours in 1997. The totals are:

1988

4,000 x 8 = 32,000 hours spent on published graphics
32,000 hours total per 150 cartographic personnel = 213 hours per person

1992

9,100 x 6 = 54,600 hours spent on published graphics
54,600 hours total per 150 cartographic personnel = 364 hours per person

1997

14,350 x 4 = 57,400 hours spent on published graphics
57,400 hours total per 150 cartographic personnel = 382 hours per person

Note: These numbers do not include the totals listed in the High-Resolution Graphics Preparation section of this report.

(8) Are there any special requirements for this activity?

The graphics processing system must be easy to use for graphics artists as well as people who work with computers all the time. The functions on the computers must match the corresponding functions in the "real world" so that artists can pick up the automated tools quickly without having to learn new terminology. In 1988, training must be available so that illustrators brought up with traditional methods of preparing artwork can make the transition to preparing art on the computer. Training in USGS publications standards and design of illustrations must be offered to authors so they can produce computer plot files that the illustrators can use without extensive changes. Authors must know how to design data bases that are flexible enough for both analysis and display. In 1992 and 1997, people will be more computer-literate, therefore making the transition to computer-generated graphics should not be as difficult as in 1988. In 1992 and 1997, training for illustrators should emphasize the advanced level of the two-tiered graphics processing system.

The graphics system must have online documentation as well as hardcopy manuals so that users can get help while they are working on the system.

Another requirement for 1988 and 1992 is for standard WRD plot templates for commonly used graphs such as those published by the computer graphics publications standards work group. Users should also be able to define their own templates. By 1997, AI programs should enforce the WRD publications standards requirements automatically so that creating a nonstandard graphic would be impossible.

(9) Please describe any software requirements for this activity.

A. Data base manager

A data base management system (DBMS) is needed to manage the technical information that will be displayed in the illustrations. The DBMS must allow organizing and analyzing technical and administrative data. In 1988 and 1992, the DBMS must be able to output data files that can be imported into the graphics software for processing into plot files. By 1997, the DBMS should be fully integrated with the graphics processing system.

B. Editor software

Text processing software is needed to create files containing commands or code necessary for creating plot files. The text processing software must be able to generate files that can be read directly by graphics software and translated into plot files or files that can be compiled into programs that call graphics routines. By 1992, text processing software should be fully integrated with the graphics processing system so that graphics and text can be manipulated, laid out, and output together.

C. Graphics software

1988

The software required to produce draft illustrations falls into two categories: graphics software on the host minicomputer and full-screen graphics editing and desk-top publishing software on the microcomputer or workstation. People should be able to create graphics by writing a series of commands to drive the software, by issuing program calls to a plot routine library, or by assembling a graphic on the screen by choosing from a tool palette. Once the image is created, it must be saved electronically in a form that can be incorporated into a page of text, transmitted around the network, and later changed.

Graphics software on the host minicomputer would include the graphics packages currently available (DISSPLA, TELLAGRAF, CUECHART, ARCPLOT, and ISM) or other packages that have the functions of the current ones. This software would account for the technical graphics required by WRD staff, as opposed to the artistic enhancement done by illustrators. The software must be able to generate graphs (line, bar, pie, and scatter), pages of text in various fonts, and maps. The software must have the ability to:

- Plot on the most common output devices available at the USGS, including pen plotters, inkjet plotters, and laser printers
- Create computer graphics metafiles (CGM) that can be stored and output by many types of software on many hardware devices or some other industry standard device-independent plot files having a "neutral" file format usable by all plotting packages
- Support page description language to use the full resolution of the output device;
- Store plots and modify them later;
- Put more than one plot on a page and to overlay all types of plots on a page;
- Select color and shade areas with a variety of patterns;
- Include a variety of character fonts;
- Draw legends and titles;
- Do relative or absolute scaling;
- Create basic pie or exploded pie charts with labeled and shaded slices, in two-dimensional or three-dimensional perspective;
- Create clustered and stacked bar charts with labeled and shaded bars, in two-dimensional or three-dimensional perspective;

- Create and process threedimensional images in non-real time;
- Do mapping and contouring; and
- Create statistical charts and graphs.

The graphics software must be able to import data files from the DBMS, the GIS, the text processing system, the statistical package, and the spreadsheet software.

Graphics software on the microcomputer or workstation must be an icon-driven drawing and painting program able to do freestyle drawing and full screen editing. The user must be able to create graphics or bring in existing plot files generated by the software on the host computer to enhance the charts or pictures. The package must have tools to move, rotate, and distort images on the screen; shade; draw curved lines; and add and move text. A library of standard symbols, shade patterns, shapes, lines, and other images must be available for incorporating into plots created by the user. The user must be able to trace existing hard copy images and convert them to electronic form and must be able to combine elements from different plot files into one illustration. The software must be able to handle images read in by scanning input. Once the illustration is finished on the screen, it must be saved in machine readable form that can be uploaded to the host or sent to the output device.

1992

The software to produce draft illustrations must have full-screen graphics editing and publishing capabilities and must be integrated with word processing and page layout software. People should be able to create graphics by writing a series of commands to drive the software, by issuing program calls to a plot routine library, or by assembling a graphic on the screen by choosing from a tool palette. Once the image is created, it must be saved electronically in a form that can be merged with a page of text, transmitted around the network, and changed later. If an image is changed in the full screen graphics editor, the changes must be saved back to the command file.

Graphics software in 1992 must be able to generate the same types of technical and artistic products as in 1988. In addition, the software must be able to create, process, and manipulate three-dimensional images in real time.

The graphics software must be able to import data files from the DBMS, the GIS, the text processing system, the statistical package, and the spreadsheet software. It also must be able to capture images generated by any of these packages and bring them together in one illustration. The software must be able to scan in images.

Graphics software in 1992 must include all of the full screen editing and freestyle drawing capabilities mentioned for 1988. Likewise, it still must save the finished image on the screen in a machine readable form that can be transmitted across the network and sent to the output device.

1997

The software to produce draft illustrations must have full-screen graphics editing and publishing capabilities and must be integrated with text processing and page layout software as well as with the DBMS, the GIS, and the statistical and spreadsheet packages. The graphics processor must be able to use files or images created in any part of the integrated system. People should be able to create graphics by writing a series of commands to drive the software, by issuing program calls to a plot routine library, or by assembling a graphic on the screen by choosing from a tool palette. Once the image is created, it must be saved electronically in a form that can be merged with a page of text, transmitted around the network, and later changed.

Graphics software in 1997 must be able to generate the same types of technical and artistic products as in 1988 and 1992 plus state of the art advancements.

Graphics software in 1997 must include all of the full screen editing and freestyle drawing capabilities mentioned for 1988 and 1992. Likewise, it still must save the finished image on the screen in a machine readable form that can be transmitted across the network and sent to the output device.

D. Programming languages

1988

FORTRAN for DISSPLA

1992

Whatever language is compatible with the graphics software

1992

Probably won't be using programming languages anymore

E. Statistics software

Statistics software is needed to analyze the technical data that will be displayed in the illustrations. The statistics package must be able to output files that can be imported into the graphics software for processing into plot files. Some graphics capability must be built into the statistics package so that the analyst can interpret the results of his statistical manipulations independently of the main graphics software package. By 1997, the statistics package should be fully integrated with the graphics processing system.

F. Spreadsheet software

Spreadsheet software is needed to create tables and other analyses that can be read as data to the graphics software for processing into plot files. Some graphics capability must be built into the spreadsheet software so that the analyst can interpret the results of his spreadsheet manipulations independently of the main graphics software package. By 1997, the spreadsheet software should be fully integrated with the graphics processing system.

G. Utility software

Microcomputers used as terminals will need graphics terminal emulation software so they can communicate with the host computers. This software must allow downloading of plot files from the host to the microcomputer and uploaded from the micro to the host.

(10) Please describe any equipment requirements for this activity.

A. Display/Keyboard

Most terminals used for creating and reviewing graphics would require medium (480 x 640) resolution screens with full color graphics capability, such as that of the TEK 4200 series of terminals, or microcomputer color graphics monitors with terminal emulation functions. Some terminals would need to have high resolution screens. The keyboards must include all standard alphabetic and numeric keypads plus programmable function keys, and a joystick or mouse. The terminals must have local re-draw rates of 10 seconds or less during zoom and pan operations.

B. Processor

The processor must be able to store and run the graphics software and offer reasonable response times. For example, a reasonable response time to generate a graph on the screen would be 20 seconds or less in 1988, falling to 2 seconds by 1992. A reasonable time to generate a detailed map on the screen would be 3 minutes or less in 1988, falling to 30 seconds or less in 1992. By 1997, drawing times should appear to be instantaneous.

C. Storage unit

Storage requirements must account for storage of the graphics software and the illustration plot files.

Graphics packages on each machine will require at least 70 to 100 megabytes of storage. For example, currently:

TELLAGRAF = 9,000 PR1ME records
DISSPLA = 9,000
ARCEXE = 12,000
which is 30,000 records x 2,048 bytes per record = 61,440,000 bytes

Assume each illustration plot file requires 1 megabyte storage.

1988

20,000 computer assisted graphics = 20,000 megabytes

1992

45,500 computer assisted graphics = 45,500 megabyte

1997

71,750 computer assisted graphics = 71,750 megabytes

D. Printer/Plotter

Clear legible copies of draft illustrations are a must during the review cycle. To accomplish this, high resolution plotters are needed. In the 1988 time frame, most sites could use black and white laser output with at least 300 dots per inch (dpi) text resolution and 300 x 300 dpi graphic resolution at a speed of at least 8 new pages per minute. The laser printer should be able to handle page sizes up to 11 x 14 inches and landscape and portrait orientation. Laser output must be able to produce at least 10 shades of gray. In 1988, some sites would need "top-of-the-line" color lasers if available. By 1992, most sites would need color laser output with higher resolutions, faster speeds, and larger sizes. By 1997, laser output should be able to produce any color specified as percentages of black, cyan, magenta, and yellow at sizes up to 40 x 60 inches.

To supplement the laser output and to produce drafts of large-size illustrations in 1988, the standard pen-plotter output like that available today will be needed. Both desk top and drafting plotters are necessary for previewing illustrations. Plotters must handle at least eight pens, multiple plotting media (paper, vellum, transparencies, and film) and multiple pen types (felt tip, ball point, and drafting). Desk top plotters should take paper sizes 8-1/2 x 11 inches up to 11 x 17 inches. Drafting plotters should take paper sizes up to at least 52 x 36 inches and must handle sheet feed and roll feed. By 1992, electrostatic plotter output would be used to supplement the laser output. These plotters should take paper sizes up to at least 52 x 36 inches and must handle sheet feed and roll feed with one pass color transfer.

Output devices must be configured so user can submit multiple plot files that are queued for plotting, much as the ARC/INFO plot spooler does now. After each plot, paper must advance automatically, thus freeing the user from having to advance paper manually. The quality of the lines produced at the end of the plot must be as good as the quality of the lines produced at the start of the plot. The type of output device should be transparent to the user. The user should be able to create a plot, then be able to send it to any output device and get the same general output (within the limits of the device resolution).

In addition to output devices, WRD will need input devices such as digitizers and scanners to read in data to be plotted or existing hard copy illustrations and photos. The resolution of the input devices must be at least that of the output devices. In 1988, scanners must be able to handle black and white photographs as well as black and white charts and maps. Into 1992 and beyond, the scanners should become able to handle color and larger sized illustrations. Freehand drawings done by illustrators must be captured so that the image drawn on a tablet or on a screen is stored in an electronic form.

E. Communications

The system must be linked in such a way that people at each WRD office are able to exchange illustration files among the computers at the same site as well as exchange the files with people at other WRD sites. The author must be able to pass an electronic copy of the rough draft illustration to the reviewers and the graphics artists. Such a transfer could involve a move from micro to micro, from micro to host, or from host to host.

Communication links between the host computer and the microcomputer must exist so that the plot files created on the host computer can be downloaded to the microcomputer or workstation for manipulation on the full-screen graphics editor. In 1988, the time to download a plot file must be less than 5 minutes. This speed should increase by 1992 and 1997. These links must also account for uploading plot files from the microcomputer or workstation to the host.

The host computers must be linked in such a way that the plot files created on the hosts can be transmitted from site to site during the review cycle and then on to the reports preparation site once the illustrations are approved. In 1988, the time to transfer plot files across the network should take no longer than transfers under the present file transfer request (FTR) system on the PR1ME network. The system must maintain the integrity of the file. Transfer speeds should increase steadily by 1992 and 1997.

Reports Tracking

(1) Please identify the major activities performed.

Reports tracking

(2) Please describe each identified activity and why it is needed in 1988, 1992, and 1997.

1988

Reports tracking is a mechanism or tool needed by management, (district, subdistrict, region, and headquarters personnel) to effectively and efficiently track progress of report preparation (and if desired project progress) to ensure reports are being prepared on schedule and to initiate corrective action where monitoring of progress shows slippage or a report appears to be late. Besides having the potential for an author or manager to learn the status of a report for a particular point in the preparation, review, or publication process, a reports tracking system (RTS) serves management needs, providing materials for briefings and presentations with historical information such as number and types of reports prepared for a given time period, review times by reviewers at all levels of review and cost of report preparation and publication. It also provides both authors and managers with productivity records such as bibliographic information for each WRD author.

Presently, most districts (and some subdistricts) have some form of report tracking, albeit many are on word processors of one type or another with no apparent uniformity. Some offices had reports tracking on computers prior to the headquarters's report tracking system and the recent reports tracking module added to the Automated Financial Management System (AFiMS) system for district use. Except in the southeastern region, the AFiMS reports tracking system is not being fully tested or used. At present, there does not exist an integrated system that is compatible between all WRD offices and that will track both key project and report milestones within the district (field) offices; then track the report through the review and approval steps as now being done at headquarters and at some of the field offices using the AFiMS or other district module; and finally complete the cycle through the publication preparation phase. Hence, for the base year 1988, such an integrated and comprehensive system is not assumed in place in the following analyses.

1992

It is expected that all districts, subdistricts, and other WRD field offices will have access and will use a totally integrated system, fully compatible between all field offices and headquarters and capable of entering information for project, report preparation, and publication processing. The system will be able to transfer to and from any workstation reports, graphics, editing notations, revisions to reports, and provide automatic feedback as key milestones are reached as described above. Also in 1992, the tracking system will be linked to other data bases such as Water Resources Scientific Information Center (WRSIC) and USGS libraries, and will be the mechanism to transfer and access news releases and other announcements of new publications between USGS offices.

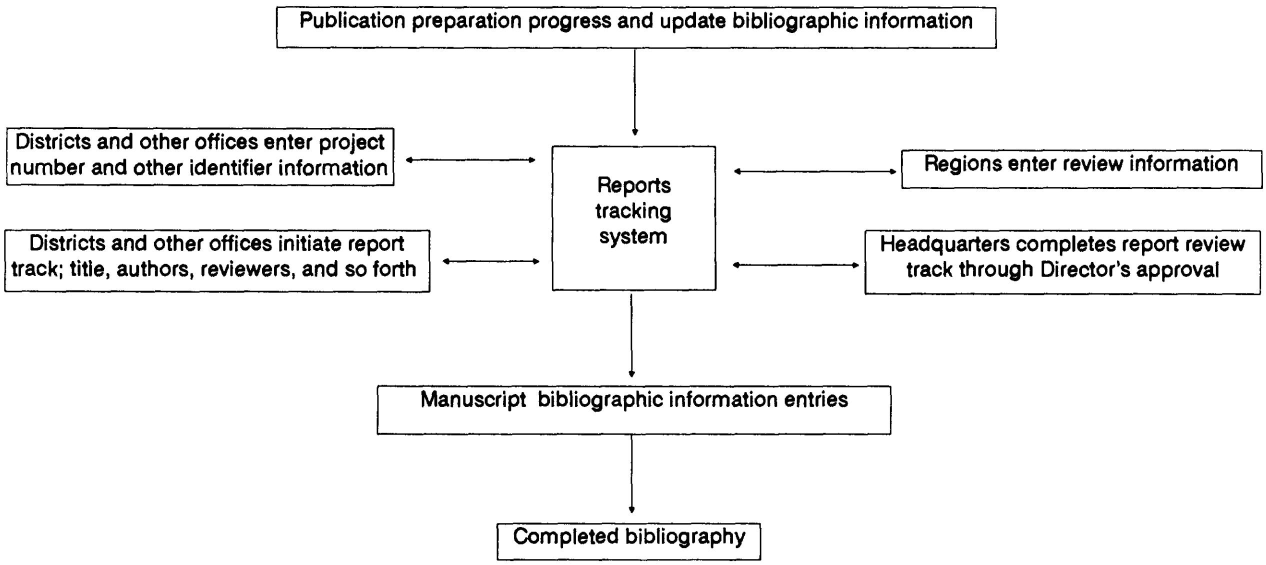
1997

Reports tracking will continue as a mechanism or tool needed by management, authors, and others to monitor project progress or progress of report preparation, review, and processing for publication. The principal difference in 1997, compared to earlier years, will be an expected greater number of persons using the system. The system will be more sophisticated, providing greater flexibility and capability from far more advanced equipment and software. Voice communication effecting data entry, retrieval, report generators for immediate display of information, and transfer of data across electronic media will greatly facilitate the manner in which this activity is implemented.

(3) Please describe the flow of information in this activity.

Reports tracking ideally starts with the establishment of a project and as a project number is assigned, district or subdistrict personnel initiates a project or a report track in the tracking system along with other key identifiers or information. (Note: While the activity described for 1988 will focus on report tracking, project tracking is another activity that districts or subdistricts may wish to monitor and possibly initiate corrective action when slippage becomes apparent. Project tracking is assumed for the 1992 period and beyond.)

Report preparation progress is entered into the reports tracking system by district, subdistrict or other appropriate field personnel as preidentified steps or milestones are completed. When a report is considered complete and sent on to region, the region personnel continue entering review information and forward on to headquarters where the final reviews are made and the completion of these steps are entered in the system, including director's review and approval. In some cases, reports are returned ("bounced") by either region or headquarters for further work by the author. This results in another cycle of entries into the system. As the reports preparation information is entered into specific files of the tracking system, another file is initiated containing the pertinent bibliographic information for authors preparing reports for a given project. While the information initially entered pertains to the manuscript, when the report is published the information in the bibliogaphic file is updated to reflect changes in title, and particularly number of pages, volume number, and so forth, which in most cases differ from manuscript information. A generalized flow diagram for the base year 1988 is shown on next page.



1992–1997

The reports tracking system in place for the 1992 period and beyond will be a single system, tracking key milestones for significant project as well as report and review processes completed, and will include tracking the progress of preparation of camera-ready copy and report status through publication. Also, automatic feedback will be an additional feature providing management and others with information as key milestones are accomplished throughout the project-report-publication phases. The flow of information should be about the same as 1988, except more entries and inquiries will be made at the field levels about project activities, and later, after the report is approved, further entries and queries about publication status. Additional links will be made with WRSIC and the USGS libraries and will interface with other USGS offices regarding news releases and information of new publications.

(4) How many locations do this activity?

1988

It is expected that 90 WRD offices will access and use one form or another of the reports tracking systems in place at the time. Since one or more of the report tracking activities will take place from a variety of locations within an office, the possible number of workstations engaged in this activity is estimated at about 1,000 or 25 percent of the 4,000 or more workstations in use today. This includes greater use of the reports tracking system by authors, reviewers, and editors and by others outside the normal reports preparation and reports processing sections.

1992

The number of locations should increase to about 175 or all WRD offices as the potential should exist for any author, manager, or individual to enter or query the system regardless of location. The number of individuals or workstations accessing the system in 1992 is estimated at 2,000 or 50 percent of the 4,000 plus workstations in use today.

1997

The number of workstations where this activity will take place is estimated at 3,000 or 75 percent of the 4,000 workstations in use today.

(5) How many times per year is this activity done?

1988

The frequency of usage or number of times this activity will occur is very difficult to estimate. It is envisioned that, as the system becomes more accessible, a greater number of WRD personnel will begin to enter information from early project and report tracking and draft manuscripts being completed, through reviews, rewrites, publication preparation, printing, and inquiries of the system for a myriad of reasons.

Currently, approximately 1,500 or more reports (including abstracts) are being prepared by WRD each year. Each report would involve 12 or more entries in the early stages of report tracking at the originating office aside from actual author entry of draft manuscripts. Each would involve, on the average, 12 review steps through director's approval (probably about half this number for those approved in the regions and districts).

There might be 10 inquiries per report to determine status of a report during the report preparation and publication phases and one or more retrievals of an author's bibliography for career development or other purposes. Therefore, aside from author entry of manuscripts and subsequent corrections and revisions, editor's notations, actual preparation of manuscripts and layouts, the reports tracking activity alone (not including extended sessions of data file transfer or extensive career development retrieval sessions) in the early years of the 1988 to 1992 period could involve 48,000 terminal sessions. These sessions would range from about a few minutes to about 10 minutes per session, based on today's estimates of a terminal session.

Although separate from the reports tracking system in the early 1988–92 period, the WRSIC activities involve the addition of 12,000 or more new abstracts each year as well as provide the potential to make inquiries of these new abstracts. The 185,000 or more abstracts presently in the WRSIC data bases are proposed to be stored on compact disk-read only memory (CD-ROM) for future use by WRD with subsequent disks being made annually for the 12,000 new abstracts. Hence, this activity involves at least 12,000 terminal sessions to enter information and any number of inquiries to search the system.

Additionally, apart from the reports tracking system for 1988, there is the potential for 1,500 or more news releases to be entered and transferred electronically to the Public Affairs Office in Reston, Va., with an equal number of retrievals from that office to view or print the news release.

Summary:

1,500 reports x 12 review steps = 18,000 sessions

1,500 reports x 10 inquiries =

15,000 sessions
33,000 total sessions
12,000 WRSIC entries
3,000 press release sessions
48,000 terminal sessions

1992

With the new integrated system proposed for these years and the potential to track project and publication progress in the district and other field offices as well as reports, and the link to other data bases such as WRSIC and the libraries, it is expected that frequency could easily quadruple, if not more. Therefore, there could easily be 200,000 entries to, or inquiries made of, the system during these years, ranging from a few minutes to a half an hour or more, particularly with the WRSIC retrievals if one were performing a literature search.

1997

The new technology should greatly facilitate the preparation and processing of many more reports and data entry, and because of greater use of information which will be so much more readily available for meetings, briefings, conferences, there could be 300,000 entries or inquiries made of the system.

(6) How many people per year do this activity?

1988

The number of people performing this activity should be similar to the number of workstations in question number 4. While the answer to question number 5 did not include entry by author of manuscript, corrections, revisions, editor's notations, and so forth, the step completed would be entered, hopefully by each, as a tracking entry and therefore the number of people should be about the same as the number of locations or about 1,000 in 1988 or in the early part of the period of 1988 to 1992.

1992

This number is expected to be about 2,000.

1997

This number may reach 3,000.

(7) How many hours per person per year are spent doing this activity?

1988

The hours per person vary from full time, for some people presently maintaining tracking systems, to the occasional user in the field entering a project number or title or entering a step completed in the report track. Taking an average of the number of terminal sessions addressed above, say 48,000 during the year, at an average of perhaps 10 minutes per session (exclusive of the more extensive retrievals and file transfers), and for 1,000 persons performing this activity at some point in the tracking process, this would average about 8 hours per person for 1988.

1992

There will be 200,000 sessions at an average of 10 minutes per session and 2,000 persons. This amounts to about 16.7 hours per person per year.

200,000 sessions ÷ 2,000 people x 10 minutes ÷ 60 minutes per hour = 16.7

1997

Time spent per person for a given step or access or entry for this activity would probably be less than earlier periods because of rapid access and retrieval afforded by the new advanced technology and equipment. However, the number of occurrences in using the system could increase considerably since the new technology should greatly facilitate the preparation and processing of many more reports and data entry, and because of greater use of information which will be so much more readily available for meetings, briefings, conferences, and so forth. Consequently, the average [total] time might be 16.7 hours per person per year.

300,000 sessions ÷ 3,000 people x 10 minutes ÷ 60 minutes per hour = 16.7

(8) Are there any special requirements for this activity?

1988

Special requirements include security provisions to prevent unauthorized users from accessing files containing confidential information such as employee identification numbers which are currently used for career development retrievals from the historic files. The capability for multiple readers and multiple writers is needed. There is a need for efficient archival capabilities to store older report records but ready access when statistical analyses are required for special reporting purposes (such as trends, cost comparisons, and so forth).

1992

Same as for 1988.

1997

Security provisions to permit access via telephone, terminals, or appropriate transmission facilities will be needed.

(9) Please describe any software requirements for this activity.

1988

A. Data base manager

The data base manager should be INFO compatible or capable of converting existing INFO data bases easily to software of the future (probably needed during the early to middle part of the period 1988 to 1992). Multiple reader and writer capability will be needed. Archival capabilities needed as mentioned above. Capability of expeditiously handling large files, 100,000 to 125,000 records of 150 to 200 bytes per record will be needed. (Disk space, particularly during sorting, has been a problem in the past. One file contains approximately 65,000 records with a record size of about 150 bytes.)

B. Text processing and editor software

State-of-the-art package is needed which is easy to use, fast, and efficient and has the capability of merging graphics generated at the work station as well as electronically receiving graphics from state-of-the art graphics packages in use at the time; multiple type font with potential to add more as special needs arise; Greek, math, and other special characters such as superscript, subscript, degree notations, and so forth. (Note: while these characters are more important to the entry and output of report information as opposed to the actual report tracking, titles, for example, occasionally contain these characters and are necessary for the reports tracking activity as well.)

C. Graphics software

The graphics software should have the capability to create regression curves, pie charts, bar graphs, and other visual materials from data generated from the data base manager and should be electronically transferable to the text editor and merged with text for reproduction.

D. Programming languages

Programming languages should be compatible with the data base manager and provide the capability to design and prepare summaries and specialized reports utilizing basic statistics to show trend and or regression analyses from data files generated from the data base manager. They should have the potential to call graphics, spreadsheets, and graphics packages into programs as necessary to generate these reports, curves, and plots for visual aids and briefing materials.

1992

There will be basically the same requirements for 1992 as for earlier years but incorporating compatible state-of-the-art software to continue efficient entry and retrieval of data, continued ability to merge text and graphics, transfer files (including graphics) between WRD offices and with others both within the Survey as well as outside agencies such as printers, publishers, and so forth.

1997

Artificial intelligence software which will accept voice and other appropriate signals to effect any number of text processing, graphic producing, communications activities to effect all of the other manipulations described above.

(10) Please describe any equipment requirements for this activity.

1988

A. Communications

File transfer of text and graphics to and from other WRD offices and other Divisions within the Survey are required. There will be extensive use of electronic mail (E-MAIL). Periods of intensive file transfers, such as total reports, will be necessary.

B. Processor

A processor that will efficiently run software and provide immediate response for data entry and short retrieval time (several seconds to 60 seconds for small to large files, respectively).

C. Keyboard/display

Display must support 132 characters and full graphics. Special characters and type fonts as described in 9B and occasional color display will be required.

D. Storage

Storage of 773 megabytes online will be required for headquarters for 1988 and 20 megabytes for each of the 90 or more locations involved in reports tracking activities.

E. Printer

Laser printer with integrated graphics (occasional color desirable) will be required. Printers should be capable of handling most of the type-fonts and special characters specified in 9B above. (Note: the tracking system reporting requirements would not normally need the quality of printing and hence all the fonts and special characters of camera-ready copy of formal series reports, but if special characters, for example, are contained in titles and other products of the tracking system and need to be reproduced for management reports and briefings, the potential should be there.)

1992

Same as 1988, but applying to equipment at 175 WRD locations.

1997

Capability of accepting the software and receive signals to accomplish above for 1997.

Editing and Correcting Manuscripts

(1) Please identify the major activities performed.

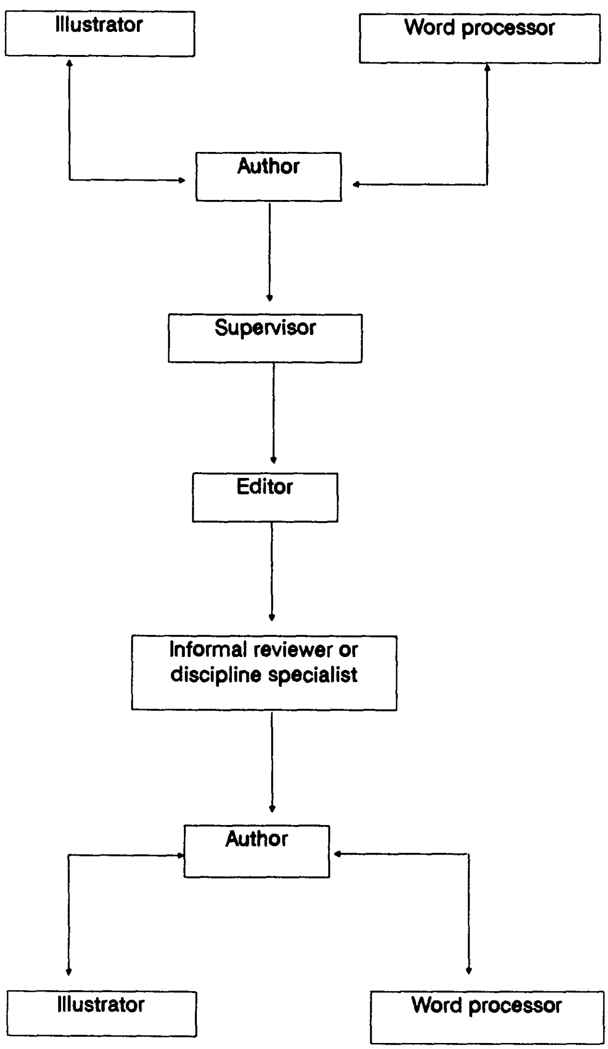
Editing and correcting manuscripts

(2) Please describe each identified activity and why it is needed in 1988.

1988

Editing and correcting are processes that consist of changing author copy of a manuscript to agree with report standards. The processes are needed to provide continuity in manuscript quality from report to report.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

An average of 230 which includes all WRD locations plus cooperators and affiliates.

(5) How many times per year is this activity done?

1988

Editors

4 times per report x 800 reports	3,200 times
3 times per abstract x 700 abstracts	2,100 times
Total	5,300 times

Authors

4 times per report x 800 reports	3,200 times
3 times per abstract x 700 abstracts	2,100 times
Total	5,300 times

10,600 x 20 sessions per report = 212,000

1992

Editors

4 times per report x 870 reports	3,480 times
3 times per abstract x 760 abstracts	2,280 times
Total	5,760 times

Authors

Same numbers as for editors 5,760 times

11,520 x 20 sessions per report = 230,400

1997

Editors

4 times per report x 970 reports =	3,880 times
3 times per abstract x 840 abstracts =	2,520 times
Total	6,400 times

Authors

Same numbers as for editors 6,400 times

12,800 x 20 sessions per report = 256,000

1988

(6) How many people per year do this activity?

These numbers will remain constant for all time intervals.

Editors:	200
Authors:	2,200

(7) How many hours per person per year are spent doing this activity?

Editors: 1,000 hours, about 1/2 time

Authors: 250 hours, as between 10 and 15 percent of an author's time is spent on this activity. Therefore, 12 percent (250 hours) is being used for computation purposes.

(8) Are there any special requirements for this activity?

Training on new equipment, knowledge of editorial practices (editors, authors), knowledge of technical subject (author).

(9) Please describe any software requirements for this activity, and (10) please describe any equipment requirements for this activity.

On screen must be user friendly.

Processor to run the software and provide immediate response for data entry and 5-second response for retrievals; station to (1) operate (work) independently and (2) operate when mainframe is "down." This requires multiple workstations in an office.

First-level screen to display 80 characters, full graphics, special characters, and color.

Second-level screen to display 132 characters, full graphics, special characters, and color; will permit accommodation of tables as wide as computer paper and provide space for editorial comments in text margins. Minimum size of 19 inches required.

Marginal window.

Line-through of wording.

Caret plus typed correction or new entry.

Multiple color choice (hardware and software requirement).

Cursor (stylus) marking of illustrations (contours, diagrams, and plots) permitting irregular-line correction or entry. May be 1992 before this is operational.

Retain master copy as a backup.

Math and simple statistical functions, cross reference and update tabular data totals.

Oversize illustrations and mockup (maximum size of 40 x 56 inches); be able to enlarge or reduce and show by quadrant or scanning. Quadrant size maximum of 20 x 28 inches; be able to show 40 x 56-inch image at reduced size on 20 x 28-inch screen. Second-level purchase (one per location or office). This will be limited to select offices in WRD; initial installations will be at regional offices, larger districts, and headquarters.

Table editing: colored numbers within table corresponding to numbered margin comments.

Split screen:

- Text and text,
- Text and table,
- Text and illustration,
- Table and illustration,
- Table and table,
- Illustration and illustration, and
- Text, table, or illustration and supporting document (WRSIC abstract, news release, manuscript routing sheet, note for monthly list, or mockup).

Paper copy retrieval (rapid) by laser printing with integrated graphics to permit editing and correcting on paper copy alone or use of paper copy while editing on screen. Black and white plus color.

- Text, tables, illustrations, supporting documents, preprinted forms
- Oversize illustrations and tables
- Photographs (best resolution possible in 1988; high resolution in 1992)

Scanning of text, illustrations, and photographs—best resolution possible; entry of scanned product into electronic report package

File transfers to and from other WRD and non-WRD locations (such as cooperating agencies).

Retention, transfer, and deletion of master edited copy in editor file. Only Reports Section editor able to correct master. All other comments are shown as "overlays" to the original. Author only shows acceptance or rejection of previous comments or shows alternative wording preferred.

1992

(2) Please describe each identified activity and why it is needed in 1992.

Same as 1988.

(3) Please describe the flow of information in this activity.

Same as 1988.

(4) How many locations do this activity?

Same as 1988.

(5) How many times per year is this activity done?

Same as 1988.

(6) How many people per year do this activity?

Same as 1988.

(7) How many hours per person per year are spent doing this activity?

Same as 1988.

(8) Are there any special requirements for this activity?

Same as 1988.

(9) Please describe any software requirements for this activity, and (10) please describe any equipment requirements for this activity.

All on screen and off screen capabilities same as for 1988, plus on screen must be user friendly, including

Cursor (stylus) marking of illustrations (contours, diagrams, plots) permitting irregular-line correction or entry. May start in 1988.

Oversize illustrations and mockup (maximum size of 40 x 56 inches); be able to enlarge or reduce and show by quadrant or by scanning. Quadrant size maximum of 20 x 28 inches; be able to show 40 x 56-inch image at reduced size on 20 x 28-inch screen. Second-level purchase. Several per office. Must interact with all editing-correcting terminals. Maybe start in 1988.

Dictionary check

Geologic names
Geographic names

References

Cross linked to GEOREF
Reformatted via software to USGS style and user-selected format

Paper-copy retrieval

Photographs: high resolution; color plus black and white

Scanning of text, illustrations, and photographs – high resolution; entry of scanned product into electronic report package.

Ability to create graphics and text template masters from a template file.

Ability to transmit and review electronically all page-size text and illustrations – including facing-page size.

1997

(2) Please describe each identified activity and why it is needed in 1997.

Same as 1988.

(3) Please describe the flow of information in this activity.

Same as 1988.

(4) How many locations do this activity?

Same as 1988.

(5) How many times per year is this activity done?

Same as 1988.

(6) How many people per year do this activity?

Same as 1988.

(7) How many hours per person per year are spent doing this activity?

Same as 1988.

(8) Are there any special requirements for this activity?

Same as 1988.

(9) Please describe any software requirements for this activity, and (10) please describe any equipment requirements for this activity.

All onscreen and offscreen capabilities same as for 1992, plus the following:

Abstract and terminal-section check versus main body of report.

Dictionary check – aquifer names

Transmit three-dimensional (holographic) images (creation, processing, manipulating)

Ability to transmit and review electronically all reports – including plates and map reports (atlases).

Technical Review and Approval

(1) Please identify the major activities performed.

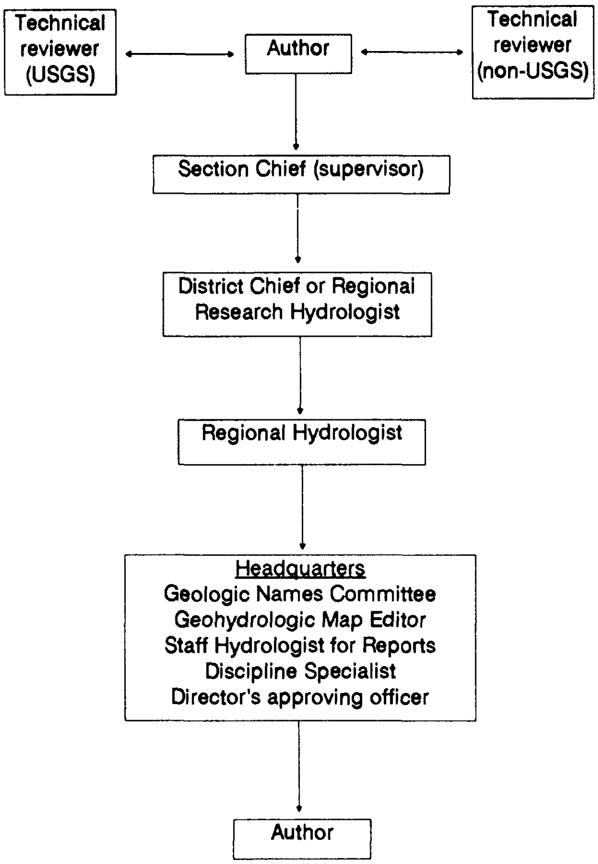
Technical Review and Approval

1988

(2) Please describe each identified activity and why it is needed in 1988.

Technical review is a process whereby technically competent and unbiased individuals carefully examine and comment on the content of newly written reports. The process is used as a quality-control procedure to ensure that reports release by USGS are technically accurate and cogent.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

An average of 230 which includes all WRD locations plus cooperators and affiliates.

(5) How many times per year is this activity done?

	1988	1992	1997
Number of reports:	800	870	970
2 Colleagues per report	1,600	1,740	1,940
1 Section Chief	800	870	970
1 District Chief	800	70	970
1 Region Reports Improvement Person	800	870	970
1/2 Regional Technical Specialists	400	435	485
1 Staff Hydrologist for Reports	800	870	970
1/4 Technical Offices	200	217	242
1 Directors approving officer	800	870	970
Total	6,200	6,742	7,517

	1988	1992	1997
Number of abstracts:	700	760	840
2 Colleagues per abstract	1,400	1,520	1,680
1 Section Chief	700	760	840
1 District Chief	700	760	840
1 Region Reports Improvement Advisor	700	760	840
1 Staff Hydrologists for Reports	700	760	840
Total	4,200	4,560	5,040
Sessions per report	x 3	x 3	x 3
Total	31,200	33,906	37,671

1988

(6) How many people per year do this activity?

Reviewers, 2,200 people for all three time periods

(7) How many hours per person per year are spent doing this activity?

Average for all reports, 50 hours

(8) Are there any special requirements for this activity?

Training, editorial knowledge, technical knowledge

(9) Please describe any software requirements for this activity, and (10) please describe any equipment requirements for this activity.

Want the same functions that are available for Editing and Correcting plus retention and deletion of reviewed copy in reviewer file.

1992

(2) Please describe each identified activity and why it is needed in 1992.

Same as 1988.

(3) Please describe the flow of information in this activity.

Same as 1988.

(4) How many locations do this activity?

Same as 1988.

(5) How many times per year is this activity done?

Same as 1988.

(6) How many people per year do this activity?

Same as 1988.

(7) How many hours per person per year are spent doing this activity?

Same as 1988.

(8) Are there any special requirements for this activity?

Same as 1988.

(9) Please describe any software requirements for this activity, and (10) please describe any equipment requirements for this activity.

All onscreen and offscreen capabilities same as for 1988, plus on-line transmission of complete reports and supporting documents to State cooperating agencies and other Federal cooperating agencies.

Technical review electronically and return to USGS without retention in that agencies files.

Voice-input review.

1997

(2) Please describe each identified activity and why it is needed in 1997.

Same as 1988.

(3) Please describe the flow of information in this activity.

Same as 1988.

(4) How many locations do this activity?

Same as 1988.

(5) How many times per year is this activity done?

Same as 1988.

(6) How many people per year do this activity?

Same as 1988.

(7) How many hours per person per year are spent doing this activity?

Same as 1988.

(8) Are there any special requirements for this activity?

Same as 1988.

(9) Please describe any software requirements for this activity, and (10) please describe any equipment requirements for this activity.

All onscreen and offscreen capabilities same as for 1988, plus any advancements in editing and general technology.

High Resolution Graphics Preparation

(1) Please identify the major activities performed.

High resolution graphics preparation

1988, 1992, and 1997

(2) Please describe each identified activity and why it is needed in 1988, 1992, and 1997.

Graphics preparation for printing is the final step in the process of creating, editing, reviewing, and preparing a graphic for publication. It is intended that this activity begin when an author has revised a final graphic after receiving director's approval for a report. It is at this time that a cartographer or illustrator will take the graphic with the hydrologic data, revise it for conformance to WRD publication policy, manipulate the image for design changes, and generate final copy on a high-resolution film output device.

It is assumed that this stage be concerned with the manipulation of the graphic image previously created using the general graphics processor described earlier. All processing at this stage is for the purpose of creating artwork that can be used directly in the printing process.

Artwork generated at this stage is for printing that requires multicolor or very high resolution output. A ready example of this need would be reports that are to be published in the formal series (especially Water-Supply Papers) or reports requiring great resolution of detail. Examples of high-resolution requirements would be for maps created using geographic information systems or remote-sensing software.

(3) Please describe the flow of information in this activity.

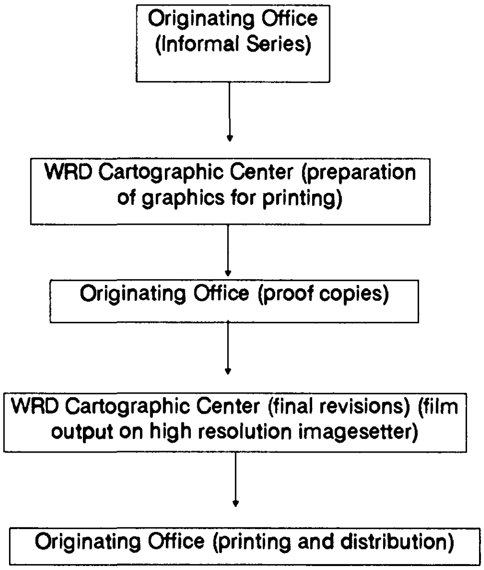
For reports to be published in the informal and formal series see flow charts on next page.

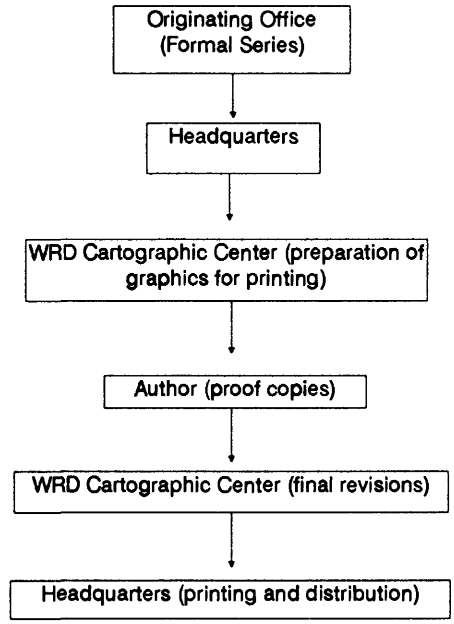
It is recommended that for all reports either the originating office or headquarters arrange final printing. The printing stage is one that does not need the services of a WRD Cartographic Center. All map reports, either Hydrologic Atlas, Water-Resources Investigations Report (WRIR), or Open-File should be printed using National Mapping Division presses in headquarters.

A possible exception to this routing would be either for the Cartographic Center or another office to prepare the final, typeset text. In that case, the illustrations would be routed to that office for merging with the report prior to publication.

Illustrations, text, and illustration sizing for report layout. Illustration sizes will be provided by the Cartographic Center to the text preparation site. The text preparation site or author will make special requests through an Illustrations Check List.

Note: The "Illustration Check List" needs to be automated for transmission with electronic graphics files.





(4) How many locations do this activity?

The number of WRD offices that become final processing centers for preparation of illustrations for publications will increase dramatically in the next decade. Initially, some of the sites will prepare formal series reports for a number of districts, but by 1997, numerous individual districts as well as the more traditional headquarters offices will be doing final illustration preparation.

1988

4 sites

1992

13 sites

1997

40 sites

(5) How many times per year is this activity done?

Daily at all sites

1988

48 people x 500 sessions =24,000 times per year

1992

75 people x 500 sessions = 37,500 times per year

1997

125 people x 500 sessions = 62,500 times per year

Note: Other special product items, including slides, overheads, videos, posters and simulations are not included in these counts.

(6) How many people per year do this activity?

This number will more than double while the number of locations will go up 10 times.

1988

48 people

1992

75 people

1997

125 people

(7) How many hours per person per year are spent doing this activity?

1,500 hours per person will remain constant through the three time periods.

(8) Are there any special requirements for this activity?

The graphics preparation software must serve as a bridge between the analytical graphics software used by hydrologists and the current needs of the printing industry. It is anticipated that this software is not to be used for analytical or decision-support systems but rather to transfer the graphic image to a printed document. While this software has its own unique purpose it must be able to be used in conjunction with any other WRD graphics presentation packages. Special attention must be paid to the extreme size of the graphics files and need for storage of these files. Files should be able to be stored in a compressed form and retrieved in full-format.

Specialized training is required for personnel creating graphics in any of the other four major areas (GIS, Hydrologic Applications, Administrative, or Hydrologic Information) if those graphics are intended to be printed using this high resolution graphics system. An example is that an ARC/INFO data base may serve all requirements for analysis but not be suitable for creating reproducible graphics.

The initial stage of high-resolution graphics preparation for printing (1988) will demand complete typographic control for graphs and diagrams but not for maps due to the curvilinear and crowded nature of map lettering. However, it is required that all point, line, and area symbols be plotted directly on film negatives. These negatives are to be prescreened, composite, by color film separates for use directly on a printing press or use as intermediates for final compositing with type separates. The 1988 requirement is also only for A and B size graphics (8-1/2 x 11 or 11 x 17 inches).

During the 1988–92 period, development will have to be on increased capability of type placement, especially on maps, and larger sized graphics.

(9) Please describe any software requirements for this activity.

Input:

1988

The software must:

Import graphics from the general-purpose graphics software package, geographic information systems, remote-sensing systems, or other WRD systems that generate graphic images.

Support Computer Graphics Metafiles (CGM) for transfer of computer graphics from one system to another.

Import text files from the general-purpose word processing package or create short text strings within this package.

Accept Page Description Language (PDL) files, including editing these files. It is anticipated that PostScript will be the standard at least through 1992.

1992

The software must:

Input and support current Federal Information Processing Standards (FIPS) Graphic Kernel Standard (GKS) standards that are in effect.

Support electronic scanning, manipulation, and storage of line art and photographs including electronic airbrushing.

System Requirements:

1988

The system requirements will be:

Easy of use, plain-English menus, "what you see is what you get" (WYSIWYG) that is, an absolute display with graphics in place using generic codes

Support creation of master templates of commonly used book formats.

Support use of multiple windows for different operations working concurrently.

Support measurements made in points, picas, inches, or millimeters

1992

The system requirements will be:

Cursor movement for scaling, cropping, or positioning either by eye placement or input page coordinates.

All common commands operate with a maximum of two sequential movements and all other commands operate with a maximum of three sequential movements. This can be done with the use of pull-down menus (subject to this limit) or a command-line driven program (not subject to limit).

To input coordinates through keyboard, arrow keys, cursor, digitizer, light pen, mouse, or other pointing devices.

1997

The system will recompose changes in real time

Specific Graphic Requirements:

1988

The requirements are for the ability to:

Position or move graphic elements by either moving or specifying degree of rotation.

Use color, pattern, or area fill, including seed pixels.

Specify up to 100 shades of gray in 1 percent increments, and angles in 5-degree increments.

Store a composite color graphic image with individual colors sent to high-resolution film output device for printing separates or a multicolor image to a laser printer for proofing.

Store USGS standard map and illustration symbols with ability to place, scale, and rotate these symbols.

1992

Ability to rotate, scale, or crop graphic images by using a pointer device will be needed.

1997

Complete set of tools for working with scanned images and line art will be needed.

Interactive editing of a graphic image will be needed. This will allow complete real-time manipulation of any element in the graphic, including ability to rotate, scale (horizontally or vertically), crop, or change design characteristics.

Text Requirements:

1988

Will need the ability to create curvilinear type as defined by mathematical expressions rather than bitmapping or vectoring.

The system will use traditional (standard) typesetting terminology.

The system will use true type fonts and show absolute positioning of text.

1992

Text placement will be improved, including fitting text onto a curved line.

Output:

1988

Graphics output will use a PDL that addresses resolution of output device rather than a fixed internal resolution.

There will be flexible output including plain paper, film, printing plate, or proof on paper.

Must be able to send a composite color graphic image as individual colors to high-resolution film output device for printing separates or a multi-color image to a laser printer for proofing.

Must be able to print PDL files. It is anticipated that PostScript will be the standard at least through 1992.

1992

Graphics files will be output using current FIPS GKS standards

(10) Please describe any equipment requirements for this activity.

A. Display/Keyboard:

All display screens must be a minimum of 19 inches, with some 25 inch units. All systems must have support for multiple pointing devices for addressing locations on the screen (such as light pens).

Display screens must be color with a minimum resolution of 1,024 x 1,024 with the option of higher-resolution for some stations.

All screens must be able to move, zoom, and pan in almost real time. An acceptable response time for a zoom repaint would be under 5 seconds. Moving operations should be in real time.

B. Processor:

The processor must be capable of intensive operations on a high-resolution graphic image. This requires that most operations must be able to be done and displayed in 20 seconds or less, with some complex operations being done in less than 2 minutes.

Most processing will be done on the main central processing unit (CPU) with some operations being done locally in the display screens.

C. Storage:

0.25 megabytes per graphic

1992

9,600 illustrations x 0.25 MB = 2,400 MB or 2.4 GB (gigabyte). This is for one copy of each illustration plus other presentation graphics. Number should be tripled to account for multiple copies.

D. Output Devices:

300, 600, and 1,000 dpi laser paper printers:

The printers should have:

A choice of either 8-1/2 x 11 or 11 x 7 inch output at 10 new pages per minute.

300 dpi color laser printers with 8-1/2 x 11 inch output and minimum speed of 1 page per minute

1,000 and 2,500 dpi laser film imagesetters with a minimum speed of 45 minutes for most complex 11 x 17-inch image and a maximum image size choice of 12 x 20 or 18 x 20 inches

2,000 x 2,000 and 4,000 x 4,000 line slide recorders with 35-millimeter format and a minimum speed of 3 minutes per slide

300, 600, and 1,000 dpi monochrome and color scanners

Color electrostatic plotters, 400 dpi resolution with choice of 24-, 36-, or 44-inch roll stock output and a length of output at least 70 inches

Laser film recorders, minimum resolution of 1,000 dpi with a maximum output size of 44 x 70 inches (to match largest press size for printing Hydrologic Atlases).

Note: all equipment must be controlled from a central platform and not require separate operating systems to utilize any of these different output devices.

E. Communications:

Use standards as developed for general-purpose graphics package.

Publishing

(1) Please identify the major activities performed.

Publishing

1988

(2) Please describe each identified activity and why it is needed in 1988.

Page layout

After the edited manuscript is typeset, the text, figures, and tables are arranged in accordance with USGS specifications. It can be done manually or on a machine. Formal reports (Professional Papers, Bulletins, Circulars, Water-Supply Papers, and Techniques of Water Resources Investigations) that go through the Office of Scientific Publications in the Geologic Division are presently having page layout done on their typesetting equipment Xyvision. This equipment has been purchased (not leased) by the Geologic Division and should be in place for some time. Informal series reports are prepared for printing at various offices throughout WRD and layout, with the exception of several locations, is done for the most part manually.

B. Printing

For formal series reports going through the Office of Scientific Publications, Geologic Division, the Xyvision equipment can take anything with ASCII files. The Branch of Eastern Technical Reports has just purchased and received (October 27, 1987) an L300 (Linotronic 300), which should be online by December 1, 1987. This is a laser typesetter, but not like a laser printer. It has 56 fonts; the same fonts as on the Mergenthaler that the Geologic Division also purchased. It has high resolution option-capacity of 2,540 lines per inch. Art and tables can be scanned in, scaled, cropped, cleaned up, touched up, erased, moved, and repositioned.

For informal series reports, with the exception of several offices having more sophisticated equipment, the WRD offices are preparing these on word processors or, in some cases, desk-top publishers.

A desk top publishing system might be an option for all reports not in the formal series. The number one requirement should be that the system works with text in ASCII. The system should have PostScript so that a report that would go to a formal series could go into the L300 or into the Xyvision, then coded and then to the L300. It should be suited to technical publications. The desk-top publishing program needs are:

Sophisticated features to allow formatting, repeating elements such as body text and major headings, style sheets.

To be able to select fonts, automatic hyphenation and justification, and to control character spacing (kerning) and line spacing (leading) in decimal increments.

To automatically number pages and chapters and up to eight levels of headings, as well as to automatically number footnotes and illustrations.

To be able to specify the minimum number of lines to be isolated in widows and orphans.

To offer color options for both text and graphics and to be able to see the page in different views. (For example, actual size, reduced to a full-page view, and enlarged size. Editing functions must operate in all views.)

To be able to specify such items as typeface, type size, bold face, italic typeface, underlines, paragraph indentation and alignment, and tabs, spacing between paragraphs, and ruled lines, Greek letters and math symbols, captions for illustrations and tables.

To be able to communicate or import graphics from other programs or to scan graphics and to scale, crop, and edit.

To be able to specify paper sizes and layout features such as broadmeasure.

To be able to specify running heads and running feet.

To be able to run with any PostScript-compatible printer or typesetter and be printed out on a laser printer for reports that aren't in the formal series, or on the L300 in the Geologic Division.

A laser printer should not be the sole source of output.

There should be the option of downloading onto the Xyvision or a word processor for entering into the formal series to be edited and respaced, or the ability to send the files to a commercial typesetter.

The program should have WYSIWYG. The display should enable one to move and edit text and to place, size, and crop graphics, and see the results.

The system should have text processing and be able to, while in page make-up program, to open word processing documents with formatting intact, accommodate changes in multi-page text, and wrap text around a graphic element.

To be able to insert, delete, and swap pages within a document.

The system should have speedy reformatting if a style change is made.

A page make-up program should have layout measurements expressed in picas and points and should have tracking that governs white space.

The system should support the same fonts the typesetter uses, otherwise the type being set will be typographically inferior when it comes out of the commercial typesetter.

The system should have the ability to send files to remote typesetters.

The system should have features like automatic fraction building as most of the WRD reports have equations in them.

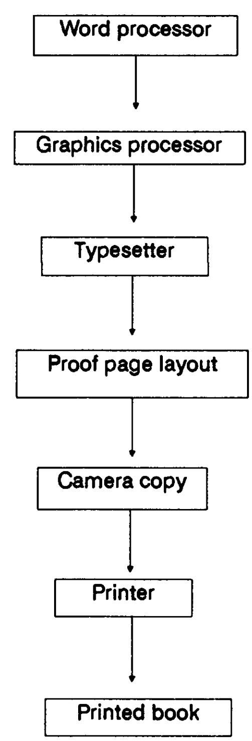
The system should have horizontal and vertical rules, expanded and condensed typefaces.

The program should be able to format up to 100 pages as most WRD reports will fall within this range.

When an area is drawn to contain an imported graphics image, the program must be able to reformat text around the graphic block without having to first pull up the text in a column, change the column guide, then drag the bottom of the column back down. It would be great to find a program that is both sophisticated and easy to learn, but if a choice is to be made, the choice should be sophistication.

The output should be camera ready so it can go directly to the commercial printer or multi-copies could be run on the printer, collated, and stapled.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

50 WRD reports processing offices plus any sites active in Geologic Division for processing WRD reports.

(5) How many times per year is this activity done?

100 people x 260 workdays = 26,000 times per year

(6) How many people per year do this activity?

Approximately 100 persons per year (includes both WRD and Geologic Division personnel performing this function)

(7) How many hours per person per year are spent doing this activity?

Approximately 520 hours per person per year. This is constant because increases in machine performance and software will allow personnel to accomplish more in same amount of time.

(8) Are there any special requirements for this activity?

Knowledge of USGS publications specifications and knowledge of the printing process, including color processing.

(9) Please describe any software requirements for this activity.

A. Data base manager

B. Editor software

Compatible with graphics and word processor package, capable of merging text and graphics, editor notation with text and graphics, and bring both together on the screen.

C. Programming languages

Compatible with other software to pull publishing elements together such as graphics or other text or to call in other programs or subprograms as appropriate.

D. Statistics software

Not a critical need of layout per se. The software packages above should be able to integrate this function as needed.

E. Spreadsheet software

Same as statistics.

F. Utility

Print spooler to handle graphics contained in page layout.

(10) Please describe equipment requirements.

A. Display/keyboard

132 characters per line; full page graphics and text; special characters like sub and superscripts, Greek letters, math symbols, and so forth.

B. Processor

Must have ASCII files to transmit to Xyvision or more advanced typesetting equipment.

C. Storage unit

Must be able to handle the number of reports in preparation and be able to archive or store printed reports to recall readily for reprints as needed.

D. Printer/plotter

Formal series publications (text and graphics) must be transferable to, and compatible with, Xyvision typesetting (ASCII files) and with L300 printer. Laser printer (300 dpi or greater) for informal series is needed.

E. Communications

File transfers from other WRD offices (ASCII files) to Xyvision or L300 printer for formal series; to and from the 90 WRD locations noted above for all other WRD reports.

1992

(2) Please describe each identified activity and why it is needed in 1992.

Page layout

Same as for 1988 except that more layout will be performed on machines in WRD offices. Specifications could change for layouts performed by the Geologic Division (GD) (that is, modifications such as updated features may no longer require ASCII files or other restrictions called for in 1988).

Printing

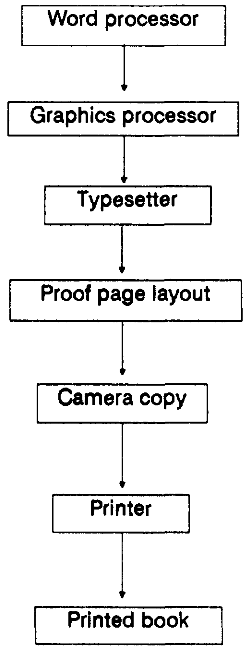
Same as for 1988 except that specifications for those publications to GD may change as noted above. Also, files from graphics processors as well as word processors should be transferable between equipment performing layout activities.

(3) Please describe the flow of information in this activity.

See flow chart on next page.

(4) How many locations do this activity?

75 WRD reports processing offices plus Geologic Division sites.



(5) How many times per year is this activity done?

There could be an increase in the number of reports prepared in the future because of the efficiencies resulting from automated procedures, reducing overall preparation and processing time. It is estimated that there may be approximately 975 WRD publications (excluding abstracts):

150 people x 260 workdays = 39,000 times per year.

(6) How many people per year do this activity?

Approximately 150 persons per year (includes both WRD and Geologic Division personnel performing this function).

(7) How many hours per person per year are spent doing this activity?

Approximately 520 hours per person per year. (This remains a constant as compared to 1988 even though the number of reports has risen. Improvements in functionality of software allow this to stay constant).

(8) Are there any special requirements for this activity?

Same as 1988

(9) Please describe any software requirements for this activity.

Same as 1988 except that specifications for file transfers between equipment may be more flexible and permit other than ASCII files, for example.

(10) Please describe any equipment requirements for this activity.

Again specifications may change for file transfer to typesetters and printers such as existing today for the Xyvision and L300. Also, capabilities should exist to include color in layouts and typesetting for publication. Transfer of files, containing both text and graphics, will be transferred faster than in previous years.

1997

(2) Please describe each identified activity and why it is needed in 1997.

The requirements for 1997 should be the same as 1992 – upgrading as technology becomes available for faster output and higher resolution for graphics, better color, and so forth. The number of locations (question number 4) will increase to 125 WRD reports processing offices. Geologic Division sites will no longer process WRD reports. The number of times (question number 5) will increase to 52,000. The number of people (question number 6) will increase to 200.

Distribution, Archiving, and Bibliographic Retrieval

(1) Please identify the major activities performed.

Distribution, Archiving, and Bibliographic Retrieval

Reports are the only tangible product of WRD. We are under legal and moral obligation to disseminate these reports and maintain a complete record of our investigations as a publicly funded agency. Additionally, it is to our own advantage within WRD to keep an easily accessed library of all of our products as reference material to build on for new investigations. An essential component of our agencies credibility is the internal consistency of our reports.

Problem: Storage of WRD reports for subsequent retrieval and distribution.

The archive-retrieval system should provide:

- Citation information for management and planning purposes.
- Retrieval of original text or graphics for inclusion in subsequent reports.
- Retrieval for inhouse reference and research.
- Retrieval for distribution of hardcopy to cooperators or public information requests.

Prior to 1988 this has been accomplished by storage at designated regional libraries and at the originating office in "hardcopy" form.

The goal of the archive function is similar to that of the hydrologic data base, online access to all WRD reports (including graphics). The update and distribution of the archive could be handled in parallel fashion with annual distribution of read-only media containing new reports and addenda or corrections to previous reports. The annual electronic publication would be distributed to all district offices and be available to cooperating agencies or the public in general for the cost of reproduction. The system should include software for rapid (seconds to a few minutes) retrieval of bibliographic information based on author, subject, title, or keyword requests. The initial retrieval should include a complete abstract if requested. A less rapid (minutes to a couple of hours) retrieval system would be sufficient for retrieval of the entire document.

The Archive system is technically possible with 1988 technology but it will improve productivity only after:

- Integration of text and graphics in our initial input and edit cycles;
- Development of a reports tracking system which includes electronic review and approval; and
- Development of textual database system for rapid retrieval of abstract information.

A system could be developed using optical recording technology which would allow our current hardcopy system to remain intact and produce electronic copy of reports, but it would not increase productivity; it would add an additional processing layer to an already overloaded reports system. Therefore, complete integration of a new archival system is not proposed until 1992, assuming the following components are functional:

1988–92

Integration of text and graphics

Electronic review RTS system, that is, whole document tracking system.

Development of WRD abstract search and retrieval system on a single system accessible to everyone through the network. The system will automatically update WRSIC data base.

1992–97

Reproduce and distribute the electronic version of the abstract retrieval system.

Enhance the bibliographic and abstract archival system to include connections to the complete document retrieval system.

Begin work on inclusion of all text and graphics on read only media for general and official distribution in lieu of printing.

1997

Complete product functioning

Begin the inclusion of color and map products when technology is available (that is, high density low cost storage systems).

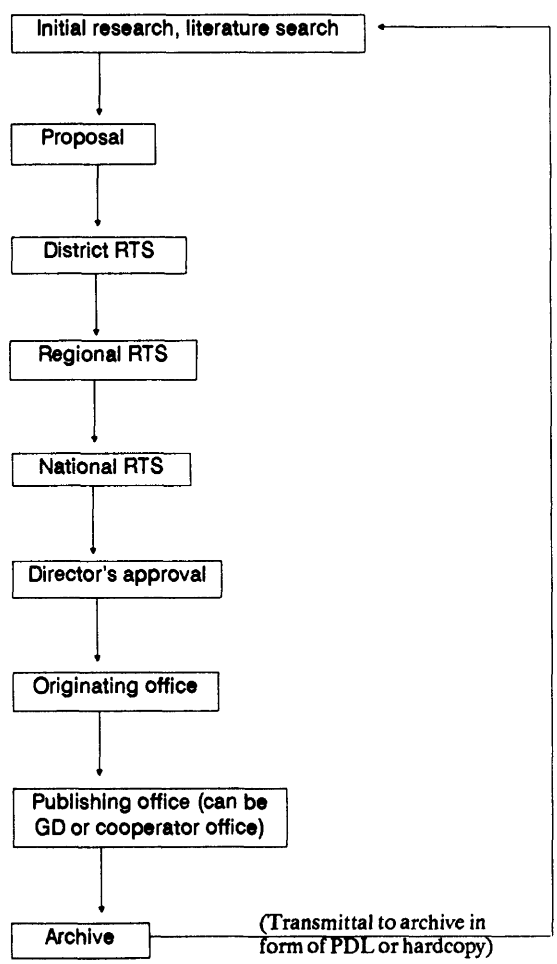
(2) Please describe each identified activity and why it is needed in 1988, 1992, and 1997.

1988–92

Archival activity

Hardcopy storage of approved documents at regional libraries and originating office. Bibliographic data and abstracts available through the network at a central location.

(3) Please describe the flow of information in this activity.



(4) How many locations do activity?

Approximately 90 offices will archive the reports and abstracts produced in WRD. This will be constant for all three time periods

(5) How many times per year is this activity done?

1988

Approximately 1,500 archivable reports and abstracts are produced each year.

1992

1,630 reports and abstracts

1997

1,810 reports and abstracts

(6) How many people per year do this activity?

As reports are our only product, everyone is involved at some level, that is, 4,000 people. Our current hardcopy archive process (copying, documenting, mailing, obtaining appropriate signatures, and so forth) is performed by some authors and 350 reports personnel.

350 report personnel will archive documents. This will remain constant for all time periods.

(7) How many hours per person per year are spent doing this activity?

In terms of hours per report

Document preparation = 2 hours per report

Librarian time = 2 hours per report

1,500 reports x 4 = 6,000 hours per year for archival processing

6,000 hours per 350 reports personnel = 17 hours per person per year

This number will be constant for 1988, 1992, and the 1997 time periods.

(8) Are there special requirements for this activity?

Yes, original documents must be preserved and designated archive locations must be easily accessible to the public.

(9) Please describe any software requirements for this activity.

The software for electronic archival is not yet developed or designed. Consequently, we have no system dependencies at this time. As a design evolves it is likely that a third party textual data base will be required. The data base must be capable of efficient storage and retrieval of random length text records.

Other standard support software (graphics, statistics, spreadsheets, and word processing) will be required to analyze the archive data base for management purposes.

(10) Please describe any equipment requirements for this activity.

A. Display/Keyboard

During the 1988–92 period the electronic archive and retrieval process will be limited to text only. A dumb American National Standards Institute (ANSI) standard terminal with full keyboard is sufficient from a user prospective.

B. Processor

Must be adequate to provide immediate response (second) for data entry and no more than a few minutes response for database search.

C. Storage

1,500 abstracts per year at 3,000 characters per abstract = approximately 5 Mbytes per year plus data-base overhead of 10 times the data set = approximately 50 Mbytes per year on a single system at some location on the network.

D. Printer/Plotter

Each retrieval site must have at least a 300 dpi laser printer. Most archival sites must have an optical character reader (OCR) system to accommodate situations where hardcopy is the only original source.

E. Communications

All originating offices must have access to a single archive system during the 1988–92 period

Reference

U.S. Geological Survey, 1986, Goals of the U.S. Geological Survey, earth science in the public service: U.S. Geological Survey Circular 1010, 17 p.

page 139 follows

SUPPLEMENTARY DATA V.--Administrative Work Group

page 141 follows

SUPPLEMENTARY DATA V.—ADMINISTRATIVE WORK GROUP

The administrative function group addressed Distributed Information Systems-II (DIS-II) as it affects the administrative activities of each Water Resources Division (WRD) office. The work group reviewed the following functions:

Payroll

- Financial management
- Procurement and contracts
- Personnel
- Office automation
- Management Information System (MIS) and Executive Information Systems (EIS) planning
- Travel
- General services inventory systems

The process consisted of assigning tasks to individual members for development. A group review was conducted in Sacramento, Calif., on November 9–10 to finalize each functional requirement statement and to develop the summary report.

In broad outline the administrative functional requirements of DIS-II may be characterized as follows:

- An electronic storage, retrieval, and transfer system for all information forms including documents, tables, images, audio, and software.
- Immediate access to the electronic system by all employees with sufficient processing capability to perform tasks quickly.
- Integration of subsystems that will provide a common syntax to perform administrative and management tasks, and subsystem boundaries that are transparent to the user.
- Assumed continuation of distributed processing at major WRD offices with sufficient network capacity and systems interfacing to allow easy data flow between various office entities, internal and external to WRD.

As a group, the functional requirements idenified for the WRD administrative area imply that certain technical features will be needed in DIS-II. The administrative function will need specific features in each of the following categories: operating environment, communication software, communications equipment, and Artificial Intelligence (AI) support. These are described below:

- Operating environment.—The user must have a friendly facility allowing for easy control of multiple concurrent information management processes. All software must be operable within a multiple processing environment where background tasks operate concurrently with the foreground task. The environment must have a user-friendly graphical interface incorporating windows and icons on a high resolution display and with a pointing input device in addition to a standard keyboard. In 1988 the environment must support Microsoft-Disk Operating System (MS-DOS) compatible software; by 1992 Operating System/2 (OS/2) must also be supported. Also by 1992, voice and video input devices should be provided; voice recognition should be available by 1997.
- Communication software.—The user must have the ability to exchange information in many forms with other facilities both locally and remotely. This will require software that implements Federal Government Open Systems Interconnection standards to the maximum extent. In 1988, communications to remote computers operating 3270 Full Screen is necessary. Information exchange with local scientific operating and network systems (such as UNIX and TCP/IP) is also required.
- Communications equipment.—In 1988, hardware and software must provide reliable transmission of all supported information forms (such as text, tables, graphs and other images, and software) at effective speeds of at least 100 characters per second. By 1992, speeds should be several times that rate and a similar increase should be expected by 1997. Also by 1992, voice and video information forms should be supported via the then-current Federal standard transmission facilities.
- Artificial intelligence (AI) support.—By 1992, the system should support AI software that will further simplify the task of correlating multiple information sources. This facility may take the form of expert system software specifically tailored to a particular functional area or more generally supporting various types of analysis. (The AI software itself need not be procured with DIS-II.)

It is recognized that most of the administrative requirements for DIS-II are available, possible, and feasible within the current DIS framework. The general obstruction to the perception of DIS-II is acquisition or development of necessary software. Specific items that must be dealt with are:

- An efficient text-string search capability for many functional areas,
- Transcription of documents from paper to electronic storage, and
- Technical development of a management accepted scheme for electronic signatures for most, if not all, purposes.

The schedule for upgrading the technology available to WRD administrative functions should be guided by the following considerations:

- If Amdahl applications continue to require an interactive mode, then there is an immediate need to improve the quality of the interactive processing, particularly the full screen personnel system.
- At each site, administrative functions in 1988 need to progress to at least an IBM PC-AT equivalent workstation that would provide support for pre- and post-processing of information as well as a much friendlier interface when manipulating the various systems with which administrative functions interact, in particular the new departmental financial system.
- Administrative users need to become familiar with a window-type operating environment – this could be accomplished on personal computers before the full introduction of 32-bit workstations throughout the administrative functions.
- When 32-bit workstations become widespread in WRD, these same workstations should be provided to the administrative function. The additional cost over that of a personal computer is likely to be nominal compared to the benefits of a homogeneous environment throughout the office.

Payroll

(1) Please identify the major activities performed.

Payroll

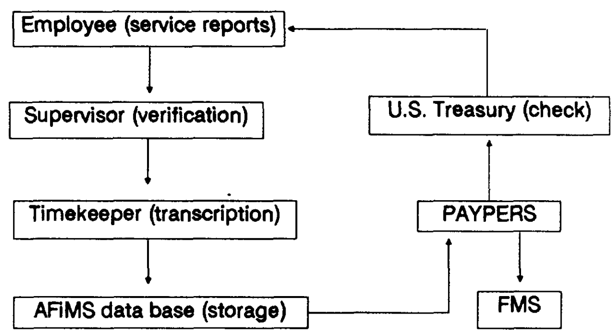
(2) Please describe each identified activity and why it is needed.

1988

Payroll is the process of collecting time and attendance information, calculating costs for benefits and salary, certifying payroll records, and forwarding payroll records to the Department payroll system. It is the system by which employees are compensated for their work and is required and regulated by law.

(3) Please describe the flow of information in this activity.

AFiMS is the WRD Automated Financial Management System. FMS is the U.S. Geological Survey Financial Management System. PAYPERS is the Department of Interior (DOI) payroll and personnel system.



(Transmission)

(4) How many locations do this activity?

All cost centers; approximately 80 offices.

(5) How many times per year is this activity done?

26 pay periods x 4,000 employees = 104,000

(6) How many people per year do this activity?

80 offices x 50 people each = 4,000

(7) How many hours per person per year are spent doing this activity?

1 timekeeper = 200 hours per year per office
50 employees x
0.5 hour x
26 pay periods = 650 hours per year per office
850 hours per year per office

850 hours per year per office x 80 offices
= 68,000 ÷ 4,000 = 17 hours per year per person

(8) Are there any special requirements for this activity?

Security and reliability are of primary consideration. Payroll files must be maintained in a manner that ensures physical security and personnel confidentiality. Payroll must be processed in a timeframe prescribed by the Department PAYPERS system.

(9) Please describe any software requirements for this activity.

(9a) Data base manager: INFO
(9b) Editor software: None

(9c) Graphics software: None
(9d) Programming languages: INFO
(9e) Statistics software: None
(9f) Spreadsheet software: None
(9g) Utility software: Multiple Indexed Direct Access System (MIDAS) (PR1ME), file transfer (PR1ME File Transfer System (FTS))

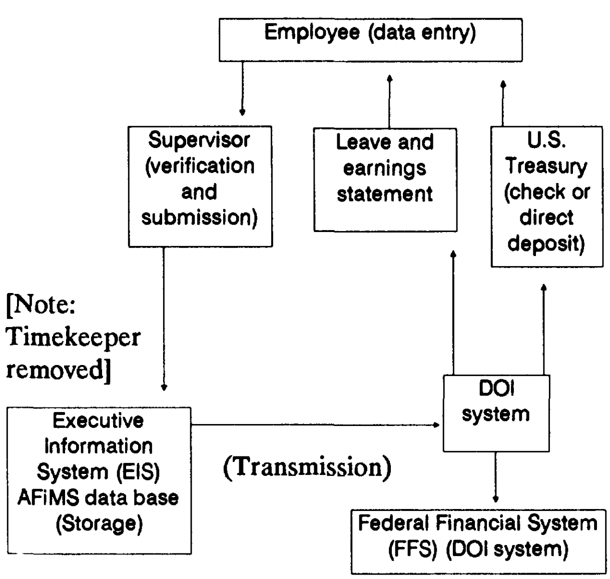
(10) Please describe any equipment requirements for this activity.

(10a) Display/Keyboard: VT100 functional compatability
(10b) Processor: Must execute above software
(10c) Storage unit: 10-megabytes direct access storage per cost center
(10d) Printer/Plotter: 132-column and printing on preprinted forms
(10e) Communications: GEONET (FTS) transmission from cost centers to central site, Remote Job Entry (RJE) transmission (UT200) from central site to Department system (PAYPERS).

1992 and 1997

Payroll is the process of collecting time and attendance information, calculating costs for benefits and salary, certifying payroll records, and forwarding payroll records to the department payroll system. It is the system by which employees are compensated for their work and is required and regulated by law.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

All cost centers; approximately 80 offices.

(5) How many times per year is this activity done?

26 pay periods x 4,000 employees = 104,000

(6) How many people per year do this activity?

50 employees per office x 80 offices = 4,000 (automated time and attendance).

(7) How many hours per person per year are spent doing this activity?

Employees (50) x
0.5 hour x
26 pay periods = 650 hours per year per office

Supervisors (5) x
1.0 hour x
26 pay periods = 130 hours per year per office
780 hours per year per office

780 hours per year per office x 80 offices
= 62,400 ÷ 4,000 = 16 hours per year per person

(8) Are there any special requirements for this activity?

Security and reliability are of primary consideration. Payroll files must be maintained in a manner that ensures physical security and personnel confidentiality. Payroll must be processed in a timeframe prescribed by the Department PAYPERS system.

(9) Please describe any software requirements for this activity. You may list functions of the software or a specific product.

(9a) Data base manager: Yes, likely relational interconnected to other WRD subsystems
(9b) Editor software: None
(9c) Graphics software: Yes, management and analysis
(9d) Programming languages: No
(9e) Statistics software: Yes, management and analysis
(9f) Spreadsheet software: Yes, as needed to do graphics and statistics
(9g) Utility software: None beyond Data-Base Management System (DBMS) software (9a) and communications (10e)

(10) Please describe any equipment requirements for this activity.

(10a) Display/Keyboard: 132-column, graphics, QWERTY
(10b) Processor: Support software (above) in interactive processing mode, near immediate

system response is required for keyed data with system command responses performed within 2 seconds.

(10c) Storage unit: 10-megabytes direct access storage per cost center

(10d) Printer/Plotter: 132-column and printing on preprinted forms color graphics

(10e) Communications: GEONET transmission from cost centers to Department system.

Financial Management

Financial management includes budgeting, funding, and expenditure activity of the Water Resources Division at all levels of the organization.

(1) Please identify the major activities performed.

- Budget
- Funding
- Expenditures

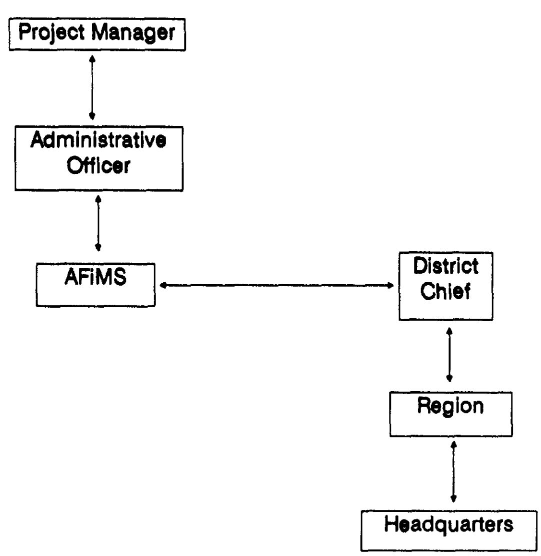
Budget

(2) Please describe each identified activity and why it is needed.

To budget is to plan the financial aspects of the individual organizations as to resources of funds and potential usage of those funds required to meet the mission of the Division in accordance with its charter and appropriation.

1988

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

All WRD cost centers, subdistricts, and some individual offices = 100 locations.

(5) How many times per year is this activity done?

500 entries (250 entries 2 times per year) x 100 locations = 50,000

(6) How many people per year do this activity?

About 5 people per location x 100 locations = 500

(7) How many hours per person per year are spent doing this activity?

1 week per person per time = 80 hours per person per year

(8) Are there any special requirements for this activity?

Historical cost data, with spreadsheets and matrices to be utilized in this activity.

(9) Please describe any software requirements for this activity.

(9a) Data base manager: Yes
(9b) Editor software: No
(9c) Graphics software: Yes
(9d) Programming languages: No
(9e) Statistics software: Yes
(9f) Spreadsheet software: Yes
(9g) Utility software: Yes, for graphics

(10) Please describe any equipment requirements for this activity.

(10a) Display/Keyboard: 132 character, with graphics
(10b) Processor: No
(10c) Storage unit: 0.2 megabyte
(10d) Printer/Plotter: Letter quality printer with graphics
(10e) Communications: GEONET

1992

Use of Federal Financial System (FFS) with local pre- and post-processing for project costing, aggregating budgets by locations, and so forth, will allow more time to analyze data.

(3) Please describe the flow of information in this activity.

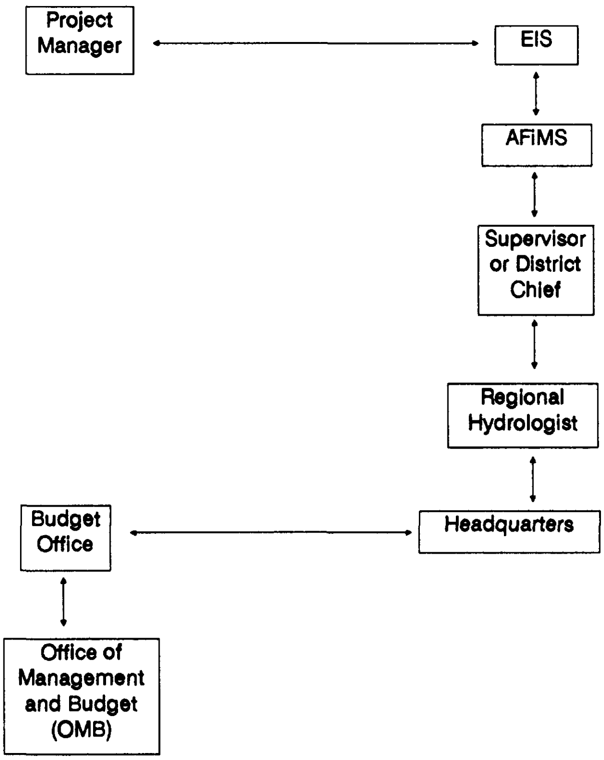
See flow chart on next page.

(4) How many locations do this activity?

All WRD cost centers, subdistricts, and some individual offices = 100 locations.

(5) How many times per year is this activity done?

500 entries (250 entries 2 times per year) x 100 = 50,000



(6) How many people per year do this activity?

About 5 people per location x 100 locations = 500

(7) How many hours per person per year are spent doing this activity?

1 week per person per time = 80 hours per person per year

(8) Are there any special requirements for this activity?

Access to the Bureau's FFS

(9) Please describe any software requirements for this activity.

(9a) Data base manager: Yes
(9b) Editor software: No
(9c) Graphics software: Yes
(9d) Programming languages: No
(9e) Statistics software: Yes
(9f) Spreadsheet software: Yes
(9g) Utility software: Interface with FFS

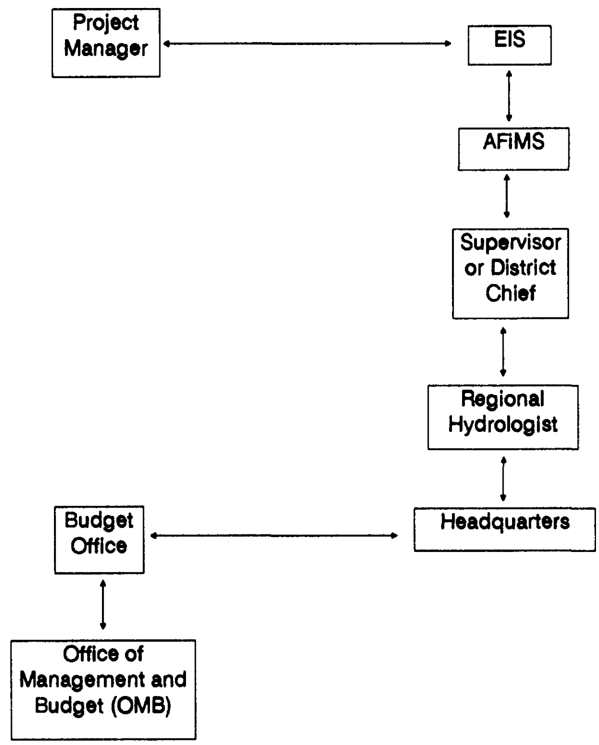
(10) Please describe any equipment requirements for this activity.

(10a) Display/Keyboard: 132 character terminal with graphics
(10b) Processor: No
(10c) Storage unit: 2 megabyte
(10d) Printer/Plotter: Letter quality printer with graphics
(10e) Communications: GEONET

1997

Use of FFS with local pre- and post-processing for project costing, aggregating budgets by locations, and so forth, will allow more time to analyze data.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

All WRD cost centers, subdistricts, and some individual offices = 100 locations.

(5) How many times per year is this activity done?

500 entries (250 entries 2 times per year) x 100 = 50,000

(6) How many people per year do this activity?

About 5 people per location x 100 locations = 500

(7) How many hours per person per year are spent doing this activity?

1 week per person per time = 80 hours per person per year

(8) Are there any special requirements for this activity?

Access to the Bureau's FFS

(9) Please describe any software requirements for this activity.

(9a) Data base manager: Yes
(9b) Editor software: No
(9c) Graphics software: Yes
(9d) Programming languages: No
(9e) Statistics software: Yes
(9f) Spreadsheet software: Yes
(9g) Utility software: Interface with FFS

(10) Please describe any equipment requirements for this activity.

(10a) Display/Keyboard: 132 character terminal with graphics
(10b) Processor: No
(10c) Storage unit: 4 megabyte
(10d) Printer/Plotter: Letter quality printer with graphics
(10e) Communications: GEONET

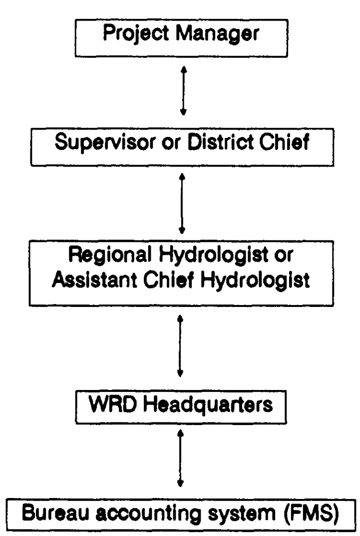
Funding

(2) Please describe each identified activity and why it is needed.

1988

Funding: to coordinate the funding activities of the organization by tracking the source of funds, following up on document preparation with cooperators, assigning applicable funds to correct projects and customers using existing software, and reviewing the funding of the organization on a periodic basis (at least quarterly, and then monthly during the last 3 months of the fiscal year).

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

All WRD cost centers, subdistricts, and some individual offices = 100 locations.

(5) How many times per year is this activity done?

250 entries x 100 locations = 25,000

(6) How many people per year do this activity?

2 people per location x 100 locations = 200

(7) How many hours per person per year are spent doing this activity?

500 hours per location ÷ 2 people = 250

(8) Are there any special requirements for this activity?

Historical funding data, using spreadsheets and matrices for this activity.

(9) Please describe any software requirements for this activity.

(9a) Data base manager: Yes
(9b) Editor software: No
(9c) Graphics software: Yes
(9d) Programming languages: No
(9e) Statistics software: Yes
(9f) Spreadsheet software: Yes
(9g) Utility software: AFiMS

(10) Please describe any equipment requirements for this activity.

(10a) Display/Keyboard: 132 character terminal with graphics
(10b) Processor: No
(10c) Storage unit: 2 megabyte
(10d) Printer/Plotter: Letter quality printer with graphics
(10e) Communications: GEONET

1992

Fiscal Year 1992 will see the Division utilize more sophisticated equipment, yet the process will remain much the same. Paper documents will need to be tracked with cooperators, but not sent forward as is currently done. Funding will still need to be applied to correct projects and customers in order to spend the funds.

(3) Please describe the flow of information in this activity.

See flow chart on next page.

(4) How many locations do this activity?

All WRD cost centers, subdistricts, and some individual offices = 100 locations.

Project Manager

↕

Supervisor or District Chief

↕

Regional Hydrologist or Assistant Chief Hydrologist

↕

WRD Headquarters

↕

Bureau accounting system (FMS)

(5) How many times per year is this activity done?

250 entries x 100 locations = 25,000

(6) How many people per year do this activity?

2 people per location x 100 locations = 200

(7) How many hours per person per year are spent doing this activity?

500 hours per location ÷ 2 people = 250

(8) Are there any special requirements for this activity?

Historical funding data.

Interactive with Bureau accounting system, with pre- and post-processing at local level.

(9) Please describe any software requirements for this activity.

(9a) Data base manager: Yes
(9b) Editor software: No
(9c) Graphics software: Yes
(9d) Programming languages: No
(9e) Statistics software: Yes
(9f) Spreadsheet software: Yes
(9g) Utility software: Local FFS interface software

(10) Please describe any equipment requirements for this activity.

(10a) Display/Keyboard: 132 character terminal with graphics, windows.
(10b) Processor: Yes, multitasking workstation
(10c) Storage unit: 5 megabyte
(10d) Printer/Plotter: Letter quality printer with graphics
(10e) Communications: GEONET

1997

Fiscal Year 1997 will see the Division utilize more sophisticated equipment, yet the process will remain much the same. Paper documents will need to be tracked with cooperators, but not sent forward as is currently done. Funding will still need to be applied to correct projects and customers in order to spend the funds.

(3) Please describe the flow of information in this activity.

Project Manager

↕

Supervisor or District Chief

↕

Regional Hydrologist or Assistant Chief Hydrologist

↕

WRD Headquarters

↕

Bureau accounting system (FMS)

(4) How many locations do this activity?

All WRD cost centers, subdistricts, and some individual offices = 100 locations.

(5) How many times per year is this activity done?

250 entries x 100 locations = 25,000

(6) How many people per year do this activity?

2 people per location x 100 locations = 200

(7) How many hours per person per year are spent doing this activity?

500 hours per location ÷ 2 people = 250

(8) Are there any special requirements for this activity?

- Historical funding data.
- Interactive with Bureau accounting system, with pre- and post-processing at local level.

(9) Please describe any software requirements for this activity.

(9a) Data base manager: Yes
(9b) Editor software: No
(9c) Graphics software: Yes

(9d) Programming languages: No
(9e) Statistics software: Yes
(9f) Spreadsheet software: Yes
(9g) Utility software: Local FFS interface software

(10) Please describe any equipment requirements for this activity.

(10a) Display/Keyboard: 132 character terminal with graphics, windows.
(10b) Processor: Yes, multitasking workstation
(10c) Storage unit: 10 megabyte
(10d) Printer/Plotter: Letter quality printer with graphics
(10e) Communications: GEONET

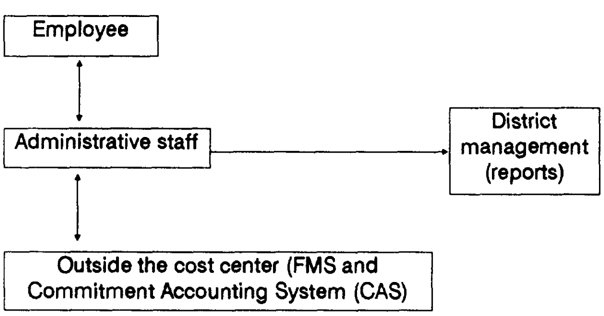
Expenditures

(2) Please describe each identified activity and why it is needed.

Expenditures: to track the usage of financial resources, at the project level, by object class, and to report these data by customers. Expenditures are incurred in many ways, procurements, travel, payroll, and so forth. Many requirements from Treasury, OMB, and the Department are to be followed in the expenditure of funds. Reporting is required at various levels of the bureau and the department.

1988

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

All WRD cost centers, subdistricts, and some individual offices = 100 locations.

(5) How many times per year is this activity done?

6,000 entries x 100 locations = 600,000

(6) How many people per year do this activity?

1 person per location x 100 locations = 100

(7) How many hours per person per year are spent doing this activity?

1 person per location x 2,000 hours = 2,000

(8) Are there any special requirements for this activity?

Expenditures require a flexible data base, with spreadsheet and graphics capabilities.

(9) Please describe any software requirements for this activity.

(9a) Data base manager: Yes
(9b) Editor software: No
(9c) Graphics software: Yes
(9d) Programming languages: No
(9e) Statistics software: Yes
(9f) Spreadsheet software: Yes
(9g) Utility software: AFiMS

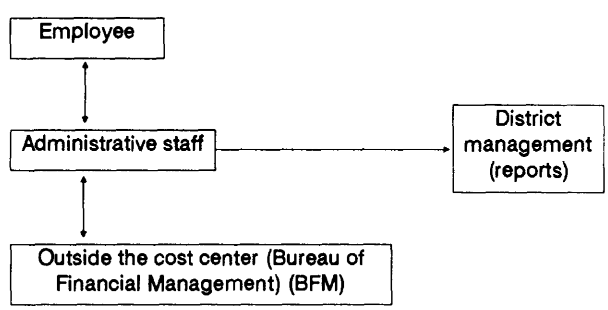
(10) Please describe any equipment requirements for this activity.

(10a) Display/Keyboard: 132 character terminals with graphics
(10b) Processor: No
(10c) Storage unit: 1 megabyte
(10d) Printer/Plotter: Letter quality printer with graphics
(10e) Communications: GEONET

1992

1992 would see the Division using more sophisticated technology in passing data to other parts of the organization, using an upgraded version of FFS, and a higher degree of graphic presentations.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

100 locations.

(5) How many times per year is this activity done?

7,000 entries x 100 locations = 700,000

(6) How many people per year do this activity?

1 person x 100 locations = 100

(7) How many hours per person per year are spent doing this activity?

1 person per location x 2,000 hours = 2,000

(8) Are there any special requirements for this activity?

Generate vendor payments directly.

Interface with FFS with local pre- and post-processing.

(9) Please describe any software requirements for this activity. You may list functions of the software or a specific product.

(9a) Data base manager: Yes
(9b) Editor software: No
(9c) Graphics software: Yes
(9d) Programming languages: No
(9e) Statistics software: Yes
(9f) Spreadsheet software: Yes
(9g) Utility software: Local FFS interface software

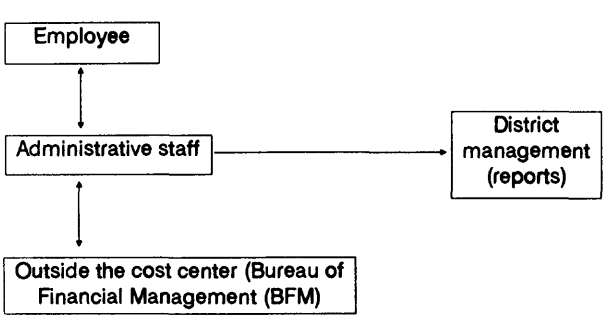
(10) Please describe any equipment requirements for this activity.

(10a) Display/Keyboard: 132 character terminals with graphics, windows
(10b) Processor: Multitasking workstation
(10c) Storage unit: 3 megabyte
(10d) Printer/Plotter: Laser printer with graphics
(10e) Communications: GEONET

1997

1997 would see the Division using more sophisticated technology in passing data to other parts of the organization, using an upgraded version of FFS, and a higher degree of graphic presentations.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

100 locations

(5) How many times per year is this activity done?

9,000 entries x 100 locations = 900,000

(6) How many people per year do this activity?

1 person per location x 100 locations = 100

(7) How many hours per person per year are spent doing this activity?

1 person per location x 2,000 hours = 2,000

(8) Are there any special requirements for this activity?

- Generate vendor payments directly.
- Interface with FFS with local pre- and post-processing.

(9) Please describe any software requirements for this activity. You may list functions of the software or a specific product.

(9a) Data base manager: Yes
(9b) Editor software: No
(9c) Graphics software: Yes
(9d) Programming languages: No
(9e) Statistics software: Yes
(9f) Spreadsheet software: Yes
(9g) Utility software: Local FFS interface software

(10) Please describe any equipment requirements for this activity.

(10a) Display/Keyboard: 132 character terminals with graphics, windows
(10b) Processor: Multitasking workstation
(10c) Storage unit: 6 megabyte
(10d) Printer/Plotter: Laser printer with graphics
(10e) Communications: GEONET

Procurement and Contracts

(1) Please identify the major activities performed.

Procurement and contracts

(2) Please describe each identified activity and why it is needed.

To procure all equipment, supplies, and services needed to support WRD mission.

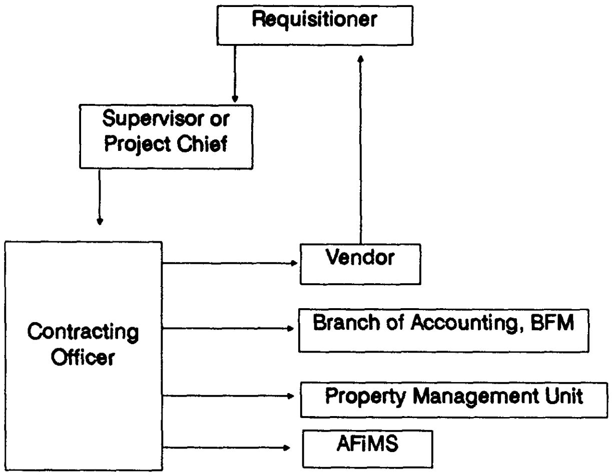
1988

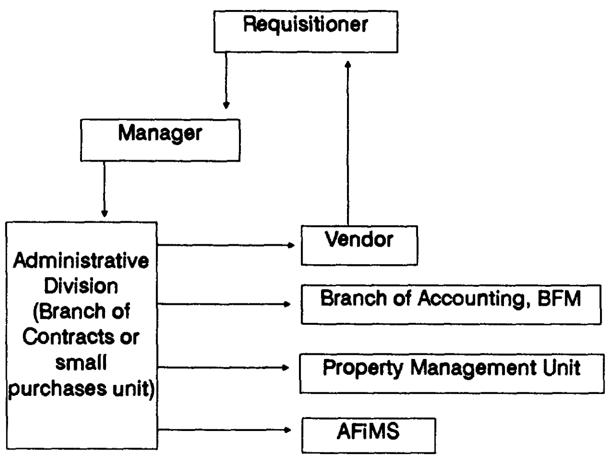
(3) Please describe the flow of information in this activity.

See flow chart on next page.

(4) How many locations do this activity?

All WRD locations = 100





(5) How many times per year is this activity done?

480 transactions per location x 100 locations = 48,000

(6) How many people per year do this activity?

16 people per location x 100 locations = 1,600

(7) How many hours per person per year are spent doing this activity?

1.5 hour per transaction x 480 transactions ÷ 16 people = 45

(8) Are there any special requirements for this activity?

- Need for specialized forms such as requisitions, purchase orders (PO), and so forth, to document requirements and authorize vendors to deliver.
- Need to identify and document authority to
  - authorize expenditure of funds and
  - obligate funds.
- Need to monitor progress and progression of purchase request through to receipt of merchandise.
- Need to generate reports to document compliance with procurement legislation and monitor dollar volume.
- Need to maintain documentation on procurement transactions for 3 years (per official retention schedules).

(9) Please describe any software requirements for this activity.

(9a) Data base manager: INFO
(9b) Editor software: WordMARC Composer (WMC)
(9c) Graphics software: No
(9d) Programming languages: No
(9e) Statistics software: No
(9f) Spreadsheet software: No
(9g) Utility software: Yes, forms building packages

(10) Please describe any equipment requirements for this activity.

(10a) Display/Keyboard: 132 character, QWERTY, windows
(10b) Processor: None
(10c) Storage unit: 1 megabyte, paper copy files
(10d) Printer/Plotter: Impact printer with form feed
(10e) Communications: None

1992

(3) Please describe the flow of information in this activity.

See flow chart on next page.

(4) How many locations do this activity?

All WRD locations = 100

(5) How many times per year is this activity done?

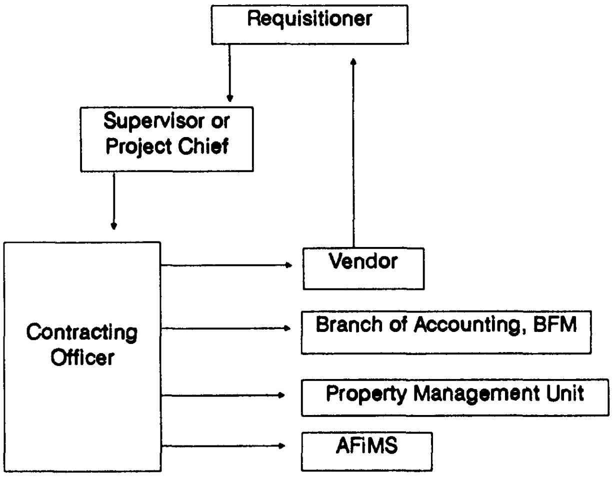
480 transactions per location x 100 locations = 48,000

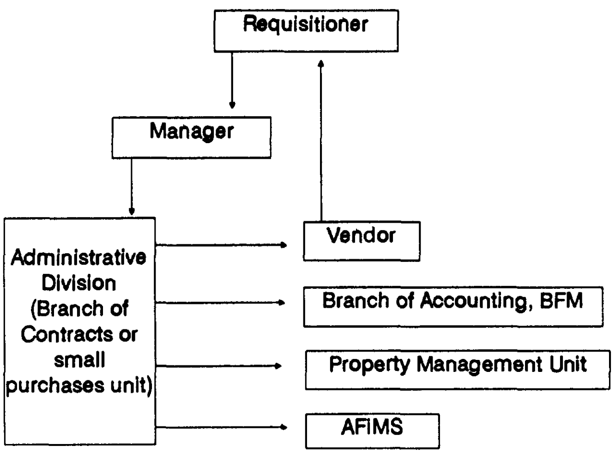
(6) How many people per year do this activity?

16 people per location x 100 locations = 1,600

(7) How many hours per person per year are spent doing this activity?

1.0 hour per transaction x 480 transactions ÷ 16 people = 30





(8) Are there any special requirements for this activity?

- Need for electronic forms such as requisitions, PO, and so forth, to document requirements and authorize vendors to deliver.
- Need to identify and document authority
  - to authorize expenditure of funds,
  - to obligate funds, and
  - by electronic signature.
- Need to monitor progress and progression of purchase request through to receipt of merchandise.
- Need to generate reports to document compliance with procurement legislation and monitor dollar volume.
- Need to maintain documentation on procurement transactions for 3 years (per official retention schedules).
- Security will be an important consideration because of use of electronic signature.
- Need for online access to regulatory and vendor information.

(9) Please describe any software requirements for this activity.

(9a) Data base manager: Yes
(9b) Editor software: Yes
(9c) Graphics software: Yes, drawing specifications
(9d) Programming languages: Yes, designing forms and so forth
(9e) Statistics software: Yes
(9f) Spreadsheet software: Yes
(9g) Utility software: Yes, forms creation, use of scanners and Optical Character Readers (OCR), text string search capability, communications that are Open Systems Interconnect (OSI) compatible to maximum extent possible.

(10) Please describe any equipment requirements for this activity.

(10a) Display/Keyboard: 132 character, high resolution, mouse, scanner windows
(10b) Processor: Multiuser and multitasking work stations
(10c) Storage unit: 5 megabytes
(10d) Printer/Plotter: Laser or latest technology printers and plotters.
(10e) Communications: GEONET with multitude of WRD and non-WRD sites. Access to "libraries". Direct placement of orders with vendors.

1997

(3) Please describe the flow of information in this activity.

See flow chart on next page.

(4) How many locations do this activity?

All WRD locations = 100

(5) How many times per year is this activity done?

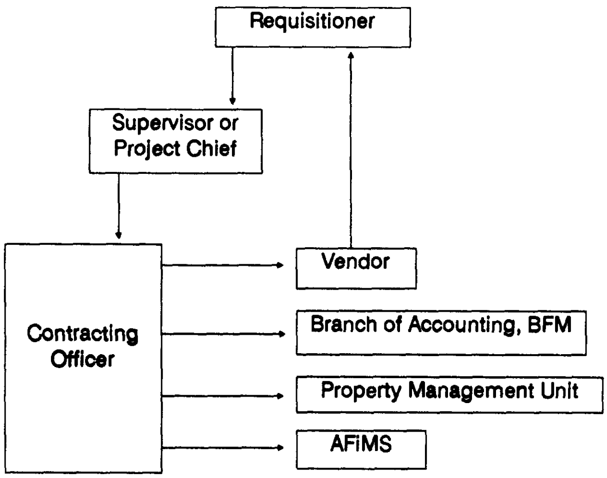
480 transactions per location x 100 locations = 48,000

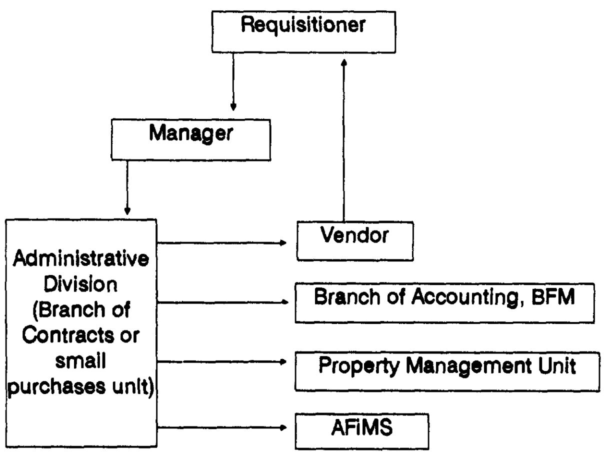
(6) How many people per year do this activity?

16 people per location x 100 locations = 1,600

(7) How many hours per person per year are spent doing this activity?

1.0 hour per transaction x 480 transactions ÷ 16 people = 30





(8) Are there any special requirements for this activity?

- Need for electronic forms such as requisitions, PO, and so forth, to document requirements and authorize vendors to deliver.
- Need to identify and document authority
  - to authorize expenditure of funds,
  - to obligate funds, and
  - by electronic signature.
- Need to monitor progress and progression of purchase request through to receipt of merchandise.
- Need to generate reports to document compliance with procurement legislation and monitor dollar volume.
- Need to maintain documentation on procurement transactions for 3 years (per official retention schedules).
- Security will be an important consideration because of use of electronic signature.
- Need for online access to regulatory and vendor information.

(9) Please describe any software requirements for this activity.

(9a) Data base manager: Yes, highly relational
(9b) Editor software: Yes
(9c) Graphics software: Yes, drawing specifications
(9d) Programming languages: No
(9e) Statistics software: Yes
(9f) Spreadsheet software: Yes, price comparison
(9g) Utility software: Yes, forms creation, use of scanners, OCR, text string search capability, communications OSI compatible to maximum extent possible.

(10) Please describe any equipment requirements for this activity.

(10a) Display/Keyboard: 132 character, high resolution, mouse, scanner, windows
(10b) Processor: Multiuser and multitasking work stations
(10c) Storage unit: 10 megabytes
(10d) Printer/Plotter: Laser or latest technology printers and plotters.
(10e) Communications: GEONET with multitude of WRD and non-WRD sites. Access to "libraries". Direct placement of orders with vendors.

Personnel

There are a variety of tasks involved with personnel activities. Currently, the only function utilizing computer technology is the Personnel Action System (PAS) for automated Request for Personnel Action (Standard Form 52) and Automated Vacancy Announcement and Distribution System (AVADS) for electronic retrieval of vacancy announcements.

(1) Please identify the major activities performed.

Recruitment and placement
Career development

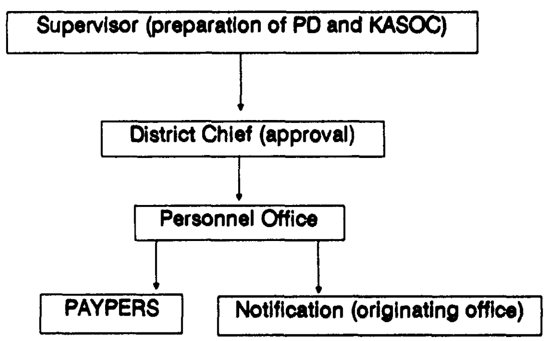
Recruitment and Placement

(2) Please describe each identified activity and why it is needed.

Recruitment and placement involves filling vacancies from vacancy announcements and Office of Personnel Management (OPM) registers, promotions, and a wide variety of related activities. Although PAS is utilized to transmit actions to the personnel office, writing Position Descriptions (PD) and Knowledge, Aptitudes, Skills, and Other Characteristics (KASOC) generally are not automated in any type of computerized format.

1988

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

80 locations

(5) How many times per year is this activity done?

100 actions x 80 locations = 8,000

(6) How many people per year do this activity?

5 supervisors per location x 80 locations = 400

(7) How many hours per person per year are spent doing this activity?

0.50 hour for assembling paperwork;
0.75 hour to enter on PAS and prepare transmittal for supporting documents;
0.25 hour for district approval;
2.00 hours for preparation of PD by supervisor;
0.50 hour for preparation of KASOC by supervisor =
4.0 hours x 100 actions ÷ 5 supervisors = 80

(8) Are there any special requirements for this activity?

The Privacy Act dictates that strict security be maintained for this activity. Only those who need to enter data or approve these actions can have access to the system.

(9) Please describe any software requirements for this activity.

(9a) Data base manager: No
(9b) Editor software: Yes, Model 204
(9c) Graphics software: No
(9d) Programming languages: No
(9e) Statistics software: No
(9f) Spreadsheet software: No
(9g) Utility software: Yes, compatible with AVADS and PAS

(10) Please describe any equipment requirements for this activity.

(10a) Display/Keyboard: QWERTY display and keyboard
(10b) Processor: No
(10c) Storage unit: One megabyte
(10d) Printer/Plotter: Standard printer
(10e) Communications: Communicate with Amdahl computer for utilization of PAS and AVADS

1992

By 1992, virtually all aspects of recruitment and placement will be computerized. Standardized PD and KASOC will be available in data bases for supervisors to select those items which are pertinent for the position in question. Personnel directories will be automatically updated whenever there is a change in an employee's grade, title, position, and so forth.

(3) Please describe the flow of information in this activity.

See flow charts on next page.

(4) How many locations do this activity?

80 locations

(5) How many times per year is this activity done?

100 actions x 80 locations = 8,000

(6) How many people per year do this activity?

5 supervisors per location x 80 locations = 400

(7) How many hours per person per year are spent doing this activity?

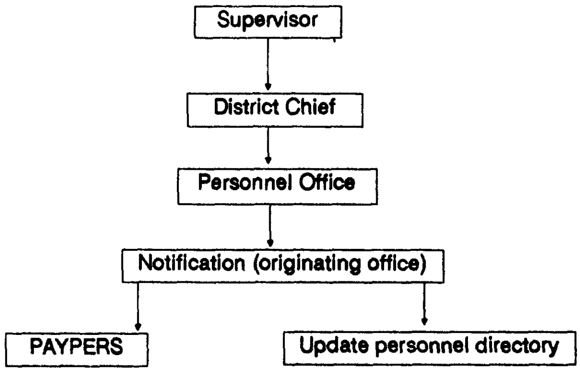
0.50 hour to enter on PAS and prepare transmittal for supporting documents;

0.25 hour for district approval;

1.00 hour for preparation of PD by supervisor;

0.25 hour for preparation of KASOC by supervisor =

2.0 hours x 100 actions ÷ 5 supervisors = 40



(8) Are there any special requirements for this activity?

The Privacy Act dictates that strict security be maintained for this activity. Only those who need to enter data or approve these actions can have access to the system.

(9) Please describe any software requirements for this activity.

(9a) Data base manager: Yes, for items in PD, KASOC, and AVADS
(9b) Editor software: Yes, for necessary changes to PD and KASOC
(9c) Graphics software: No
(9d) Programming languages: No
(9e) Statistics software: No
(9f) Spreadsheet software: No
(9g) Utility software: Yes, text string retrieval

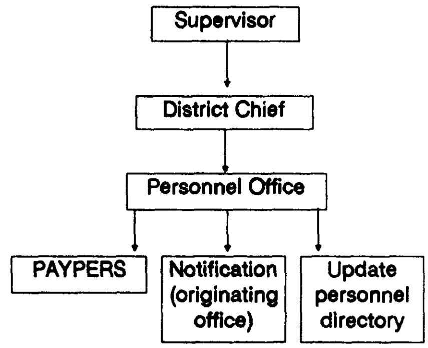
(10) Please describe any equipment requirements for this activity.

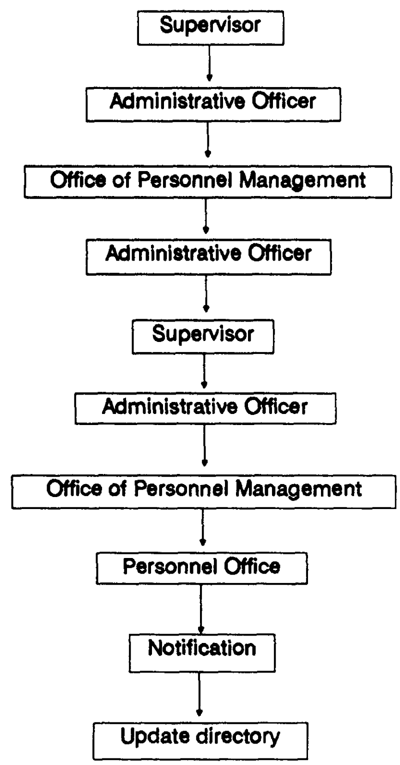
(10a) Display/Keyboard: QWERTY display and keyboard
(10b) Processor: No
(10c) Storage unit: 2.5 megabytes
(10d) Printer/Plotter: Standard printer
(10e) Communications: Compatible with the Bureau personnel system

1997

By 1997, electronic communication will make it possible for offices to have direct access to the OPM registers.

(3) Please describe the flow of information in this activity.





(4) How many locations do this activity?

80 locations

(5) How many times per year is this activity done?

100 actions x 80 locations = 8,000

(6) How many people per year do this activity?

5 supervisors per location x 80 locations = 400

(7) How many hours per person per year are spent doing this activity?

0.50 hour to enter on PAS and prepare transmittal for supporting documents;
0.25 hour for district approval;
1.00 hour for preparation of PD by supervisor;
0.25 hour for preparation of KASOC by supervisor =
2.0 hours x 100 actions ÷ 5 supervisors = 40

(8) Are there any special requirements for this activity?

The Privacy Act dictates that strict security be maintained for this activity. Only those who need to enter data or approve these actions can have access to the system.

(9) Please describe any software requirements for this activity.

(9a) Data base manager: Yes, for items in PD, KASOC, and AVADS
(9b) Editor software: Yes, for necessary changes to PD and KASOC
(9c) Graphics software: No
(9d) Programming languages: No
(9e) Statistics software: No
(9f) Spreadsheet software: No
(9g) Utility software: Yes, text string retrieval

(10) Please describe any equipment requirements for this activity.

(10a) Display/Keyboard: QWERTY display and keyboard
(10b) Processor: No
(10c) Storage unit: 2.5 megabytes
(10d) Printer/Plotter: Standard printer
(10e) Communications: In addition to communicating with Division and Bureau systems, hardware and software must be compatible with OPM computer to make online requests for certifications.

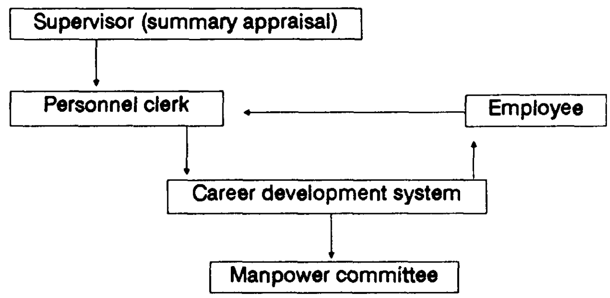
Career Development

(2) Please describe each identified activity and why it is needed.

1988

Currently, WRD utilizes the Amdahl computer for its career development program. Items such as training and performance appraisals are manual systems. The present system is cumbersome to use or to update. Individuals must update their Career Development Plan (CDP) to include any new training, assignments, or awards and supervisors provide a narrative summary of the annual appraisal rating.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

80 locations

(5) How many times per year is this activity done?

80 (annual updates for 50 employees and 30 ad hoc queries per year) x 80 locations = 6,400

(6) How many people per year do this activity?

1 person per location x 80 locations = 80 people

(7) How many hours per person per year are spent doing this activity?

0.5 hour per update x 80 updates per year = 40 hours

(8) Are there any special requirements for this activity?

The Privacy Act dictates that strict security be maintained at all times.

(9) Please describe any software requirements for this activity.

(9a) Data base manager: Yes
(9b) Editor software: Yes
(9c) Graphics software: No
(9d) Programming languages: No
(9e) Statistics software: No
(9f) Spreadsheet software: No
(9g) Utility software: Yes, software being designed by Clebsch and Monis should be in place

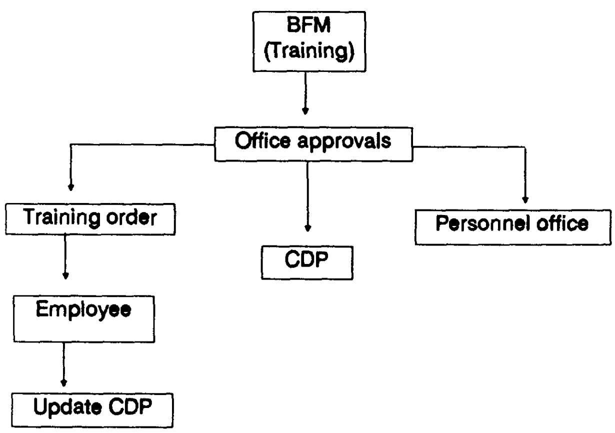
(10) Please describe any equipment requirements for this activity.

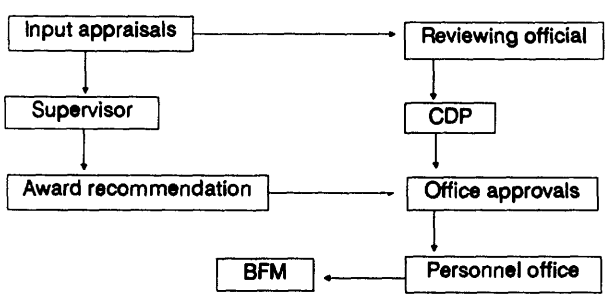
(10a) Display/Keyboard: Standard
(10b) Processor: No
(10c) Storage unit: 1 megabyte per location
(10d) Printer/Plotter: Standard printer
(10e) Communications: GEONET

1992 and 1997

By 1992, an employee's career development plan will automatically be updated whenever there is an additional training course, a new appraisal, or an action generated by an SF-52. The CDP will be streamlined and individual employees will maintain their own plan.

(3) Please describe the flow of information in this activity.





(4) How many locations do this activity?

100 locations

(5) How many times per year is this activity done?

65 CDP (annual updates 40 employees and 25 queries per year) + 30 training orders + 100 appraisals (80 annual, 20 interim) = 195 actions x 100 locations = 19,500

(6) How many people per year do this activity?

4,000

(7) How many hours per person per year are spent doing this activity?

40 hours per year CDP;
15 hours per year training orders;
60 hours per year appraisals =
115 hours per year per location ÷ 40 people = 3

(8) Are there any special requirements for this activity?

The Privacy Act dictates that strict security be maintained at all times.

(9) Please describe any software requirements for this activity.

(9a) Data base manager: Yes
(9b) Editor software: Yes
(9c) Graphics software: No
(9d) Programming languages: No
(9e) Statistics software: No
(9f) Spreadsheet software: No
(9g) Utility software: Yes, software designed by Clebsch and Monis should be in place

(10) Please describe any equipment requirements for this activity.

(10a) Display/Keyboard: Standard terminal and keyboard
(10b) Processor: No
(10c) Storage unit: 2 megabytes per location
(10d) Printer/Plotter: Standard printer and plotter
(10e) Communications: GEONET

Office Automation

Office automation includes interoffice communication, message transfer using electronic mail, filing correspondence, and information directories.

(1) Please identify the major activities performed.

Filing
Communications

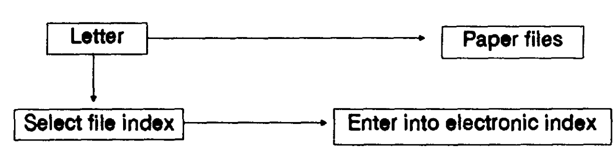
Filing

1988

(2) Please describe each identified activity and why it is needed.

Filing is the handling of written communication and the ability to locate and retrieve copies of correspondence. The method of operation is hand typed and index added to retrieval and filing directory.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

100

(5) How many times per year is this activity done?

8 filings per day per secretary
x 2 secretaries per location
x 250 days per year
4,000 filings per location x 100 locations = 400,000

(6) How many people per year do this activity?

2 secretaries per office x 100 offices = 200 people

(7) How many hours per person per year are spent doing this activity?

0.2 hour per letter x 8 filings per day x 250 days per year = 400 hours per year per person

(8) Are there any special requirements for this activity?

None

(9) Please describe any software requirements for this activity.

(9a) Data base manager: Yes
(9b) Editor software: Yes
(9c) Graphics software: No
(9d) Programming languages: No
(9e) Statistics software: No
(9f) Spreadsheet software: No
(9g) Utility software: No

(10) Please describe any equipment requirements for this activity.

(10a) Display/Keyboard: 132 character, QWERTY
(10b) Processor: No
(10c) Storage unit: 10 megabytes per office
(10d) Printer/Plotter: Letter quality
(10e) Communications: GEONET

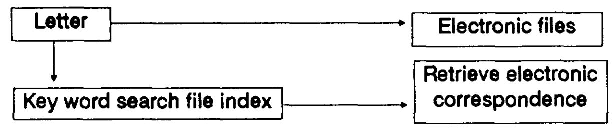
1992

(2) Please describe each identified activity and why it is needed.

There will be online departmental and U.S. Geological Survey (USGS) manual and policy statements.

The method of operation will be electronic. The filing system will automatically scan the "To, From, Subject, Date" sections to set up filing index. All correspondence will be stored as electronic information.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

100

(5) How many times per year is this activity done?

12 filings per day per secretary
x 2 secretaries per location
x 250 days per year
6,000 filings per location x 100 locations = 600,000

(6) How many people per year do this activity?

2 secretaries per office x 100 offices = 200 people

(7) How many hours per person per year are spent doing this activity?

0.1 hour per letter x 12 filings per day x 250 days per year = 300 hours per year per person

(8) Are there any special requirements for this activity?

None

(9) Please describe any software requirements for this activity.

(9a) Data base manager: Yes
(9b) Editor software: Yes
(9c) Graphics software: Yes
(9d) Programming languages: No
(9e) Statistics software: No
(9f) Spreadsheet software: No
(9g) Utility software: No

(10) Please describe any equipment requirements for this activity.

(10a) Display/Keyboard: 132 character, full page screen with graphics, QWERTY
(10b) Processor: No
(10c) Storage unit: 50 megabytes per office
(10d) Printer/Plotter: Letter quality with graphics
(10e) Communications: GEONET

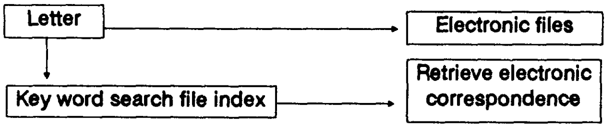
(2) Please describe each identified activity and why it is needed.

1997

Same as 1992.

(3) Please describe the flow of information in this activity.

See flow chart on next page.



(4) How many locations do this activity?

100

(5) How many times per year is this activity done?

24 filings per day per secretary
x 2 secretaries per location
x 250 days per year
12,000 filings per location x 100 locations = 1,200,000

(6) How many people per year do this activity?

2 secretaries per office x 100 offices = 200 people

(7) How many hours per person per year are spent doing this activity?

0.05 hour per letter x 24 filings per day x 250 days per year = 300 hours per year per person

(8) Are there any special requirements for this activity?

Current 1997 state-of-the-art systems

(9) Please describe any software requirements for this activity. You may list functions of the software or a specific product.

(9a) Data base manager: Yes
(9b) Editor software: Yes
(9c) Graphics software: Yes
(9d) Programming languages: No
(9e) Statistics software: No
(9f) Spreadsheet software: No
(9g) Utility software: No

(10) Please describe any equipment requirements for this activity.

(10a) Display/Keyboard: 132 character, full page screen with graphics, QWERTY
(10b) Processor: No
(10c) Storage unit: 100 megabytes per office
(10d) Printer/Plotter: Letter quality with graphics
(10e) Communications: GEONET

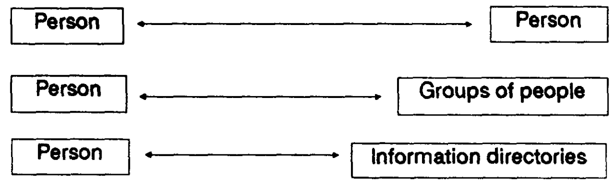
Communications

(2) Please describe each identified activity and why it is needed.

Keep employees, as a group, current with activities and events pertinent to their duties. Enables rapid transfer of information to other offices improving operations and decision making processes.

1988

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

100

(5) How many times per year is this activity done?

5 actions per person
x 20 persons per location
x 250 days per year
25,000 actions x 100 locations = 2,500,000

(6) How many people per year do this activity?

20 people per location x 100 locations = 2,000

(7) How many hours per person per year are spent doing this activity?

0.1 hour per action x 1,250 actions = 125

(8) Are there any special requirements for this activity?

- Each employee needs access to a terminal.
- MAIL2 software

(9) Please describe any software requirements for this activity.

(9a) Data base manager: No
(9b) Editor software: Yes
(9c) Graphics software: No
(9d) Programming languages: No
(9e) Statistics software: No
(9f) Spreadsheet software: No
(9g) Utility software: MAIL2

(10) Please describe any equipment requirements for this activity.

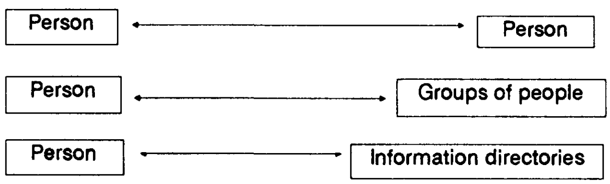
(10a) Display/Keyboard: 132 character, QWERTY
(10b) Processor: No
(10c) Storage unit: 1 megabyte per office
(10d) Printer/Plotter: Medium resolution printer
(10e) Communications: GEONET

(2) Please describe each identified activity and why it is needed.

1992

1992 has improved electronic mail program and adds audio (dictation) input. Graphics added to messages.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

100

(5) How many times per year is this activity done?

10 actions per person
x 30 persons per location
x 250 days per year
75,000 actions x 100 locations = 7,500,000

(6) How many people per year do this activity?

30 people per location x 100 locations = 3,000

(7) How many hours per person per year are spent doing this activity?

0.1 hour per action x 2,500 actions = 250

(8) Are there any special requirements for this activity?

- Each employee needs access to a terminal.
- Gateway for exchange with non-WRD persons.

(9) Please describe any software requirements for this activity.

(9a) Data base manager: No
(9b) Editor software: Yes
(9c) Graphics software: Yes
(9d) Programming languages: No
(9e) Statistics software: No
(9f) Spreadsheet software: No
(9g) Utility software: Audio input, output, text string search

(10) Please describe any equipment requirements for this activity.

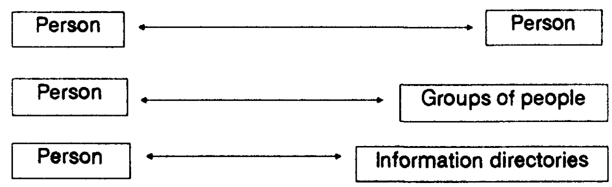
(10a) Display/Keyboard: 132 character resolution, QWERTY with full page screen, mouse or touch screen, color
(10b) Processor: No
(10c) Storage unit: 10 megabytes per office
(10d) Printer/Plotter: Letter quality printer with color graphics plot
(10e) Communications: GEONET with digitized audio capability

(2) Please describe each identified activity and why it is needed.

1997

Improved electronic mail program with voice recognition (dictation) input. Graphics added to messages via video input capability.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

100

(5) How many times per year is this activity done?

10 actions per person
x 40 persons per location
x 250 days per year
100,000 actions x 100 locations = 10,000,000

(6) How many people per year do this activity?

40 people per location x 100 locations = 4,000

(7) How many hours per person per year are spent doing this activity?

0.1 hour per action x 2,500 actions = 250

(8) Are there any special requirements for this activity?

- Each employee needs access to a terminal.
- Gateway for exchange with non-WRD persons

(9) Please describe any software requirements for this activity.

(9a) Data base manager: No
(9b) Editor software: Yes
(9c) Graphics software: Yes
(9d) Programming languages: No
(9e) Statistics software: No
(9f) Spreadsheet software: No
(9g) Utility software: Audio input, voice recognition and synthesis with style sheet for voice pattern output.

(10) Please describe any equipment requirements for this activity.

(10a) Display/Keyboard: 132 character, QWERTY with full page screen, mouse or touch screen, color
(10b) Processor: No
(10c) Storage unit: 20 megabytes per office
(10d) Printer/Plotter: Letter quality printer with color graphics plot
(10e) Communications: GEONET with three-dimensional video

Management Information System (MIS) and Executive Information System (EIS)

(1) Please identify the major activities performed.

Management Information System (MIS)
Executive Information System (EIS)

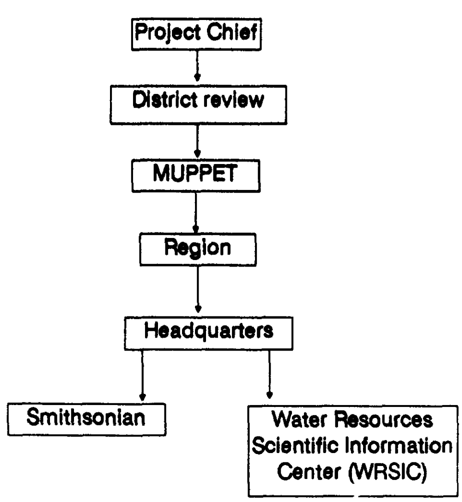
(2) Please describe each identified activity and why it is needed.

1988

MIS is the current management system used by headquarters to answer information requests and store historical data on Division projects.

The EIS will be the repository for information on all aspects of project activity in the Division.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

80

(5) How many times per year is this activity done?

Once per location x 80 locations x 30 people = 2,400

(6) How many people per year do this activity?

30 per location x 80 locations = 2,400

(7) How many hours per person per year are spent doing this activity?

4 hours

(8) Are there any special requirements for this activity?

- No special requirements beyond those currently available.
- File transfer capabilities.

(9) Please describe any software requirements for this activity.

(9a) Data base manager: No
(9b) Editor software: Yes, ED
(9c) Graphics software: No
(9d) Programming languages: PL/1, INFO, CPL
(9e) Statistics software: No
(9f) Spreadsheet software: No
(9g) Utility software: No

(10) Please describe any equipment requirements for this activity.

(10a) Display/Keyboard: Yes, display, QWERTY, 132 characters
(10b) Processor: Yes, 15 second response time
(10c) Storage unit: 5 megabytes per location
(10d) Printer/Plotter: Yes, high speed, laser
(10e) Communications: GEONET

(2) Please describe each identified activity and why it is needed.

1992

EIS is created to fill need to provide field managers planning support as well as meeting region and headquarters needs. Streamline, enhance and standardize district and regional program review process. Allow project chiefs to create better projects, and managers to make better decisions and monitor progress.

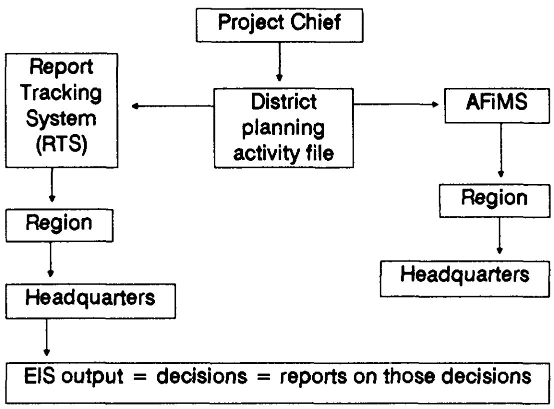
(3) Please describe the flow of information in this activity.

Will need to expand current RTS to include ability to query other data bases (cooperators, universities, Other Federal Agencies (OFA), and so forth).

See flow chart on next page.

(4) How many locations do this activity?

100 expanded to include major subdistrict project offices



(5) How many times per year is this activity done?

10 actions x 100 locations x 30 people x 4 sessions = 120,000

(6) How many people per year do this activity?

30 per location x 100 locations = 3,000

(7) How many hours per person per year are spent doing this activity?

10 hours per action x 10 actions = 100

(8) Are there any special requirements for this activity?

Highly integrated system. Willl interface with all other data bases, such as reports and financial. Need to communicate with outside data bases and users. Will provide mechanism to enhance reports data and provide additional data. Managers will be able to pull together all needed information (financial, personnel, and so forth) to make necessary decisions. Security required (Privacy Act).

(9) Please describe any software requirements for this activity.

(9a) Data base manager: Highly relational DMBS such as Oracle
(9b) Editor software: Full screen, mouse, windows
(9c) Graphics software: Full color package, user-friendly, enhanced business graphics
(9d) Programming languages: Artificial intelligence, fourth or fifth level languages
(9e) Statistics software: Yes
(9f) Spreadsheet software: Integrated with AI
(9g) Utility software: Text string search capability highly relational data bases

(10) Please describe any equipment requirements for this activity.

(10a) Display/Keyboard: High resolution color graphics, windows
(10b) Processor: State-of-art production
(10c) Storage unit: 20 megabytes per location
(10d) Printer/Plotter: High speed, holographics
(10e) Communications: GEONET

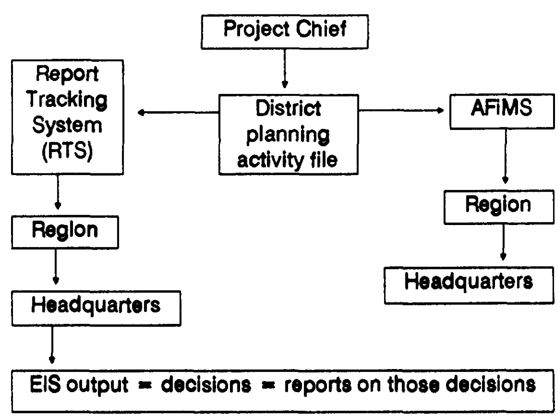
(2) Please describe each identified activity and why it is needed.

1997

EIS will fill need to provide field managers planning support as well as meeting region and headquarters needs. Streamline, enhance and standardize district and regional program review process. Allow project chiefs to create better projects, managers to make better decisions and monitor progress.

(3) Please describe the flow of information in this activity.

Will need to expand current RTS to include ability to query other data bases (cooperators, universities, Other Federal Agencies (OFA), and so forth).



(4) How many locations do this activity?

100

(5) How many times per year is this activity done?

10 actions x 100 locations x 30 people x 4 sessions = 120,000

(6) How many people per year do this activity?

30 per location x 100 locations = 3,000

(7) How many hours per person per year are spent doing this activity?

10 hours per action x 10 actions per person = 100

(8) Are there any special requirements for this activity?

Highly integrated system. Will interface with all other data bases, such as reports and financial. Need to communicate with outside data bases and users. Will provide mechanism to enhance reports data and provide additional data. Managers will be able to pull together all needed information (financial, personnel, and so forth) to make necessary decisions. Security required (Privacy Act).

(9) Please describe any software requirements for this activity.

(9a) Data base manager: Highly relational DMBS such as Oracle
(9b) Editor software: Full screen, mouse, windows
(9c) Graphics software: Full color graphics, user-friendly, enhanced business graphics
(9d) Programming languages: Artificial intelligence, 4th or 5th level languages
(9e) Statistics software: Yes
(9f) Spreadsheet software: Integrated AI
(9g) Utility software: Yes

(10) Please describe any equipment requirements for this activity.

(10a) Display/Keyboard: High resolution color, windows
(10b) Processor: State-of-art production
(10c) Storage unit: 40 megabytes
(10d) Printer/Plotter: High speed, holographics
(10e) Communications: GEONET

Travel

Official travel is conducted to ensure mission accomplishment.

(1) Please identify the major activities performed.

Authorization and requests
Vouchers

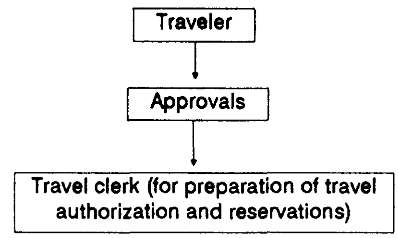
Authorization and Request

(2) Please describe each identified activity and why it is needed.

Travel authorizations and requests to attend meetings are required by regulations and by sound management practices to prevent unauthorized travel.

1988

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

100 locations: all cost centers and large subdistricts and field offices

(5) How many times per year is this activity done?

120 area travel authorizations and requests to attend meeting per year,
50 trip travel authorizations per year,
60 airline and motel reservations per year =
230 x 100 locations = 23,000

(6) How many people per year do this activity?

1 travel clerk per location,
25 travelers per location =
26 x 100 = 2,600

(7) How many hours per person per year are spent doing this activity?

80 hours for travel authorizations and request to attend meeting
60 hours for airline and motel reservations
140 hours ÷ 26 persons = 5

(8) Are there any special requirements for this activity?

- Typewriter or word processor
- Official Airline Guide
- Processed within specified timeframes.

(9) Please describe any software requirements for this activity.

(9a) Data base manager: No
(9b) Editor software: Yes, for word processor
(9c) Graphics software: No
(9d) Programming languages: No
(9e) Statistics software: No
(9f) Spreadsheet software: No
(9g) Utility software: No

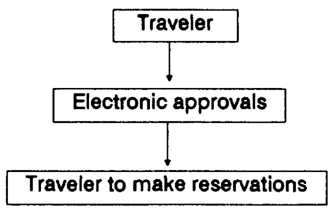
(10) Please describe any equipment requirements for this activity.

(10a) Display/Keyboard: Typewriter or word processor

(10b) Processor: No
(10c) Storage unit: No
(10d) Printer/Plotter: No
(10e) Communications: Phone, mail

1992 and 1997

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

100 locations: all cost centers and large subdistricts and field offices

(5) How many times per year is this activity done?

120 area travel authorizations and requests to attend meeting per year,
50 trip travel authorizations per year,
60 airline and motel reservations per year =
230 x 100 locations = 23,000

(6) How many people per year do this activity?

1 travel clerk per location,
25 travelers per location =
26 x 100 = 2,600

(7) How many hours per person per year are spent doing this activity?

34 hours for travel authorizations and request to attend meeting
15 hours for airline and motel reservations
49 hours ÷ 26 persons = 2

(8) Are there any special requirements for this activity?

- Electronic processing from step-to-step.
- Electronic signature for approvals.
- Electronic access to reservation lines (that is, Official Airline Guide (OAG), hotels, cars).

(9) Please describe any software requirements for this activity.

(9a) Data base manager: Yes
(9b) Editor software: Yes
(9c) Graphics software: No
(9d) Programming languages: No
(9e) Statistics software: No
(9f) Spreadsheet software: No
(9g) Utility software: Yes, access to external data-base services (OAG, car rental companies, and motel reservation systems).

(10) Please describe any equipment requirements for this activity.

(10a) Display/Keyboard: Standard terminal
(10b) Processor: No
(10c) Storage unit: 1.5 megabytes per site
(10d) Printer/Plotter: Standard printer
(10e) Communications: Yes, gateway to external data-base services to transfer information to the office

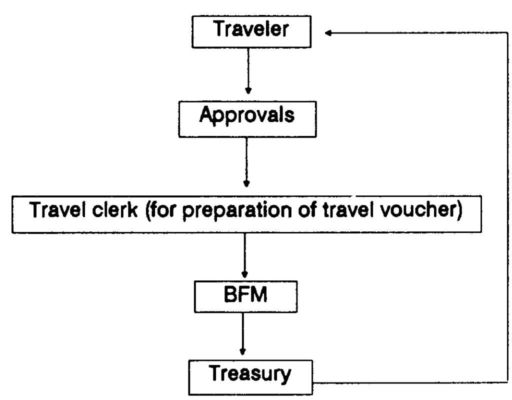
Vouchers

(2) Please describe each identified activity and why it is needed.

Travel vouchers are filed to reimburse employees for expenses incurred related to official travel.

1988

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

100 locations: all cost centers and large subdistricts and field offices

(5) How many times per year is this activity done?

300 vouchers per location x 100 locations = 30,000

(6) How many people per year do this activity?

1 travel clerk per location,
25 travelers =
26 x 100 locations = 2,600

(7) How many hours per person per year are spent doing this activity?

0.5 hour per voucher x 300 vouchers per year =
150 hours per year per location,
0.25 hours x 300 vouchers per year per location =
75 hours per year per location =
225 ÷ 26 people = 5.8

(8) Are there any special requirements for this activity?

- Typewriter or word processor.
- Data entry into AFiMS or CAS.
- Processed within specified time frames.

(9) Please describe any software requirements for this activity.

(9a) Data base manager: No
(9b) Editor software: Yes, word processor
(9c) Graphics software: No
(9d) Programming languages: No
(9e) Statistics software: No
(9f) Spreadsheet software: No
(9g) Utility software: No

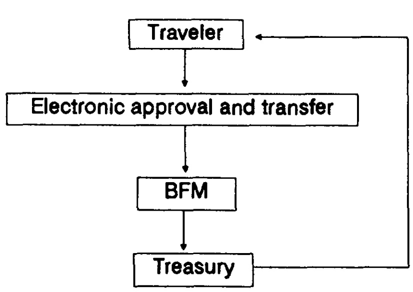
(10) Please describe any equipment requirements for this activity.

(10a) Display/Keyboard: Keyboard with numeric key pad to enter data into AFiMS and CAS
(10b) Processor: No
(10c) Storage unit: No
(10d) Printer/Plotter: No
(10e) Communications: Phone, mail

1992

By 1992, the individual traveler will electronically file his own voucher.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

100 locations: all cost centers and large subdistricts and field offices

(5) How many times per year is this activity done?

300 vouchers per location x 100 locations = 30,000

(6) How many people per year do this activity?

25 travelers x 100 locations = 2,500

(7) How many hours per person per year are spent doing this activity?

0.25 hours x 300 vouchers per year per location ÷ 25 travelers = 3

(8) Are there any special requirements for this activity?

Computer terminal available for all travelers.

(9) Please describe any software requirements for this activity.

(9a) Data base manager: Yes
(9b) Editor software: Yes
(9c) Graphics software: No
(9d) Programming languages: No
(9e) Statistics software: No
(9f) Spreadsheet software: No
(9g) Utility software: Yes, software for travel voucher preparation

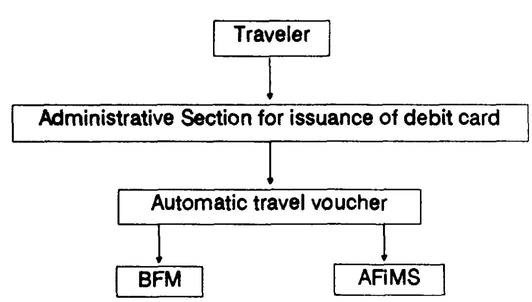
(10) Please describe any equipment requirements for this activity.

(10a) Display/Keyboard: QWERTY word processor key board with numeric pad
(10b) Processor: No
(10c) Storage unit: 1.6 megabytes per site
(10d) Printer/Plotter: Standard printer
(10e) Communications: GEONET

1997

The traveler will be issued "debit" cards with debit limits automatically built into the card. Traveler will use the card for airline, motel, and car rental reservations as well as for meals. Upon return, the travel voucher will automatically be generated by inserting the card into a computerized debit card reader.

(3) Please describe the flow of information in this activity.



(4) How many locations do this activity?

100 locations: all cost centers and large subdistricts and field offices

(5) How many times per year is this activity done?

300 vouchers per location x 100 locations = 30,000

(6) How many people per year do this activity?

25 travelers x 100 locations = 2,500

(7) How many hours per person per year are spent doing this activity?

0.1 hours x 300 vouchers per year per location ÷ 25 travelers = 1.2

(8) Are there any special requirements for this activity?

Debit card reader available to all travelers.

(9) Please describe any software requirements for this activity.

(9a) Data base manager: Yes
(9b) Editor software: Yes
(9c) Graphics software: No
(9d) Programming languages: No
(9e) Statistics software: No
(9f) Spreadsheet software: No
(9g) Utility software: Yes, software for travel voucher preparation

(10) Please describe any equipment requirements for this activity.

(10a) Display/Keyboard: QWERTY word processor key board with numeric pad
(10b) Processor: No
(10c) Storage unit: 1.6 megabytes per site
(10d) Printer/Plotter: Standard printer
(10e) Communications: GEONET

General Services Inventory Systems

(1) Please identify the major activities performed.

This is a loosely formed group of regularly or periodically performed tasks that are tightly controlled by Federal Regulation and prescribed form. Among these tasks are:

- Controlled property
- Vehicles
- Space

(2) Please describe each identified activity and why it is needed.

Controlled property.—Equipment that is assigned to an individual and is considered the employee's responsibility. Semiautomated listings are maintained by the Administrative Division (AD) and verification of listings are required annually. Transfer and disposal of equipment is initiated by field offices on prescribed forms.

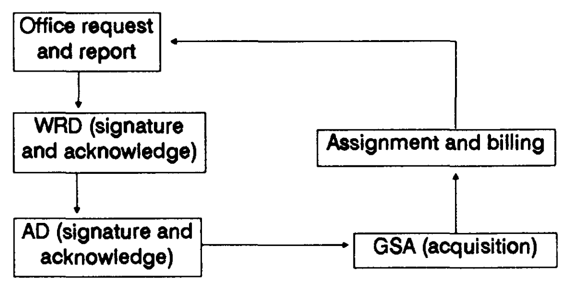
Vehicles.—Requests for vehicles are submitted to the General Services Administration (GSA) through WRD General Services Unit and AD. Vehicle usage statistics are reported to BFM on a monthly basis.

Space.—Detailed requests and justifications for office space needs are prepared by field offices and submitted to GSA through WRD and AD.

1988

(3) Please describe the flow of information in this activity.

System of standard forms via conventional mail:



(4) How many locations do this activity?

Cost center activity; approximately 80.

(5) How many times per year is this activity done?

100 x 80 = 8,000

(6) How many people per year do this activity?

2 x 80 = 160

(7) How many hours per person per year are spent doing this activity?

200

(8) Are there any special requirements for this activity?

None.

(9) Please describe any software requirements for this activity.

(9a) Data base manager: No
(9b) Editor software: No
(9c) Graphics software: No
(9d) Programming languages: No
(9e) Statistics software: No
(9f) Spreadsheet software: No
(9g) Utility software: No

(10) Please describe any equipment requirements for this activity.

(10a) Display/Keyboard: No
(10b) Processor: No
(10c) Storage unit: No

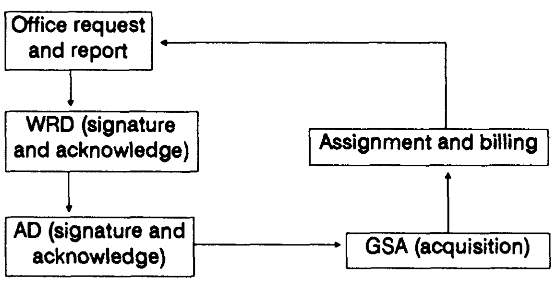
(10d) Printer/Plotter: No
(10e) Communications: No

1992 and 1997

Interface to new bureau systems as they are implemented.

(3) Please describe the flow of information in this activity.

Electronically stored standard forms transmitted via GEONET:



(4) How many locations do this activity?

Cost center activity; approximately 80.

(5) How many times per year is this activity done?

100 x 80 = 8,000

(6) How many people per year do this activity?

2 x 80 = 160

(7) How many hours per person per year are spent doing this activity?

200

(8) Are there any special requirements for this activity?

- Compatability with Bureau and Department electronic system when available. Barcode scanner for property management.
- Computer aided design (CAD) system for space definition.

(9) Please describe any software requirements for this activity.

(9a) Data base manager: Yes, storage of "standard form" formats.
(9b) Editor software: Yes, data entry may be part of DBMS (9a)
(9c) Graphics software: CAD
(9d) Programming languages: Yes, fourth generation for initializing forms
(9e) Statistics software: No
(9f) Spreadsheet software: No
(9g) Utility software: CAD

(10) Please describe any equipment requirements for this activity.

(10a) Display/Keyboard: Support formatted screen data entry
(10b) Processor: General purpose
(10c) Storage unit: megabyte
(10d) Printer/Plotter: Standard printer
(10e) Communications: GEONET

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