X

OUTLINE FOR

A HYDROLOGIC DATA BASE FOR PORTUGAL

U.S. Geological Survey

Open-File Report 81-424

UNITED STATES

DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

OUTLINE FOR

A HYDROLOGIC DATA BASE FOR PORTUGAL

By

Norman E. Hutchison

Prepared for the Government of Portugal, under the auspices of the

Agency for International Development, U.S. Department of State

January 1981

UNITED STATES DEPARTMENT OF THE INTERIOR

James G. Watt, Secretary

GEOLOGICAL SURVEY

Doyle G. Frederick, Acting Director

CONTENTS

ILLUSTRATIONS

APPENDIXES

A HYDROLOGIC DATA BASE FOR PORTUGAL

By

Norman E. Hutchison

SUMMARY

The Agency for International Development requested the assistance of the U.S. Geological Survey (USGS) to help the Government of Portugal in the investigation and management of ground water resources in the Algarve region. The assistance was to be provided in four specialty areas, but the scope of this report is limited to making recommendations on the design of a hydrologic data base for Portugal.

It is recommended that a small data base be developed initially to meet the needs for ground-water data in the Algarve region utilizing personnel in the Division of Geohydrology in the Directorate of Water Resources Development. This data base may eventually be expanded to cover all regions of Portugal and include all types of hydrologic data, including streamflow, precipitation, and surface-water quality, as well as ground-water data. Consideration should be given to implementing a commercial data base management system (DBMS) in 2-3 years when significant amounts of data, including surface-water data, begin to be entered from other regions of Portugal.

Training in computer programming and data base systems should be provided to provide a broad base of support for the data base system and ground-water modeling.

It is also recommended that a uniform system for identifying hydrologic sites and basins be developed for eventual use by all agencies (departments) involved in water resources development and management in Portugal.

INTRODUCTION

The Agency for International Development requested the assistance of the U.S. Geological Survey to help the Directorate of Basic Sanitation (DGSC) and the Directorate of the Water Resources Development (DGRAH) of Portugal in the investigation and management of ground water resources of the Algarve region. The assistance involved the assignment of four Geological Survey employees, in four different specialty areas, to short consultant details generally of 2 weeks duration. The specialty areas were:

1. Ground water geophysics: To assist in interpretation of electrical logs.

2. Remote sensing: To introduce remote sensing applications for ground water exploration and management using satellite and aircraft information.

3. Water resources management: To cooperatively design a preliminary scheme of the Algarve region water management system.

4. Water data storage and retrieval: To assist in developing a system for the Algarve region to be later expanded to all of Portugal.

A private firm was also contracted with to provide assistance in ground-water modeling.

The purpose of this part of the overall mission is to accomplish item 4 above, namely, to assist in developing a water data storage and retrieval system patterned after the U.S. Geological Survey's National Water Data Storage and Retrieval System (WATSTORE). The author spent the period of September 14-26, 1980, in Lisbon working primarily as a consultant with Nguyen Quang Trac, UNESCO advisor, and personnel in the Division of Geohydrology in the Directorate of Water Resources Development (DGRAH). At the request of the Portuguese Government, this project was expanded to include development of a system for all types of hydrologic data for use in all regions of Portugal.

REVIEW OF PRESENT SYSTEM

Organizational Structure

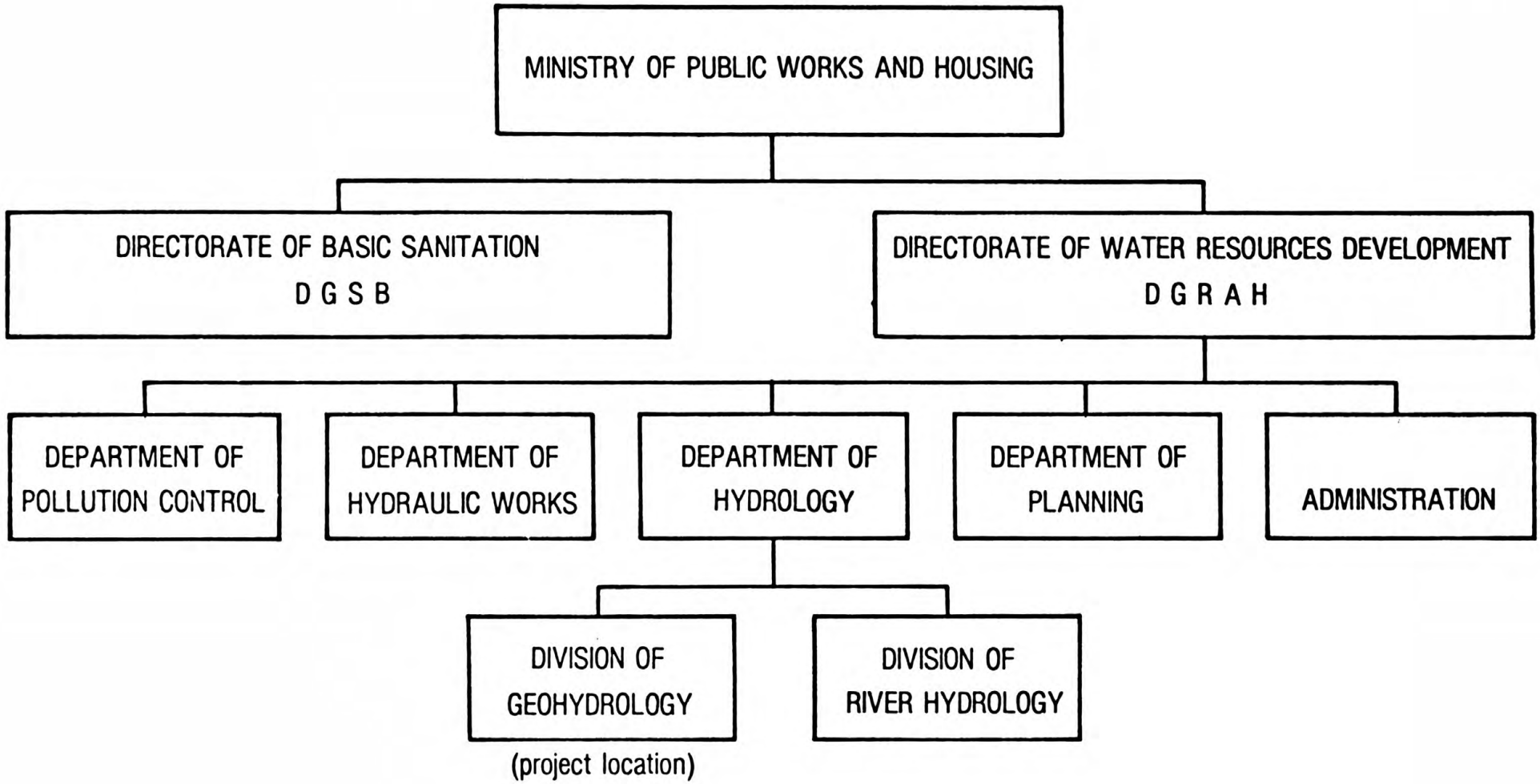
The organizational location of the present system for which an automated ground-water data base is to be developed, is in the Directorate of Water Resources Development, Department of Hydrology, Division of Geohydrology. The organizational structure is shown in Figure 1.

The Agency for International Development is sponsoring this project to assist the Directorate of Water Resources Development in planning a data storage and retrieval system for Portugal. UNESCO also has a regular assistance program with the Department of Hydrology. A project to evaluate the data-collection network for streamflow and rainfall and to present recommendations for restructuring was completed in October 1980, under UNESCO sponsorship.

Data System

About 5,000 wells have been inventoried by the Division of Geohydrology in the Setubal and Algarve regions and an estimated 50,000 wells are expected to be inventoried in the Algarve and remainder of Portugal, within the next 5-10 years. These data are being coded on 3 or 4-page forms and are stored in manual files. Data on location, well description, hydrogeology, water quality, water use, and water level are being collected. The data are not punched or keyed into machine-readable format. No other hydrologic data systems exist in Portugal that can be adapted to this project. Personnel in the Division of River Hydrology punch precipitation data onto cards for use in preparing a report, and they plan to do the same thing for streamflow data. These data can probably be machine-converted to any data storage and retrieval system eventually adopted.

The USGS National Water Data Storage and Retrieval System (WATSTORE) was considered but it is too large and complex a system to be implemented for Portugal at this time. WATSTORE software is also composed of PL/1, FORTRAN, COBOL, and SYSTEM 2000 components, which is a complicating factor in that the Division of Geohydrology personnel only have experience in FORTRAN. The WATSTORE Ground-water Site-Inventory File managed by SYSTEM 2000 DBMS was proposed by USGS as a system for storing ground-water data for Portugal over a year ago.


MINISTRY OF PUBLIC WORKS AND HOUSING
DIRECTORATE OF BASIC SANITATION
D G S B
DIRECTORATE OF WATER RESOURCES DEVELOPMENT
D G R A H
DEPARTMENT OF POLLUTION CONTROL
DEPARTMENT OF HYDRAULIC WORKS
DEPARTMENT OF HYDROLOGY
DEPARTMENT OF PLANNING
ADMINISTRATION
DIVISION OF GEOHYDROLOGY
(project location)
DIVISION OF RIVER HYDROLOGY

However, this proposal was rejected because of high initial costs and because personnel were available in DGRAH to develop an in-house system. Many design features from WATSTORE will be incorporated into the design of a hydrologic data base for Portugal, however. Some software, particularly WATSTORE FORTRAN applications programs, can be of use and will be made available at no cost to Portugal upon request.

RESOURCES AVAILABLE

Computers

The possible computer systems that a hydrologic data system could reside on include an IBM 360/44 at the University of Lisbon and a DEC 10 at the Civil Engineering Laboratory (not associated with the University). The Department of Hydrology plans to acquire an HP mini-computer in the near future which could be used as a terminal to the host computer.

The DEC 10 is a good machine with a very good support staff, and has adequate resources for running ground-water models. The project team has been running models on this system for some time, either via a terminal or by jobs submitted directly to the computer center. The DEC 10 is heavily loaded with work at the present time, and charges are relatively high, so it is not considered as a likely candidate to house the data base.

The University of Lisbon computer center has the minimum resources for system development and implementation of a small preliminary system. The computer costs on the University computer are less than on the DEC 10, and the university staff is interested in having the system on its computer, so this is a good candidate for housing the system.

The University of Lisbon plans to upgrade their computer some time soon, but no firm decision has been made. A study has been completed, recommendations made to University officials, and a decision should be made in the near future. The scope and future plans for the data base should be reevaluated when the University computer system is upgraded or if another larger system becomes available elsewhere.

In the meantime, development work on any proposed data base system could begin on the University IBM 360/44. The present configuration of the IBM 360/44 is:

Memory	256 K-bytes total 220 K-bytes maximum available to users. Normal partitions are 146 and 52 K-bytes, but can be changed by switch between jobs.
Tapes	Two 9-track 800/1600 bpi drives.
Disk	Six 2314 (29 M-bytes each) of which four are available to users.
Printers	One 1443 at 200 lpm. one 1403 at 900 lpm. (with interchangeable print train).
Punch	One 1442N2 punch (80 columns)
Card-reader	One 2501, 1000 cpm (80 columns).

Compilers available include Fortran, Basic, and a PL/1 subset. Software to support indexed-sequential and direct access file organizations is available.

Personnel

There are 3 or 4 people available in the Division of Geohydrology to work on data base development. These include:

Natalie Nogel	Programmer
Ismeralda Amorim	Civil Engineer
Jouquim Santos (Braga)	Mining Engineer

The following people were available for consulting during the assignment and will continue to be available for consulting:

Vasco Fernades	Division Chief
Honorata Carvalho	Civil Engineer
Daniel Carvalho	Mining Engineer
Ligia Domingues	Civil Engineer
Sergio Lopes	Civil Engineer

Luis Ribeiro and Maria Emilia Augusto, Mining Engineers, were on leave during the author's assignment, but both are expected to be available for consulting on development of the data base. Several of the above people have experience with computers and have done some ground-water modeling. Natalie Nogel has a good background in FORTRAN programming, but other personnel have limited experience in programming.

Nguyen Quang Trac, Chief Technical Advisor, UNESCO, will coordinate the efforts of the team with the cooperation of Vasco Fernandes, Chief, Geohydrology Division.

ALTERNATIVES

The alternatives for implementing a data base system for Portugal include:

1. Obtain an existing system from some source and modify to meet requirements.

2. Purchase or lease a data base management system (DBMS) from a software company.

3. Develop a local Portuguese system to meet current needs using available personnel.

The third option above is most appropriate for the Divison of Geohydrology at this time. The project team needs to develop expertise in data base management and the best way to do this is by developing and implementing a small system initially. This will enable the team to become familiar with data processing procedures, define data elements, and help define system requirements more precisely for a more sophisticated system later.

The first option was rejected because other systems like WATSTORE either are too large for machine resources available, or were developed with different criteria, and so do not meet the needs of the Division of Geohydrology. WATSTORE software also consists of PL/1, FORTRAN, COBOL, and DBMS SYSTEM 2000 components, which is a complicating factor in that the Division of Hydrogeology personnel only have experience in FORTRAN programming. The cost to convert an existing system to meet the requirements of another organization can approach the cost of developing a smaller system to meet current needs. There are no other systems available in Portugal that can meet the Division's needs.

The second option to acquire a commercial data base management system (DBMS) was rejected because of high initial cost. A minimum configuration for a DBMS would cost $30-40,000 and funds of this magnitude are not available for this purpose. Personnel resources are available, however, to begin development of an inhouse system. It would be appropriate to reconsider the acquisition of a DBMS within 2 to 3 years. By then funds and machine resources may be available, and the project team would have acquired valuable experience in developing and managing a data base. Much of the work done to develop the inhouse system, such as definition of data elements and system requirements, will be useful and is required in implementation of a DBMS.

The alternatives should be reevaluated when the University computer system is upgraded or if another larger system becomes available elsewhere. The high initial cost of a DBMS can be significantly reduced if several organizations (users) can share the cost. The state-of-the-art for data base development in the next decade favors the implementation of a DBMS. The technology related to DBMS has reached the point where it is very difficult for an organization to develop its own system at less cost than implementing a DBMS.

DESIGN FOR A HYDROLOGIC DATA BASE

General Discussion

A hydrologic data base is proposed to meet the present needs for ground-water data collection in the Algarve region, and also serve as a prototype system for eventual development of a complete nationwide hydrologic data base for stream-flow, precipitation, and surface-water quality data, as well as ground-water data.

The system will reside on disk and have a direct access, indexed sequential, or virtual storage file organization, depending upon the computer system available at the time development work has progressed to a decision point. Development work can begin on the University of Lisbon IBM 360/44.

The estimated size of the data base initially is about 4 M-bytes of disk storage (5000 wells x 800 bytes/well). The estimated growth rate of the data base is about 5 M-bytes per year, assuming 5000 sites are inventoried each year and some water-level and water-quality data are collected at established wells. The estimated size of the data base eventually (5-10 years) is 40 M-bytes.

Required software include programs or subroutines to validate input records, update files, and retrieve records, and several user application programs and file management programs. The programs will be written in standard FORTRAN so as to enhance their transferability to other computer systems.

Register (site) numbers as used by the Divison of Geohydrology and Division of Hydrology are discussed in a following section. The two identification systems are similar but use different reference maps and so would have different numbers for the same site. If the data base is to have very wide application in the Directorate of Water Resources Development and the Directorate of Basic Sanitations, the same site identification number scheme will have to be used by all Departments. The same is true for hydrologic basin identification as well.

Proposed File Organization

The proposed system (see Figure 2) has the following components (files):

Data Element Definitions
Master File
Well Description File
Hydrogeologic File
Water Quality File
Water Use File
Water Level File

The Master File and programs or subroutines related to validation, update, retrieval, and listing of Master File records should be developed first to demonstrate the possible utility of the data base. These files and programs are identified by cross-hatched lines in Figure 2. A brief description of each file and program and the relation of the files to each other are discussed below.

Data elements have been partially identified for each file and these are listed in Appendixes A-F, Data Element Definitions.

Data Element Definitions

Data element definitions do not necessarily have to reside in a computer file, but they could if and when a DBMS is implemented. In the interim period, a manual data elements definitions text, as listed in Appendixes A-F, will suffice. The data element definitions file contains element number, name, description, range of values, element format, and additional notes or questions regarding each element. Only some of the above items for each element have been specified in Appendixes A-F, and one of the first tasks for the project team should be to complete the data element definitions.

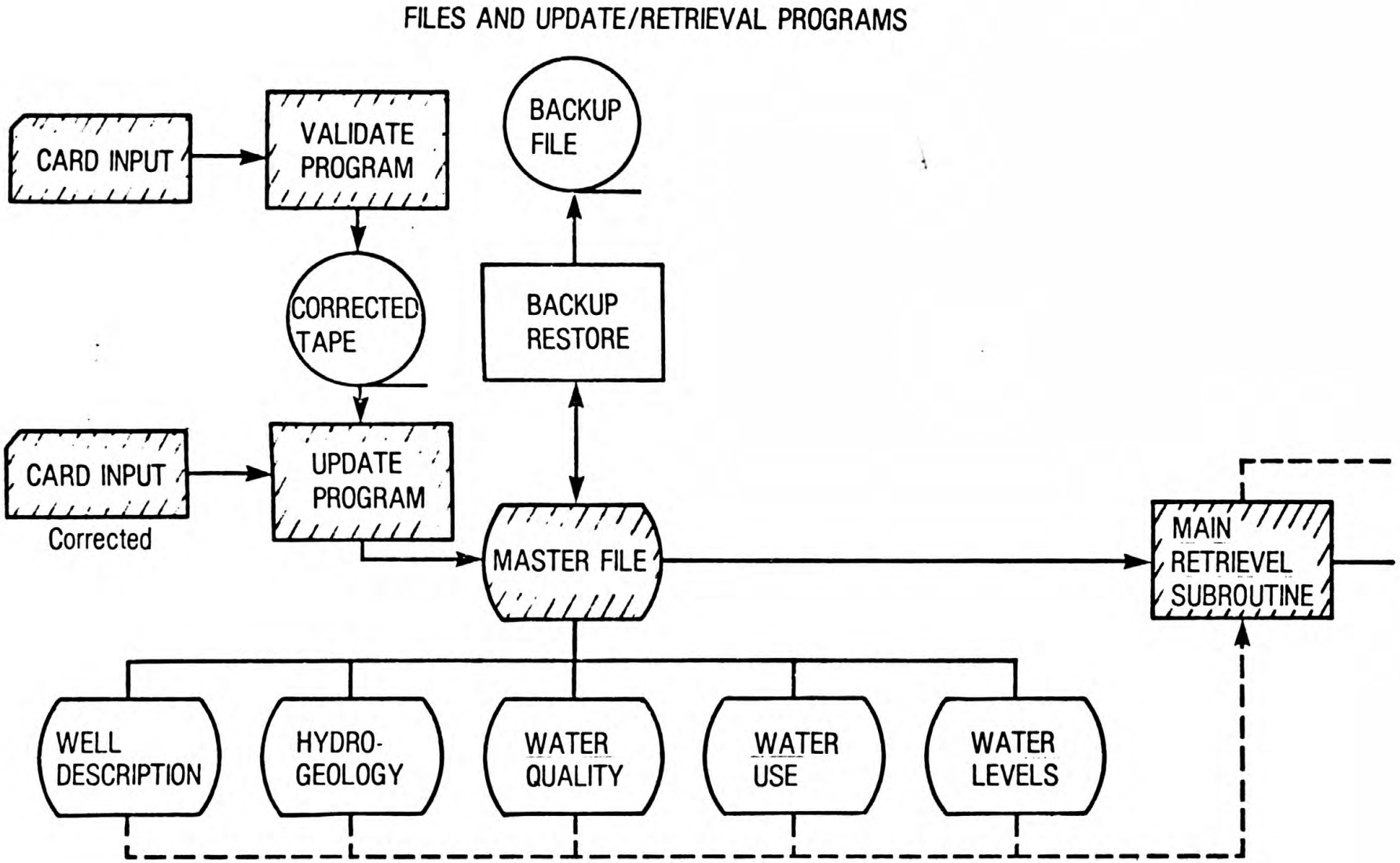
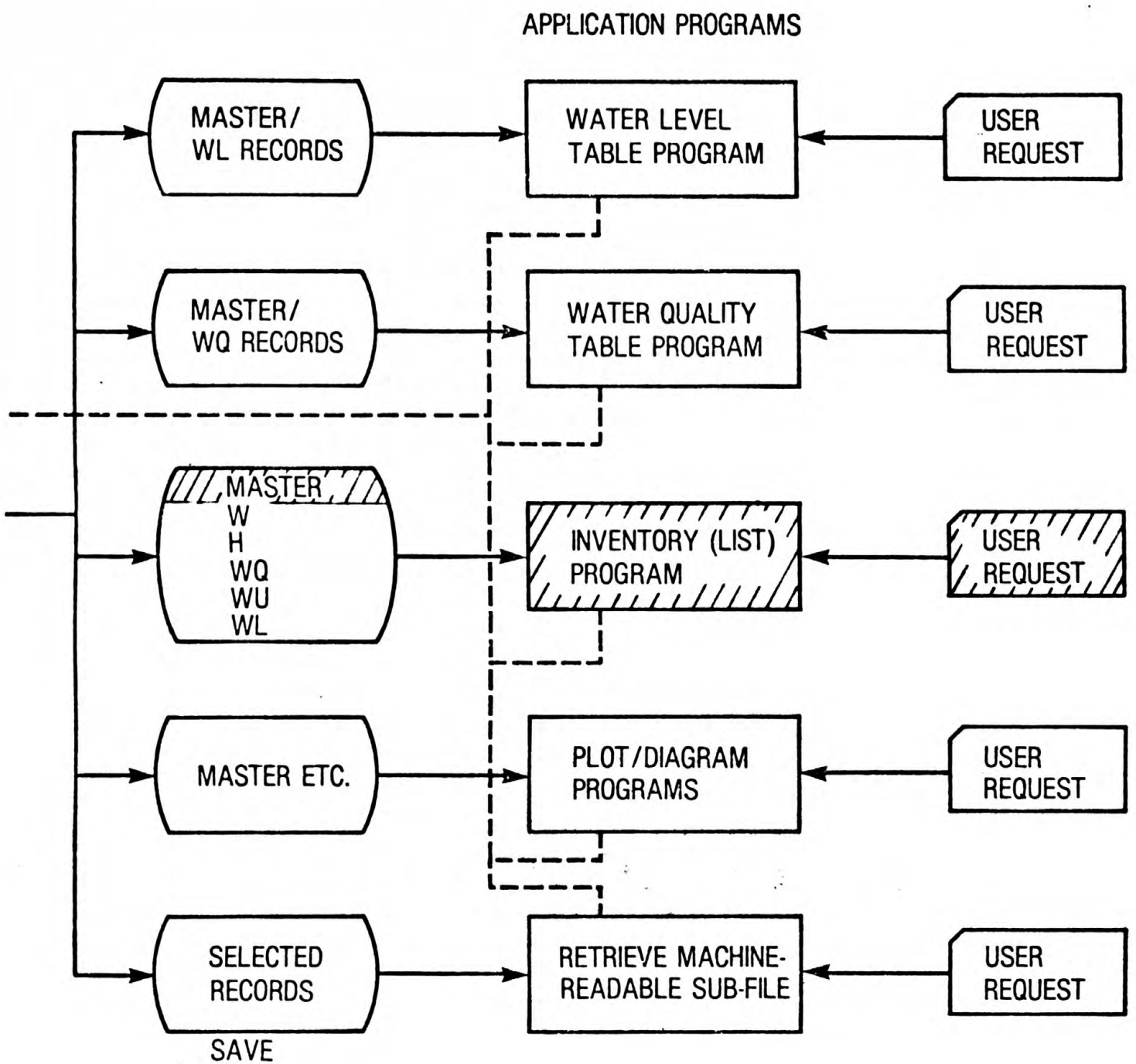


FIGURE 2. Proposed Hydrologic Data Base Organization


APPLICATION PROGRAMS
MASTER/
WL RECORDS
WATER LEVEL
TABLE PROGRAM
USER
REQUEST
MASTER/
WQ RECORDS
WATER QUALITY
TABLE PROGRAM
USER
REQUEST
MASTER
W
H
WQ
WU
WL
INVENTORY (LIST)
PROGRAM
USER
REQUEST
MASTER ETC.
PLOT/DIAGRAM
PROGRAMS
USER
REQUEST
SELECTED
RECORDS
SAVE
RETRIEVE MACHINE-
READABLE SUB-FILE
USER
REQUEST

Other team or staff members should be interviewed to obtain element descriptions and data ranges where necessary. National codes for hydrologic basin, district, and concelho (county) should be used, if available. Minor hydrologic basin codes should also be assigned. Frequesia (level below county) may be coded if this level of definition is desired.

Identification and complete definition of as many data elements as possible before development of the data base begins will be useful in reducing the number of changes in card and file formats required later. Complete data element definitions will also facilitate the conversion to DBMS, if and when this occurs.

Data elements contained in the WATSTORE Ground-Water Site-Inventory File are described in the WATSTORE Users Guide, Volume 2, Chapter II; this should be a good reference for definition of data elements contained in the Well Description File, Hydrogeologic File, Water Use File, and Water Levels File.

Master File

The Master File contains fixed (static) information about a site such as situation, location, data available, agency (organization), ownership, and general site characteristics. The data elements are listed in Appendix A. Some elements in the Master File are mandatory and must be entered before data for other files are stored. These required elements should include register (site) number (element 1), site name (element 6), coordinates (elements 10 and 11), site type (element 12), agency (element 72), hydrologic basin (element 2), district (element 4), and county (element 5). Another element (no. 110) to indicate if data are available in another file will always be stored but this can be done by the update program and need not be entered by the user.

The Master File can contain fixed-length records assembled from data submitted on two fixed-field card formats described in Appendix G. Military coordinates are input on cards and the latitude-longitude of each site can be calculated on entry or retrieval from the value of latitude-longitude for the zero-point of the military coordinate system.

The WATSTORE User's Guide, Volume 1, Chapter III, describes card and file formats, and how to use the WATSTORE Station Header File, and this should be a useful reference in developing the Master File.

Well Description File

The Well Description File contains information on well/hole characteristics, equipment, and construction. The data elements are listed in Appendix B. The common elements between the Master File and the Well Description File are agency (element 72) and site number (element 1). Card formats to enter and update the Well Description File are shown in Appendix G. The file contains both fixed-field and character-string data, but the record length can be fixed.

Data elements contained in the WATSTORE Ground-Water Site-Inventory File are described in the WATSTORE Users Guide, Volume 2, Chapter II, and this should be a good reference for definition of data elements contained in the Well Description File.

Hydrogeologic File

The Hydrogeologic File contains information on aquifer characteristics, lithology, and geology. The data elements are listed in Appendix C. The agency code and site number are the common elements between the Hydrogeologic File and other files in the data base system. Card formats to enter and update the Hydrogeologic File are shown in Appendix G.

The file contains mostly character-string data but the records can still be o fixed length.

Water Quality File

Water quality data will be the predominant data type in this file, but the file can contain any data collected at a point in time (that is randomly in time, not at fixed intervals) and identified with an element (parameter) number. Although the file will generally contain field and laboratory chemical analyses, it can also contain sporadic measurements of water levels, river stages, flow measurements, and precipitation data. The data elements initially stored in this file are listed in Appendix D. The agency code and site number are the common elements between the Water Quality File and other files in the data base. Card formats to enter and update data in the Water Quality File are shown in Appendix G.

The file contains all fixed-field data but the number of elements (parameters) can vary, therefore a variable length record would be desirable to conserve file space. A record generally contains data for an analysis, or an observation of field water quality, or water levels. An acceptable alternative for record format would be a fixed-length record, but a variable number of records per analysis or observation.

Data elements should be identified by an element number or parameter code as used by WATSTORE. The recommended record format is shown in figure 3.

Some elements (parameters) can be calculated from others stored in the file. It is recommended that these computed values not be stored in the file but be computed on retrieval.

Agency Code	Site No.	Analysis Date (begin)	Time (begin)	Analysis Date (end)	Time (end)	Analysis No.	Element No.	Element Value	Element No.	Element Value	etc.

Figure 3. Proposed Water Quality File Format

A discussion of record formats, card formats, parameter codes, and data processing procedures for the WATSTORE Water Quality File is contained in the WATSTORE User's Guide, Vol. 3, Chapters II and III. A complete list of WATSTORE parameter codes is contained in the WATSTORE User's Guide, Appendix Volume, Appendix D.

The element (parameter) values shown in figure 3 should be coded in exponential notation or modified exponential notation (see WATSTORE User's Guide, Vol. 3, Chapter II, page A-15) so that element value fields can be the same length for all elements, and only one data card format will be required.

Water Use File

The Water Use File contains monthly and yearly water use data (rates and volumes) by type of use. The data elements are listed in Appendix E. The agency code and site number are the common elements between the Water Use File and other files in the data base. Card formats to enter and update water use data are shown in Appendix G.

The file contains mostly string data but the records can be of fixed length.

Water Level File

This file contains water level and well production (discharge) data, and eventually could also be used to store daily values of river stage, flow, and precipitation. This file is designed to contain data collected frequently and at a fixed interval (that is one value per day). An exception to this general rule would be well production data which can be collected for intervals shorter than a day.

Values of water level can be stored either as distance below a reference point or as elevation (distance above sea level). The different kinds of records can be identified by an element number or by parameter codes as used by WATSTORE. (It is recommended that either distance below a reference point or elevation be stored, but not both, since one can be computed from the other).

Records containing values of streamflow and precipitation can also be identified with the element number or a parameter code and stored in this file.

The data elements to be initially stored in the Water Level File are listed in Appendix F. The agency code and site number are the common elements between the Water Level File and other files in the data base. Card formats to enter and update water level data are shown in Appendix G.

The records in this file can be fixed length and should contain space to store one item per day for a year, and one set of well production data per year.

A description of the WATSTORE daily values record is described in the WATSTORE User's Guide, Vol. 1, Chapter IV, page B-32. A modified version of this record is recommended for the Water Level File. It would not be necessary to store some of the fixed site information described in this record (only the agency code and site number are duplicated from the Master File).

Register (Site) Number

The site number used by the Geohydrology Division is composed of a map number and a sequence number. The map number consists of three numeric characters that are sometimes followed by an alphabetic character (A, B, etc.). The sequence number is presently a 3-digit number but a 4-digit number is recommended for the data base. The site number has the following form:

nnnassss

where, n = map number (numeric)
a = map qualifier (alphabetic)
s = sequence number (numeric)

The map numbers used for reference are to a scale of 1:25,000 and cover the entire country. Map numbers range from 1 to 612.

The Division of River Hydrology uses a system of map number and sequence number for precipitation stations that differs from that used by the Division of Geohydrology. This system has the following format:

nna/ss

where, n = map number ordinate (numeric)
a = map number abscissa (alphabetic)
s = sequence number (numeric)

Map numbers in this scheme vary from 01F to 32J.

Streamflow sites are numbered the same way as precipitation stations. The Division of River Hydrology also has a numbering scheme for hydrologic basins (see definition of data element No. 2 in Appendix A).

It is recommended that one site and one hydrologic basin numbering system be used by all organizations involved in water resources development and management.

Software (Programs)

The following computer programs (see fig. 2) will provide the essential functions to manage and use the Hydrologic Data Base proposed:

Validate Program
Update Program
Retrieval Subroutine (s)
Application Programs
File Management Programs

The Validate Program should consist of a main program and six subroutines to validate card input for each of the six files in the data base. The validation (edit) procedures common to all card formats, such as checking fields to verify if data are numeric or alpha, can be done in the main program. Validation unique to each file's input cards, such as checking for acceptable ranges of values, will be done in the individual subroutines.

Printed messages will alert the user to various errors detected and good records can be written to an update tape to be used later for updating the file. Error records will be corrected and resubmitted to the validate program.

The main program and the subroutine to validate Master File input cards should be developed first so that work can begin immediately in developing the Master File.

The corrected magnetic tape made by the Validate Program may have to be sorted to insure that records are in proper order for entry into the Update Program. This would be particularly true if more than one validate job is output onto the same tape.

The Update Program will consist of a main program and six subroutines to enter and/or update data in each of the six files. The update program should verify that required elements are stored in the Master File before entering data into any of the other five data files. The Update Program should perform the following functions:

Initialize the files
Add records
Update/change data elements
Delete records and data elements

The main program and the subroutine to enter and/or update Master File records should be developed first.

The Update Program should first determine if a record exists, and if it does not, then add the record to the file. If the record does exist, then update the record with data elements coded on the input cards. If fields are left blank on the input cards, then the corresponding fields in the file should not be changed.

The Retrieval Program will actually be a subroutine/s that can be called by other application programs to select requested records. The user will submit retrieval options to each application program which in turn will retrieve the requested records and create a temporary subfile for use by the application program.

The Retrieval Subroutine (s) would always retrieve Master File records as well as the records from the other data file being utilized by an application program. For instance, the Water Level Table Program will need Master File and Water Level File records. The Inventory Program may require all types of records depending upon the extent of the record inventory.

Retrieval options should include the selection of records based upon a possible list (or range) of the following data elements.

Individual site
Range of site numbers
Site type
Hydrologic basin
District
County
Aquifer system
Record type (master, well, etc.)
Date
Range of dates

Application programs that will probably need to be written include programs to:

Retrieve machine-readable records to create subfiles
for use by application programmers or models.
Inventory (list) program to list records in all of the files.
Water level table program for use in reports.
Water quality table program.
Plot/diagram programs.

Any of the application programs described in the WATSTORE User's Guide can be furnished upon request for use as examples or for revision and use with the data base.

File Management programs that may have to be written include programs for file initialization, clean deleted records from the files, fix record keys, and backup/restore. All the above need not be separate programs but the functions will have to be accommmodated some way, either by using system utility programs or by incorporating into other programs.

DEVELOPMENT SCHEDULE

The following development schedule was left with the project team as a suggested work plan for the first phase of the development effort.

Week	Activity
Sept. 29, 1980	Continue definition of data elements.
	Obtain national codes for district, county, and frequesia if available.
	Assign codes for district, county, and frequesia if no national codes available.
	Assign hydrologic basin codes and aquifer and geologic formation codes.
Oct. 6, 1980	Continue assignment of codes.
	Finalize card design for input.
	Begin program development for subroutine to validate master records.
	Punch data for 50 wells to test subroutines.
Oct. 13, 1980	Complete assignment of codes for Master File.
	Complete data element definitions for Master File.
	Continue development of subroutine to validate master records.
	Design Master File format.
Oct. 20, 1980	Test validate subroutine for master records.
	Begin program development for subroutine to update master records.
Oct. 27, 1980	Complete validate subroutine for master records.
	Initialize test Master File.
	Continue development for subroutine to update master records.

Week	Activity
Nov. 3, 1980	Continue development for subroutine to update master records.
Nov. 10, 1980	Test update subroutine for master records. Begin program development for subroutine to retrieve master records.
Nov. 17, 1980	Complete update subroutine for master records.
	Begin punching data for entry to master file.
	Continue program development for subroutine to retrieve master records.
Nov. 24, 1980	Test retrieval subroutine for master records.
Dec. 1, 1980	Continue testing retrieval subroutine for master records.
	Begin inventory list subroutine for master records.
Dec. 8, 1980	Complete testing retrieval subroutine for master records.
	Continue inventory list subroutine for master records.
Dec. 15, 1980	Continue inventory list subroutine for master records.
Dec. 22, 1980	Complete inventory list subroutine for master records.
	Review project and make future plans.

A diagram of the work plan is shown in Figure 4.

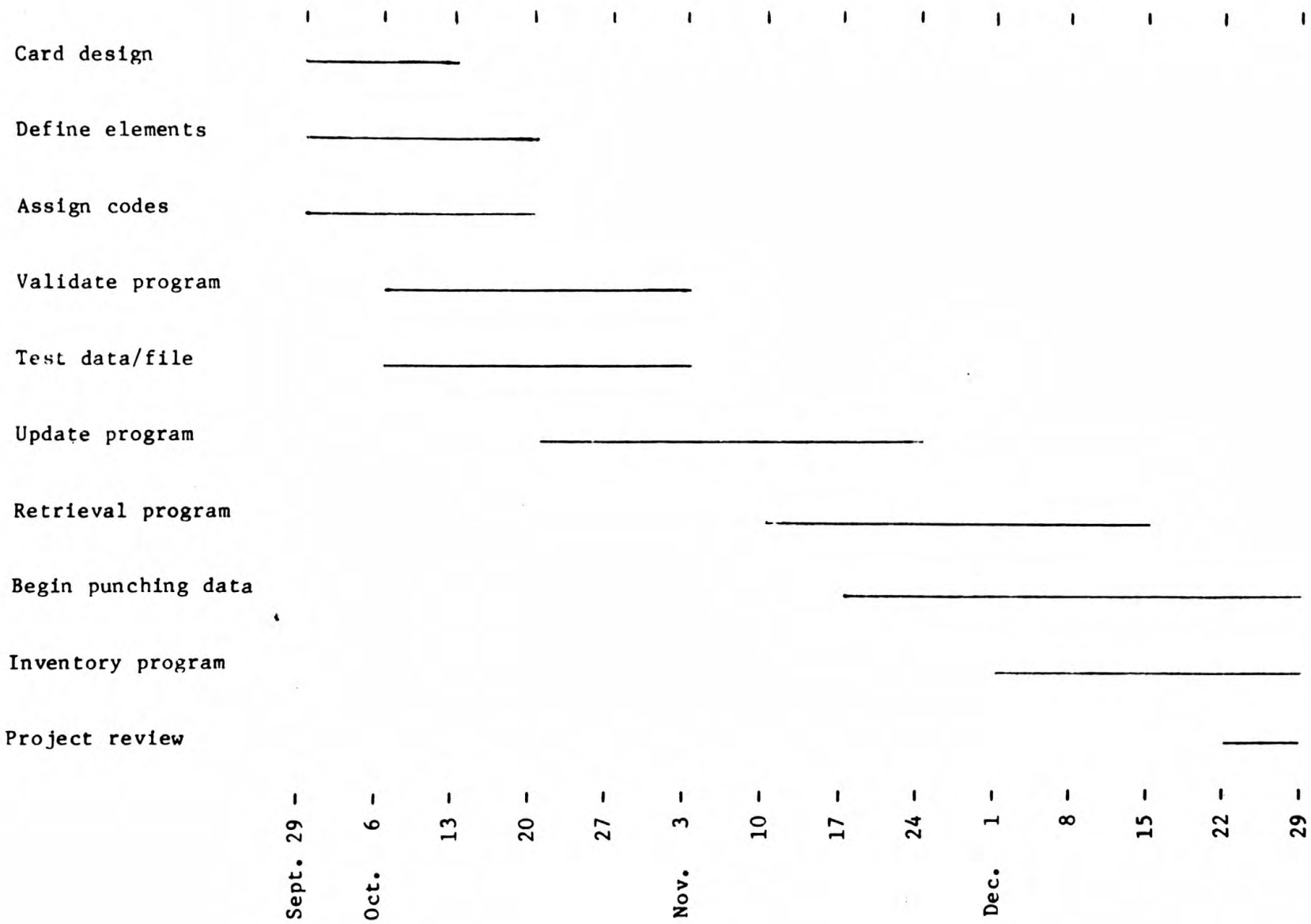


Figure 4. Development Work Plan

RECOMMENDATIONS

It is recommended that the Division of Geohydrology proceed initially to develop a small ground water data base as described in the preceding section to accommodate the data needs of the Algarve region. The system should be disk-oriented with indexed files of some type. Development work can begin on the University of Lisbon IBM 360/44 computer.

The use of a data base management system (DBMS) should be reconsidered in 2 to 3 years when the system begins to include a significant amount of data of other types and from other regions of Portugal. DBMS should also be reevaluated when the University of Lisbon computer system is upgraded or when another larger system becomes available elsewhere.

Training in computer programming and data base systems should be provided to three or four people in the Divison of Geohydrology to provide a broader base of support for the data base system and for ground-water modeling. Fortran and Basic are probably the most appropriate languages in which to acquire additional training.

It is also recommended that a uniform system for identifying hydrologic sites and basins be developed for use by all Departments in the Directorate of Water Resources Development and Directorate of Basic Sanitation.

Figure 4. Development Work Plan

ACKNOWLEDGMENTS

All personnel contacted in the Divison of Geohydrology that were contacted were very helpful in providing information. Natalie Nogel, Esmeralda Amorim, and Joaquim (Braga) Santos were particularly helpful and provided primary contacts with other parts of the organization. Adolpho Gonsolves, Deputy Director, Directorate of Water Resources Development (DGRAH) was supportive of the project and also responsible for initiating the Algarve Project. Nguyen Quang Trac, Chief Technical Advisor, UNESCO, provided many personal comforts, and appropriate professional contacts, and is also a driving force behind the Algarve Project. Fernando Nogel, Chief System Engineer, Computer Center, University of Lisbon, was helpful in showing the University Computer Center and in describing its capabilities.

Donald Finberg and Charles Buchanan, U.S. AID, Lisbon, were briefed on the project and offered their support as needed.

BIBLIOGRAPHY

1. Showen, Charles R.,1978, Computerization of Water Resources Data for Hashemite Kingdom of Jordon, UNESCO Technical Report, Serial No. FMR/SC/HYD/78/160.

2. Morgan, Charles O., 1979, Progress Report on the Design and Implementation of a Computerized Ground Water Data Base, State Hydraulics Works, Turkey, U.N.D.P. Project TUR/77/015.

3. Lang, S. M. and Leonard, A. R., 1967, Instructions for Using the Punch Card System for Storage and Retrieval of Ground Water Data, U.S. Geological Survey Open-File Report.

4. Hutchison, N. E., Compiler, 1975, WATSTORE User's Guide, Volume 1, Instructions for Station Header File and Daily Values File, U.S. Geological Survey Open-File Report 75-426.

5. Baker, Claud H., Jr., et al, 1975, WATSTORE User's Gude, Volume 2, Instructions for Ground-Water File, U.S. Geological Survey, Open-File Report 75-589.

6. Edwards, Melvin D., et al, 1977, WATSTORE User's Guide, Volume 3, Instructions for Water-Quality File, U.S. Geological Survey, Informal Document.

7. Lepkin, W. D., et al, 1979, WATSTORE User's Guide, Volume 4, Instructions for Peak Flow File, U.S. Geological Survey, Open-File Report 79-1336.

8. Hutchison, N. E., et al, 1977, WATSTORE User's Guide, Volume 5, Digital Data Systems, U.S. Geological Survey, Open-File Report 77-729.

9. Booker, Roger E., et al, 1976, WATSTORE User's Guide, Volume 6, Utility and Maintenance Programs, U.S. Geological Survey, Informal document.

10. Hutchison, N. E., Compiler, 1975, WATSTORE User's Guide, Appendix, U.S. Geological Survey, Open-File Report 75-426.

APPENDIX A

DATA ELEMENT DEFINITIONS

FOR

MASTER FILE

Fixed site information - situation, location, data available, agency (organization), ownership, and general site characteristics.

CONTENTS

Appendix A

Data Element Definitions for Master File

Element No.	Element Name
1	Register (site) number.
2	Hydrologic basin code.
3	Aquifer system code.
4	District code.
5	Concelho (county) code.
5a	Frequesia.
6	Local (site) name.
7	Designation number.
8	Owner name.
9	Map scale.
10	Coordinate (east).
11	Coordinate (north).
12	Site type.
13	Water use code.
72	Agency (department) code.
73	Reference point elevation.
110	Data available switch.

Situation	Files
	Master Well D Hydro- WQ WU WL

Element No. 1

Name: Register (site) Number

Description: Includes map number plus 4-digit sequence no. Required element.

Map number is 4 alpha-numeric characters and sequence number is always numeric.

Reference maps are to scale of 1:25000.

Range: From 160001 through 61229999.

Format: Alpha-numeric characters as described above. Eight characters as follows:

nnn = 3-digit map number, numeric.

a = 1-character qualifier, A,B, etc., alpha.

ssss = 4-digit sequence number.

If qualifier (a) not used, leave blank on form in file and on input card.

Note: An agency code is listed as parameter no. 72 to identify agency collecting (responsible) for data.

Situation

Element No. 2

Name: Hydrologic Basin Code.

Description: Major basin code plus minor basin code. Required element. The Division of River Hydrology is implementing a hydrologic basin code scheme to include a major basin code plus minor basin codes down to basin size of 4 square kilometers. The minor basin codes are even numbered on the right side of the major basin and odd numbered on the left side. The complete code will be variable length, depending upon how many levels exist between the major basin and a minor basin less than 4 square kilometers. The data base will include provision for only 3 levels of minor basin codes.

Range: From 1010101 to 9999999.

Format: Numeric, integer. Seven numeric digits, bccddee, where,

b = major basin code
c = first level minor basin code
d = second level minor basin code
e = third level minor basin code

Situation M

Element No. 3

Name: Aquifer System Code.

Description: Major Aquifer System.

Questions: What is coding system?
Required or optional?

Situation M

Element No. 4

Name: District Code.

Description: National Code. Required element.

Range: From 1 to 18?

Format: Numeric integer. Two numeric digits.

Question: Should District code include Province Code or should Province be separate code? (Province is higher level than District). Is Province necessary?

Situation M

Element No. 5

Name: Concelho (County)

Description: National Code. Required element.

Range:

Questions: Is coding system available?
What is range? If no coding system available, recommend assigning consecutive odd integers to alphabetical listing of counties in each District.

Element 5a

Name: Frequesia

Description: Local government level below county.

Question: Is this code necessary?

Element No. 6

Name:	Local (site) Name
Description:	A local village or place name.
	Required element.
Format:	Alphabetic, 40 characters.
Question:	Are 40 characters long enough for this field?

Element No. 7

Name: Designation number.

Description: Appears to be a secondary number at the site.

Question: Is this element necessary?
Or is sequence number in register (site) no. sufficient?

Element No. 8

Name:	Owner Name.
Description:	Name of person or company that is the current landowner. Optional.
Format:	Alphabetic characters, 40 characters.
No. Value:	Blanks in file and on input card .
Question:	Do we need address of owner? Perhaps a separate file can be made for ownership, address, and phone number.

Element No. 9

Name: Map Scale.

Description: Map scale.

Question: Do we need to indicate scale?
Or is scale always 1/25,000?

Element No. 10

Name: Coordinate (East).

Description: Military coordinates (kilometers) from Army Cartographic Service. Measured East of arbitrary zero at ddmmss (degrees, minutes, seconds). longitude. Required element.

Range: From zero to 376.000 kilometers.

Format: Numeric, decimal in thousandths. Seven position field on input card. xxx.xxx

Note: Latitude and longitude (degrees, minute, seconds) recommended to be in file also. Either store latitude-longitude of zero point for military coordinates or compute actual latitude and longitude for site.

Element No. 11.

Name: Coordinate (north).

Description: Military coordinate from Army Cartographic Service. Measured North of arbitrary zero at ddmmss latitude. Required element.

Range: From 0 to 580.000.

Format: Numeric, decimal in thousandths. Seven position field on input card. sss.sss

M

General Characteristics

Element No. 12

Name: Site Type.

Description: Type of site to indicate if well (drilled or dug), spring, streamflow, etc. Required. If drilled well, then code method field (parameter 14).

Range: From 1 to 9.

Format: Numeric integer. One position field.

Codes (Value):
Drilled well = 1
Dug well = 2
Spring = 3
Streamflow = 4
etc.

No Value: 9 in file. Leave blank on input card.

Question: Need to complete list of possible codes.

Element No. 13

Name: Water Use Codes.

Description: Type of use, i.e. industrial, domestic, agricultural, etc. This is principal water use.

Optional.

Range: From 1 to 9.

Format: Numeric integer. One position field.

Codes (Value):

Industrial = 1
Domestic = 2
Agricultural = 3
etc

No Value Code: -1 in file. Leave blank on input card.

Note: Type of water use by month is element 98.

M
W
H
WQ
WU
WL

Element No. 72

Name: Agency (department) code.

Description: Code to identify agency collecting (responsible) for the data for this site. Required element.

Note: Need to determine if agency (Directorates, Servicos, etc.) codes are available from another government agency. If not, agency codes should be assigned to those agencies involved in water resources.

Element No. 73

Name: Reference point.

Description: Altitude of reference point used to determine water levels.

Format:

M

Element No. 110 (Switch)

Name: Data available Switch.

Description: Switch to indicate if data available in other fields, either computer or manual files.

Format: One byte switch. Switch is off (0) or on (1) to indicate data are available in corresponding file.

Code (Value):

	Yes	No
	1	0
Well Description	-	-
Hydrogeology	-	-
Water Quality	-	-
Water Use	-	-
Water Levels	-	-
Pumpage	-	-
Bibliographic	-	-
Field Notes	-	-

APPENDIX B

DATA ELEMENT DEFINITIONS

FOR

WELL DESCRIPTION FILE

Well/hole characteristics, equipment, and construction information.

CONTENTS

Appendix B

Data Element Definitions for Well Description File

Element No.	Element Name.
13a	Date Completed.
14	Depth of Well.
15	Method.
16	Drilling Company.
17	Engine Type.
18	Power.
19	Pump Depth.
86	Depth to hole dimension.
87	Hole diameter.
88	Depth to pipe dimension.
89	Pipe diameter.
90	Depth to filter dimension.
91	Filter diameter.
92	Reference point description.

Element No. 13a

Name: Date completed.

Description: Date well first completed.

Element No. 14

Name:	Depth of well.
Description:	Total depth of well, in meters. Optional.
Range:	From 0 to 600.0 meters.
Format:	Numeric, decimal in tenths. Four position field on input card. xxx.x
No Value:	999.9 in file. Leave blank on input card.

Element No. 15

Name: Method.

Description: Method of construction. Optional.

Range: Code 1 to 9.

Format: Numeric. One position field on input card.

No Value: -1 in file. Leave blank on input card.

Code (Value): Drilled = 1
Dug = 2
Rotary = 3

Question: Need codes assigned.

Element No. 16

Name:	Drilling Company.
Description:	Name of company who drilled well. Optional.
Format:	Alphabetic, 10 characters.
No Value:	Blanks in file and on input card.

Element No. 17

Name: Engine Type.

Description: Type of engine. Optional.

Format: Numeric integer 1 to 9. One position field on input.

No Value: -1 in file and blank on input card.

Element No. 18

Name:	Power.
Description:	Horsepower output of pump engine. Optional.
Range:	From 0 to 99.
Format:	Numeric integer. Two position field.
No Value:	99 in file. Blank on input card.

Element No. 19

Name:	Pump depth.
Description:	Depth in meters to pump. Optional.
Range:	From 0 to 9.00 meters.
Format:	Numeric decimal in hundredths. Four position field on input card.
No Value:	9.99 in file. Blank on input card.

Element No. 86 (string)

Name:	Depth to Hole Dimension.
Description:	Depth below reference point to hole dimension.
Range:	from 0 to 999.9 meters.
Format:	xxx.x numeric decimal. four positions on input card.
No Value:	Blank in card.

Element No. 87 (String)

Name: Hole Diameter.

Description:

Range: From 0 to 9999 mm.

Format: xxxx numeric decimal. Four positions on input card.

No value: Blank in card.

Element No. 88 (String)

Name: Depth to Pipe Dimensions.

Description: Depth below reference point to pipe dimension.

Range: From 0 to 999.9 meters.

Format: xxx.x numeric decimal. Four positions on input card.

No value: Blank in card.

Element No. 89 (String)

Name: Pipe Diameter.

Description:

Range: From 0 to 999 mm.

Format: xxx numeric decimal. Three positions on input card.

No Value: Blank in card .

Element No. 90 (String)

Name:	Depth to filter dimension.
Description:	Depth below reference point to filter dimension.
Range:	From 0 to 999.9 meters.
Format:	Numeric decimal. Four positions on input card.
No Value:	Blank in card.

Element No. 91 (String)

Name: Filter Diameter.

Description:

Range: From 0 to 999 mm.

Format: Numeric decimal. Three positions on input card.

No Value: Blank in card.

Note: Element No.'s 93-94 reserved for field observations (remarks).

Element No. 92

Name: Reference Point Description.

Description: Location and description of reference point used to determine water level.

APPENDIX C

DATA ELEMENT DEFINITIONS

For

HYDROGEOLOGIC FILE

Aquifer characteristics, lithology, and geologic data.

CONTENTS

Appendix C

Data Element Definitions for Hydrogeologic file

Element No.	Element Name.
27	Aquifer Thickness.
28	Lithologic Code.
29	Depth to Formation.
30	Stratigraphic Code.
31	Remarks.
84	Transmissivity.
85	Storage Coefficient.

Element No. 27 (String)

Name: Aquifer Thickness.

Description: Thickness of formations and/or aquifers.

Format: Numeric. Five position field on input card.
Record to tenths of meter.
xxx.x

Range: 0 to 999.

No Value: 999.9

Element No. 28 (String)

Name:	Lithologic Code.
Description:	Description of aquifer or formation.
Format:	Numeric code, 2 alpha characters. xx

Element No. 29 (String)

Name:	Depth to Formation.
Description:	Depth to the top of formation or aquifer in meters.
Format:	Numeric. Decimal in tenths.
	Five position field on input card. xxx.x
Range:	0 to 600.0
No Value:	999.9 in file. Leave blank on input card.

Element No. 30 (String)

Name:	Stratigraphic Code.
Description:	A code to describe formation.
Format:	Numeric code, 3 digits. xxx

Element No. 31 (String)

Name: Remarks.

Description: Additional information on aquifer or formation.

Format: Numeric code.

Range: 0 - no remarks.
1 - remarks.

Question: This field may not be necessary.

Element No. 84

Name: Transmissivity.

Description:

Format: x.xx E-xx

H

Element No. 85

Name: Storage Coefficient.

Description:

Format: x.xx E - xx

APPENDIX D

DATA ELEMENT DEFINITIONS

FOR

WATER QUALITY FILE

Data collected at a point in time, that is randomly, not at fixed interval. Generally, consist of field and laboratory chemical analyses, but could also contain sporadic measurements of water levels, river stages, flow measurements, and precipitation data.

CONTENTS

Appendix D

Data Element Definitions for Water Quality File

Element No.	Element Name.
33	Analysis Number.
34	Analysis Date
34a	Analysis Date (End).
35	Field pH.
36	Dissolved Solids (Total).
37	Conductivity (Field).
38	Hardness.
39	Hardness (Total).
40	Sodium Adsorbtion Rate (SAR).
41	Calcium (meq/L).
43	Maganese (meq/L).
45	Sodium (meq/L).
47	Potassium (meq/L).
49	Ammonia.
51	HCO3.
53	CO3.
55	Sulfate.
57	Chlorine.
59	NO3.
61	Total Cations.
62	Total Anions.
63	pH (lab).
64	Conductivity (lab).

Element No. 33

Name:	Analysis Number.
Description:	Number assigned by lab. Required if Water Quality data stored.
Format:	Numeric. 4-position field on input card.
Range:	1 to 9999.
Question:	Is this number unique or unique for the site only?

Element No. 34

Name: Analysis Date.

Description: Required if WQ data entered, i.e. if water quality data coded.

Format: Numeric. 8-position field.
ddmmyyyy
day = d (2 positions)
month = m (2 positions)
year = y (4 positions)

Range: 01011800 to 31121990.

Note: The above format appears to be the form used for date, but format yyyymmdd would be better for sorting. Earliest and latest (range) for editing check can be set to different values than those listed above.

Time of day in which the analysis was collected is recommended as an additional data element. For composite samples this is begin date.

Element No. 34a

Name: Analysis Date (End).

Description: This element is not listed on the data form, but should be provided for if composite samples (those that cover period of time with begin and end date and time).

Note: May not need this element if composite samples are not collected. (Composites probably only apply to surface water samples).

Element No. 35

Name: PH (Field).

Description: Optional. Field PH.

Range: 0 to 14.0.

Format: Numeric. 3-position field on input card.
xx.x

Element No. 36

Name: Dissolved solids (total).

Description: Total dissolved solids concentration mg/l. Optional.

Range:

Format:

Element No. 37

Name: Conductivity (Field).

Description: Electrical conductivity (field) in mhs/cm at 25 C.

Range:

Format: Numeric. Five position field.
No decimal. xxxxx

Element No. 38

Name: Hardness.

Description:

Range:

Format:

Element No. 39

Name: Hardness (total).

Description:

Element No. 40

Name: Sodium Adsorbtion Rate (SAR).

Description:

Element No. 41.

Name: Calcium (meq/L).

Description:

Format:

Element No. 43

Name: manganese (meq/L).

Description:

Element No. 45

Name: Sodium (meq/L).

Description:

Element No. 47

Name: Potassium (meq/L).

Description:

Element No. 49

Name: Ammonia.

Description:

Element No. 51

Name: HCO3.

Description:

Element No. 53

Name: CO3.

Description:

Element No. 55

Name: Sulfate.

Description:

Element No. 57

Name: Chlorine.

Description:

Element No. 59

Name: NO3.

Description:

Element No. 61

Name: Total cations.

Descriptions

Element No. 62

Name: Total anions.

Description:

Element No. 63

Name: PH (Lab).

Description: Lab PH.

Element No. 64

Name: Conductivity (Lab).

Description: Lab determined conductivity.

Note: Element No.s 65-70 reserved for future WQ parameters.

APPENDIX E

DATA ELEMENT DEFINITIONS

FOR

WATER USE FILE

Monthly and yearly water use data (rates and volumes) by type of water use.

CONTENTS

Appendix E

Data Element Definitions for Water Use File

Element No.	Element Name.
95	Month.
96	Rate.
97	Duration.
98	Type Water Use.
99	Industrial Use.
100	Domestic Use.
101	Agricultural Use.

Element No. 95 (String)

Name: Month.

Description: Month Code for which water use data collected.

Format: Two numeric integers.

Code (Value):

January = 01
February = 02
etc
December = 12

Note: If multiple uses of water at a well are possible, then type of use (parameter No. 98) may be coded.

Element No. 96 (string)

Name: Rate.

Description: Rate of water use, cubic meters per hour (m^3/h).

Element No. 97 (String)

Name: Duration.

Description: Duration of water use, hours per day (h/day).

Element No. 98 (String)

Name: Type Water Use (by month).

Description: Type of use, for example industrial, domestic, agriculture, and so forth by month.

Range: From 1 to 9.

Format: Numeric integer. One position field.

Code (Value):

Industrial = 1
Domestic = 2
Agricultural = 3
etc.

Element No. 99

Name: Industrial use.

Description: Number of days per year of industrial water use.

Element No. 100

Name: Domestic use.

Description: Number of days per year of domestic water use.

Water Use WU

Element No. 101

Name: Agricultural Use.

Description: Number of days per year of agricultural water use.

Note: Element No's. 102-109 reserved for additional water use parameters.

APPENDIX F

DATA ELEMENT DEFINITIONS

FOR

WATER LEVEL FILE

Water level data collected frequently (more than 12 times a year) and for a fixed interval or at specific time (etc. daily). Also contains well production data.

This file can also be used to store daily values of river stage, flow, and precipitation.

CONTENTS

Appendix F

Data Element Definitions for Water Level File

Element No.	Element Name.
74	Method of Measurement (A).
75	Date of Measurement.
76	Depth of Water Level.
77	Method of Measurement (WL).
78	Discharge.
79	Duration of Pumping.
80	Drawdown.
81	Air Temperature (^{o}C).
82	Water Temperature (^{o}C).
83	Conductivity (18^{o}C).

Element No. 74 WU

Name: Method of measurement (A).

Description: Method used to measure altitude (element no. 73).

Format: Numeric integer. One position.

Code (Value):

Map = 1
Level = 2
Altimeter = 3

WL
WQ

Element No. 75 (String)

Name: Date of water level measurement.

Description: Date water level measured or altitude of reference point determined or verified (element no. 73).

WL
WQ

Element No. 76 (String)

Name: Depth of water level (meters).

Description: Distance measured from reference point (element No. 73) to water surface.

Note: Altitude of water level not necessary to store. Can be determined from altitude of reference point (element 73) and depth of water level (element 76).

Element No. 77 (String)

Name:	Method of measurement.
Description:	Method of measuring depth to water level (element 76).
Format:	Numeric integer.
Code/Value:	Need to asign values for these codes.

Element No. 78 (String)

Name: Discharge.

Description: Discharge from well by pumping.

Element No. 79 (String)

Name: Duration of pumping.

Description: Length of time pumping sustained.

Format: hhmm, where
h = hours
m = minutes.

WL

Element No. 80 (String)

Name: Drawdown.

Description:

Element No. 81 (String)

Name: Air Temperature (^{o}C).

Description: Air temperature in degrees celsius.

WL

Element No. 82 (String)

Name: Water Temperature (C°).

Description:

Element No. 83 (String)

Name: Conductivity (18 C).

Description:

Question: Is this element necessary, or should temperature value always be stored with conductivity values?

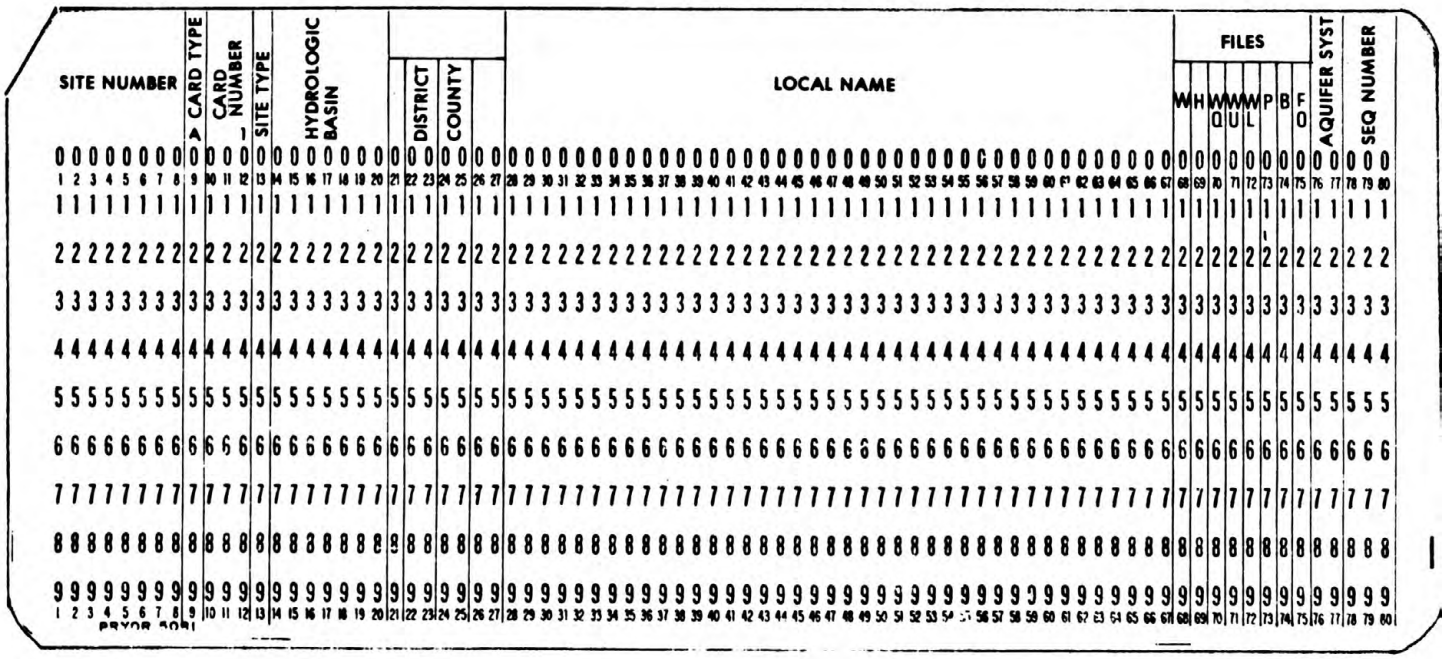
APPENDIX G

Card Formats

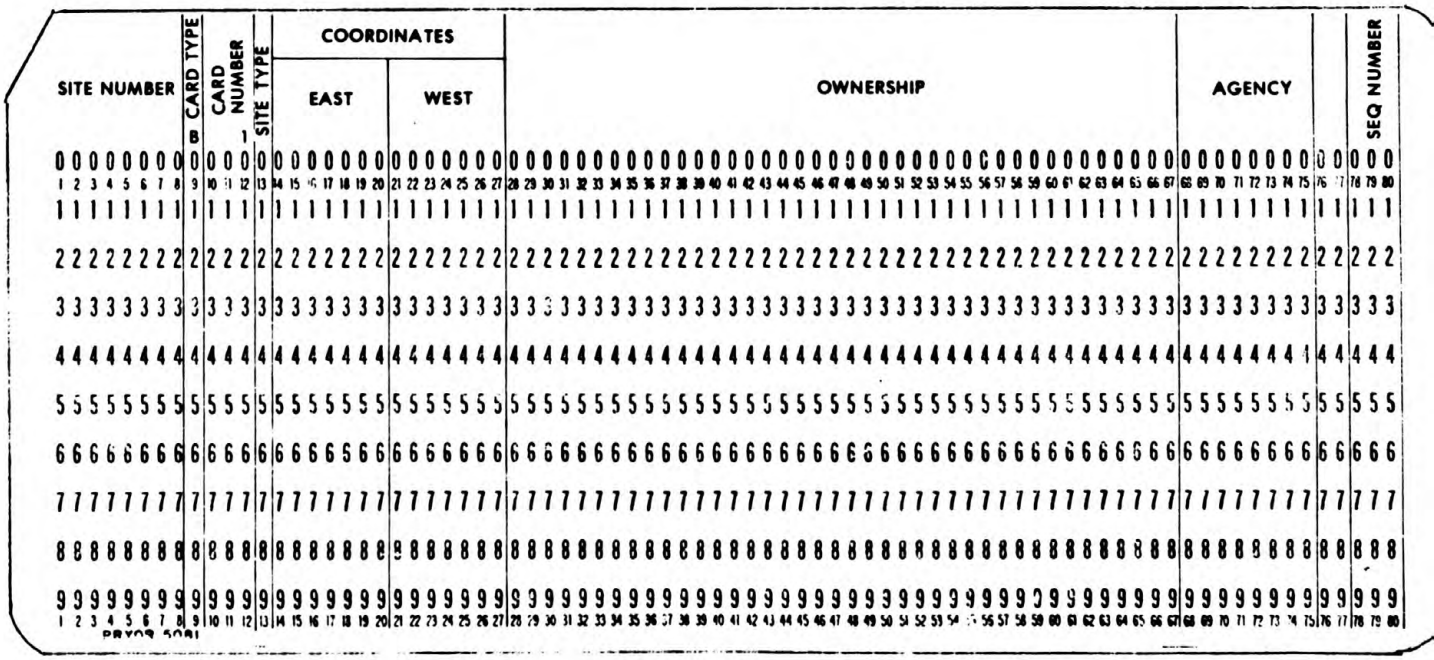
APPENDIX G

CARD TYPES

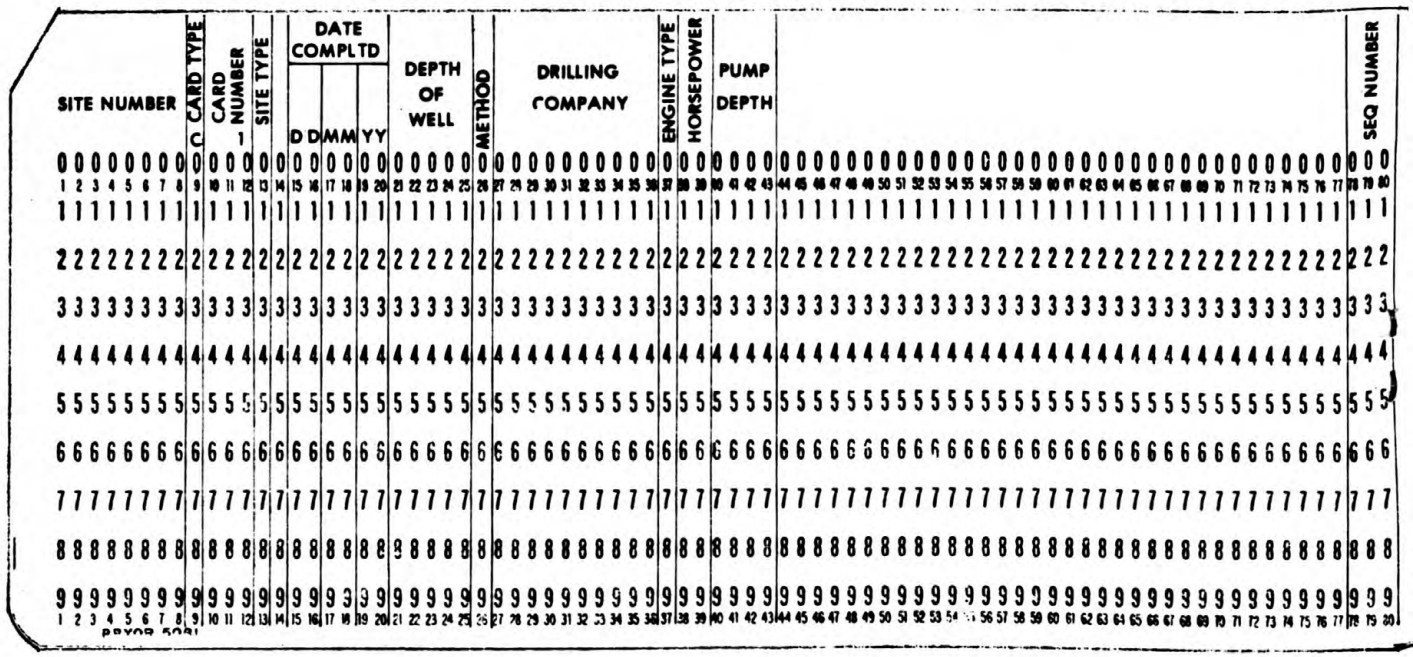
Type	Name	Description
A, B	Master Cards	Fixed site information - situation, location, data available, agency (organization), ownership, general site characteristics.
C, D	Well Description Cards	Well (hole) characteristics, equipment, construction information.
E	Hydrogeologic Cards	Aquifer characteristics, lithology, geology, production data, etc.
F	Water Quality Cards	Field and laboratory chemical analyses.
(?)	Water Use Cards	Water Use (volume) by category and month.
(?)	Water Level Cards	Water level date, depth, and method.



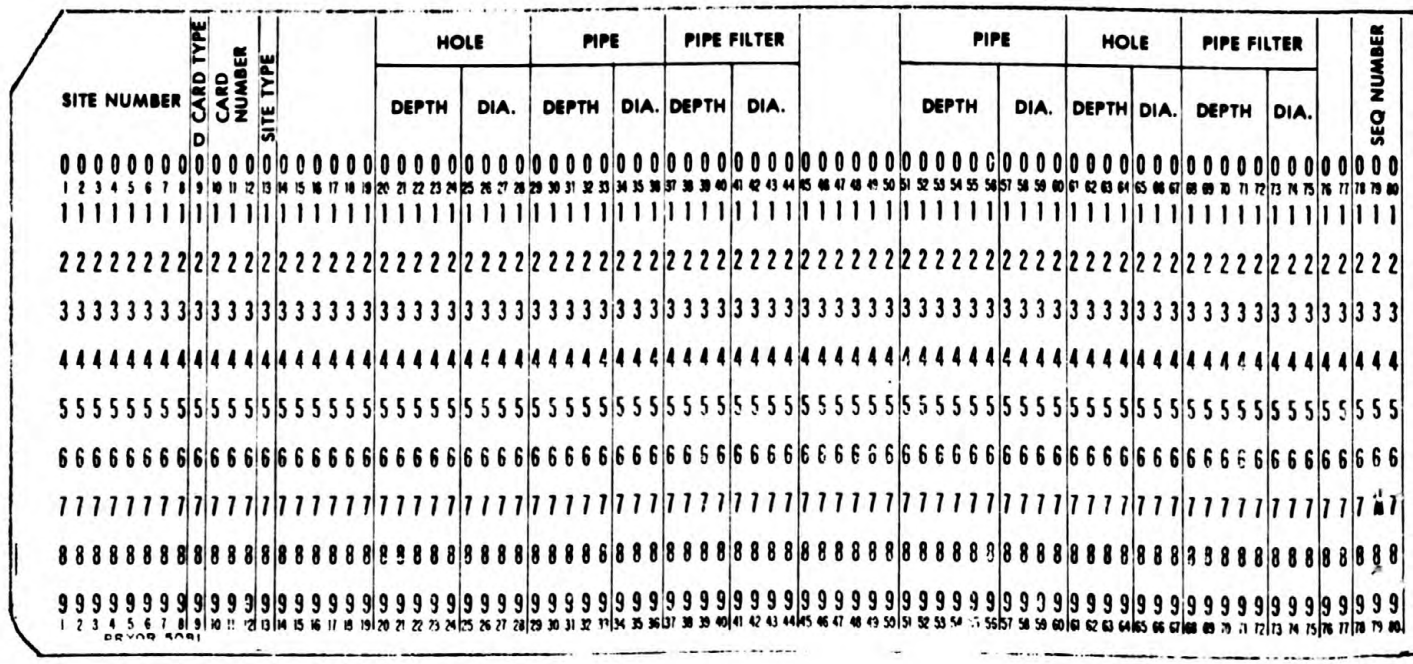
Master Card A



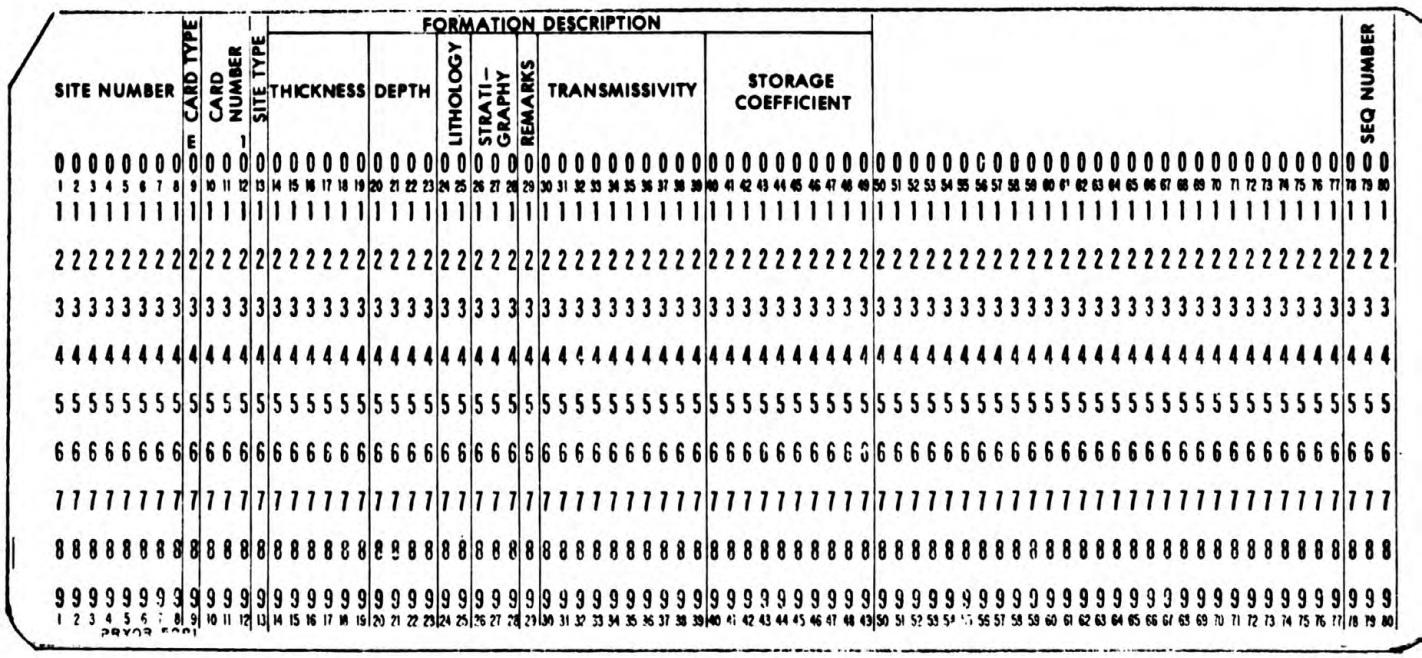
Master Card B



Well Description Card C



Well Description Card D



Hydrogeologic Card E

Water Quality Card

Water Use Cards

Water Level Cards

The above card formats have not been completed at time of printing.