THE REPUBLIC OF UGANDA

UGANDA WATER ACTION PLAN

WATER RESOURCES DEVELOPMENT AND MANAGEMENT

GROUNDWATER DATABASE

ANNEX REPORT - VOLUME 2 (DOC. 011)

MINISTRY OF NATURAL RESOURCES

DIRECTORATE OF WATER DEVELOPMENT

1995

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VOLUME 2

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LIST OF ABBREVIATIONS

AfDB	African Development Bank
CLICOM	Climatological database
Danida	Danish International Development Assistance
DWD	Directorate of Water Development
GIS	Geographic Information System
GPS	Global Poistioning System
HYDATA	Hydrological database
HYDROCHEM	Hydrochemical database
IFAD	International Fund for Agricultural Development
KFW	Kreditanstalt für Widerafbau
LWF	Lutheran World Foundation
NEIC	National Environmental Information Centre
NGO	Non-Governmental Organisation
NURP	Northern Uganda Reconstruction Project
RTWSP	Rural Towns Water and Sanitation Programme
RUWASA	Rural Water and Sanitation (East Uganda) Project
STWSP	Small Towns Water and Sanitation Programme
SWIP	South-West Integrated Health and Water Programme
UNICEF	United Nations Childrens Fund
UTM	Universal Transverse Mercator projection
WATSAN	National Water and Sanitation Programme
WB	World Bank
WDD	Water Development Department (Now DWD)

ANNEX 9

GROUNDWATER DATABASE AND DATABASE LINKS

ANNEX 9

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1 GROUNDWATER DATABASE AND DATABASE LINKS

1.1 Introduction

Groundwater has played a significant role in domestic water supply in Uganda with construction of tubewells commencing in the early part of this century and private drilling contractors in operation as early as in the mid 1920s. Other drilling activities have been undertaken by the Geological Survey and the Water Development Department (WDD) now reorganized as the Directorate of Water Development (DWD). The total number of boreholes is close to 14,000 of which almost all carry a more or less comprehensive record. Furthermore, there are in the order of 15-20,000 identified springs of which some 5,000 are protected, and an unknown number of dug wells for which records in general do not exist.

Following the end of the civil war in 1986, borehole rehabilitation and construction activities have again gained momentum with several large-scale programmes presently being implemented. These programmes are almost invariably financed by international and bi-lateral donor agencies and NGOs. The degree of individual project coordination with DWD varies from negligible to full integration as DWD does not have sufficient staff and other resources for coordinating all the groundwater development activities under the different programmes. DWD may furthermore not always be the contractor for these programmes and the need for record keeping and data collection thus tends to be defined by the individual programmes rather than by DWD.

In order to facilitate efficient and appropriate groundwater resources management by DWD, it has been decided to prepare a design for a national groundwater databank. It should be realized that such a databank will emphasize groundwater availability and quality rather than detailed technical data on individual installations. A reasonable amount of technical data for waterpoint installations have been included though, and it is believed that this database, in addition to detailed information on the groundwater situation, may also serve most of the requirements for information about technical installations at individual groundwater extraction points (boreholes, dug wells and protected springs).

The databank is intended to be one of a larger number of databases on water resources, water supply facilities, construction work, cost and monitoring etc. which eventually should constitute a DWD management information system. The proposed databank will thus fulfil the DWD requirements for groundwater information but may be supplemented by individual project databases as and when appropriate. It should furthermore be mandatory for future implementation programmes or contractors of boreholes, dug wells and protected springs to submit groundwater data to DWD following the proposed database format.

1.2 Ongoing groundwater development programmes and database status

The present groundwater development activities in Uganda are undertaken by a relatively large number of programmes and projects. The overall annual construction rate is 3,500 waterpoints, of which 1,600 are boreholes (deep and shallow hand-augered), 1,600 are protected springs and 300 are large diameter dug wells.

1.2.1 Danida/Rural Water and Sanitation East Uganda Project (RUWASA)

The RUWASA programme started pilot activities in 1989 and full-scale construction in 1991. The programme covers eight districts in south-eastern Uganda (Mukono, Jinja, Kamuli, Iganga, Tororo, Pallisa, Mbale and Kapchorwa) and is envisaged to have a 10 year implementation period during which it is estimated to construct a total of 10,000 waterpoints. The programme is restricted to rural areas and practically all extraction facilities will be hand-operated point-sources thus providing a large number of observation points but only limited groundwater extraction.

The number of waterpoints constructed by RUWASA so far is 1,900 (900 boreholes, 800 protected springs and 200 dug wells), and the present annual construction rate is 500 boreholes, 300 protected springs and 110 dug wells.

RUWASA is fully integrated into DWD and maintains databases which have been developed in collaboration with DWD's relevant professional staff. However, the databases have been developed for RUWASA's use only, and have not been correlated to other programmes' data registration. The RUWASA data registration furthermore gives high priority to construction information (for project monitoring purposes) and is thus not directly suitable for groundwater registration and/or monitoring.

The databases related to groundwater development, presently maintained by RUWASA, are a hydrogeological and borehole database, a water quality database and individual databases for protected springs, dug wells and hand-augered boreholes. Location data for all waterpoints are being established as grid coordinates by use of Global Positioning System (GPS). Full chemical water quality testing is carried out more or less as a routine procedure and all waterpoints are as a minimum tested for physical parameters.

All RUWASA databases have been prepared using dBASE IV software and the project has recently defined activities to establish links between their individual databases and to make the RUWASA databank compatible to the DWD requirements.

1.2.2 UNICEF/South-West Integrated Project (SWIP)

The SWIP programme was launched by UNICEF in 1987 following a period of handpump and borehole emergency rehabilitation in the Luwero triangle, and activities in other parts of Uganda since 1984. Construction activities (related to groundwater) under SWIP comprise tubewells and spring protection in the districts of Masaka, Rakai, Mbarara, Kasese, Bushenyi, Rukungiri and Kabale.

SWIP has its main office in Mbarara and the programme is only partially coordinated by DWD. Data is maintained in the form of hard copies only and presently includes some 1,700 boreholes and approx. 4,000 protected springs. The current construction rate under the SWIP programme is 250 boreholes and 800 protected springs per year.

SWIP has two GPS units but they are not being routinely used, and borehole location data in terms of coordinates are not available. Water quality data only includes a limited number of physical parameters. No chemical control is carried out.

1.2.3 World Bank/Northern Uganda Reconstruction Project (NURP)

NURP is an integrated reconstruction programme which includes urban and rural water supply and groundwater development activities in nine districts (Apac, Gulu, Lira, Kitgum, Soroti, Kumi, Palissa, Arua and Moyo). Drilling work is being carried out by DWD and these activities are expected to run for three years and to include a total of 360 boreholes.

With DWD as the drilling agency, the reporting follows standard DWD formats. No computerized databases are maintained.

1.2.4 Plan International

Plan International has recently called for pre-qualification of drilling contractors to construct boreholes in Luwero district. No specific reporting format has been developed and the production rate is expected to be 100 boreholes per year.

1.2.5 WaterAid

British WaterAid has an ongoing shallow well construction/rehabilitation programme in Kabarole district, totalling 180 wells per year. Some 40 hand-augered boreholes have recently been completed in Mbale district, and a new programme is about to be launched in Kitgum district with an annual production of about 250 hand-augered boreholes.

Spring protection is ongoing in Rukungiri district with 700 springs protected already, and a construction rate of 500 per year over the next two years. The activities in Bushenyi district have now been halted due to lack of funding, after protection of a total of 120 springs.

All spring, borehole and well sites are located by use of GPS (four units in operation and three more under procurement), and there are plans to do test pumping for all new boreholes. The programme furthermore carries out limited water quality tests (basically physical parameters).

1.2.6 CARE

The annual construction rate under the CARE programme is 50 new boreholes and some rehabilitation in addition to a few protected springs. CARE maintains a lotus database with location and construction details, and regularly reports to DWD.

1.2.7 Directorate of Water Development (DWD) and UNICEF/Water Sanitation Programme

The WATSAN programme coordinated by DWD is dependent on funding from various sources such as Government and donor agencies, mainly UNICEF. The programme carries out spring protection, borehole rehabilitation and recently a shallow well programme was started. The construction rate varies in accordance with available funding, and is on average 200 augered boreholes/dug wells and 500 protected springs per year. Standard DWD hard-copy reporting is used.

1.2.8 WB, AfDB and KFW/Rural Towns Water and Sanitation Programme (RTWSP)

The RTWSP encompasses a number of activities for development of urban and small towns water supply. This type of water supply will partly be based on surface water but to a variable degree also on groundwater from tubewells and springs. The total number of towns expected to be covered by the programme is more than 60 within an estimated implementation period of 10 years. Feasibility studies and demand studies are far from completed and the total number of groundwater extraction points to be developed is therefore difficult to establish. It is envisaged, however, that the total number of groundwater extraction points under the three programmes will be more than one thousand.

The Small Towns Water and Sanitation Programme (STWSP) which is about to commence pilot activities, is by far the largest of the activities under the RTWSP. During the programme preparation and planning stages of the STWSP, the programme has been fully integrated into DWD and this model is expected to continue during the implementation phases.

Computerized databases are yet to be established in accordance with DWD requirements.

1.2.9 Other programmes

Minor construction activities are undertaken by Lutheran World Foundation (LWF) in Moroti district (40 boreholes and 20 protected springs per year). The International Fund for Agricultural Development (IFAD) is to construct about 100 boreholes in Hoima district. An additional 80 boreholes are constructed annually under Italian aid programmes in Hoima, Mubende and Kotido districts.

No readily available databases are maintained and DWD does not receive reports from these programmes.

1.2.10 Comparative analysis and conclusions on database need

A vast amount of groundwater information has over the years been accumulated within the DWD but the data has not been compiled in a systematic manner and is therefore not readily accessible. Various manual data extraction exercises have been made by individual programmes for specific purposes but this has neither resulted in a systematic data organization nor improvement of data accessibility.

There are at present no guidelines as to what type of data should be recorded in relation to groundwater development activities and no requirements or procedures for reporting of such data to DWD. Individual projects have established (hard copy and few computerized) formats which basically fulfil their own reporting and monitoring needs rather than the requirements of a national groundwater resources database. It should be noted, though, that several projects recently have approached DWD in order to establish database formats and that obviously there is a clearly expressed need for this.

As only a limited number of the ongoing programmes maintain computerized databases there are very few considerations to be made in terms of compatibility of individual formats. It has been recommended by several projects, however, that the new format be established by use of dBASE IV compatible software, and combined with appropriate GIS software for production of maps. Arc/Info is the GIS software currently in use at the National Environmental Information Centre (NEIC) and at the Biomass project in the Department of Forestry, whereas UNICEF use AtlasGIS.

1.3 Objectives and requirements

1.3.1 Objectives of the national groundwater database

The objectives of establishing a national database is to organize and systematize all relevant available groundwater data in order to prepare an overview of the groundwater resources in terms of quantity, quality and availability.

The database will serve as an efficient tool in groundwater resources management and may constitute an important basis for planning of future groundwater development activities through combination with e.g. census data whereby detailed information on coverage and service level may be compiled. Groundwater monitoring will further be enhanced.

1.3.2 Functional requirements

The database will include static as well as dynamic data. Static data are geology, drilling dimensions and location, whereas dynamic data, which may change with time, are e.g. water level, chemistry and pump installation data. The database is designed to include, at all times, the latest available information on dynamic data. When updating such data the format will automatically indicate that other (earlier) data are available and that these are stored in related databases.

The basic record identification will be the national I.D. number which is unique for each waterpoint. Such I.D. may be supplemented by a local I.D. given by the individual projects of contractors. The national I.D. includes a district and waterpoint type identification code and is given automatically upon data entry. This is to ensure a unique numbering system when receiving data from a large number of different construction sites simultaneously.

All waterpoints are registered with indication of district, county, sub-county, parish, village and waterpoint name as well as with grid coordinates. This is to facilitate data extraction in accordance with administrative boundaries as well as area-wise extraction following standard grid references. The grid references and map drawing facilities have been given particular attention in order to ensure an easy integration of the database with possible future Geographical Information Systems (GIS) to be established under the auspices of DWD or otherwise.

It is envisaged that the groundwater database users broadly will fall into one of the following three groups:

- DWD Management as national resources administration authority
- individual projects, agencies and contractors when planning construction of new facilities, and

- district authorities as the local water resources authority and as representatives for local waterpoint operation and maintenance organizations

The requirements of these individual users will obviously not always coincide and the database therefore offers a high degree of flexibility and combination potential in data extraction. Data extraction possibilities will thus include area-wise extraction as well as cross-sectional subject specific extraction.

1.3.3 System description

The database has been designed to include basically two different types of data, i.e. waterpoint information and groundwater information. The waterpoint information includes (1) identification and location data, (2) construction data and (3) pump installation data. The groundwater information is given under another three headings; (4) geological and hydrogeological data, (5) hydrochemical data and (6) yield test, flow and water level data. Further to these six headings, a category (7) other information, has been included, which may include e.g. information on ownership and users, etc.

The database is first and foremost intended as a groundwater database which also includes the most frequently used installation data. It is envisaged that it will be operated and maintained by professional staff at DWD head office and that a relatively uniform level of quality control and data reliability thus can be ensured prior to entry in the database.

The database is designed to receive and store data, to be reported in a standard format, from the individual implementation programmes and (at a later stage) from monitoring activities carried out at decentralized (e.g. district) level. Another key point in the design has been to ensure full compatibility and interaction with other planned DWD databases, and to the extent possible, with external databases (e.g. census data).

1.3.4 Data collection format and reporting procedures

The data collection format is organized in the two major groups and seven sub-headings given above. Data may be entered:

- as one of several given options
- as numeric and date format
- as descriptive text

The use of codes has been avoided in order to minimize the risk of interpretational and entry errors. Descriptive text is used to store e.g. geological descriptions in the original

form without introducing any new elements of interpretation during a coding process prior to date entry.

The data collection and reporting format is a clear text questionnaire designed for professionals involved in groundwater development. The format covers all potential groundwater sources, i.e. protected springs, dug wells and shallow and deep boreholes, and closely follows the menu operated database software.

1.3.5 Database operation and maintenance

Data entry has been initiated as an additional activity aiming at reducing the present backlog of data and developing the database up to a point where the database is fully up-dated and operational.

The database should eventually be established within the Water Resources Department in Entebbe and thus share facilities with the already developed surface water database. The office should be staffed with permanent staff qualified in database management and hydrogeology as well as data entry operators.

An important aspect of data entry is quality control which must include not only a direct check of data transformation and entry errors but also a qualified assessment of the data value prior to entry. It has e.g. been noted that some chemical data are grossly incorrect and the pre-entry assessment must therefore ensure that such data are omitted from the database in order not to distort e.g. average calculations etc.

Quality control should be established at two levels; i) control of data transformation from various original documents to new standard formats, including data quality assessment, and ii) check of data entry errors and omissions. This quality control could be carried out by a qualified senior hydrogeologist.

Database maintenance should be a continuous process based on mandatory reports submitted by the individual implementors in the DWD prescribed database format. Such reports should be carefully scrutinized by qualified professionals, and if necessary queries requesting clarification addressed to the report submitter, before data entry.

1.4 Use of the groundwater database

The database is intended to accommodate the groundwater information needs of internal DWD staff, as well as requests from external bodies. It is furthermore intended as a corner-stone in a future groundwater management and monitoring system.

Database users should be able to receive data in print-out as well as diskette formats, and all data should be linked to specific grid coordinates in order for the users to combine such data with other area characteristics and thereby develop a fully integrated geographical information system.

The database must be operated and up-dated by DWD staff, only thereby ensuring a consistent and correct database management. DWD must ensure that information is readily obtainable upon request and within a reasonable time. If necessary, a fee to cover the direct costs involved in such data submission could be charged.

1.5 Relations between the groundwater database and external databases

The DWD groundwater database is intended to be the first step in a phase which eventually will constitute a DWD management information system. The groundwater database will receive data from the various projects which are in operation in Uganda. However, the present uncoordinated and inhomogeneous designs of individual project databases prevent DWD from obtaining computerized exchange of uniform and standardised data for water resources management purposes with most project databases. Therefore, input to the proposed DWD groundwater database is paper based, using predesigned forms (see Appendix 1.1).

1.5.1 External databases of interest

Three external databases have been identified as having data which may be of interest in a groundwater resources management context. Therefore, the possibilities for data exchange with these databases have been assessed. The three databases are:

- the climate (CLICOM) database at the Meteorological Department in Kampala
- the surface water database (HYDATA) operated by the Water Resources Department in Entebbe
- the project database operated by Ministry of Finance and Economic Planning

1.5.2 Exchange of data with external databases

The Meteorological Department is using a PC software CLICOM, which is developed in USA. The database reportedly contains information on monthly rainfall from some 150 stations scattered all over Uganda. According to the documentation the software is able to exchange data in LOTUS 1-2-3 format, but due to hardware problems, this has not been verified yet.

The database operated by the Water Resources Department contains information on the water levels, rating curves and discharges. Data is stored in the database system HYDATA, developed by Institute of Hydrology, Wallingford, UK. The database system contains a number of facilities for data processing and quality assurance, which meet most of the present requirements of the users. The facilities for data exchange from HYDATA to other systems are limited. However, a programme file already installed has been identified and tested for applicability. It was demonstrated that this auxiliary programme satisfies the basic requirements for data retrieval and export to other relevant database formats.

The database operated by Ministry of Finance and Economic Planning is based on dBASE and exchange of data on selected projects will be a standard routine. However, only the financial part is computerized, whereas the project profiles are written in WordPerfect.

The DWD database will be able to deliver any retrieved information in a number of different formats. The built-in general query facilities will enable export of data from the various files of the database in the following formats:

- spreadsheet files (Quattro, Lotus 1-2-3 and DIF format)
- database files (dBASE, Paradox)
- ASCII files (comma separated).

The proposed groundwater database will thus be able to exchange information with databases containing other relevant information.

WATERPOINT INFORMATION

1. IDENTIFICATION AND LOCATION DATA

Type of waterpoint; Borehole:___ Dug Well:___ Protected Spring:___

Identification; National I.D.No._____ Project I.D.No._____

Location; LONGITUDE/LATITUDE:___ UTM:___, if UTM, ZONE Number:_____
Longitude E:_____ Latitude N/S:_____ Altitude:_____
UTM E:_____ UTM N/S:_____ Altitude:_____

District:_____, County:_____, Sub-County:_____
Parish:_____, Village:_____, Waterpoint:_____

Waterpoint ownership; Private:____ Communal:____ Institutional:____

Waterpoint use; Domestic:___, Irrig.:___, Livestock.:___ Industrial:___

Waterpoint abandoned; Low yield:___, Water quality:___, Technical:___

2. CONSTRUCTION DATA

Date for completion of construction; day/month/year:_____

Total depth of borehole/well at date of completion; m:_____

Borehole/well diameter; mm:_____ From:_____ To:_____
mm:_____ From:_____ To:_____
mm:_____ From:_____ To:_____
mm:_____ From:_____ To:_____

Casing/well ring diameter; mm:_____ Length (m):_____

Casing/well ring material; PVC:___ Mild steel:___ Concrete:___
Bricks:___ Other:___

Bottom of casing/well lining; (m b.g.l.):_____

Borehole sealing; None:____ Cement:____ Bentonite:____ Other:____

Filter slot size & intervals; mm:_____ From:_____ To:_____
mm:_____ From:_____ To:_____
mm:_____ From:_____ To:_____

Development of borehole filters; Gravel pack:_____ Natural dev._____

Spring, Height x Width (m); H:_____ x W:_____

No. of spring outlets :_____

3. INSTALLATION DATA

Type of pump installation; Submersible pump:___ Centrifugal pump:___
Handpump:___ Bucket:___

Date of pump installation; day/month/year:_____

Name of pump:_____, Pump capacity:_____ m^3/h

Pump installation/intake depth:_____ m b.g.l.

Riser pipe material; Galvanized iron:___ Stainless steel:___ PVC:___
Riser pipe diameter:_____ mm

Pumping rod material; Galvanized iron:___ Stainless steel:___ Wire:___
Pumping rod diameter:_____ mm

GROUNDWATER INFORMATION

4. GEOLOGICAL AND HYDROGEOLOGICAL DATA

Depth to bedrock; m b.g.l.:_____

Overall geological setting; :_____

Lithology; From:____ To:____ Description:_____
(m b.g.l.) From:____ To:____ _____
From:____ To:____ _____
From:____ To:____ _____
From:____ To:____ _____
From:____ To:____ _____

Aquifer depth (top of aquifer), type and yield;
Depth (m b.g.l.):_____ Overburden:_____ Yield m^3/h:_____
Depth (m b.g.l.):_____ Bedrock:_____ Yield m^3/h:_____

5. HYDROCHEMICAL DATA

Date of sampling; day/month/year:_____

Sampling method; Pumping:_____ Air-lift sampling:_____ Bucket:_____

Sample preservation; None:____ Acid:_____ Other:_____

For pump and air-lift samples; Discharge before sampling (liter):_____

PARAMETER	UNIT	RESULT	DATE	FIELD/LAB
Turbidity	FTU			
Temp.(time of sampling)	°C			
Conductivity	µS/cm			
pH	---			
Tot. alkalinity ($CaCO_3$)	mg/l			
Hardness ($CaCO_3$)	mg/l			
Calcium (Ca^{2+})	mg/l			
Magnesium (Mg^{2+})	mg/l			
Sodium (Na^+)	mg/l			
Potassium (K^+)	mg/l			
Carbonate (CO_3^{2-})	mg/l			
Bicarbonate (HCO_3^-)	mg/l			
Sulphate (SO_4^{2-})	mg/l			
Chloride (Cl^-)	mg/l			
Nitrate (NO_3^-)	mg/l			
Ammonium (NH_4^+)	mg/l			
Tot. Iron (Fe^{2+}+Fe^{3+})	mg/l			
Manganese (Mn^{2+})	mg/l			
Fluoride (F^-)	mg/l			
Free Carbon dioxide (CO_2)	mg/l			
Tot. dissolved solids	mg/l			
Faecal coli	no/100ml			

6. YIELD TEST, FLOW AND WATER LEVEL DATA

Date of test; day/month/year:_____ Duration of test:_____hrs.

Type of test; Pump test:____ Air-lift test:____ Natural flow:____

Transmissivity:_____ m^2/day Specific capacity.:_____ m^3/h/m

Discharge during testing:_____ m^3/h

Static water level (m b.g.l.):_____, Date (day/month/year):_____

Other Static water level data? Y/N:____

Hydrofracturing? Y/N:____ if Y; day/month/year:_____

Other test pumping/yield data? Y/N:____

7. OTHER INFORMATION

ANNEX 10

DWD GROUNDWATER DATABASE

SPECIFICATION OF REQUIREMENTS

DWD Groundwater database

Specification of requirements

July, 1994

ANNEX 10

LIST OF CONTENTS

1 INTRODUCTION

Groundwater has played a significant role in domestic water supply in Uganda with construction of tubewells commencing in the early part of this century and private drilling contractors in operation as early as in the mid 1920s. Other drilling activities have been undertaken by the Geological Survey and the Water Development Department (WDD) now reorganized as the Directorate of Water Development (DWD). The total number of boreholes is close to 14,000 of which almost all carry a more or less comprehensive of record. There are furthermore in the order of 15-20,000 identified springs of which some 30% are protected, and an unknown number of dug wells for which records in general do not exist.

Following the end of the civil war in 1986, borehole rehabilitation and construction activities has again gained momentum with several large-scale programmes presently being implemented. These programmes are almost invariably financed by international and bi-lateral donor agencies and NGOs. The degree of individual project coordination with DWD varies from negligible to full integration as the DWD does not have sufficient staff and other resources for coordinating all the groundwater development activities under the different programmes. The DWD may furthermore not always be the contractor for these programmes and the need for record keeping and data collection thus tends to be defined by the individual programmes rather than by the DWD.

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The databank is intended to be one of a larger number of databases on water resources, water supply facilities, construction work, cost and monitoring etc. which eventually should constitute a DWD management information system. The proposed databank will thus fulfil the DWD requirements for groundwater information but may be supplemented by individual project databases as and when these feel a need for it. It should furthermore be mandatory for future implementation programmes or contractors of boreholes, dug wells and protected springs to submit groundwater data to the DWD following the proposed database format.

1.1 Objectives

The purpose of developing a national groundwater database is to provide a tool for storage, analyze and presentation of groundwater data. The system must provide means of quality

control/quality assurance of the data being entered into the system. The system should be capable of functioning as well as a tool in the daily work as a system for creating overviews.

1.2 References

/1/ UGANDA WATER ACTION PLAN, Water resources and management, PHASE II, Inception report, December 1993.

1.3 Reading guide

The description of the specifications of requirements is organized such a way that chapter 2 contains an overall system design and a general description of the functions, the system is supposed to execute. Furthermore, the limitations of the system is stated here.

Chapter 3 contains a more thorough description of the elements which are supposed to be covered by the system.

Chapter 4 describes the external framework to other existing and future systems, which will exchange information with the groundwater database.

2 GENERAL DESCRIPTION

The DWD groundwater database is going to contain various types of information on the Uganda groundwater. The information will come from various sources, i.e.:

- DWD itself,
- the main drilling operators such as RUWASA, Unicef/SWIP, WaterAid etc.
- Department of Hydrology, Entebbe, under DWD
- Meteorological Department in Kampala
- Census Department

The groundwater database should be capable of handling data on:

- boreholes
- dug wells
- protected springs

The information of each individual point should cover:

- Identification and location data
- Construction data
- Installation data
- Geological and hydrogeological data
- Hydrochemical data
- Yield test, flow and water level data
- Other information (textual description)

The system developers are aware of the fact that not all of this information will be available, and the system should accept partial input. However, as the system later on should be capable of presenting information on maps, the location of the points is crucial. Therefore it has been decided, that the coordinates to the point must be given, at least to the village/enumeration area level. Coordinates should be given either as latitude/longitude or as UTM (in zone 35/36).

2.1 System description

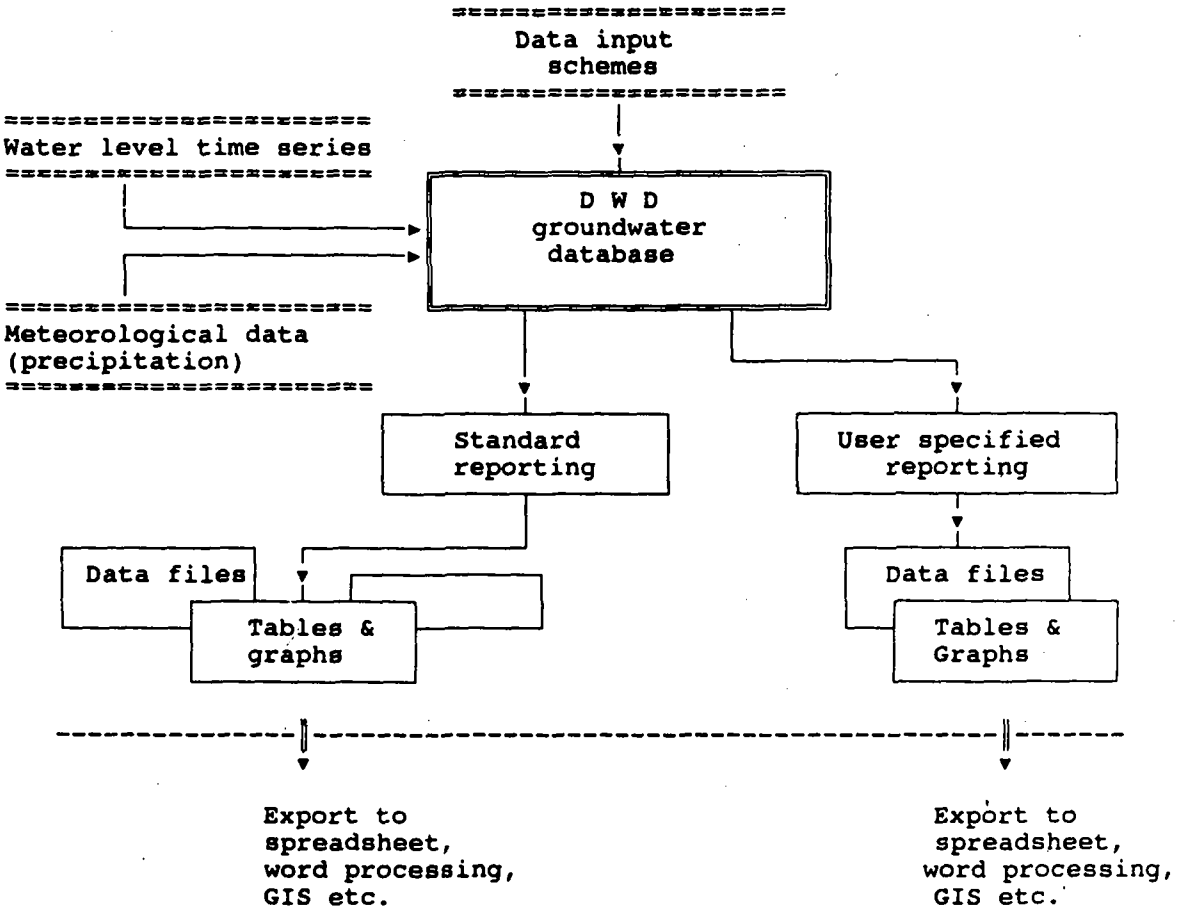
The DWD groundwater database shall serve two purposes, namely:

- Systematize the data on groundwater from various sources in Uganda and

- Provide information on the quantity and quality of the groundwater resource.

The information will come from various sources, each using their own systems for data storage. It is anticipated, that DWD will receive data from the drilling operators in form of schemes, filled out with the required information. These schemes will be considered as being the original input to the system.

The overview of the system will look like this:



2.2 The functions of the software

The software should be able to handle input being entered manually into the database. There should exist possibilities of printing reports to screen/printer or to a file. The should

be facilities for exporting data to common standard software, e.g. spreadsheets, database standards and to comma separated ASCII files. The software should be capable of exporting relevant information to a GIS system. The system should be menu driven. The dialogue should be in English.

2.3 Limitations

The system will be developed to be executed on IBM PC or compatibles. Since DWD at present has no network facilities, the system will act as a standalone application to the users. However, facilities for concurrent updating of the databases should be built in to secure future demands.

The system will be dependant of the available information from the data deliverers. If the system is not updated on a regular basis, or if the quality assurance of the input, the system will not be able to give useful information.

2.4 Future for the software

The DWD groundwater database is meant to be the very first step in creating an information management system for groundwater data. As mentioned above, this part of the system will cover information on the points (boreholes, dug wells and protected springs) and - if available - on the hydrochemical quality of the water.
It is the intension that the system at - a later stage - will be extended with new facilities, such as cost calculations, drilling production rates, project information etc.

2.5 User profile

The users of the system will primarily be the technical staff at DWD and - to some extent - also the management of DWD. The users are assumed to have a basic knowledge to computers.

2.6 Requirements to the development phase

The DWD groundwater database will be developed in a prototype version. This version will form the basis for the resulting database, which will be finished during the WAP Phase II project. The prototype serves several purposes, i.e.

- to verify the extent and structure of the database
- to demonstrate and validate the functionality of the database

The prototype is developed in Paradox 4.5, UK version, but it has not yet been decided whether the resulting system will be developed using this or other standard database software.

The DWD will provide a limited number of old borehole files, converted into a paper format, which fits the input requirements of the prototype. All necessary conversions to the units used by the new system must have been performed prior to entering data into the database. This conversion will form part of the quality assurance system, which must be established.

2.7 Delivery

The system will be handed over to DWD in form of the specified database files, the basic location file based on the CENSUS database (names and numbers for districts, counties, subcounties and parishes). Furthermore, the source code of the software will be delivered. The system will be delivered with a user's manual.

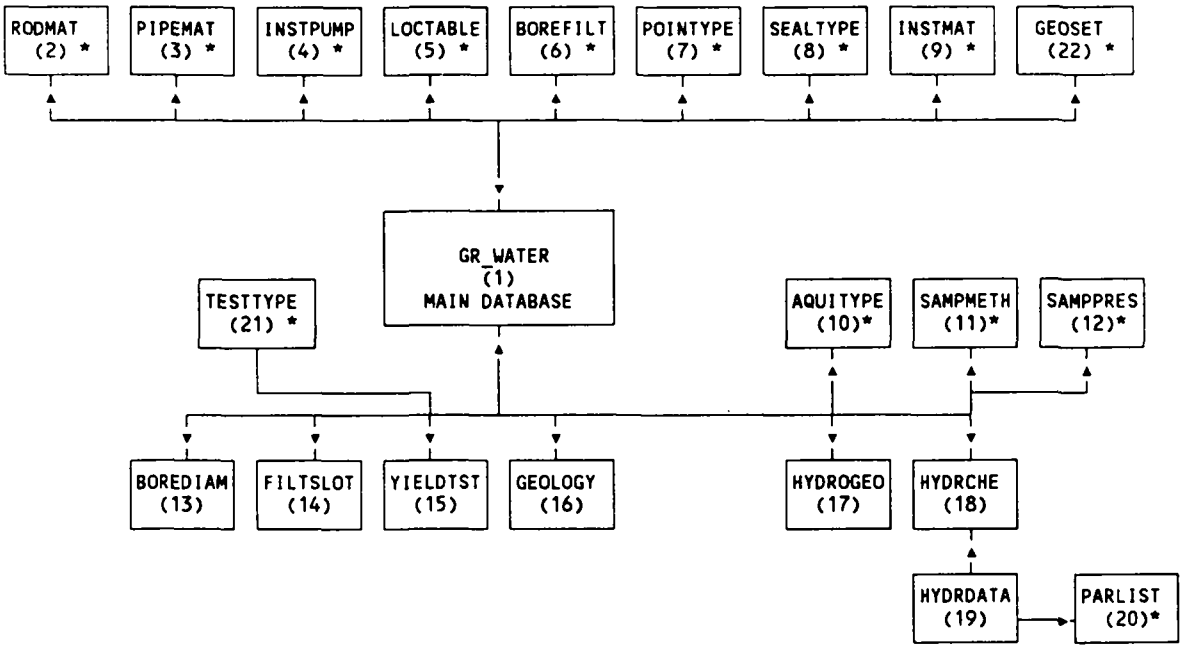
3 SPECIFIC REQUIREMENTS

3.1 Definitions

The database will be built as a relational database, keeping information separated in individual files divided after their contents. The individual files will be linked together, using common fields.

Some of the database files are used as **LookUpTables** which means, that user input is checked against the contents of a file. If the input does not conform with the possible choices, the user will be notified and asked to reenter the input. Another possibility is to press [F1] and use the arrow keys to select among the possible choices, followed by a [F2] keypress. This will transfer the selected information to the database field in question. In the screen images, the fields with table lookup are marked with **[F1]**. The **LookUpTables** are marked with an * in the overview below.

The overview of the database will be as shown below:



List of database files:

1) GR_WATER: Main database file, containing one record per borehole/dug well/protected spring. The description includes:

IDENTIFICATION AND LOCATION DATA,
CONSTRUCTION DATA,
INSTALLATION DATA,
part of GEOLOGICAL AND HYDROGEOLOGICAL DATA,
OTHER INFORMATION.

2) RODMAT: List of accepted pumping rod materials. This table is a **LookupTable** used by **GR_WATER(Installation data)**.

3) PIPEMAT: List of accepted riser pipe materials. This table is a **LookupTable** used by **GR_WATER(Installation data)**.

4) INSTPUMP: List of pump types. This table is a **LookupTable** used by **GR_WATER(Installation data)**.

5) LOCTABLE: List of locations in Uganda. The list contains a unique number for each location and - form each location - the name of **DISTRICT, COUNTY, SUBCOUNTY, PARISH and ENUMERATION AREA.**

6) BOREFILT: Information on borehole filter development. This table is a **LookupTable** used by **GR_WATER(Installation data)**.

7) POINTYPE: List of accepted point types. This table is a **LookupTable** used by **GR_WATER(Identification and location data)**.

8) SEALTYPE: List of accepted borehole sealing types. This table is a **LookupTable** used by **GR_WATER(Installation data)**.

9) INSTMAT: List of accepted casing/well materials. This table is a **LookupTable** used by **GR_WATER(Installation data)**.

10) AQUITYPE: List of accepted aquifer types. This table is a **LookupTable** used by **HYDROGEO**.

11) SAMPMETH: List of accepted sampling methods for hydrochemical data. This table is a **LookupTable** used by **HYDROCHEM.**

12) SAMPPRES: List of accepted sample preservation methods. This table is a **LookupTable** used by **HYDROCHEM.**

13) BOREDIAM: File with borehole/well diameters in different depth intervals. The records in this file are related to records in **GR_WATER** by **NationalIdNo.** and **SerialNo.** The relation between GR_WATER and BOREDIAM is a **one-to-many** relation.

14) FILTSLOT: File with filter slot sizes and diameters in different depth intervals. The records in this file are related to records in GR_WATER by **NationalIdNo.** and **SerialNo.** The relation between GR_WATER and FILTSLOT is a **one-to-many** relation.

15) YIELDTST: File with yield test, flow and water level data. The records in this file are related to records in GR_WATER by **NationalIdNo.** and **SerialNo.** The relation between GR_WATER and YIELDTST is a **one-to-many** relation.

16) GEOLOGY: File with geological description of the location. The records in this file are related to records in GR_WATER by **NationalIdNo.** and **SerialNo.** The relation between GR_WATER and GEOLOGY is a **one-to-many** relation.

17) HYDROGEO: File with aquifer type, yield and depth. The records in this file are related to records in GR_WATER by **NationalIdNo.** and **SerialNo.** The relation between GR_WATER and HYDROGEO is a **one-to-many** relation.

18) HYDRCHEM: File with hydrochemical sample information. The records in this file are related to records in GR_WATER by **NationalIdNo.** and **SerialNo.** The relation between GR_WATER and HYDRCHEM is a **one-to-many** relation.

19) HYDRDATA: File with results of hydrochemical analyse of groundwater. The records in this file are related to records in GR_WATER by **NationalIdNo.** and **SerialNo.** The relation between HYDRCHEM and HYDRDATA is a **one-to-many** relation.

20) PARLIST: List of parameters and units, used to describe the hydrochemical

analyses. This table is a **LookupTable** used by **HYDRDATA.**

21) TESTTYPE: List of accepted testtypes for yield test. This table is a **LookupTable** used by **YIELDTST.**

22) GEOSET: List of types of overall geological settings. This table is a **LookupTable** used by **GR_WATER.**

3.1.1. Identification of boreholes, dug wells and protected springs.

Today, no standardized way of giving a location a unique number exists. The various donor organizations and drilling operators keep their own numbering systems. Therefore, a national groundwater database should be able to assign one single and unique identification of each individual location. As the Census Department operates a number system, covering DISTRICT, COUNTY, SUBCOUNTY, PARISH and ENUMERATION AREA, this should be used as a basis for the new numbering system. Within each of these units, a single serial number should be used to identify the location.

The proposed unique identification code should be as follows:

D : District code
C : County code
S : Subcounty code
P : Parish code

s : Serial No.

On basis of the Census data files, a database covering all locations in Uganda should be formed. When assigning a number to a location for a borehole, a dug well or a protected spring, only location numbers, which are found in this database should be accepted. All necessary location names will be found in this database and therefore, they will not have to be stored within the groundwater database.

The structure of the location database will be as shown below:

Field Name	Field Type	Description
Number	N*	National ID-No.
Dname	A25	District Name
Ccname	A25	County Name
Ssname	A25	SubCounty Name
Pname	A25	Parish Name
Village	A50	Enumeration area Name
Dcode	S	District code
Ccode	S	County code
Scode	S	Subcounty code
Pcode	S	Parish code
Enum	S	Enumeration area code

3.1.2. Identification and location data

The database should be able to store the following data items on identification and location. It will be necessary to be able to store the coordinates in two ways, namely as UTM-coordinates and as longitude/latitude. The UTM coordinates requires a zone number as well, as Uganda covers two UTM zones, zone 35 and 36.

The screen image shown below contains the required information but will not necessarily be the final edition.

Type of waterpoint;	Borehole:___	Dug Well:___	Protected Spring:___
Identification;	National I.D.No._____		Project I.D.No._____
Location;	Grid E:_____	Grid N/S:_____	Altitude:_____
District:_____,	County:_____,		Sub-County:_____
Parish:_____,	Village:_____,		Waterpoint:_____
Waterpoint ownership;	Private:____	Communal:____	Institutional:____
Waterpoint use;	Domestic:___,	Irrig.:___,	Livestock.:___ Industrial:___
Waterpoint abandoned;	Low yield:___,	Water quality:___,	Technical:___

3.1.3. Construction data

It is necessary to keep information on the construction of the borehole / dug well or protected spring. This will comprise DATE FOR COMPLETION, TOTAL DEPTH, DIAMETERS OF THE BOREHOLE, SEALING MATERIAL, FILTER SLOT SIZES etc. as shown below.

The screen image shown below contains the required information but will not necessarily be the final edition.

The number of choices as regards Borehole Sealing Material should be limited by a table lookup facility.

Date for completion of construction; day/month/year:_____

Total depth of borehole/well at date of completion; m:_ _____

Borehole/well diameter; mm:_____ From:_____ To:_____

mm:_____ From:_____ To:_____

mm:_____ From:_____ To:_____

mm:_____ From:_____ To:_____

Casing/well ring diameter; mm:_____ Length (m):_____

Bottom of casing/well lining; (m b.g.l.):_____

Borehole sealing; None:____ Cement:____ Bentonite:____ Other:____

Filter slot size & intervals; mm:_____ From:_____ To:_____

mm:_____ From:_____ To:_____

mm:_____ From:_____ To:_____

Development of borehole filters; Gravel pack:_____ Natural dev._____

Spring, Height x Width (m); H:_____ x W:_____

No. of spring outlets :_____

3.1.4. Installation data

Various data on the installation of Casing/pumps etc. should be stored in the database, as shown below.

Any input to the fields CASING/WELL RING MATERIAL, TYPE OF PUMP, RISER PIPE MATERIAL and PUMPING ROD MATERIAL should checked against a table lookup to assure uniform contents of the fields.

Casing/well ring material; PVC:___ Mild steel:___ Concrete:___
Bricks:___ Other:___

Type of pump installation; Submersible pump:___ Centrifugal pump:___
Handpump:___ Bucket:___

Date of pump installation; day/month/year:_____

Name of pump:_____, Pump capacity:_____ m^3/h

Pump installation/intake depth:_____ m b.g.l.

Riser pipe material; Galvanized iron:___ Stainless steel:___ PVC:___

Riser pipe diameter:_____ mm

Pumping rod material; Galvanized iron:___ Stainless steel:___ Wire:___

Pumping rod diameter:_____ mm

3.1.5. Geological and hydrogeological data

This part of the database should contain information on the geological and hydrogeological conditions at the location. The field OVERALL GEOLOGICAL SETTING should contain a short description in words. No checks of the contents should be performed.
A number of records should be available to describe the lithology in various depth intervals.

In the hydrogeological part, the database should contain information on overburden (in which depth is it found) and depths and yields of possible fractures.

Depth to bedrock; m b.g.l.:_____

Overall geological setting; :_____

Lithology; From:____ To:____ Description:_____

(m b.g.l.) From:____ To:____ _____

From:____ To:____ _____

From:____ To:____ _____

Aquifer type, yield and depth (top of aquifer);

Depth (m .b.g.l.):	Fracture:	Overburden:	Yield m^3/h:
:____	:_	:_	:____
:____	:_	:_	:____
:____	:_	:_	:____

3.1.6. Hydrochemical data

The storage of hydrochemical data is important, though water analyses are not part of the standard programme in several of the donor programmes. It should be possible to store an unlimited number of chemical analyses to each location. The parameters should not be limited to a predefined selection, as the parameters of interest changes according to the geological conditions.

Below is shown a preliminary screen image of the hydrochemical part of the database. The parameters shown are only meant as examples. The parameters being entered by the dataentry-operators should be checked against a lookup table to assure uniform input.

Date of sampling; day/month/year:_____

Sampling method; Pumping:_____ Air-lift sampling:_____ Bucket:_____

For pump and air-lift samples; Discharge before sampling (liter):_____

PARAMETER	UNIT	RESULT	DATE	FIELD/LAB
Turbidity	FTU			
Temp.(time of sampling)	°C			
Conductivity	µS/cm			
pH	---			
Tot. alkalinity ($CaCO_3$)	mg/l			
Hardness ($CaCO_3$)	mg/l			
Calcium (Ca^{2+})	mg/l			
Magnesium (Mg^{2+})	mg/l			
Sodium (Na^{+})	mg/l			
Potassium (K^{+})	mg/l			
Carbonate (CO_3^{2-})	mg/l			
Bicarbonate (HCO_3^{-})	mg/l			

Sulphate (SO_4^{2-})	mg/l			
Chloride (Cl^-)	mg/l			
Nitrate (NO_3^-)	mg/l			
Ammonium (NH_4^+)	mg/l			
Tot. Iron ($Fe^{2+}+Fe^{3+}$)	mg/l			
Manganese (Mn^{2+})	mg/l			
Fluoride (F^-)	mg/l			
Free Carbon dioxide (CO_2)	mg/l			
Tot. dissolved solids	mg/l			
Faecal coli	no/100ml			
Other chemical data?	Y/N:			

3.1.7. Yield test, flow and water level data

As described in the part on the hydrochemical part (3.1.6) it should be possible to store an unlimited number of yield test data to each location.

Date of test; day/month/year:_____ Duration of test:_____hrs.

Type of test; Pump test:____ Air-lift test:____ Natural flow:____

Transmissivity:_____ m^2/24h Specific capacity.:_____ m^3/h/m

Discharge during testing:_____ m^3/h

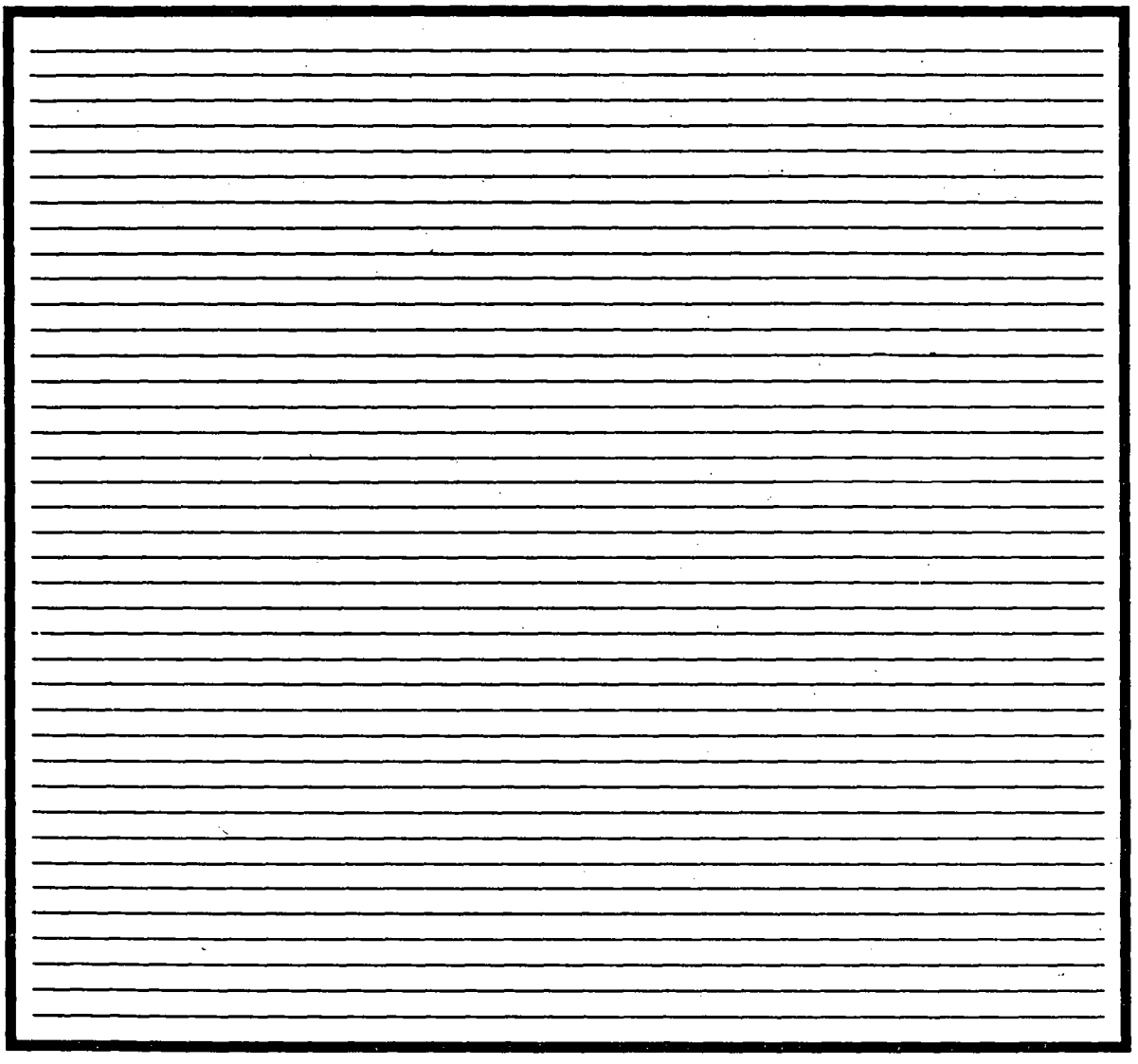
Static water level (m b.g.l.):_____, Date (day/month/year):_____
Other Static water level data? Y/N:____

Hydrofracturing? Y/N:____ if Y; day/month/year: _____

Other test pumping/yield data? Y/N:____

3.1.8. Other information

This part of the database is left open for any input relevant to the location. Here, any special circumstances may be described in plain text. No checks on the contents will be performed.



3.1.9 Database file structures.

Structure for the main database (GR_WATER).

Field Name	Field Type	
Id_national	N*	Identification of location
SerialNo.	S*	Borehole number
Waterpoint	A20	Name of waterpoint
Id_project	A10	Local identification
WaterpointType	A16	Type of waterpoint
GridType	A1	UTM or Geographic coordinates
UTMZone	S	Zone no. (36 is default)
GridEast	N	UTM-East
GridNS	N	UTM-North
Longitude	A8	Longitude (DD.MM.SS)
Latitude	A8	Latitude (DD.MM.SS)
N/S	A1	N)orth or S)outh
Altitude	N	Altitude in meters
PrivateOwnership	A1	Ownership
CommunalOwnership	A1	
InstitutionOwnership	A1	
Domestic_use	A1	Waterpoint use
Irrigation	A1	
Livestock	A1	
Industrial	A1	
AbandonLowYield	A1	Abandoned due to low yield
AbandonQuality	A1	Abandoned due to quality
AbandonTechnical	A1	Abandoned due to Technical problems
CompletionDate	D	Day of completion
TotalDepth	N	Total depth
CasingWellRingDiameter	N	
CasingWellRingLength	N	
BottomCasingWellLining	N	
BoreholeSealing	A16	
BoreholeFilters	A16	
SpringHeight	N	
SpringWidth	N	
NoOfSpringOutlets	S	
RingMaterial	A16	
PumpType	A16	
DateOfPumpInstallation	D	
NameOfPump	A20	
PumpCapacity	N	
IntakeDepth	N	
PipeMaterial	A16	Riser pipe material
PipeDiameter	N	Riser pipe diameter
RodMaterial	A16	Pumping rod material

RodDiameter	N	Pumping rod diameter
DepthToBedrock	N	
OverallGeologicalSetting	A25	
OtherInformation	M240	

Structure for Borehole diameters (BOREDIAM)

Field Name	Field Type	
Id_national	N*	Identification
SerialNo.	S*	
From	N*	Depth from
To	N	Depth to
Diameter	N	Diameter in mm.

Structure for information on Filter slot sizes (FILTSLOT)

Field Name	Field Type	
Id_national	N*	Identification
SerialNo.	S*	
From	N*	Depth from
To	N	Depth to
Diameter	N	Diameter in mm.

Structure for information on Yield test (YIELDTST)

Field Name	Field Type
Id_national	N*
SerialNo.	S*
DateOfTest	D*
Duration	S
TestType	A15
Transmissivity	N
SpecificCapacity	N
DischargeDuringTesting	N
StaticWaterLevel	N
StaticWaterLevelDate	D
Hydrofracturing	A1
HydrofracturingDate	D

Structure for information on Geology (GEOLOGY)

Field Name	Field Type
Id_national	N*

SerialNo.	S*	
LithologyFrom	N*	Depth from
LithologyTo	N	Depth to
Description	A50	Description of lithology (free text)

Structure for information on Hydrogeology (HYDROGEO)

Field Name	Field Type	
Id_national	N*	
SerialNo.	S*	
Depth	N*	
Type	A10	Fracture/Overburden
Yield	N	Yield in m3/h

Structure for information on Hydrochemical samples (HYDRCHEM)

Field Name	Field Type
Id_national	N*
SerialNo.	S*
DateOfSampling	D*
SamplingMethod	A20
SamplePreservation	A5
DischargeVolume	S

Structure for information on Hydrochemical data (HYDRDATA)

Field Name	Field Type	
Id_national	N*	
SerialNo.	S*	
DateOfSampling	D*	
Parameter	A30*	From PARLIST
Attribute	A1	
Result	N	
Field/Lab	A1	Measurement or analysis
Date	D	Date of laboratory analysis

Structure for information on Casing/well ring materials (INSTMAT)

Field Name	Field Type
RingMaterial	A16*

Structure for information on Pumptypes (INSTPUMP)

Field Name	Field Type
PumpType	A16*

Structure for information on Parameters (PARLIST)

Field Name	Field Type
Parameter	A30*
Unit	A10

Structure for information on Riser pipe materials (PIPEMAT)

Field Name	Field Type
RiserPipeMaterial	A16*

Structure for information on Pointtypes (POINTYPE)

Field Name	Field Type
PointType	A16*

Structure for information on Pumping rod materials (RODMAT)

Field Name	Field Type
PumpingRodMaterial	A16*

Structure for information on Sampling methods (SAMPMETH)

Field Name	Field Type
SamplingMethod	A20*

Structure for information on Sample preservation (SAMPPRES)

Field Name	Field Type
SamplePreservationMethod	A5*

Structure for information on Sealing methods (SEALTYPE)

Field Name	Field Type
SealingMaterial	A16*

Structure for information on yield test types (TESTTYPE)

Field Name	Field Type
Testtype	A15*

Structure for information on Overall geological settings (GEOSET)

Field Name	Field Type
OverallGeologicalSetting	A50*

3.2 Reports

The system should be prepared with some standard reports. It has not yet been decided which types, but the following types have been discussed:

1) Report on a single waterpoint, giving the available information. This should include:

   Location and identification data
   Installation data
   Construction data
   Geological data
   Hydrogeological data and
   Hydrochemical data

2) Reports on district level such as:

   Information on the waterpoints (type, location, name etc.)

   Information on yield test data from all waterpoints within a district.

3.3 GIS capabilities

To strengthen the overview of data it has been decided to implement a Geographic Information System (GIS) and link it to the database via files. It has not yet been decided which system to use, but it must be able to be executed in the same hardware environment as the groundwater database. The system should be able to show locations of the waterpoints on a Uganda Map and it should be possible to "click" on a waterpoint and get detailed information on screen. The system should be able to print out maps on ordinary printertypes.

4 EXTERNAL INTERFACE REQUIREMENTS

4.1 User interface

The user interface should bee based on a menu driven approach. Wherever possible, the input should be controlled against predefined tables. This will assure a more systematic contents of the data fields.

4.2 Hardware interface

The system should be able to run on IBM PC's or true compatibles. The possible future introduction of a network in DWD should be taken into consideration by the system developers.

4.3 Software interface

For thee time being, no data on groundwater are "computerized" within DWD. Up to now, all files are kept in a paperbased database. However, a number of the drilling operators are maintaining databases to some extent. The exchange of information from these databases should be taken into consideration.

5 REQUIREMENTS TO THE PERFORMANCE OF THE SOFTWARE

There are no specific requirements to the performance of the software as regards response time at queries. Response times at retrieving individual records in the database should be "reasonable".

6 QUALITY FACTORS

Quality factors:

1: Not critical
2: Not so critical
3: Important
4: Very important
5: Most important

Reliability: 5
The probability of having the system running for a given period without errors?

Maintenance: 3
How long time does it take to find and correct errors?

Possibility of expansion: 5
How easy is it to expand the system with new features?

User friendliness: 5
How easy is it to get acquainted with the system for users without much computer experience?

Reusability: 2
How much of the application is reusable for other purposes?

Integrity: 5
The ability of the application to protect its data.

Efficiency: 3
How fast is the system able to retrieve required information?

ANNEX 11

DWD GROUNDWATER DATABASE

USER´S MANUAL

DWD

Groundwater database

User's manual
April/July 1994

Table of contents

1. Introduction and objective

Groundwater has played a significant role in domestic water supply in Uganda with construction of tubewells commencing in the early part of this century and private drilling contractors in operation as early as in the mid 1920s. Other drilling activities have been undertaken by the Geological Survey and the Water Development Department (WDD) now reorganized as the Directorate of Water Development (DWD). The total number of boreholes is close to 14,000 of which almost all carry a more or less comprehensive of record. There are furthermore in the order of 15-20,000 identified springs of which some 30% are protected, and an unknown number of dug wells for which records in general do not exist.

Following the end of the civil war in 1986, borehole rehabilitation and construction activities has again gained momentum with several large-scale programmes presently being implemented. These programmes are almost invariably financed by international and bi-lateral donor agencies and NGOs. The degree of individual project coordination with DWD varies from negligible to full integration as the DWD does not have sufficient staff and other resources for coordinating all the groundwater development activities under the different programmes. The DWD may furthermore not always be the contractor for these programmes and the need for record keeping and data collection thus tends to be defined by the individual programmes rather than by the DWD.

In order to facilitate efficient and appropriate groundwater resources management by the DWD, it has been decided to prepare a design for a national groundwater databank. It should be realized that such a databank will emphasize groundwater availability and quality rather than detailed technical data on individual installations. A reasonable amount of technical data for waterpoint installations have been included though, and it is believed that this database, in addition to detailed information on the groundwater situation, may also serve most of the requirements for information about technical installations at individual groundwater abstraction points (boreholes, dug wells and protected springs).

The databank is intended to be one of a larger number of databases on water resources, water supply facilities, construction work, cost and monitoring etc. which eventually should constitute a DWD management information system. The proposed databank will thus fulfil the DWD requirements for groundwater information but may be supplemented by individual project databases as and when these feel a need for it. It should furthermore be mandatory for future implementation programmes or contractors of boreholes, dug wells and protec-

ted springs to submit groundwater data to the DWD following the proposed database format.

The purpose of developing a national groundwater database is to provide a tool for storage, analyze and presentation of groundwater data. The system provides means of quality control/quality assurance of the data being entered into the system. The system should be capable of functioning as well as a tool in the daily work as a system for creating overviews.

The developers are aware that there is an ongoing development of "turnkey" groundwater database systems. However, since none of those which were assessed during January and February 1994 were able to store the required information, it was decided to develop this system. It was found that it was important to begin the process of storing the vast amounts of waterpoint information in this phase.
If a standard system at a later stage proves to fulfil the requirements, it should be considered to convert the data to such a system. This will - of course - facilitate the maintenance of the database system.

2. System description

The overall design has been outlined below:

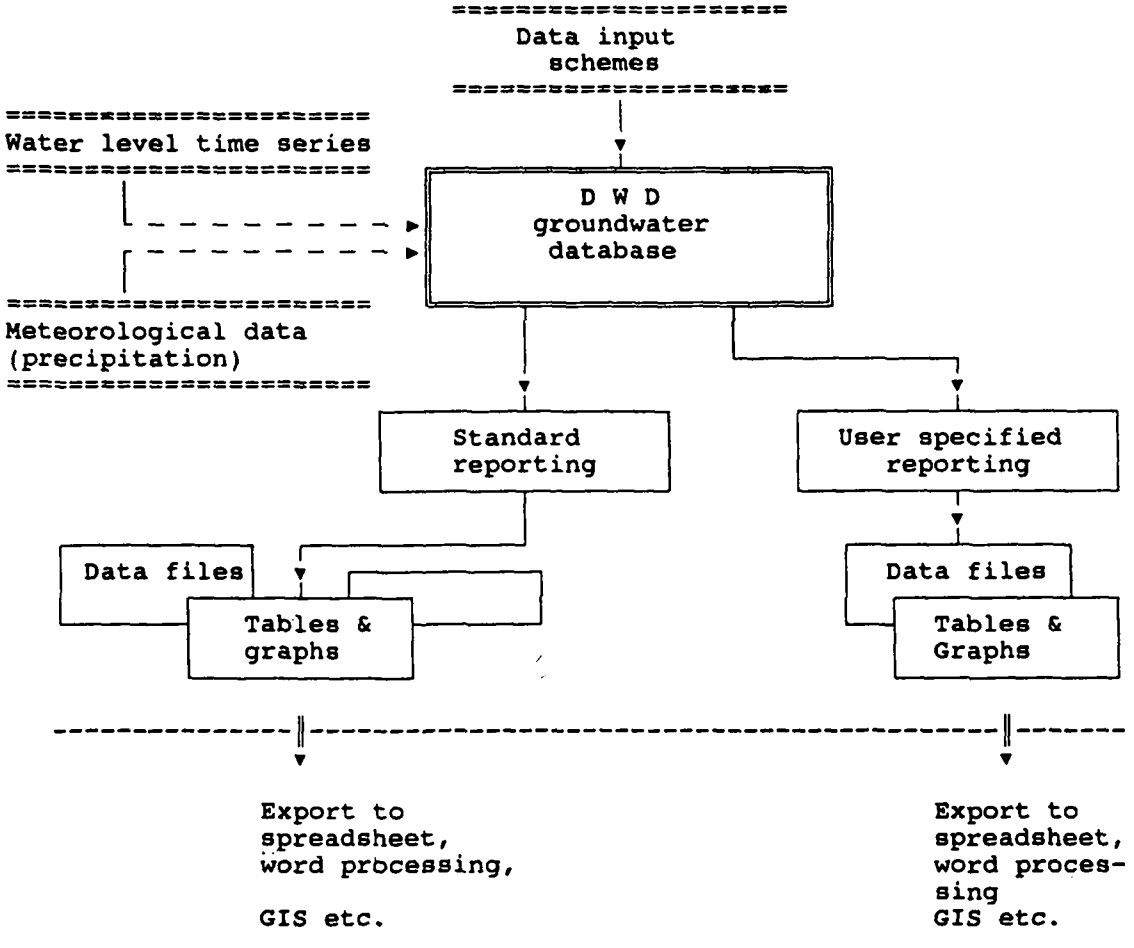


Figure 1. System diagram

With pre-defined reports in the form of tables, plots and data files DWD may be used for reporting.
The users may carry out this form of reporting without extensive knowledge of Paradox and the other software types used. The reporting takes place solely by indication in menus and dialogue boxes, and by entering statements of periods, etc.

The "optional data base" and the "user controlled reporting" must, however, cover all the special treatment carried out in connection with the daily work. Data may be extracted in a format which may be imported by standard-software or which may be processed further in Paradox.

Menu guidance

The user interface has been adapted to modern standards and is based on the CUA standard. The data base is operated by means of menus and dialogue boxes. The program may be operated by both keyboard and mouse. The individual choices are made by pointing and thereupon pressing **Enter**, or by **clicking** the mouse on the required choice.

The menus are all based on pull-down-menus in which the possible choices are listed.

The general screen has been divided into three parts. In the top line the possible overall choices are listed, also called the main menu. When a choice is made in the main menu, either a sub-menu will appear in the form of a pull-down menu with new menu points or a function will be carried out.

In the bottom line additional comments on the current choice appear, highlighted on the main menu or the sub-menus.

The remaining intermediate 23 lines, 2-24, are used as work area, i.e. in this area input diagrams, reports, etc., are shown.

Dialogue boxes

In many places the operation is based on the use of so-called dialogic boxes where the user in a box on the screen must make a choice or enter a value or a name. After the pointing out or entering the choice must be confirmed. This is done by pointing at an **OK**-key and pressing **Enter**. The alternative is to regret the choice by activating an **Exit**-key.

If a mouse is used, the required selection must be chosen by a "**click**" on the mouse and then on either the **OK**-key or the **Exit**-key.

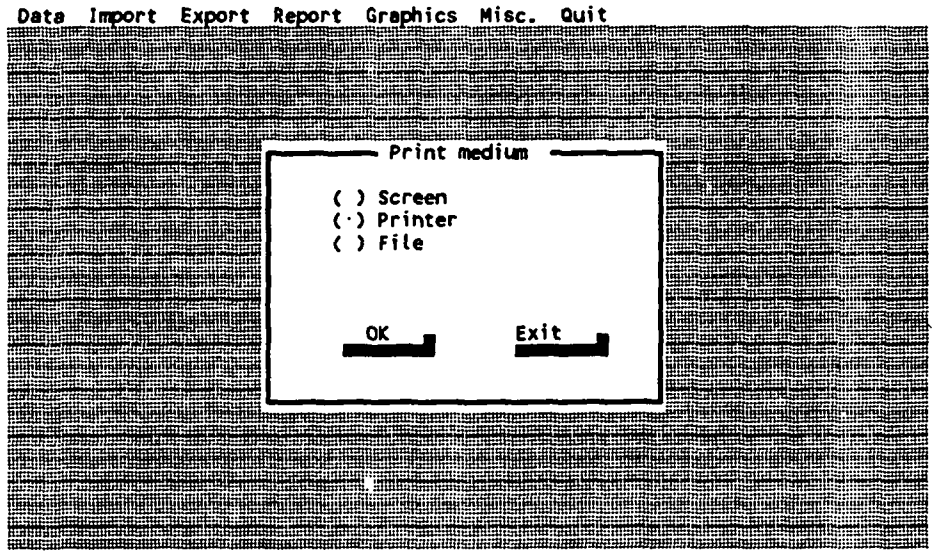


Figure 2. Example of a dialogue box.

In figure 3 an example of a dialogue box is shown. In this example the user is asked to state the printer medium to be used: the screen, the printer or transport to a file. If a mouse is used, a click must be made opposite the medium by which the print-out is to take place, and thereupon the **OK** key must be clicked. If the keyboard is used, the dot · is moved about by means of the up-arrow key and the down-arrow key, and subsequently the **Tab**-key to highlight one of the keys: **OK** or **Exit** and thereupon the **Return** key. It is also possible to press the **Alt** key + initial letter, in this case e.g. **<alt>+O** or **<alt>+A**.

If the **OK** is selected, a new choice of print medium has been made; if **Exit** is chosen, the print medium is the same as when the dialogue box was fetched.

Presentation of data

In order to get as much information as possible from the data base some standard reports have been built in, which makes it possible very

quickly to carry out some standard reporting of data. Documentation is available both in the form of tables and as graphical presentation.

Search routine

As mentioned above DWD has a number of built-in standard tools to illustrate the condition of the groundwater. However, it may at times be necessary to carry out special analyses of data and groups of data, into which it is not immediately possible to build routines in the software. Therefore it is made possible to carry out optional searches in the data base, i.e. the user may connect the individual registers as he wishes, set up concrete search criteria, point out specific data, etc. In this way the user of DWD can always find data which are of interest at a given time.

Exchange of data

Data which in this way have been chosen in the data base are shown in a table on the screen. The table may immediately be inspected, and data may also be exported to other software where a special processing of data may take place, e.g. statistical analysis.

Protection of data

The operation of the data base has been organized in a way so that some users are allowed to enter, edit and delete parts of the data material, whereas other users may only inspect data and print out reports, etc.

3. How to start the program

The DWD program may be started by means of PARADOX 4.5 UK version by executing the script of DWD.SC.

It is advisable to install a menu choice in the upstart menu of each individual user which sees to it that the user is guided correctly into DWD.

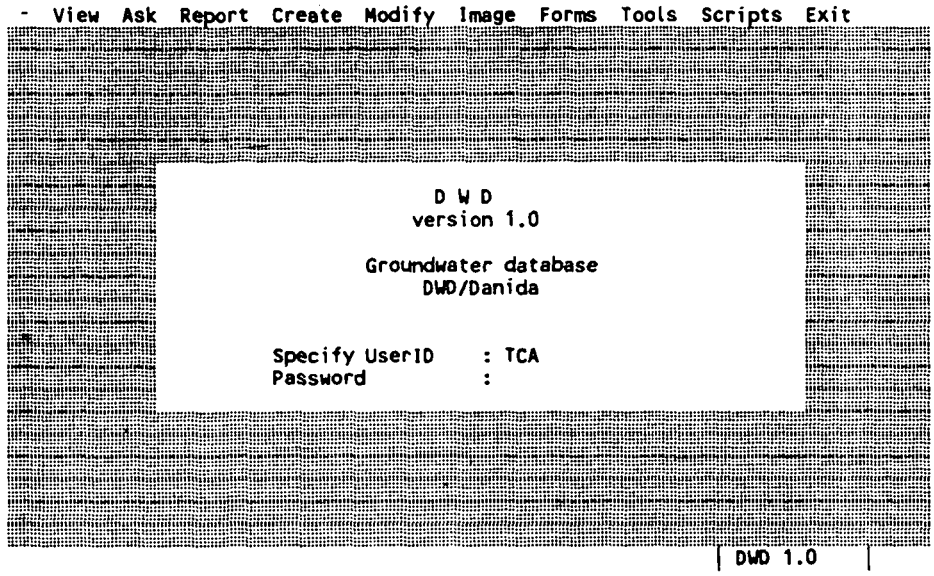


Figure 3 *Display shown when DWD is activated. Initials and password must be entered before the data base can be operated.*

When the program has been called, DWD's start up display (figure 4) is shown, where user-id and password must be entered in order to get access to the data base. When this user information has been entered, some rights are assigned to the user in a way so that some users are allowed to carry out all functions in the data base, whereas others are prevented from making changes in the basic data material and are therefore only allowed to inspect, search and extract data. Assignment of rights is described in section 11.

On the display (figure 4) the user-id, e.g. **TCA**, is entered and subsequently the personal password. If correctly corresponding initials and

password are entered, DWD's main menu is shown. If incorrect initials or password are inserted, 2 more attempts are granted, before the program is interrupted. Please note that the program distinguishes between capital and small letters in the login procedure.

If a non-registered user wishes to use DWD, it is necessary to ask a registered user to be added to the system as a new user. (See section 8, *add user* and *assign rights*).

4. Viewing and editing data

In DWD, data are edited/viewed in specific data entry schemes for defined for each of the data-base files.
In the DATA menu, data are divided into two different groups, divided by a separator line. The main database, which holds the majority of the data input is found above the separator line, whereas all tables, which are used as **lookup tables** are located below this line. The contents of these files are normally not subject to changes, however they may be modified by users with such rights.

In the sections 4.1 to 4.6, you will find a general description of how data are added/edited or removed. After this, a description of each of the database files is given.

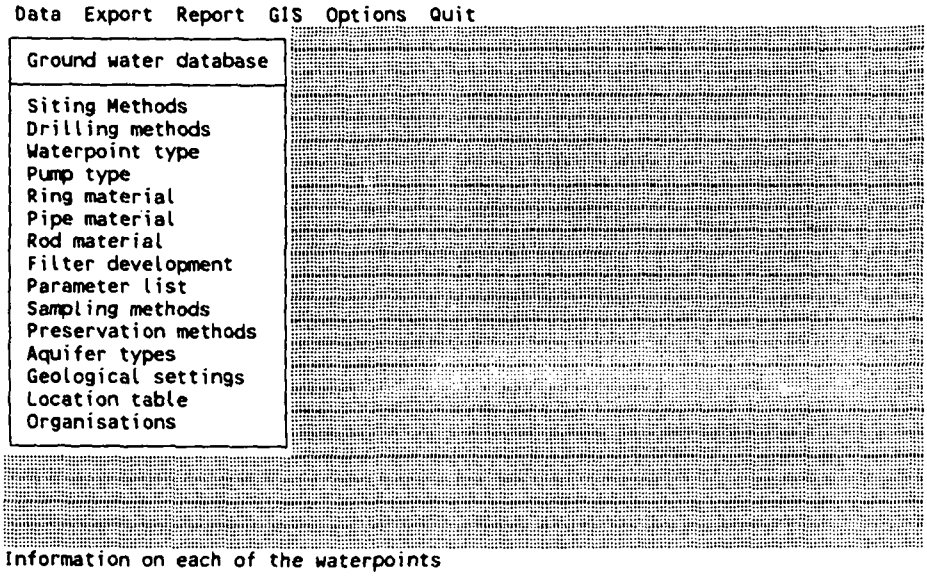


Figure 4 The DATA curtain.

If you choose **Data** on the main menu, a curtain is shown, where you can choose the type of data, which should be modified/viewed etc.

If you want to edit or add data to the central groundwater database (GR_WATER), **Identification and location data** are chosen. Now, a screen image will appear on screen (fig. 6), showing the first part of the information on a water point. The screen is divided into two levels, which in this example gives the data from the

master record (blue fields with white letters and/or numbers) and the related detail records (pink fields with white letters and/or numbers). On top of some of the screen images, two red fields may appear. These are **DisplayOnly** fields, which cannot be changed.

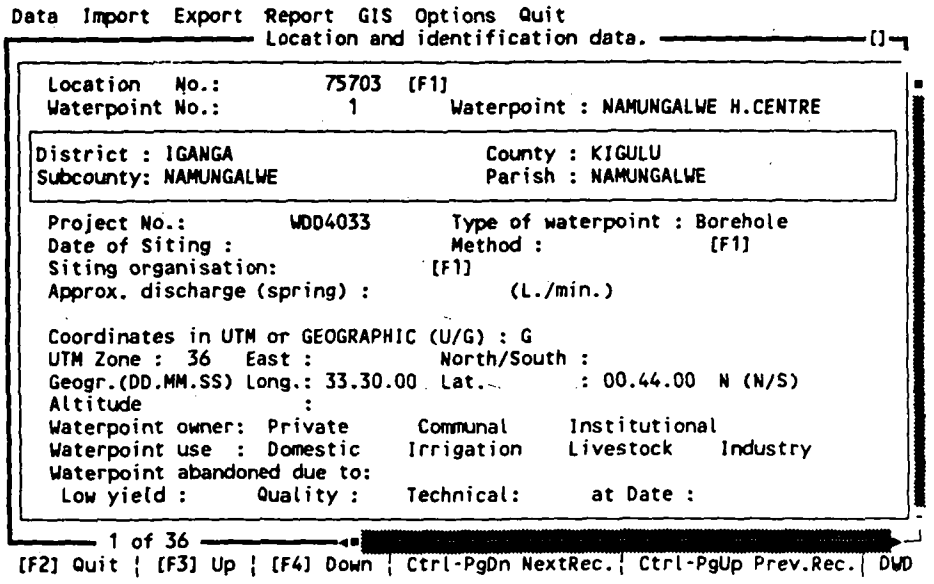


Figure 5 The first screen image of the database.

When the cursor is to be moved from one level to another, the **F3-** or the **F4** buttons are pressed. Depending of which level you are in, you can scroll the information on waterpoint level or at detail level simply by pressing **PgUp/PgDn**, **Crtl-PgUp/-Pgdn** or the **Arrow** keys.

When a data item is to be entered or changed, the arrow keys are used to bring the cursor to the field in question. Now, data may be entered. If something is already written in the field, this may be emptied by pressing the **<Backspace>**- or the **<Ctrl-Backspace>** button. Now the new value can be entered. If only part of the field is subject to change, the value/string may be edited by pressing **<Alt>+<F5>**. This will avoid that the entire value/string is to be re-entered.

When the actual screen image is modified, you can go to the next page by pressing an **<arrow>** key or the **<PgDn>** key. You can also continue to the next record by pressing **<Ctrl>+<PgDn>**. It is important to notice that **any change** being made

is in effect as soon as you continue to another record. If you want to regret your modifications this is only possible in the record where the cursor is. Regret is activated simply by pressing **<Ctrl+U>**.

4.1 Editing of data

When a result should be changed or entered manually, the arrow-keys are used to move the cursor to the required field. Thereupon the result may be entered. If an incorrect result has been inserted in the field, which needs to be corrected, it is necessary first to delete it by means of the **<Backspace>** key which deletes backwards, or the **<Ctrl>+<Backspace>**; and then the new value may be entered. If it is a keying error, entered values/texts may be edited by pressing **<alt>+<F5>**; in this way it is not necessary to alter the entire contents of the field in question. When the display has been corrected, it is possible to go on to the next item which needs to be corrected or controlled, and at the same time the data base is brought up to date. When changes of the data file in question have been made, it is possible to leave the editor by using **F2**, which makes the program return to the main menu. It is important to understand that corrections which are made on these displays, are a fact as soon as the record with the corrected data is left, i.e. if the keys **PgDn/Down arrow/Up arrow** are used to go on to the next record. Thus , it is only possible to regret the corrections for the record which the cursor "points" at. Regrets are made by pressing **Ctrl+U**.

4.2 How to enter dates

All dates in DWD must observe the following syntax : **dd.mm.yyyy**; i.e. a new date must be entered by stating the day number followed by a full stop, then number of month followed by a full stop, and finally the year.

As an example the following dates are correct:

1.01.94
1.1.1994
31.10.83,

whereas the dates shown below are unacceptable:

1st Jan.94
1/1/1994
31-10-84
29.2.1994
31.11.80

4.3 How to enter notes and comments

In some displays, e.g. in case of "other information" it is possible to enter a comment in a memo box. The box is fetched by pressing **<alt>+F5**, after which it is possible to enter comments. It is possible to write a text corresponding to approximately 64 kB.

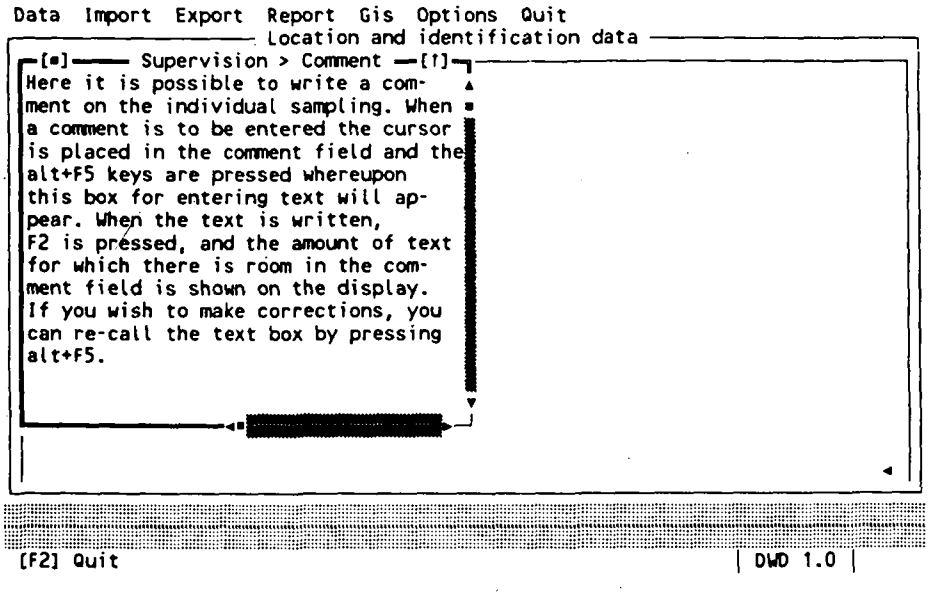


Figure 6. Memo box to enter comments.

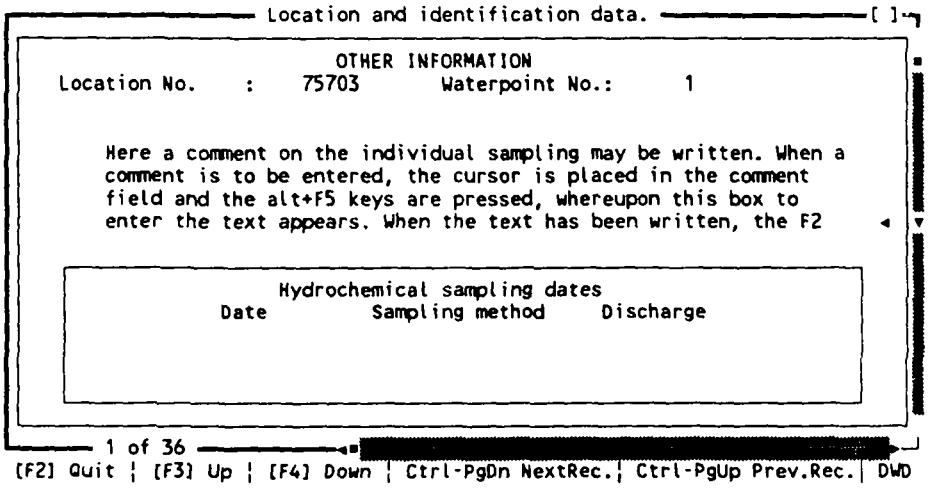


Figure 7. When the text has been entered, as much text as possible will be shown on the screen.

When the comment has been written, **F2** is pressed. The box will disappear, and the first lines of the entered comment can immediately be seen on the screen (figure 8). If the comment is to be edited or inspected, the box may be fetched again by pressing **<alt>+F5**.

4.4 Search process

In the data file being handled it is possible to page through the records by means of the **Ctrl-PgDn** or **Ctrl-PgUp** keys. Furthermore, a specific record can be found if a search function is being used.
If you wish to search for a water point in a given parish, you press **Alt-F** when you are standing in the **National ID** field. This brings up a box, where you can specify **District, County, Subcounty and Parish.** A search is started and if one or more waterpoints exist within this parish, the first one will be shown. Now, **Ctrl-PgDn** (and **Ctrl-PgUp**) can be used to locate the waterpoint in question.

If you wish to search for data for a given date, you must place the cursor in the date field and press **Ctrl+Z**, and enter the required date in the small box which has appeared in the centre of the screen. The entering is ended with **Enter**. If this date has data, they will be shown on the

screen after a short search. If not, you will be told that the search was without result.

4.5 Creation of a new record

To create a new record press the **INS** key; a clear diagram will appear on the screen. The diagram may now be filled in with the relevant information and **F2** should be pressed. The entered information is now saved in the data base.

4.6 Delete a record

If a record is to be deleted in the file, you must search for the information attached to the given record. When the information appears on the screen, you press the **DEL** key. A box will then appear on the screen in which you are asked to confirm that the current record is to be deleted from the file of records. If the **Ok** key is activated, the record with the information on the client will be deleted; if, however, the **Quit** key (which is preselected) is pressed, the process will be interrupted and nothing has been deleted.

Please note, **that only records, which have no related records** (the ones in the pink fields on the screens) **can be deleted.** As long as there exist related records, deletion of the master record will be rejected. In such cases, each of the related records must be deleted prior to deleting the master record.

Only users with right on level 1 or higher may delete data.

4.7 Location and identification data

This part of the database forms the central part of the data storage facilities. Here, almost all data are stored in the master file (GR_WATER) and in related detail tables such as **xx,xx and xx.** This part of the database presents its fields in 5 successive screen images, holding information on:

- Identification and location
- Construction
- Installation
- Geology and hydrology
- Other information and water chemistry

The screen images will be explained in the following. You move between the images by pressing **<PgDn>/<PgUp>** or by using the **<Arrow>** keys at the last or first field in each screen.

First **Identification and Location data:**

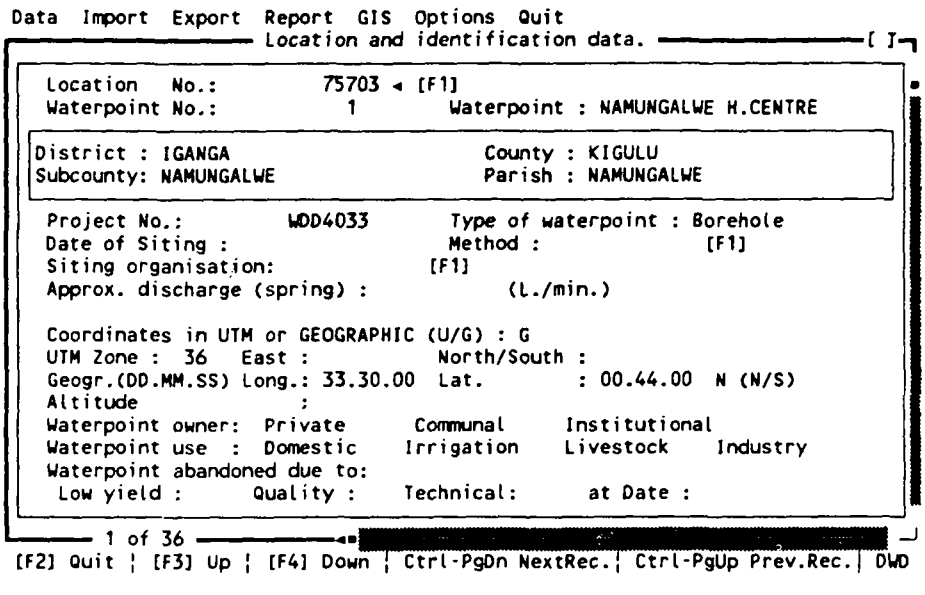


Figure 8. First screen image of the main table in the database.

Explanation to the fields:

The **Location No.** (DATATYPE=N*) identifies the location of the waterpoint as regards **District, County, Subcounty** and **Parish.** These combinations are stored in the **Location table** (explained later). This field has a so-called **LookUp**-facility. When the cursor is placed in this field, you can go to the location table simply by pressing **F1.** Once you enter the location table, you find the location in question the following way:

1) Move the cursor to the **Dname** field.
2) Press **<Ctrl>+z**

This brings up a box in which you may enter a search criteria. Let's take that you seek a location in **KAMULI** district. Then you:

3) Enter **KAMULI..** and press **<Enter>**
(it is necessary to enter the "..")

Now, the cursor is placed at the first occurrence of **KAMULI** (if found).

4) Now move the cursor to the **County** field. Find the correct county and move on to subcounty and repeat moving the cursor until also the correct **Parish** is found.

Having found the right location, you press **F2** which:

5) brings you back to the main table and

6) supplies the names of the location in the pink fields below the number.

Now, the **Waterpoint number** is supplied, too. This is done automatically and should not be changed! If a record is deleted at a later stage, the serial number **is not reused** thus leaving an empty number in the row.

The **Waterpoint field** (DATATYPE=S*) allows input of a name or an identification of the waterpoint. No tests are performed on the user input.

The **Project No.** (DATATYPE=A25) can contain a local identification code being used. Input is automatically converted to capitals to ensure some degree of uniform input.

Type of waterpoint (DATATYPE=A16) is a **LookUp field.** Input is controlled against the table **POINTYPE.** Press **F1** to choose the correct type.

Date of Siting (DATATYPE=DATE) is self-explanatory

Method (DATATYPE=A11) is the siting method. The possible choices are shown by pressing **F1.**

Approx. discharge (spring) may hold the amount of discharge in L/min.

The **coordinates** of the water may be stored in two ways. Either as Geographical or as UTM. If given in UTM, the zone must be specified.

The **geographic** coordinates are given as **DD.MM.SS** (DATATYPE=A8). Remember to specify, if it is North or South of Equator. **Only coordinates given in LONGITUDE and LATITUDE are transferred to the AtlasGIS files.** No conversions between the UTM and geographic coordinates are done in this version of the database

The **Altitude** (DATATYPE=N) field may hold the altitude in meters above sea level.

In the **Waterpoint owner** (DATATYPE=A1) fields you may specify the type of the owner simply by entering a **X** in either of the fields.

In the **Waterpoint use** (DATATYPE=A1), an **X** may be entered in one or more of the fields.

If the **waterpoint** is **abandoned** (DATATYPE=DATE) for some reason, this may be registered by entering an **X** in one or more of the fields. The **date of abandoning** may be entered in the last field of the screen.

Now onwards to the next image **Construction data:**

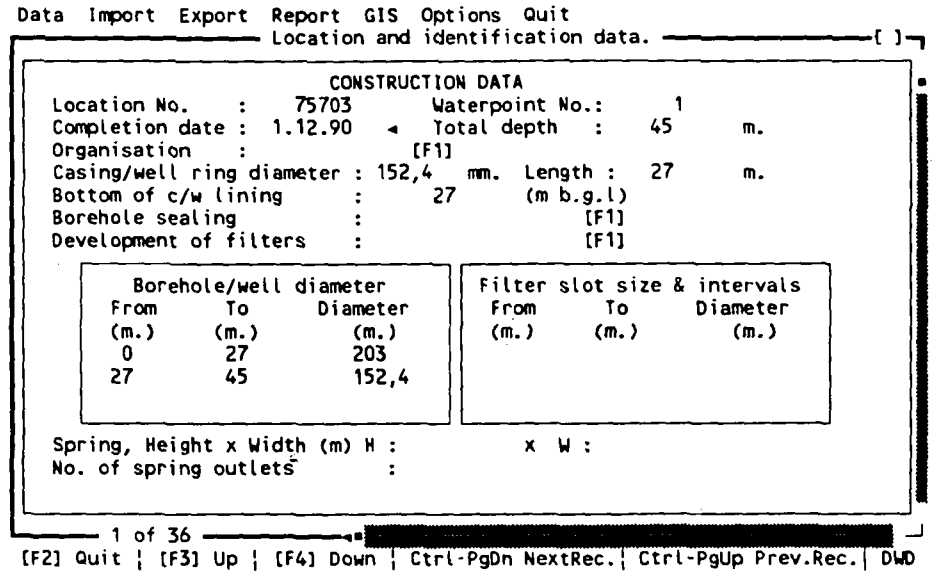


Figure 9. Second screen image of the main table in the database.

Completion date (DATATYPE=DATE) is self-explanatory

Total depth (DATATYPE=N) is the depth in metres.

Organisation (DATATYPE=A10) is the name of the organisation responsible for the construction. By pressing **F1** the possible organisations are listed. Choose one by moving the cursor and press **F2**.

Casing/well ring diameter (DATATYPE=N) is given in mm.

Length (DATATYPE=N) is the length of the casing-/well ring in metres.

Bottom of c/w lining (DATATYPE=N) is given in metres.

Borehole sealing (DATATYPE=A16) holds information on the sealing material used. Press **F1** for **LookUp help.**

Development of filters (DATATYPE=A16) holds information on the borehole filter material used. Press **F1** for **LookUp help.**

The two boxes with pink fields differ from the rest of the fields on this screen. They are related tables to the master table. You get into the first one by pressing **F4.**

Now you may enter one or more records with information on **Borehole/well diameters.**

From and **To** (DATATYPES=N) is start and end of the interval as m.b.g.l., whereas **Diameter** is given in mm.
If you want to input more records, you simply move the cursor to the next free record.
The records are sorted by the **From** field in ascending order.
You **leave** the box by pressing **F4** (go to "Filter slot size & intervals") or **F3** if you wish to return to the master table.

If you choose to enter information on **Filter slot size & intervals**, this is done in exactly the same way as explained above.

You **leave** the box by pressing **F3** (go to "Borehole/well diameters") or **F4** if you wish to return to the master table.

Spring Height and **Spring Width** (DATATYPES=N) are given in meters.

No. of spring outlets (DATATYPE=S) is self-explanatory.
Third part of the database: **Installation data.**

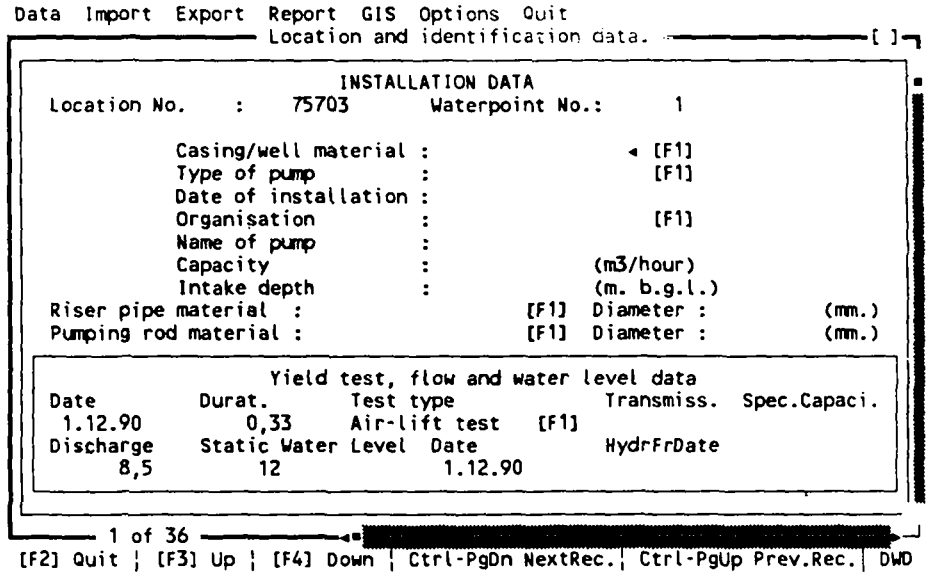


Figure 10. Third screen image of the main table in the database.

Casing/well ring material (DATATYPE=A16) has **LookUp help**. Press **F1** for help.

Type of pump (DATATYPE=A16) has **LookUp help.** Press **F1** for help.

Date of installation (DATATYPE=D) is self-explanatory.

Organisation (DATATYPE=A10) holds the name of the organisation responsible for the installation. Press **F1** for help.

Name of pump (DATATYPE=A20) is a free format field. Input is converted to capitals to assure some degree of uniform input.

Capacity (DATATYPE=N) is the pump capacity in m3/hour.

Intake depth (DATATYPE=N) is given in meters b.g.l.

Riser pipe material (DATATYPE=A16) holds information on the material used. Press **F1** for help.

Pumping rod material (DATATYPE=A16) holds information on the material used. Press **F1** for help.

The **Diameters** (DATATYPES=N) are given in mm.

The last part of this page holds information on yield tests. The functionality is as described for **Borehole/well diameters** etc. Press **F4** to enter this part.

You may enter one ore more records in this section, but only the first one will be visible. You can scroll the information by using **<PgDn>** ,**<PgUp>** or the arrow keys.

Date (DATATYPE=DATE) is the date of the yield test.

Durat. (DATATYPE=N) is given in hours (with decimals, if necessary).

Test type (DATATYPE=A11) has **LookUp help**. Press **F1** for help.

Transmiss. (DATATYPE=N) holds information on transmissivity.

Spec.Capaci. (DATATYPE=N) holds information on the specific capacity.

Discharge (DATATYPE=N) is the discharge during test.

Static Water Level (DATATYPE=N) is self-explanatory.

Date (DATATYPE=DATE) is the date of the static water level.

HydrFrDate (DATATYPE=DATE) is the date of hydrofracturing.

Return to the master table by pressing **F3** or **F4**.

The records are sorted

The fourth screen image: **Geological and hydrogeological data.**

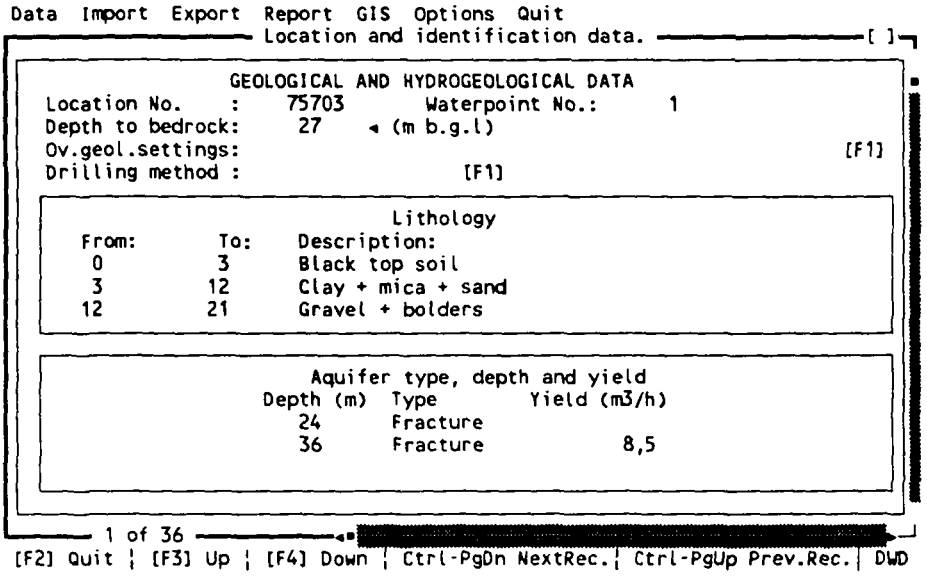


Figure 11. Fourth screen image of the main table in the database.

Depth to bedrock (DATATYPE=N) is given in meters b.g.l.

Ov.geol.settings (DATATYPE=A50) is an overall description of the geology. Press **F1** for **LookUp help**. You will find a number of standard texts describing the geology.

Drilling method (DATATYPE=A16) is self-explanatory. Press **F1** for **LookUp help**.

The description of **Lithology** follows the same outline as described above for **Borehole/well diameters** etc. Press **F4** to move to the pink fields.

From and **To** fields (DATATYPE=N) given in meters describe the interval for which the description is valid.

Description (DATATYPE=A50) is a free format description of the lithology.

You can put in as many records to each borehole as necessary.

The records are sorted in ascending order according to the value of **From**.

Press **F3** to return to the master table or **F4** to go to **Aquifer type, depth and yield.**

The information on **Aquifer type, depth and yield** acts the same way as described for **Lithology.**

Depth (DATATYPE=N) is the aquifer depth.

Type (DATATYPE=A10) holds the aquifer type. Press **F1** for **LookUp help.**

Yield (DATATYPE=N) holds the actual yield in m3/hour.

You can put in as many records to each borehole as necessary.

The records are sorted in ascending order according to the value of **Depth.** You can only have one record for each depth.

Press **F4** to return to the master table or **F3** to go to **Aquifer type, depth and yield.**

The fifth screen image: **Other information.**

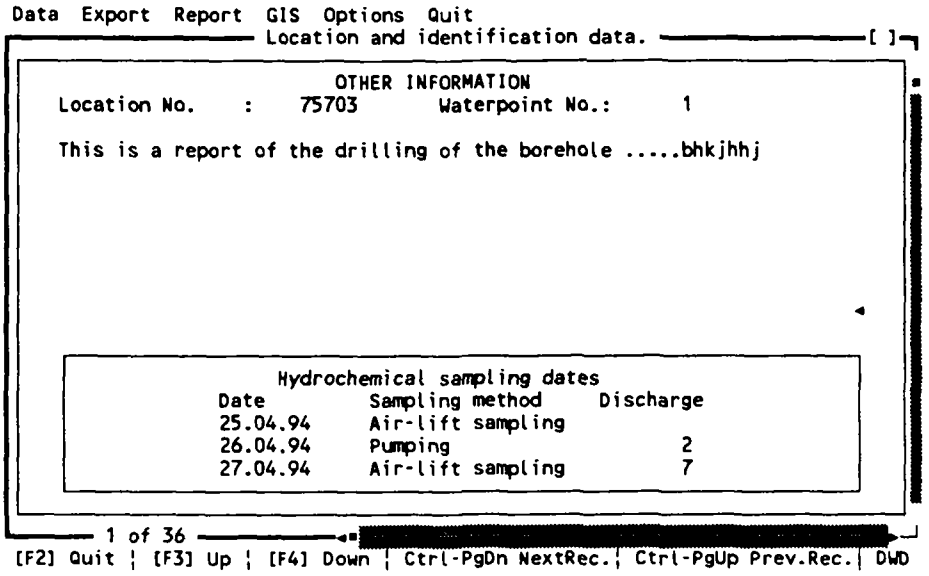


Figure 12. Fifth screen image of the main table in the database.

The fifth screen gives information on **Other information**. Here, you may input any comment relating to the waterpoint. Press **<Alt>+F5** to enter **Edit mode**. Now you can type in your text. When finished, press **F2** to return to the master table. As described above, the text (or part of it) will be shown on screen.

The last part holds the link to the **Hydrochemical** samples.

If you want to enter information on **Hydrochemical analyses** you should do it this way:

Goto the box named **Hydrochemical sampling dates** by pressing **F4**. Enter the **date of sampling**. When this is done, press **<Alt-h>** to open the screen with hydrochemical information. Now, the following screen image appears:

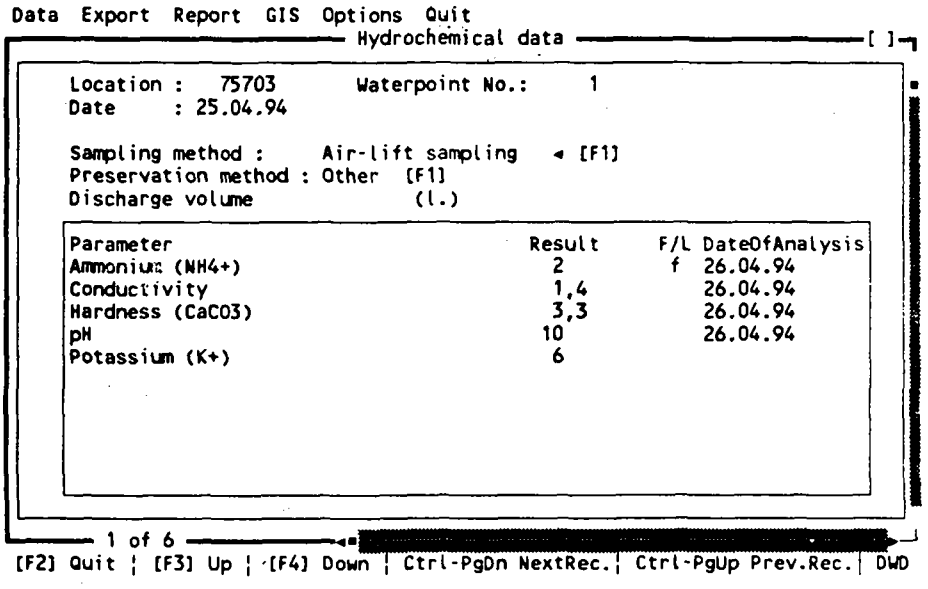


Figure 13. Fifth screen image of the main table in the database.

The sixth screen gives information on **Hydrochemical analyses.**

Like the other screen images, this is also divided into two parts. The upper part (The blue fields contain information on the sampling whereas the pink fields contain information on the chemical analyses performed.

For each parameter (press **F1** to show the list of parameters) you may enter:

Parameter name (according to the list of parameters)

Attribute (one character)

Result (DATATYPE=N)

Field or laboratory analysis (DATATYPE=A1)

Date of analysis (DATATYPE=D)

Be aware, that you can only have one analysis of the same parameter from one waterpoint on a specific sampling date, since data are uniquely identified by **Waterpoint No., Date and Parameter.** If you try to enter the same parameter twice, you will get an error message on the screen, saying that the key already exists. In

this case you must delete the last one to skip the error status.

You can scroll between the chemical analysis in the database by pressing **<PgUp>** or **<PgDn>**, if the cursor in the upper part of the screen image. You may even scroll to analyses from other waterpoints. When you press **<F2>** for **Quit**, you are automatically taken to the record, from which you called the **Hydrochemical samples**.

This marks the end of the description of the master table **GR_WATER**.

LookUp tables

The following paragraphs from 4.8 to 4.21 cover the tables being used as **LookUp tables**. Various fields in the master table are controlled by the contents of these tables to assure uniform input. This is very important since the possibilities of making queries will depend of the "quality" of the field information.

The LookUp tables may be modified in the same way as the master table. However, it requires that you have rights to enter/modify data!

The **LookUp values must be present** in the tables **prior to using them**. The correct way will be to update the LookUp tables before they are to be used from the master table.

Almost all of the tables have **MultiRecord** structure which means that several records from the database appear simultaneously on screen. You may scroll the information using the arrow keys or the <PgUp> and <PgDn> keys.

4.8 Siting methods.

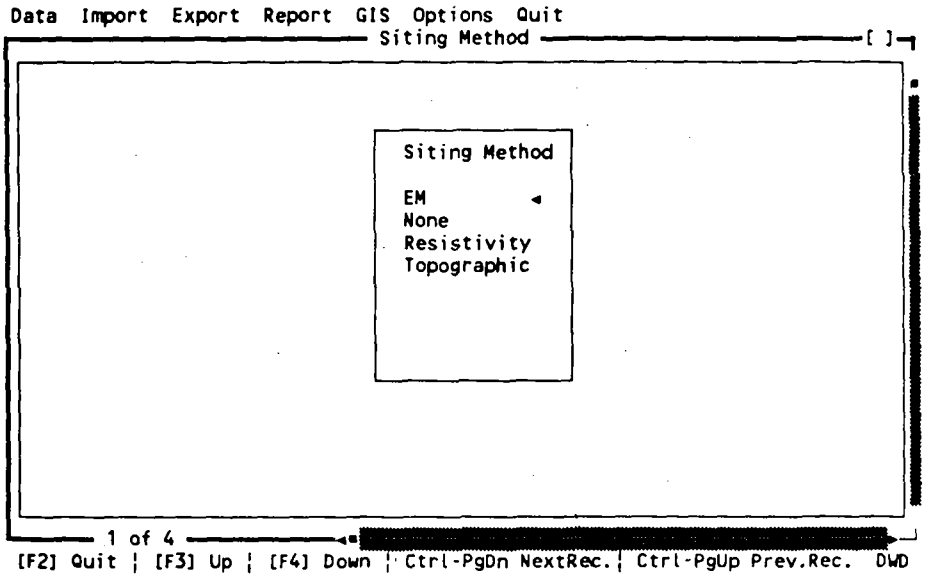


Figure 14. Screen image of the siting methods.

4.9 Drilling methods.

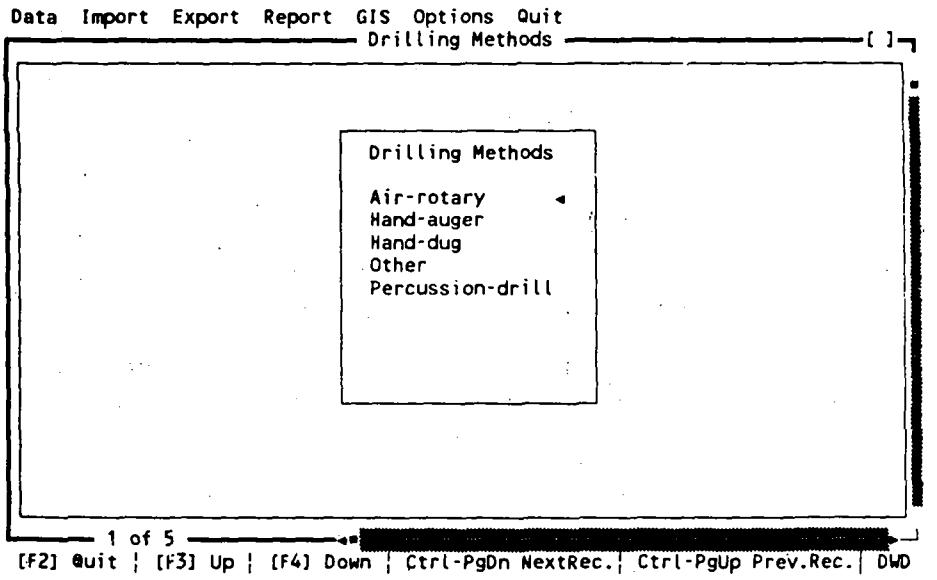


Figure 15. Screen image of the drilling methods.

4.10 Waterpoint types.

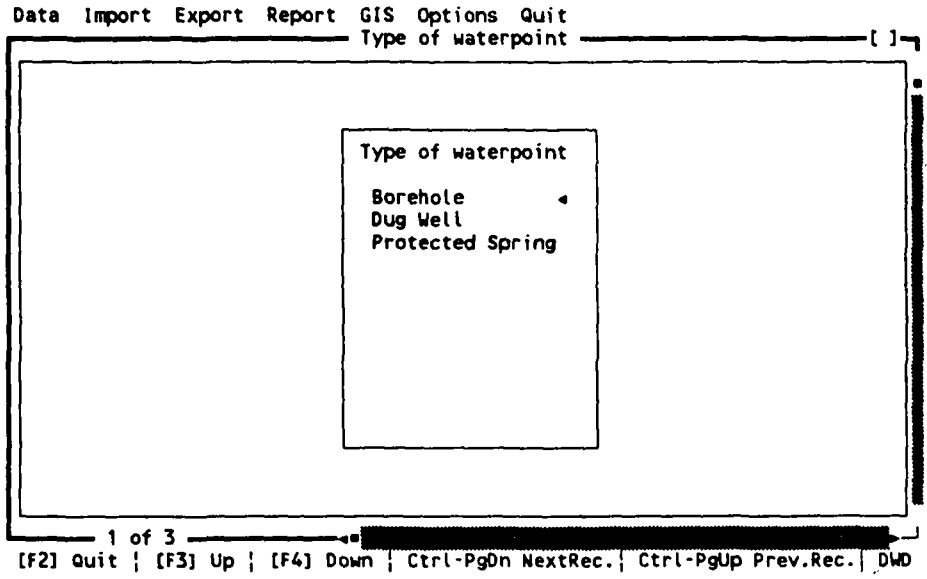


Figure 16. Screen image of the waterpoint types.

4.11 Pump types.

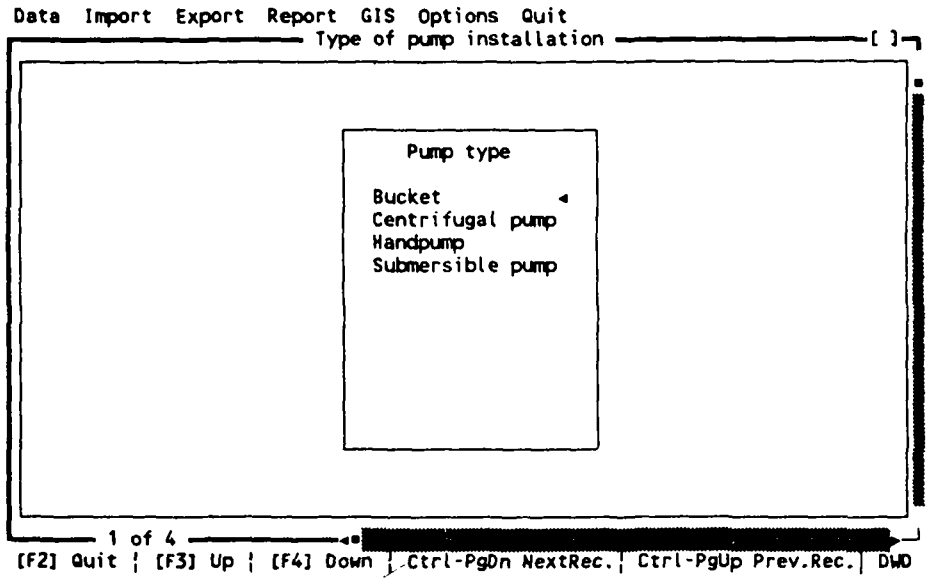


Figure 17. Screen image of the pump types.

4.12 Ring material.

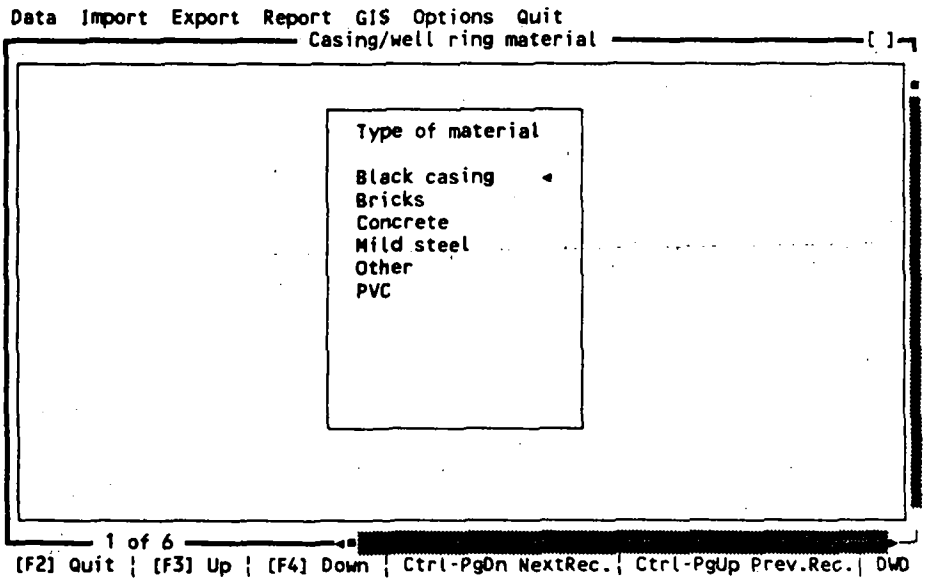


Figure 18. Screen image of the ring materials.

4.13 Pipe material.

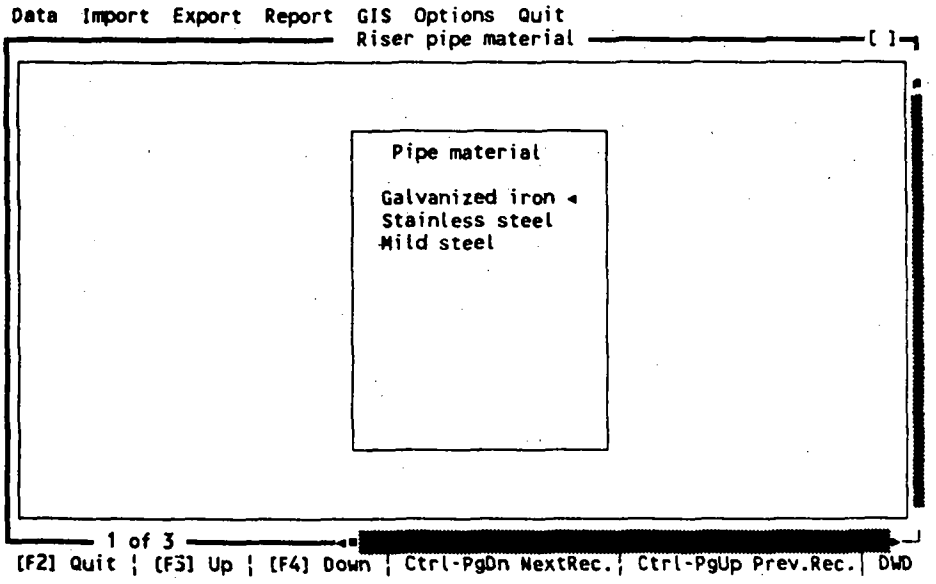


Figure 19. Screen image of the pipe materials.

4.14 Rod material.

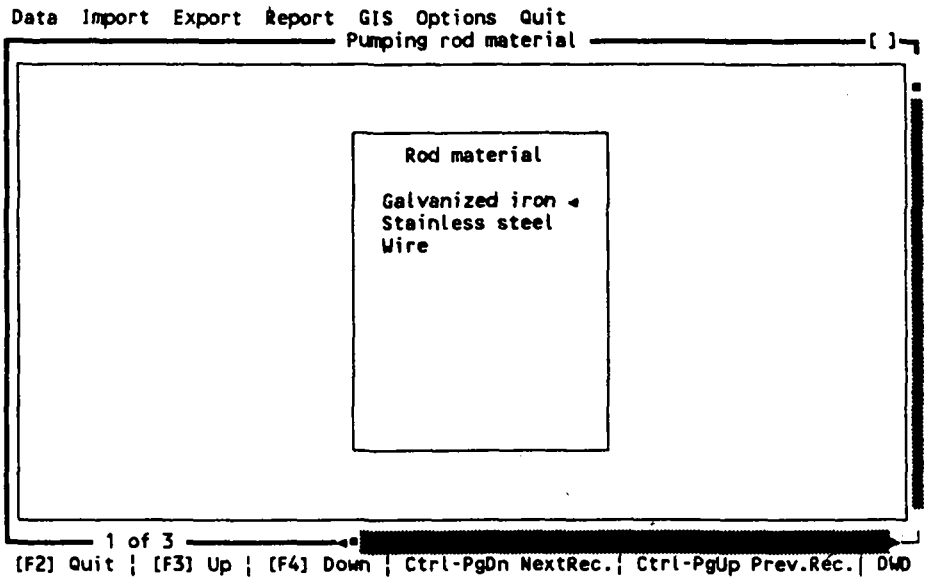


Figure 20. Screen image of the pumping rod materials.

4.15 Filter development.

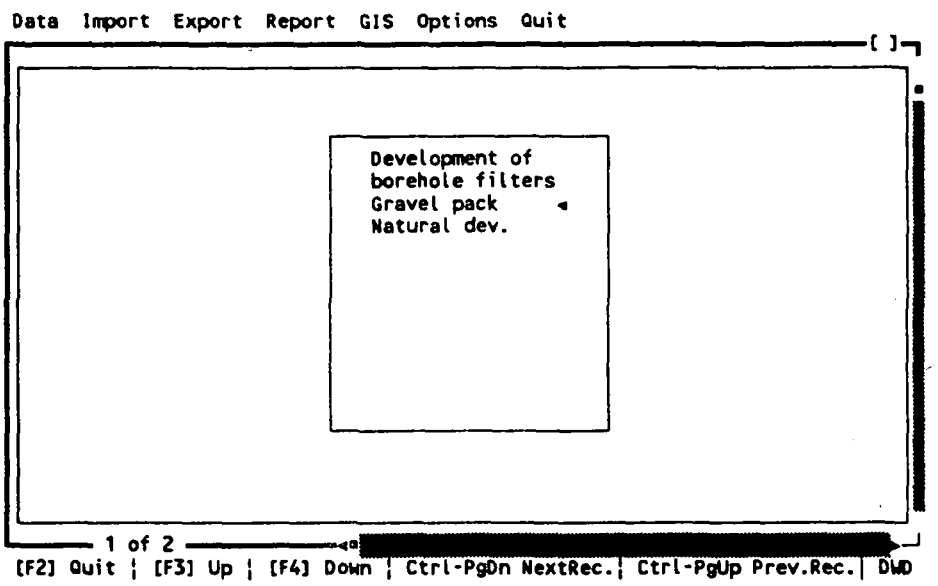


Figure 21. Screen image of the filter developments.

4.16 Parameter list.

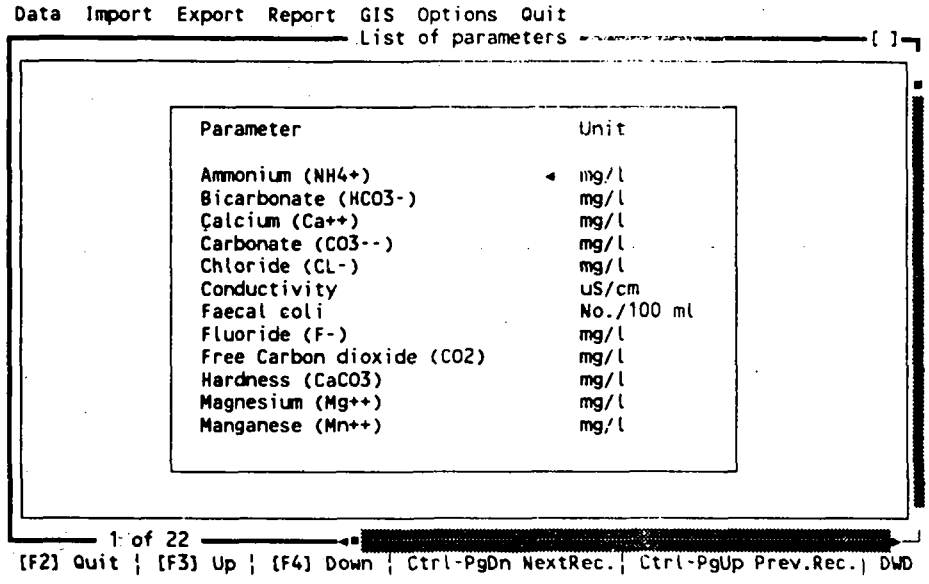


Figure 22. Screen image of the hydrochemical parameter list.

4.17 Sampling methods.

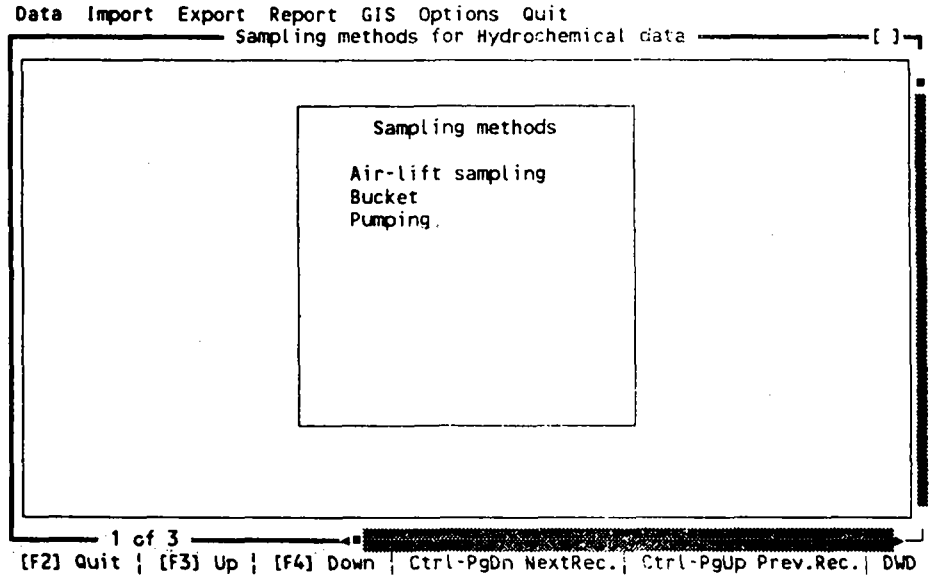


Figure 23. Screen image of the sampling methods.

4.18 Preservation methods.

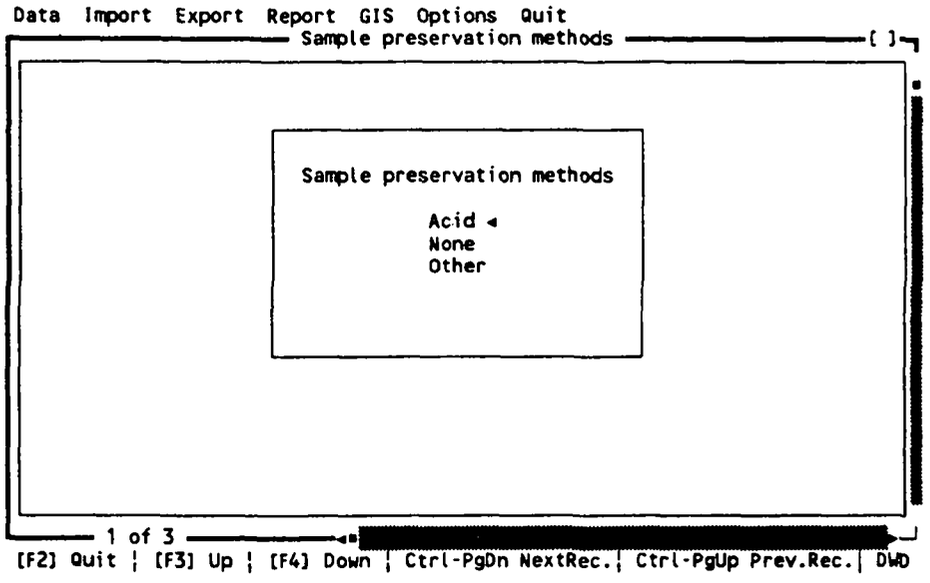


Figure 24. Screen image of the sample preservation methods.

4.19 Aquifer types.

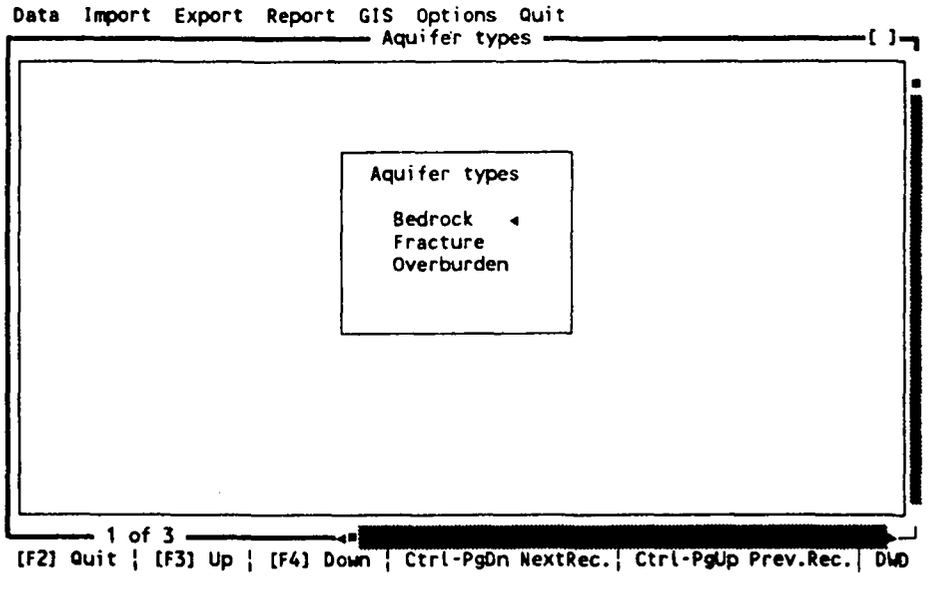


Figure 25. Screen image of the aquifer types.

4.20 Location table.

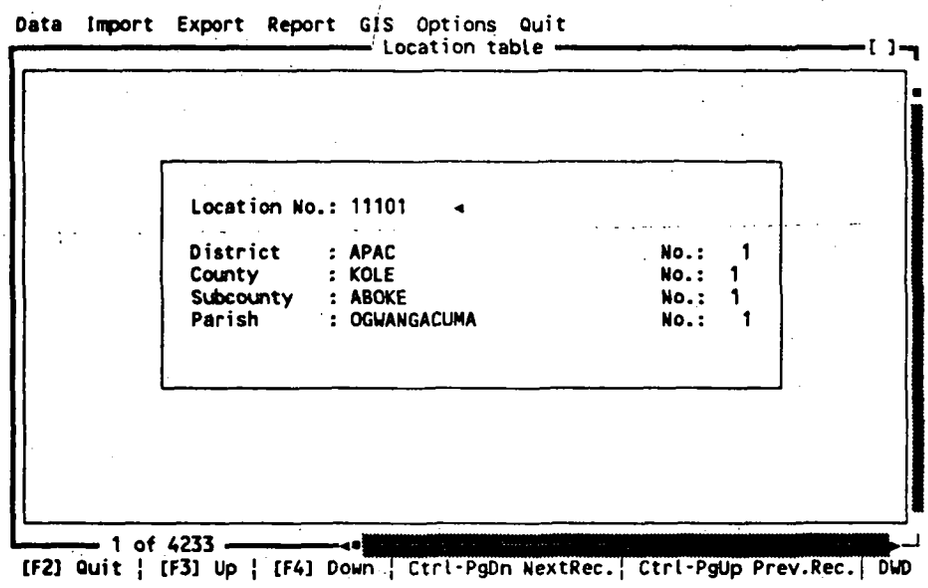


Figure 26. Screen image of the location table.

4.21 Organisations.

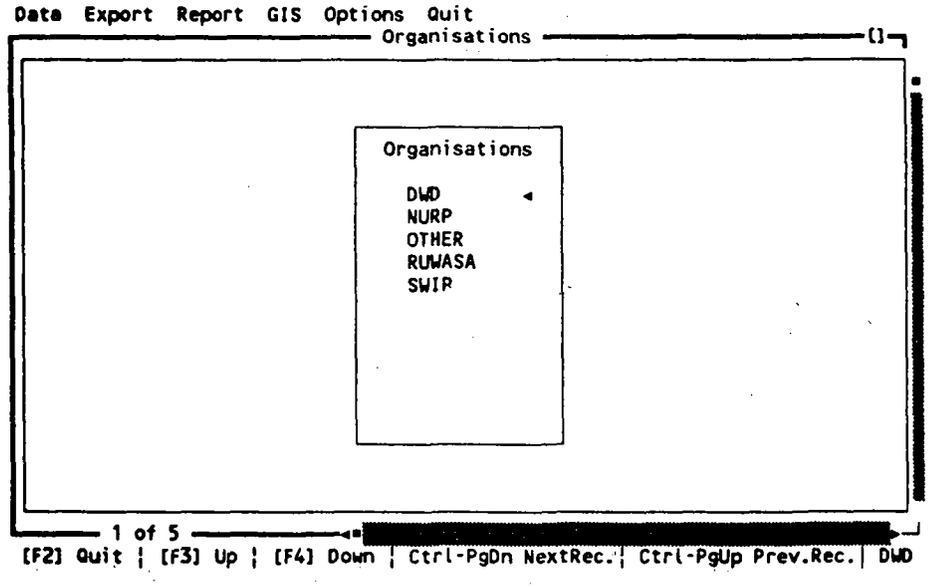


Figure 27. Screen image of the organisations table.

5. Exporting data

In order to obtain maximum information from the data base a function has been built in which enables you to carry out an optional search in the data base and export the selected data to another type of software. That the search is optional means that the user may choose the files in which to search, the variables to be found, how the relations between the different files should be, the conditions which the selected data must fulfil and the format in which they are to be exported.

The figure shows the display appearing when **Export** is selected in the main menu. The figure shows a dialogue box with the records, in which searches may be made immediately. Opposite each of the 12 file names is a box [ ], in which you must write an X, if you wish to include the file in the following search. The X is entered by placing the cursor in the required box and by pressing any key or by clicking on the box by means of the mouse. An X is removed by pressing/clicking once more.

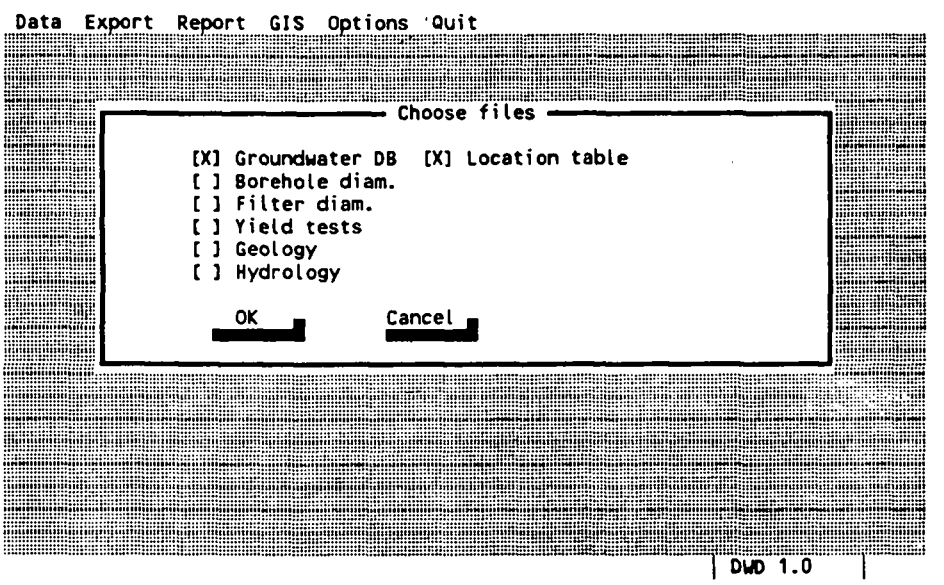


Figure 28. List of records constituting the searches.

You mark the individual records by moving the cursor to the box opposite the individual record and pressing the space bar. In the same manner a mark is removed by moving the cursor to the box with the X and pressing the space bar.

In the example shown above the Groundwater table and the Location table have been marked. If the **OK** key is used to quit, a new display will show a list of existing annual data bases. Here the annual databases which are to be included in the search can be selected. The selection is ended by pressing the **OK** key.

The Groundwater table and the Location table have now been selected and the extent of the search may be specified as to the fields to be included, and as to how the two registers should be tied together, etc.

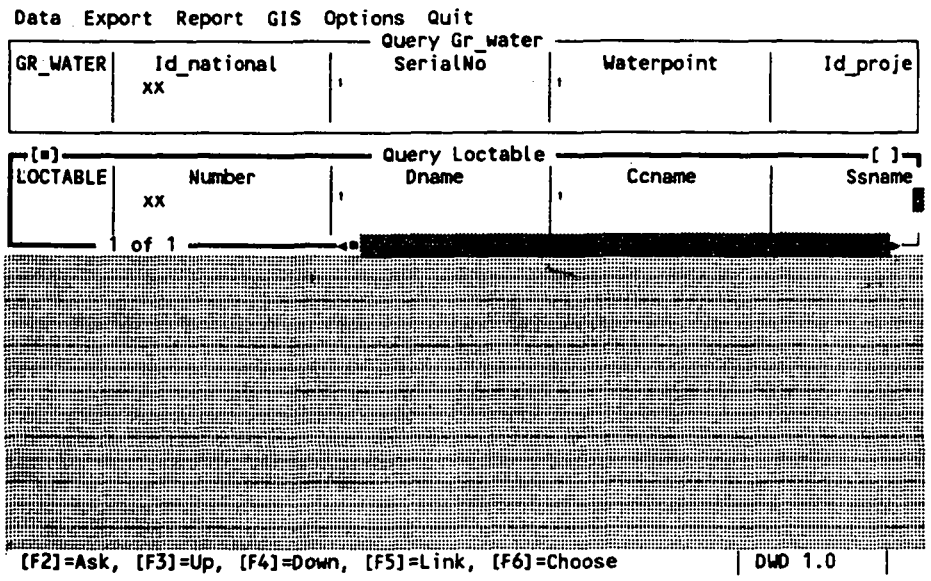


Figure 29. Search boxes in which relations and conditions as regards the search are created.

For each of the selected files a window will appear, where the fields of the files are represented, partly by their field names and partly by a box. In each of these boxes it may be stated whether this particular field is to be included in the selection procedure, whether it is to be used to create a relation to another file, or whether a condition regarding the contents of this field should be made.

In order to be able to operate on the screen it is necessary to know how to move about between the different files, how to create relations, etc.

Try to move between the two files by means of the 2 functional keys, **F3** and **F4**. Inside each file the **TAB** keys are used to move from field to field.

The functional key, **F6**, is used to mark that a particular field should be included in the selection. When **F6** has been pressed, a check mark ✓ appears; another touch on **F6** removes the check mark again.

When a relation is to be created between the two fields, the two fields which are to be related are selected, thereupon the cursor are moved to the field in the first file; press **F5** here and a label, e.g. **xx**, is entered, whereupon the cursor is moved to the corresponding field in the second file, here **F5** is pressed and the same label, **xx**, is entered. By this marking a relation has been created between the two files by means of the selected fields and the entered labels.

Finally, it is possible to lay down some criteria in the individual fields which must be met before data can be included in the selection procedure. This requires a nomination of the condition(s) in each individual field. When the conditions, the relations and the marking of the fields have been carried out, the query may be started by pressing **F2**. The table will now show the data which fulfilled all requirements made at the selection. More detailed information as to how relations between the files are made and how requirements are made, etc, can be obtained by reading PARADOX, chapters 5 and 6 which deal with the user's manual.

In figure 29 it can be seen how a selection with a connection between two files can be carried out. A relation is made between the 2 files: GR_water (the Groundwater database) and Loctable by means of the field: Id_nationalber of station. The relation is stated by the entered label **xx**.

By means of ✓ the fields:
GR_WATER->Id_national, GR_WATER->SerialNo,
GR_WATER->Waterpoint
and LOCTABLE->Dname, LOCTABLE->Ccname

have been selected for inclusion in the final data set.

When **F2** is pressed, the selected data will appear in a **reply** table as shown in figure 31. The selected data may now be inspected by means of the arrow keys or a mouse.

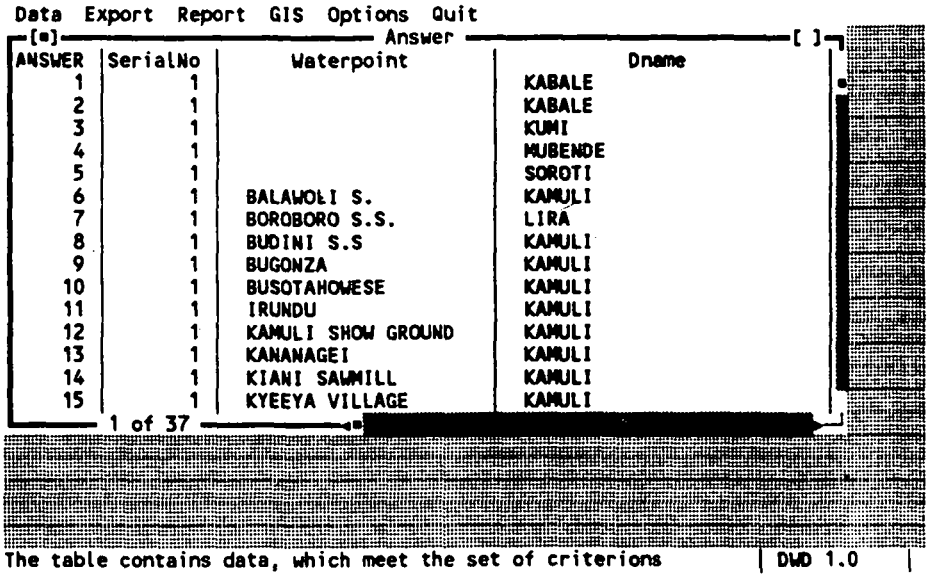


Figure 30. Result of the search

If, however, you wish to treat the selected data, they must be exported out of DWD. This can easily be done by using DWD's export function.

Export of selected data

In connection with the **Search** function an export function has been built in which can export the selected data to external programs. Data may be exported to several, different file formats. Thus, it is possible immediately to export data to Quattro Pro, in comma separated ascii files, in PARADOX tables, dBASE IV, Lotus 1-2-3 and VisiCalc.

When the inspection of the selected data has ended, a box will immediately appear on the screen, where it must be stated in which format the selected data are to be saved.

The system has been pre-selected to export to Quattro Pro, but by using the arrow keys or the mouse the required format can be indicated and the session is finished by pressing the OK-key.

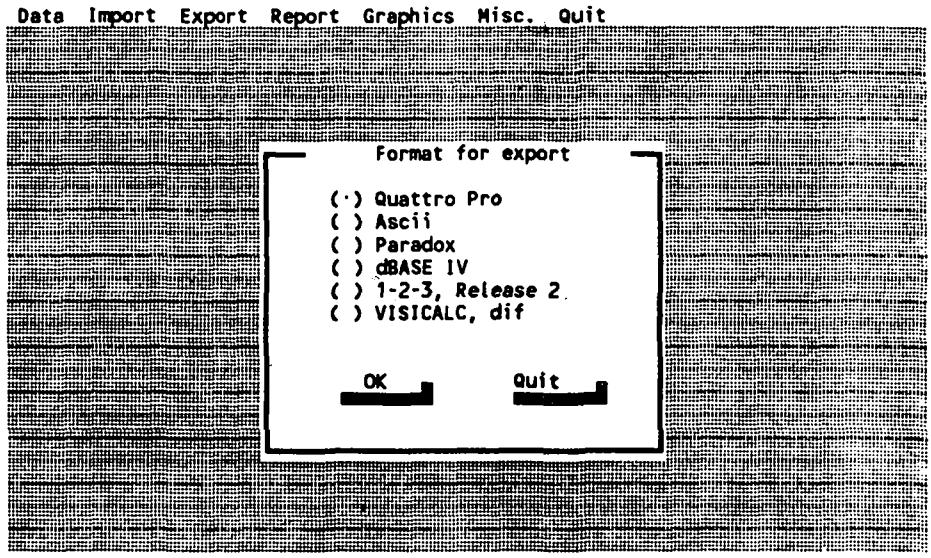


Figure 31. Dialogue box to state the format in which data are to be saved.

You will now be asked to give the data a file name, and the data will be exported in the required format. The data will be stored in the directory stated as privatdir under "Placing of files". Privatdir has been preselected to "C:\PDOX_DWD".

Depending on the format chosen for exporting the data, the file will get its surname. The table below shows the possible surnames.

Export file format	Surname
Quattro Pro	.wq1
LOTUS 1-2-3	.wk1
dBASE IV	.db
VisiCalc	.dif
Ascii	.txt

6. Reports

Some routines for reporting purposes have been developed so far. However, these will only form a subset of reporting requirements for the future.

When requirements evolve, new standard reports can be included in the system.

Generally, reports may be printed on **Screen, printer or to a file**. If **Screen** is selected, you have the possibility of copying the information to a printer after viewing it on screen. You leave a report shown on screen by pressing **F2**.

The **Report menu curtain** is shown below:

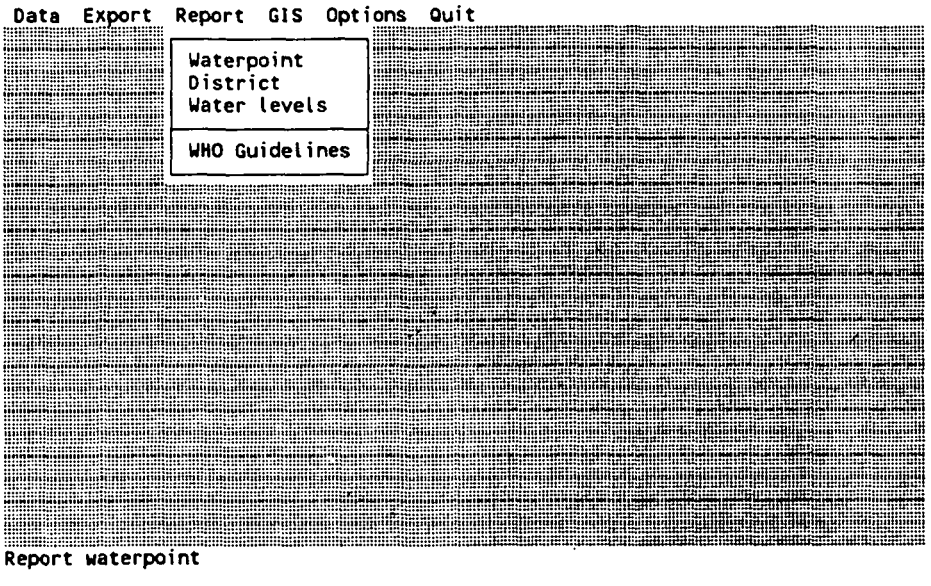


Figure 32. The Report curtain

So far, there are four choices:

Waterpoint: This choice prints out all information about one single waterpoint. The waterpoint is selected in a list, which appears on screen.

This choice prints out data from the following tables:

GR_WATER, BOREDIAM, FILTSLOT, YIELDTST, GEOLOGY and HYDROGEO.

District: This report prints out information on the waterpoints within a district.

Start by selecting the district from the list shown on screen.

Water levels: This report prints out information on water levels at each waterpoint within a district.

WHO Guidelines: This is actually not a real report, but a list of hydrochemical parameters which exceed WHO Guideline values. The values are shown on screen.

7. GIS

It is possible to extract selected data and transfer these to the **AtlasGIS** system, which is also installed on the computer. This is to be used for presentation purposes and for spatial analyses on data.

You transfer data simply by selecting each of the three parts shown below.

Only data with **Longitude** and **Latitude** are transferred!

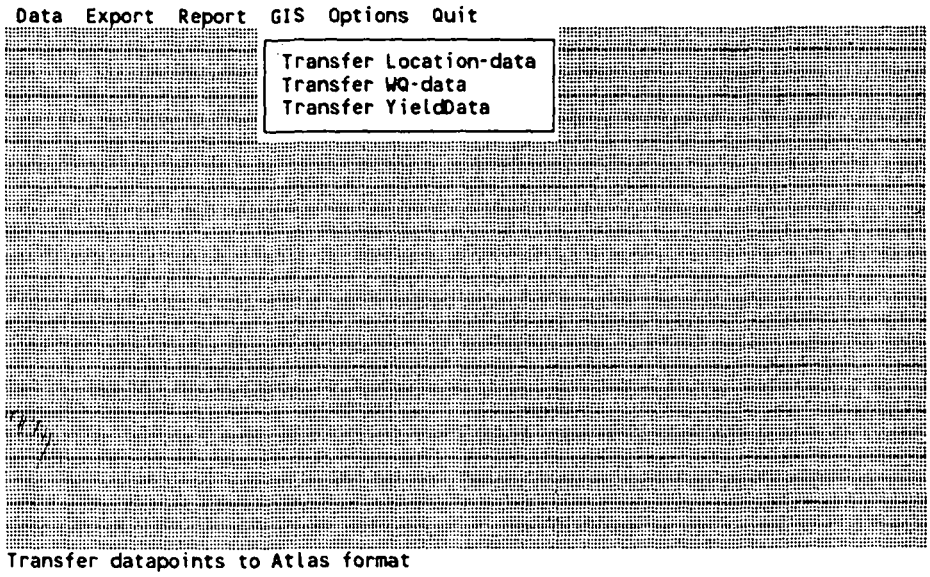


Figure 33. Transfer data to AtlasGIS.

Data are transferred to **DBASE** format, which is used by AtlasGIS. The files are automatically copied to the directory in which the GIS data reside.

It is beyond the scope of this user manual to explain the use of the GIS. A very good tutorial is delivered with the system and working your way through it will give a very good introduction to the world of GIS.

However, a few comments on the use of the GIS is given here.

If you want to **start the AtlasGIS**, you must first **leave the database** and return to DOS.

Now, change directory to C:\AGIS by typing:
cd \agis and press <Enter>.

Type **AGIS DWD** and press <Enter>.
AtlasGIS is now starting. It takes some time, because it is a very big program. Please, be patient!

After some time, a map of Uganda appears on screen.
If you want to show some of the information transferred from the database, you do the following:

1) Select **File** and press <Enter>
2) Select **Datapoint** and press <Enter>
3) Select **Use** and press <Enter>

Now, the system suggests to look in the directory **C:\AGIS\UGANDA** which happens to be the correct directory.

4) Press **<Space>** to get a list of possible files.

The information on the waterpoints are stored in **GRWDATA.**

The information on yield tests are stored in **YIELDATA.**

The information on hydrochemical data are stored in **WATERQUA.**

Choose one of them (only one can be active at a time!

AtlasGIS might ask you, if the index is to be rebuilt. Answer **Yes** to this.

Now, to show the points at the screen, do this:

5) Select **View** from the main menu
6) Select **Redraw**

Now, the screen is redrawn, showing the positions of waterpoints. You can zoom in on a smaller area by selecting **View/Map/In**
This brings a cursor to the screen. Click on the area, which you want to zoom into.

You can get the available information on any datapoint on screen. This is done in this way:

1) Select **Edit** from the main menu.
2) Select **Datapoint** from the Edit menu.
3) Select **PopUp** from the Datapoint menu.

Now, a cursor appears on screen.
Move it to a datapoint and click the mouse button.
A window will appear on screen showing the data for this point. When finished, press <Done> to select another one or to finish.

Remember, that even though you can alter the information on the waterpoints here, **it has no effect in the groundwater database!**. These are two different systems!

You end the **AtlasGIS** by returning to the **File** menu and choose **Quit. Do not save the current mapfile.**

8. Options

Miscellaneous contains a number of different functions. The functions cover e.g. a temporary suspension and also a change of the user-id.

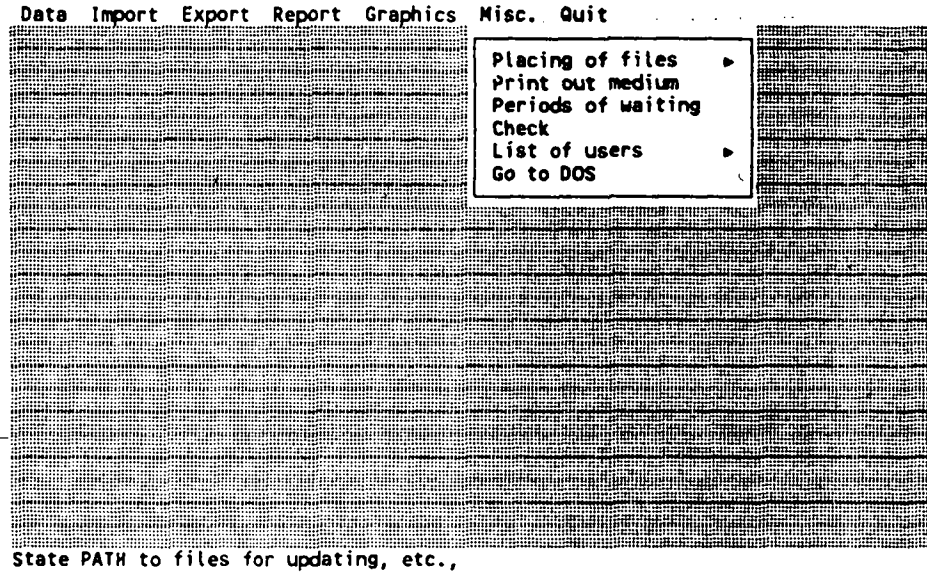


Figure 34. Pull-down menu for Miscellaneous.

8.1 Placing of files

In order to safeguard data which are imported into or exported from the data base, the data are placed in specific areas.

The DWD program has been preselected to use the user's private paradox area: C:\PDOX_HAV\. This area will be used to place data which are being exported out of the data base, and when importing DWD will search in this area for the data to be entered.

It is possible to divide the different types of input and output data according to subject. By means of a sub-menu it is possible to designate different areas/drives as places for new standard code lists for updating, Arop files, Water chemistry data for import plus a statement of one's own private paradox work area.

The entries are carried out by means of a dia-
dialogue box as shown below.

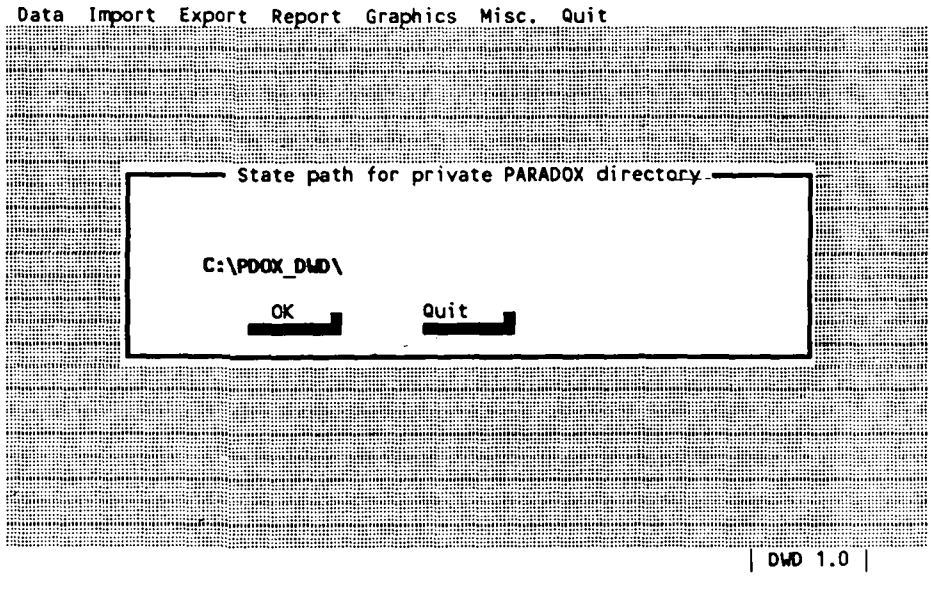


Figure 35. Input box for entering a directory.

8.2 Print out medium

Here you may choose whether reports/print outs should be sent to a file, to a printer or to the screen. The pre-selection is "screen". After each report you are asked whether it should be printed out as well; but you have to pass this menu choice to direct a printout to a text-file. When a file has been selected, the user is asked for a file name every time a printout is generated. Afterwards the report will be traceable with this name and the extension: ".rpt".

8.3 Periods of waiting when messages are shown

When a message is displayed, it remains on the screen for a given amount of time. Depending on the speed of the hardware and the user's patience the periods of waiting may be too short or too long. That is why it is possible to change the period of time during which the messages are displayed on the screen.

You change the time by selecting **Periods of waiting** in the **Options** pull-down menu. Your choice will bring forth a slide gauge on the screen which you may use to alter the period of

waiting by means of the mouse, the arrow keys or by writing the desired period of waiting.

When the mouse or the arrow keys are used, the slide gauge is moved in the required direction depending on whether the period of waiting should be shorter or longer. You may also state the required period by writing the figures.

A period of 2500 is preselected, it may be regulated within the interval of [0;8000].

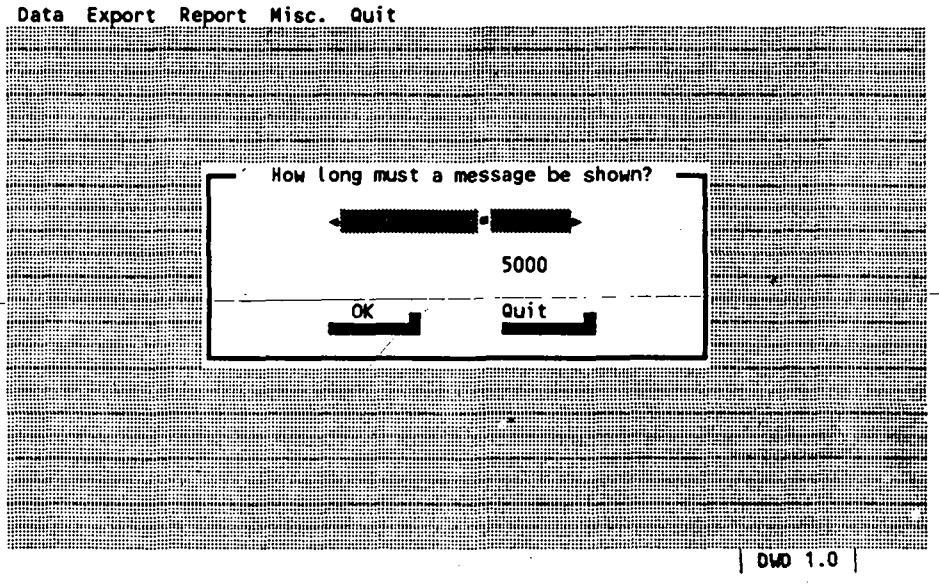


Figure 36. Slide gauge to state period of waiting when messages are shown.

8.4 User list

Here it is possible to add a new user of DWD, to change your own password, and to assign rights in the system.

If a new user is to be added, you must choose:

Options / User list / Create.

Hereafter the new user's initials and password must be entered. As a confirmation the password must be entered once more, and if this procedure is carried out in the correct manner, a new user is added - if the entry was wrong, an error message will appear on the screen, and the process must be repeated.

If you wish to change your password, do as follows:

Options / User list / Change.

Hereafter you must enter your present password, then the new one and finally as a control the new password once more. If this procedure is carried out in the correct manner, the new password will be registered - if not, an error message will appear on the screen.

Options / User list / Right.

This function can/should only be selected by a user. A table is shown on the screen containing all initials of all users of DWD. Opposite each user the user's password and a code (figure) are shown stating the rights which the individual user has in the system.

There are three degrees of rights **0, 1, and 2.**

0 gives the right to inspect data but no right to correct, delete or add data in the data base.

1 gives the right to inspect, edit and add data in the data base.

and finally,

2 gives the right to inspect, edit and add data in the data base and the right to assign rights to other users. Only **one** user should have this right.

8.5 Go to DOS

If this function is chosen, DWD is suspended, and you will return to DOS. In DOS you may carry out orders, and you may afterwards return to DWD by writing **EXIT.**

9. Quit

The program may be quitted in two ways. Either you quit the program and go to Paradox, or you quit DWD and Paradox and go to DOS.

Annex A. Questions and answers

What do I do, if I have modified the contents of a field, but immediately regret it and want to keep the previous version?

If you have changed or erased the contents of a field, the original version can be recreated by pressing <Ctrl>+u

What do I do, if I by error delete a record?

If you have deleted a record and regret in immediately after, the record can be recovered by pressing <Ctrl>+u. It only goes for the last record and only if you have not left it. If more records are deleted, only the last one can be recovered.

How do I alter the contents of a field without retyping all of it?

Place the cursor in the field to be modified. Press <Alt>+F5 and use the arrow keys to move the cursor to the right position. Use the <Ins> key to insert characters etc. or <Backspace> to erase. Leave this mode by pressing <Enter>.

How do I erase the contents of a field?

When the contents of a field is to be erased, the cursor is moved to the field. When in the correct field press <Ctrl>+<Backspace>.

Where do I find the data which I have exported?

Data which have been exported are found in the directory **C:\PDOX_DWD.**

What do I do, if I get the message: **UNEXPECTED CONDITION: LINK RANGE ...?** and Paradox aborts directly to DOS?

This is one of the worse problems, since Paradox is not able to recover from an error, which have occurred in one or more tables. The problem is, that a table might have been corrupted due to some hardware or software problem.
The solution is to "repair" the tables with the

built-in tool "TUTILITY".
From the DOS-prompt you simply type: TUTILITY
and press <Enter>

Now, the utility program starts. From the main menu, Table is chosen.
Select the table: GR_WATER and choose ***verify****. If a problem is found, the program will ask for a name for a copy of the old version. Type f.x. OLDGRW. Now TUTILITY will repair the damages found.*
Repeat this procedure for the following tables:

BOREFILT
FILTSLOT
GEOLOGY
HYDROGEO and

HYDRCHEM and
HYDRDATA if any hydrochemical data have been entered.

What do I do, if the script is cancelled by the error: **Field No_Of_Boreholes does not exist**?

This means that the script (the program) is in an error state, which is not handled. The problem is, that there is a record in the database, which has an empty field within ***Waterpoint No****.*
It is most certain the last one entered.
Do the following:
1) Press <Ctrl>+q to exit the script
2) Press F2 to end the tables (You might do this a number of times, until the message: "Nothing to process now" appears.
3) Press F8 to empty the screen.
4) Exit Paradox from the menu
5) Start Paradox as usual from DOS (you might want to switch the PC off and on to start the normal way).
Search for the last record entered using the <Ctrl>+z function. When it is found, the record must be deleted and the information re-entered. It is most likely, that it is an empty record with no other information than the ***Location No****.*

How do I backup the data in the database?

You do the following:
1) Leave the database system and go to DOS.
2) Type CPBACKUP GRWATER C:\GRW_CALL\DATA.**

and press <Enter>
Now, the IBM standard backup system starts. It asks for a floppy disk to be inserted into the A-drive.

3) When finished, terminate the backup procedure.

Store the floppy in a safe place. Have 2 or 3 generations of backups. ***Make a backup each morning before you start entering data.***

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