TRAINING COURSE

ON

SOFTWARE FOR GROUNDWATER DATA MANAGEMENT

UNDER

WORLD BANK FUNDED HYDROLOGY PROJECT

LECTURE NOTES
ON

GROUNDWATER DATA HANDLING SOFTWARE

BY

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GROUNDWATER DATA HANDLING SOFTWARE

1.0 INTRODUCTION

The data base management system is developed with an objective to create a data bank or data library. Such system forms the vital link between raw data collected in the field, and its ultimate use by the specialist. The steps involved in the creation of data base and its management are (i) data acquisition, (ii) data processing, (iii) data storage and retrieval, and (iv) data presentation.

For groundwater data base management, a software known as UN Groundwater software, has been identified for demonstration. In this lecture, the features of UN groundwater software will be discussed in detail.

2.0 UNITED NATIONS GROUNDWATER SOFTWARE

This groundwater software has been developed by the United Nations Department of Technical Co-operation for Development, Natural Resources and Energy Division, Water Resources Branch, New York. The authors of the programs are Dr. J. Karanjac and Dr. D. Braticevic.

This software is in two parts, Part-1 deals with data base and utilities and Part-II deals with mathematical models.

The programs are written for personal computers running under the PC-DOS or MS-DOS operating system and is called GW. Recently Windows version of the UN software has also been released and is known as GWW. The main files and features of the software are

GW (DOS version)

GW1 Hydraulic Conductivity
GW2 Ground Water Chemistry
GW3 Pumping Tests
GW4 Well Hydraulics and Well Construction
GW5 Water Level Data Base and Hydrographs
GW6 Well Logs and Lithological Cross-sections
GW11 Graphics

GWW (Windows version)

MASFILE.EXE Master data
CHEM.EXE Chemistry Data
CHEMW.EXE Chemistry Vs Depth
CHEMT.EXE Chemistry Vs Time
HG.EXE Hydrograph
MAP.EXE Mapping

LITH.EXE	Well log
XSECT.EXE	Cross section
XSMD.EXE	Fence diagram
SDDT.EXE	Step drawdown test
GSC.EXE	Grain Size curve
MISC.EXE	Miscellaneous
UFILE.EXE	Users file
FORM.EXE	Form design
UNITS.EXE	Units conversion

Windows version has detailed help facility available. The users who have working knowledge of Windows can easily see the help files available and can use the software easily. In DOS version the help facility is not available. Therefore, few utilities of DOS version are explained in next sections.

3.0 HARDWARE REQUIREMENTS

This section describes the hardware requirements for running the programs under DOS.

Mathematical Co-processor

Although you can run any of the programs without a math co-processor, some of programs will run very slowly if the system is not equipped with a co-processor. For example, the pumping tests program (GW3) may take about one hour to process a pumping test with 99 test points (time-drawdown pairs) using the Hantush leaky method if a co-processor is not used. By comparison, the same test completes in several minutes with a co-processor. Likewise, the Lithology program involves extensive calculation in rasterizing drawings for screen display or printout. Writing the textual part of a graphics screen can also be very slow unless a co-processor is installed.

Memory Requirement

Some of programs require all available memory accessed by DOS Version 3 or 4. The executable files (those with extension of EXE, such as GW1.EXE) are distributed in compressed form; the minimum memory required for running each program is normally equal to the actual size of its executable file. However, he screen driver demands an additional 140KB of memory, and the printer driver about the same. Both drivers share the same memory space, and are never engaged at the same time. If you run this program through the GW shell, an additional 16 KB of memory is used in keeping the track of all modules.

With the exception of the GW1 and GW4 modules, which do not have presently graphics routines, the programs are very memory-intensive. It is almost mandatory that these programs run from a computer equipped with 640 KB of RAM (random access memory).

The following instructions should normally be observed:

(a) Run the program GW in a computer with at least 640 KB memory.

(b) Remove all memory-resident programs.

(c) Modify your CONFIG.SYS file and reduce Buffers and Files to a small number. The maximum number of open files (by DOS and the program) is 10 (for the GW6 program). Buffers could be 5. Remember that each file and buffer uses about 500 bytes. The "shortage" of several kilobytes of memory may be critical in running the GW6 program.

Hard disk

Although all programs except GW6 can be run from a floppy disk, it is highly recommended that all programs be installed on a hard disk. Some of programs write some scratch files to disk, and erase them later. The capacity of a floppy (except high density 3.5-in 1.4 MB drive, or 5.25-in 1.2 MB drive) may not be sufficient to hold this additional information. One megabyte free space on hard disk is normally sufficient to hold scratch and output files.

Mouse

The programs GW2, GW3, GW5, GW6, and GW11 have graphics routines which maybe enhanced by using the mouse. The programs have been tested with a Microsoft Mouse, a Logitech Mouse, and a Genius Mouse. The mouse is very useful in zooming the Piper trilinear diagram (GW2), and in zooming the lithological log and /or cross section in GW6. Its primary importance is in selecting a lithological cross section line directly from the map of wells in GW6. However, all program can run without the mouse, so its use is optional, although strongly recommended.

Video Display Adapter

The following video adapters are supported by programs: colour graphics adapter (CGA), colour enhanced graphics adapter (EGA), Hercules, a special SGA for AT&T 6300 or Olivetti computers, VGA, the high-resolution SYSE adapter. To run the programs with a Hercules graphics adapter you must have the command "HGC full" in your AUTOEXEC.BAT file, or you should execute that command prior to running the GW software. Note: the WYSE driver is not completely correct in the mixed alphanumeric and graphics mode. Also, the CGA display card on a colour monitor will produce black and white graphs. This is explained by the fact that to have the resolution of 620x200 CGA mode 1 is used which is two-colour mode, that is black and white.

The programs will run without video display adapters, but you will not be able to see any graphics display on the screen. Nevertheless, you will be able to process most of the information and print it (pumping tests, hydrographs, etc.). Each program first looks for a file CONFIG.CFG in the GW director. This is the file which contains the information on the

type of video adapter you have selected to work with.

Printer

Programs GW2, GW3, GW5, GW6, GW11 can direct their output to a printer. 9-pin and 24-pin EPSON-compatible printers are supported. With some other printers it was noted that there was double line spacing due to the printer and program both issuing a carriage return and line feed. If you have a printer which is not EPSON-compatible, try to eliminate printer-generated line feed if possible by setting a switch on you printer.

Plotter

Each graph can be either displayed, printed or plotted. Only the Hewlett-Packard plotters using the HPGL (Hewlett-Packard Graphical Language) or emulating it, are supported. The output is directed to COM1 serial port, which should be configured with DOS command MODE as follows:

MOD COM1;9600,N,8,1

If you sometime experience dropouts in data, you might reduce the baud rate (instead of 9600 try 2400) and try sending the data again. You may also try the mode command as

MOD COM1;9600,N,7,1

4.0 SOFTWARE REQUIREMENTS

DOS2.11 or higher is required. In you CONFIG.SYS file there must be a line "DEVICE=ANSI.SYS". The device (file) affects cursor movement, erases specific areas of the screen and sets the graphics mode.

If there is a CONFIG.SYS file on your disk or diskette, which is read during booting the system, you must modify it by adding the above line "DEVICE=ANSI.SYS", provided your ANSI.SYS file is in root directory. If it is in a subdirectory, for example the DOS subdirectory, modify the line by establishing the path, such as:

DEVICE=\DOS\ANSI.SYS

If CONFIG.SYS does not exist on your disk, create a new one. The modification and/or creation can be done using the copy con routine in the following way (COPY CON is a standard DOS routine which is used to create small files by typing lines directly from the keyboard):

a) First check whether you have the file CONFIG.SYS on your DOS disk directory by typing DIR. If CONFIG.SYS does exist, view its contents by typing TYPE CONFIG.SYS (and RETURN). Write down the contents of the CONFIG.SYS file or memorize its contents. Use the DOS routine COPY CON to rewrite the

CONFIG.SYS file by typing:

COPY CON CONFIG.SYS (RETURN)

Retype all existing lines in your CONFIG.SYS file and add he following:

DEVICE=ANASI.SYS

followed by RETURN. You will terminate this file by typing either Ctrl Z (which means End-of-File) or by pressing F6 (which means the same), followed by RETURN.

b) If the CONFIG.SYS file does not exist, create one by typing:

COPY CON CONFIG.SYS (RETURN)

and enter only one line of text: DEVICE=ANSI.SYS, followed by RETURN, F6 and RETURN. At the end, your CONFIG.SYS file will most probably look like this:

```
FILE=10
BUFFERS=10
DEVICE=ANSI.SYS
DEVICE=MOUSE.SYS
```

or simply DEVICE=ANSI.SYS

You can view the contents of the file by typing TYPE CONFIG.SYS.

As mentioned earlier, the GW software needs the "configuration" file, CONFIG.CFG, to identify the video adapter, type of printer, and whether you are using a color or monochrome monitor.

Add the subdirectory \GW to the DOS PATH command in your AUTOEXEC.BAT file. This line may read as follows:

PATH=C:\;C:\DOS;C:\UTIL;C:\GW;C:\NORTON

5.0 INSTALLATION

DOS version

DOS version requires about 3.5 MB free space for installation

1. Put the floppy in the floppy drive a: or b:

2. Type install1. All the files will be expanded and will be copied into \GW, \EXAMPLE1 & \EXAMPLE2 directories. The \GW directory will contain all the

program files, whereas other two directories will have some example data files.

3. When you run the GW software for the first time on your PC, it will create a CONFIG.CFG file by asking you some questions, e.g., type of screen graphic driver, type of printer, DOS version you are working with and type of monitor. Answer the questions correctly and then your software will be installed. Note : if you are working with DOS version higher than 4.2, then press ESC when it asks for DOS version.

Windows version

The United Nations Groundwater Software for Windows (GWW) requires 14 MB of hard disk space and several additional MB for proper operation. Before installing GWW check that you have the necessary hard disk space.

The program files in the 5 distribution diskettes come in a self extracted (zipped) form. There are small batch files on each of the distribution diskettes that will open GWW and GWWDATA subdirectories on hard disk C or D and copy the unzipped files to the subdirectories.

To install the GWW program on drive C, type GWW and the diskette number GWW1, GWW2 etc. and press ENTER. To install the program on drive D, add the letter d without space after the number of the GWW diskette, GWW1d, GWW2d etc. and press ENTER. Start installation with disk 1.

To complete the installation, and before starting Windows and GWW, add the GWW subdirectory to the PATH, and add the line SET GWW=C:\GWW or SET GWW=D:\GWW into the Autoexec.bat file and reboot your computer.

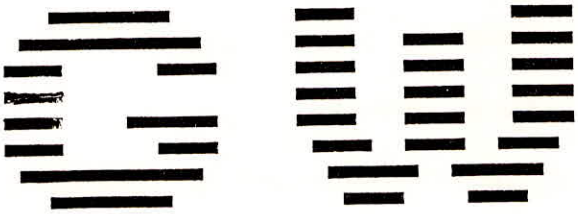
5.0 RUNNING THE GW/GWW SOFTWARE

To run the DOS version of the software, you should log to directory in which you keep your data files (GW2, GW3, GW5 AND GW6). For GW1 & GW4, which are the utility programs, it is not important in which directory you may be. You may log to the \GW directory as well.

Type GW. After few seconds the screen as shown in Fig. 1 will be displayed.

Then press any key, and the second screen will appear. The second screen is a copyright notice and some instructions. After going through this screen press any key and the programm selection screen will be displayed as shown in Fig. 2

UNITED NATIONS
DEPARTMENT OF TECHNICAL CO-OPERATION FOR DEVELOPMENT
DIVISION OF NATURAL RESOURCES AND ENERGY
WATER RESOURCES BRANCH



G R O U N D W A T E R
S O F T W A R E
PART ONE
DATA BASE and UTILITIES

Version 1.00 - December 1989

Written by: J.Karanjac, Ph.D. (Geology & Civil Engineering)
D.Braticevic, Ph.D. (Mathematics & Computer Sciences)

ESC to exit to DOS. Any key to continue.

Fig.1

UN/DTCD -- GROUND WATER SOFTWARE
PROGRAM SELECTION

Version 1.00
December 1989

1. Hydraulic Conductivity
2. Ground Water Chemistry
3. Pumping Tests
4. Well Hydraulics & Construction
5. Hydrographs
6. Lithology
11. Graphics

FUNCTIONS :

X=Exit to DOS

Use cursor keys and [Enter] to select program module.

Fig.2

To run the Windows version, the user has to first run Windows and then through File Manager, run the programm GWW.EXE. By doing this the logo of United Nations will be displayed with the following line on the Top of the screen

Data	Application	Tools	Customisation	Help

The user may select the topic and start working.

Data module is for reading an existing file or to create a new file.

Application module is to select the module in which the user wants to work e.g., hydrograph, chemistry, cross section etc.

Tools module is for design of data structure, entry form of report form etc.

Customisation module is for design of graphics, i.e., color choice fonts etc for the graphics.

Help module gives help on various topics of the software starting from data entry to report preparation.

In the next sections only DOS version has been discussed.

6.0 PERMEABILITY CALCULATIONS AND CONVERSIONS

This is primarily a utility program for calculation of permeability values (hydraulic conductivity) from grain size analysis (grain size distribution curves) and converting permeability values from one system to another.

This utility can be run either from GW main program or directly typing GW1 from the DOS prompt. The GW1 utility program consists of 6 parts (Fig. 3)

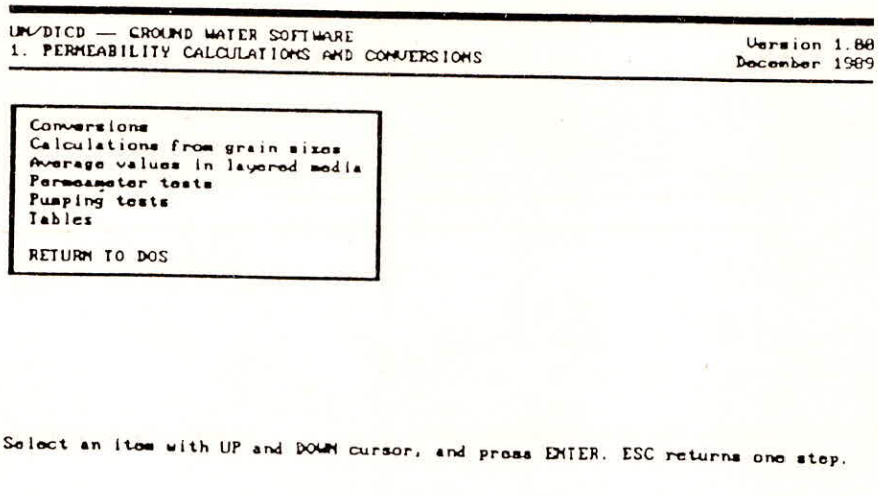


Fig.3

Conversions : This utility converts permeability values from one system to another system. The options are US gpd/ft^2, Imp gpd/ft^2, m/day, cm/d, cm/s.

Calculations from grain size : Using this utility, permeability coefficients can be calculated by one of the available six empirical formulas i.e., Hazen, USBR, Slichter, Kozeny, Zamarin, Terzaghi.

Average values in layered media : This section of the program calculates an average permeability coefficient for horizontal stratified terrain. The flow may be either parallel or perpendicular to the layers of different permeabilities.

Permeameter tests : Through this section the permeability of the samples can be calculated using the laboratory test data. Three type of data can be handled by this program i.e., constant head, falling head & no discharge.

Pumping tests : In this section the permeability coefficient is calculated from pumping tests in steady radial flow to a well, under both confined and water table conditions.

Tables : Several type of tables can be displayed and printed using this option.

7.0 GROUND WATER CHEMISTRY

This is a utility program that allows you to create, manage, and display or print reports for a groundwater quality data base.

This program can be started either by typing GW2 at the DOS prompt or by selecting the 2 from the Program selection menu of the GW program.

The following keys have special functions :

The F2 function key erases the data field completely.

The F3 function key erases the data field from cursor position to the end of the field.

The ALT-F10 key, pressed simultaneously, "fix" the screen if it appears corrupt.

PgDn and PgUp keys display on the screen one page down or up, respectively, provided the data base has more than 14 samples.

The HOME key positions the cursor to the top of the screen.

The END key positions the cursor to the bottom of the current screen.

The CTRL + HOME key sequence brings up the sample number one.

The CTRL + END key sequence brings up the last sample in the data set.

This is a data base program, with several retrieval (applications) options and a report printing capability.

The creation of the groundwater quality data base is the most important portion of this program. The programm starts with an Opening screen (Fig. 4) prompting you to type the name of a Chemistry Data File.

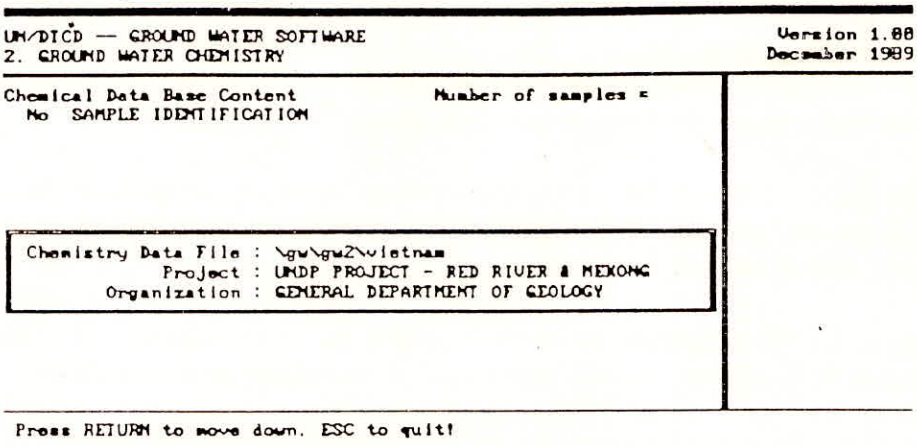


Fig.4

1. If this is the first time a Chemistry Data File is being created, than a message will appear at the bottom of the screen after the name of the file is typed:

   This file does not exist.
   Press C to create new file or ESC to exit.

If you press C than the Screen as shown in Fig. 5 will appear, showing the parameters which are available in the program. The user can select the parameters according to his need, by pressing Y on the highlighted parameter. When the parameters are selected, the values can be entered into the data sheets.

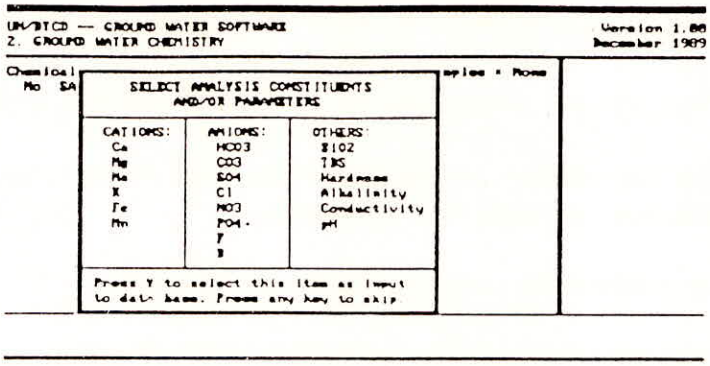


Fig.5

2. If the file exists in your data base, the program displays two lines, and the cursor moves to the second line. The user can select the samples for further processing.

Once the data base has been created or retrieved from the disk, than the following options are available:

- Input data
- Edit data
- Browse
- Delete
- Stiff diagram (screen display and printout)
- Piper diagram (screen display, printout, plot)
- Wilcox diagram (screen display, printout, plot)
- Reporting
- ASCII file reporting

These options can be used to update the existing data base and to process the data as required.

8.0 PUMPING TESTS

This is a data base program, with data analysis and presentation capabilities (screen graphics, printout). The program creates a pumping test data base. Once data are transferred to the computer, several methods should be attempted, and the standard deviation of the fit recorded. The method which produces the least standard deviation should be accepted as being most representative, provided this agrees with the local hydrogeological situation

The program starts either by typing GW3 and pressing Enter or through the GW program by selecting 3 i.e. Pumping tests. The following screen will appear (Fig.6) and you will be asked to enter the name of the file. The procedure for entering into the data base or creating a new data base is same as for Chemistry data.

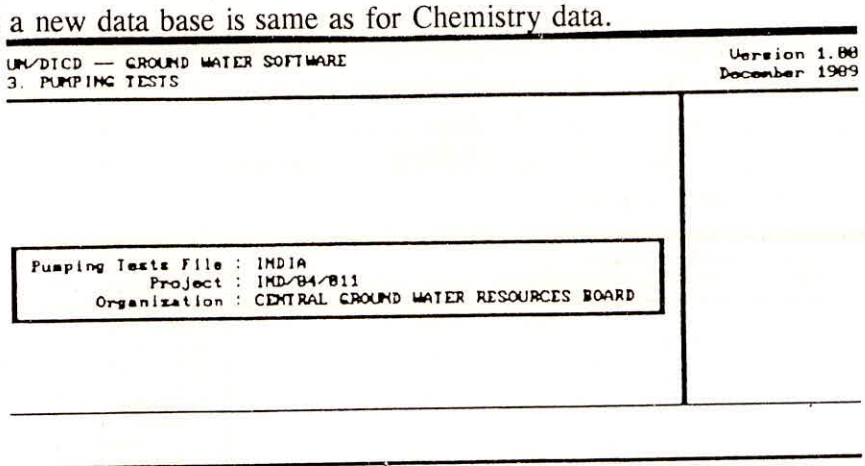


Fig.6

After the data base is opened or created than the following options are available:

- Define units
- Data input and editing, etc.
- Test analysis (Jacob, Theis, Hantush, recovery, dug wells)
- screen graphics, printing, plotting

9.0 WELL HYDRAULICS AND WELL CONSTRUCTION

The program is a collection of many problem solving routines from everyday well construction and testing practice. It will not save input data in a form of a data base. The results should be hand written if needed.

The program can be started by typing GW and selecting "4. Well Hydraulics and Construction" from the main menu or by typing GW4 from the DOS prompt, this utilities main menu appears as shown in Fig. 7.

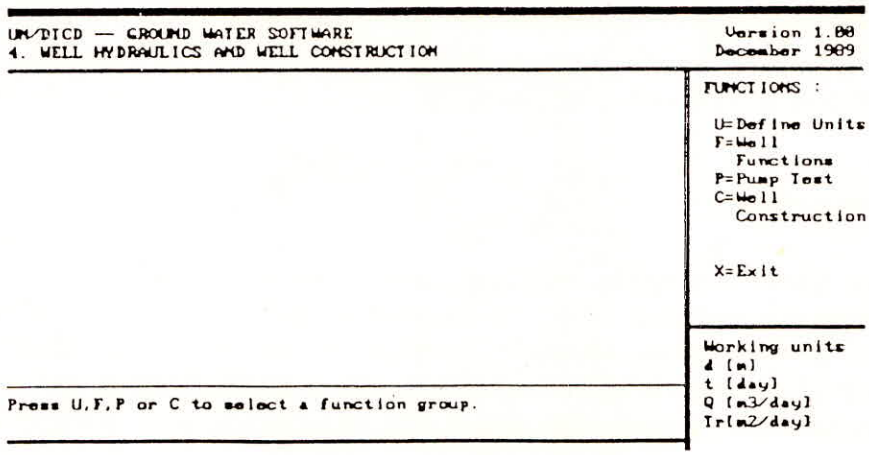


Fig.7

Main components of this program are:

Well functions : Functions shown in Fig. 8 are well functions frequently used in groundwater hydraulics. The first one, W=W(U), is the well function for the infinite artesian aquifer in which a well is pumped at a steady rate. The second well function is the function used in Hantush leaky aquifer theory. The next one is a Well function used in partially penetration wells pumping from anisotropic aquifers.

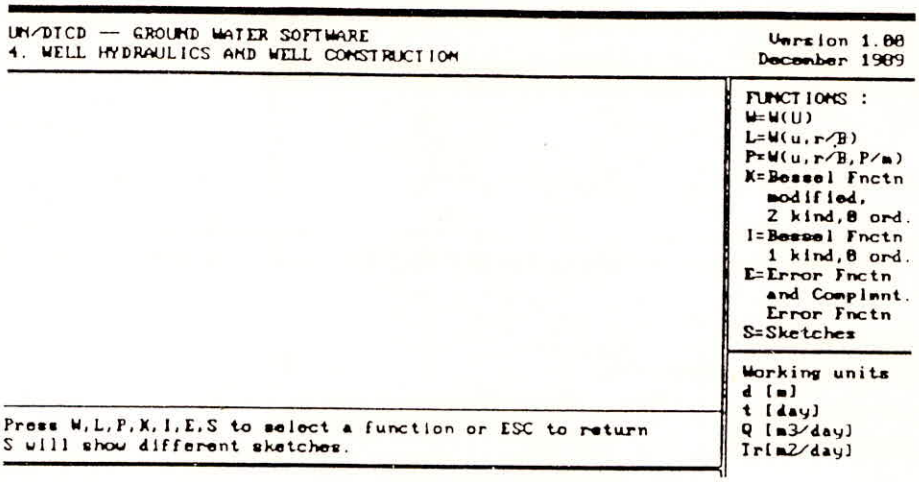


Fig.8

Pump tests : Pumping tests program shown in Fig. 9 contains two subprograms dealing with step-drawdown tests, a routine to calculate pumping rate from a circular orifice weir, a routine for estimating discharge from a flowing artesian well etc.

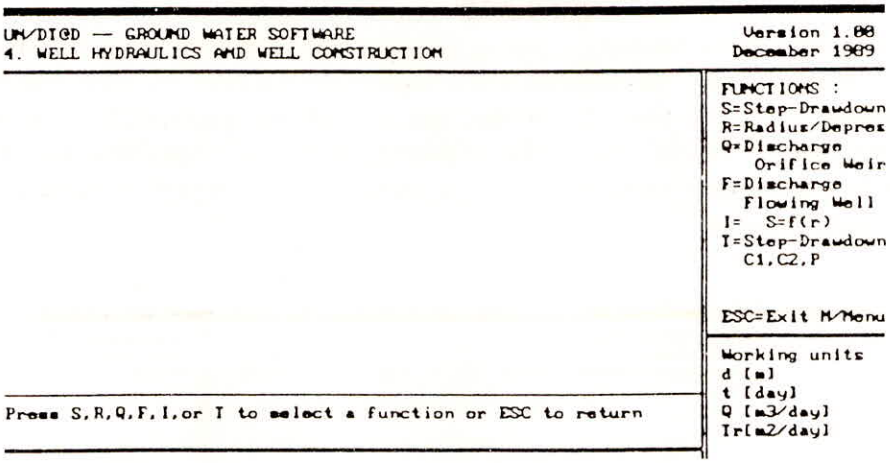


Fig.9

Well construction : Well construction, shown in Fig. 10, helps to calculate maximum permissible entrance velocity to screen. Actually it offers a recommendation for optimum screen length as a function of discharge, well diameter, open screen area, and aquifer permeability.

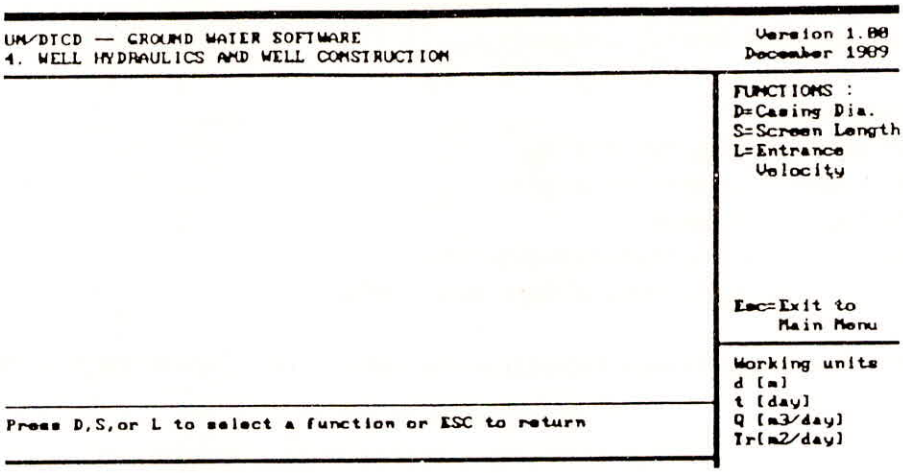


Fig.10

10.0 WATER LEVEL DATA BASE AND HYDROGRAPHS

This is a data base program which creates a water level data base, displays results on the screen, print or plots a hydrograph. The user controls what is to be edited, input, displayed, or printed (depth to water versus absolute water level elevation, whole hydrograph or only a selected time interval, individual data connected by a line or left as scattered points, etc.)

The program can be started by typing GW5 on the DOS prompt or by selecting "5. Hydrographs" from the GW main menu. Once the option has been selected, the following screen will appear (Fig. 11) and will prompt you to enter the name of the data base file. Please enter the name of the file. If the file is existing in the data base, than the cursor will move to line no 2, otherwise it will display "File does not exist, Type C to create a new file" at the bottom of the screen.

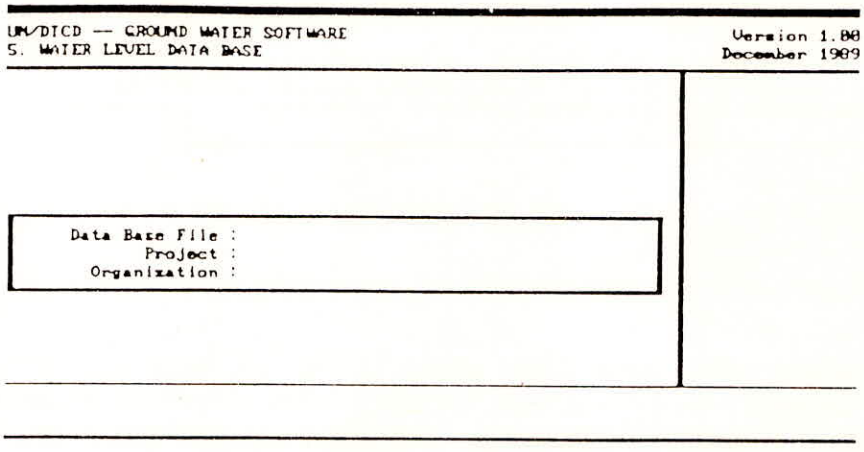


Fig.11

The program has the following components:

- Define units
- Data input, editing, deleting, etc.
- Data analysis (display, print, plot)
- Working time interval
- Change depth for altitude and vice versa
- Select connecting interval in days, hours, minutes

Using this program well hydrographs as shown in Fig. 12 can be generated.

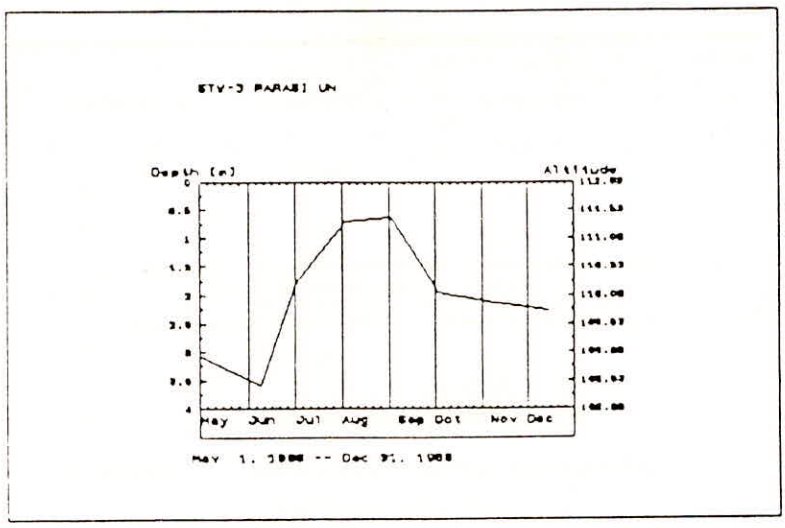


Fig.12

11.0 WELL LOGS AND LITHOLOGICAL CROSS-SECTIONS

This is a data base program which is used to create a drilling data base; update and edit it; create, display, print or plot well construction and lithological log; display, print or plot lithological cross sections in any direction and length as selected by the user. The user inputs and edits data using his/her favourite word processor from inside the program has about 30 built-in lithological symbols, but the user can create almost any additional symbol.

The first step in running this program is to tell the computer which text editor you want to use and where it is located. This information is contained in file GW6.GEN. The file GW6.GEN must be in the current directory. The file GW6.GEN, as supplied on the program diskette, looks as follows.

PROJ: NEP/86/025
ORG: GWRDB - UN/DTCD
EDITOR: C:\UTIL\PE.EXE
HSCALE: 10000
VSCALE: 1000

First line in this file is the project name, second line the organisation name, third line the path and name of editor, fourth and fifth lines are the horizontal and vertical scale. Note : Please do not change any word before the colon and the other names or scale should start from the position as in the sample file.

The program can be started by typing GW6 on the DOS prompt or by selecting "6. Lithology" from the GW main menu. Once the option has been selected, the following screen will appear (Fig. 13).

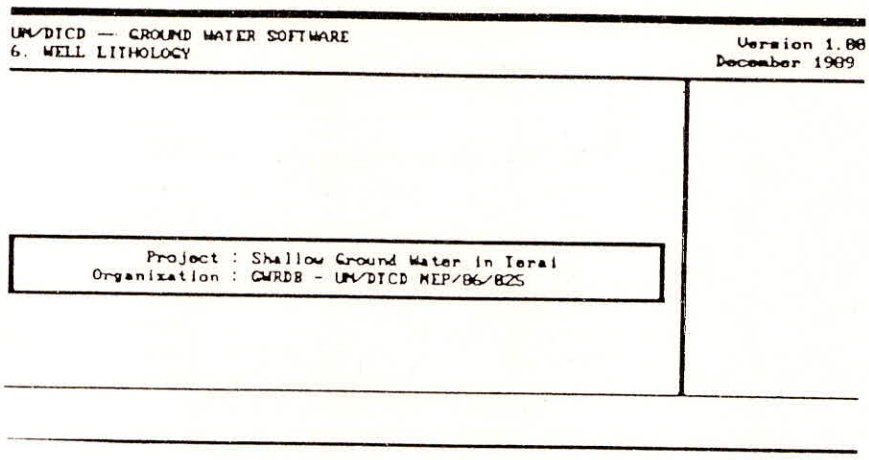


Fig.13

Press Enter. Then the main opening menu will appear (Fig.14). This program has the following components:

- Edit data
- Well log
- Select files
- New file
- Delete a file
- Cross sections (calculation, display, print, plot)
- Edit general data
- Produce a table with data summary
- Percentage or permeable versus impermeable layers

Using this program the lithlogs and cross sections as shown in Fig. 15 & 16, can be generated and printed.

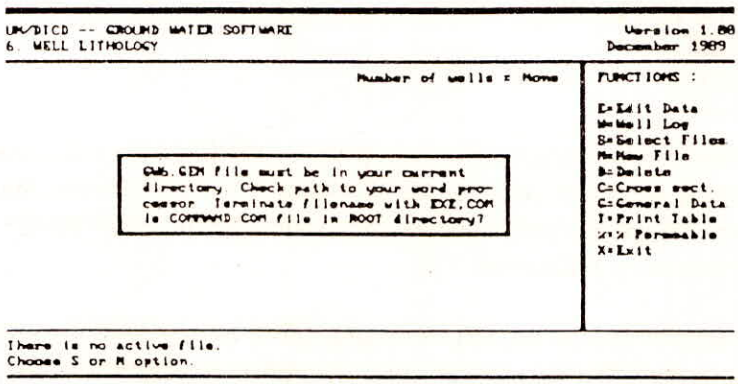


Fig.14

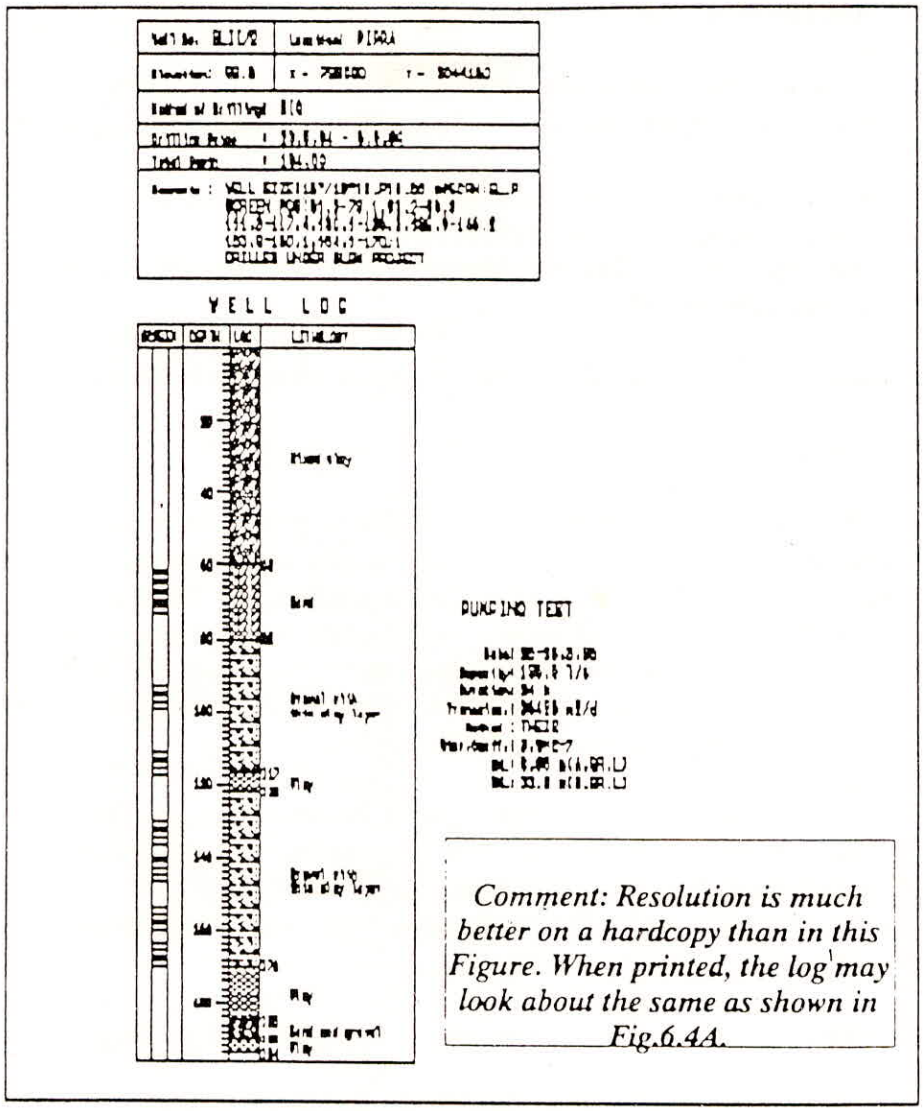

WELL LOG
PUMPING TEST
Comment: Resolution is much better on a hardcopy than in this Figure. When printed, the log may look about the same as shown in Fig.6.4A.

Fig.15

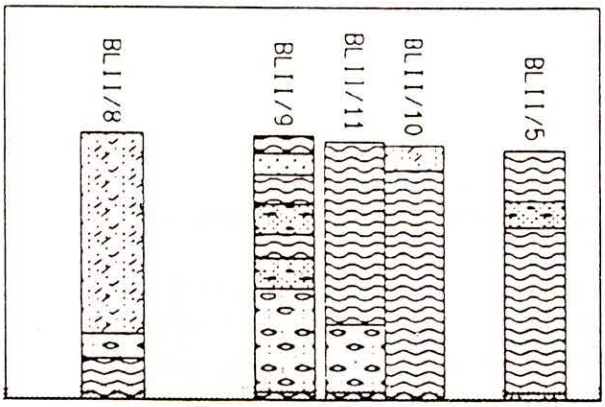

BLII/8
BLII/9
BLII/11
BLII/10
BLII/5

Fig.16

12.0 GRAPHICS

This is a utility program which is used by GW6 (Lithology) to create maps with wells, boundaries, rivers, roads, etc. It is made of the following components:

- Create or edit a coordinate system
- Display, print or plot a graphics content
- Add lines, points, text, and contours to the coordinate system
- Create contour lines

In this package, the contouring portion of the program cannot be used.

13.0 UNITS

Most of the programs offer you a choice of units for distance, time, pumping rates, and transmissivity. When you select a unit, you are expected to use the same unit throughout the program, unless directly instructed by the program to differently. Each of categories of units has a provision for user-defined units. This makes the program more flexible. However, you will be prompted for two additional parameters, should you decide to use your own units: (1) unit notation, (2) scaling factor, which is the conversion from your unit to the program's built-in default units, which are metric.

The program has several built-in units for each category. For example, the distance you be input as meters and/or feet. Any other choice requires a conversion. If you select inches as the basic input unit, you must provide the scaling factor of 0.0254, which is the number of meters per inch. The conversions from some other popular units are given here below.

Transmissivity: 1 $feet^2$ /day = 0.0931098 m^2 /day

1 m^2 /sec = 86400 m^2 /day

Pumping rate: 11/sec = 86.4 m^3 /day

1 m^3 /hr = 24 m^3 /day

1 f^3 /sec = 2446.78 m^3 /day

1 cm^3 /sec = 0.0864 m^3 /day

The program built-in units are the following:

distance:	m, feet
time:	day, hr, min
pumping capacity:	m^3 /day, gpm
transmissivity:	m^2 /day, gpd/ft