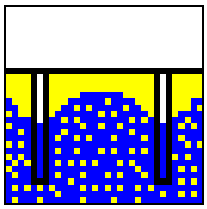
Calculation of multiple well installations with optimisation routines

# GGU-DRAWDOWN



October 1997



English translation: Civilserve GmbH, Braunschweig

# Contents:

# 1 Preface

The GGU-DRAWDOWN program allows calculation of multiple well installations. The theoretical basis for the calculations is mainly taken from HERTH / ARNDTS “Theorie und Praxis der Grundwasserabsenkung” (Ernst & Sohn, Berlin; 3rd Edition, 1994). Further to this, you are referred to the section on “Grundwasserströmung – Grundwasserhaltung” from RIESS, in the Grundbautaschenbuch (1997), where the theoretical principles are well explained.

Rectangular and any other shape of construction pits can be calculated. The influence of open water and of sheet pile walls can be taken into consideration. The program has optimisation routines for well number, well radius and well depth. After entering the construction pit dimensions, you can thus immediately switch to the optimisation routines and get, within seconds, an optimally configured groundwater maintenance. Comprehensive graphic evaluation possibilities (drawdown sections, system sections, isolines in colour and “normal”, as well as several legends) allow presentation of the complete calculation results on the screen. Besides this, you naturally have the possibility of using a “normal” data protocol.

Several example files are stored on the program disk. Before starting work with the program you should load these files to see the variety of presentation possibilities the program offers (select the menu option “File / Load” for this).

Data input is in accordance with WINDOWS conventions and can therefore be learned almost without the use of a manual. Graphic output supports the True-type fonts supplied with WINDOWS, so that an excellent layout is guaranteed. Colour output and Bitmap graphics are supported.

The following system minimum is needed to use the program:

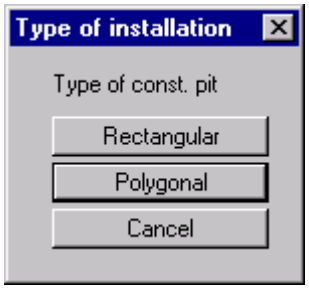
- MS-DOS compatible computer (Pentium I or higher processor),
- WINDOWS 95 / 98 and WINDOWS NT

The program system has been thoroughly tested. No errors have been discovered. Nevertheless, a guarantee for completeness and correctness of the program system and the manual, and damage resulting from any incompleteness, cannot be given.

# 2 Starting the program

By the installation and subsequent registration of the GGU software please take note of the enclosed information card, “Information relating to installation of GGU software”.

After the program start the title “GGU-DRAWDOWN” appears on the screen. After clicking on the menu option “New” in the menu item “File”, you must decide on the shape of the construction pit.




Following this, you will see the start-up screen, an example well installation.

The start-up screen shows nine **menu items** at the top edge.

- File
- Edit
- Construction pit polygon
- System
- Evaluation
- Sections
- View
- Page
- ?

After clicking on a menu item, the so-called menu options roll down, from which you can then reach all program functions.

The program works on the principle of "What you see is what you get". This means that the screen presentation represents, on the whole, that which you will see on your printer. With a consequent realisation of this principle, the screen would have to be refreshed after every alteration you make. As this can take several seconds for complex screen contents, the GGU-DRAWDOWN screen is not refreshed after every alteration. If you would like to refresh the screen contents, you may press either the [F2] key, or the [Esc] key. The [Esc] key will, additionally, set the screen presentation to A4.

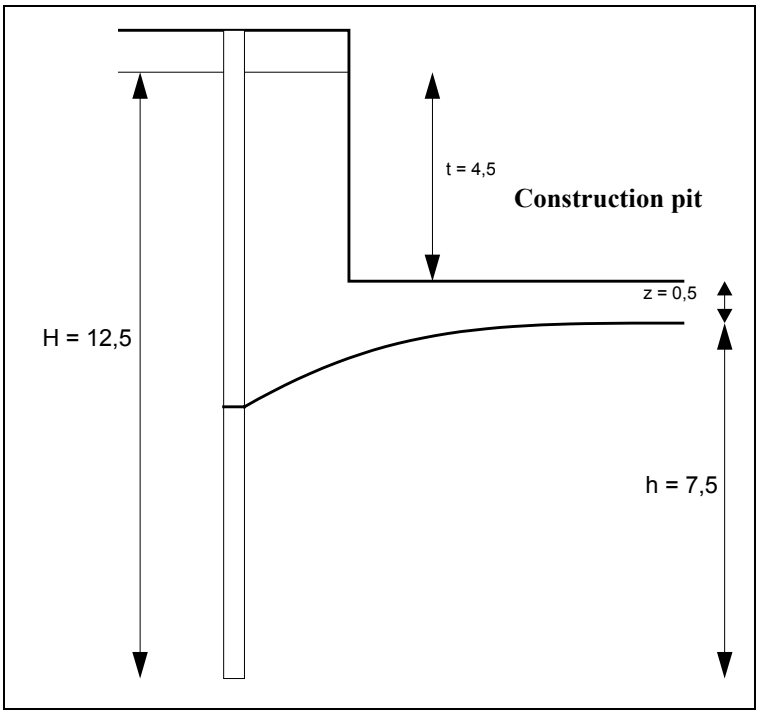
# 3 An example

As, from personal experience, the reading of manuals is a chore, there will now follow a short description of the main program functions, using an example. After studying this section you will be in a position to calculate a multiple well installation. You can take the finer details of the program from the further chapters.

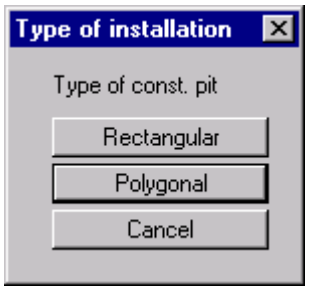
A construction pit with the following dimensions is to be calculated:

- Length = 71 m
- Width = 33.5 m
- Distance of wells from the construction pit edge = 2.0 m

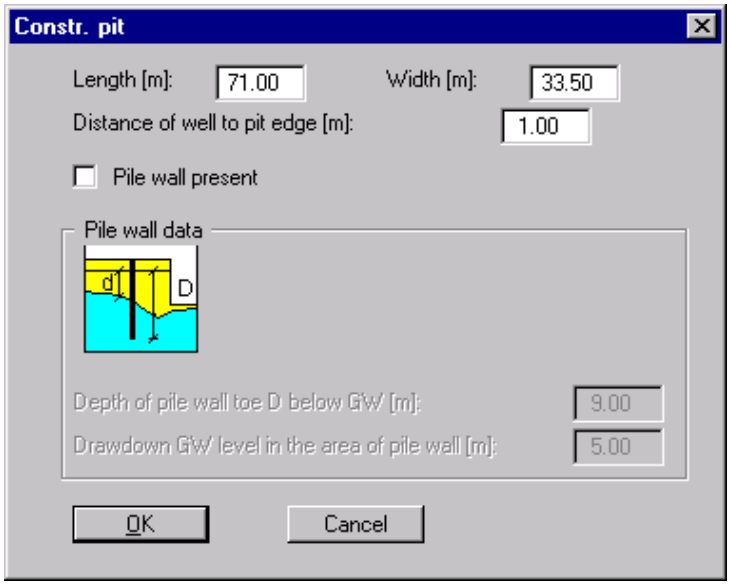
The wells are to have a radius of 0.3 m. The k-value is 5 * $10^{-4}$ m/s. Further system values can be taken from the figure.



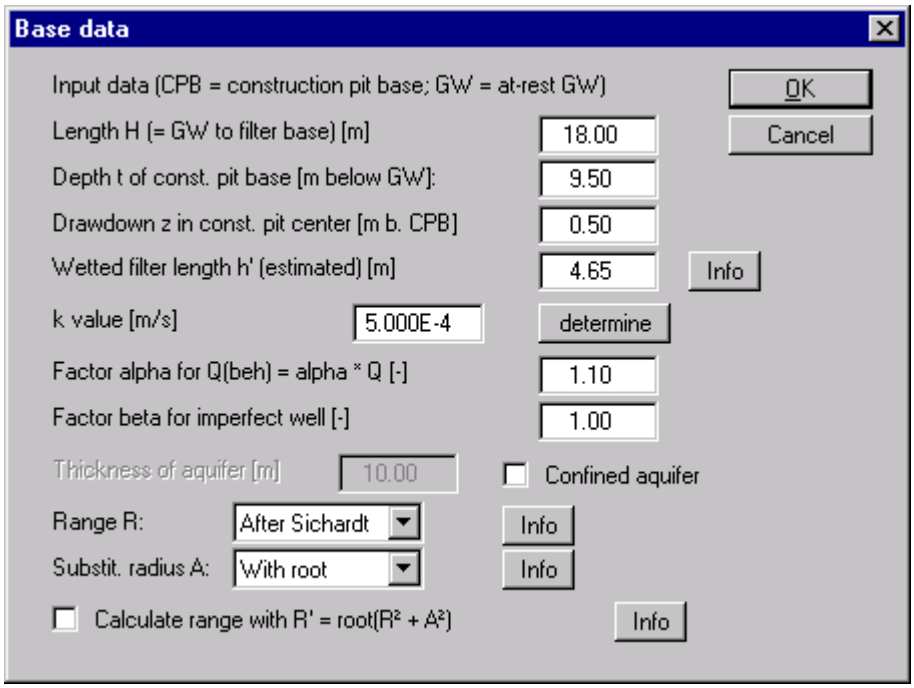

Start the GGU- DRAWDOWN program. Then select the menu option "**File / New**".



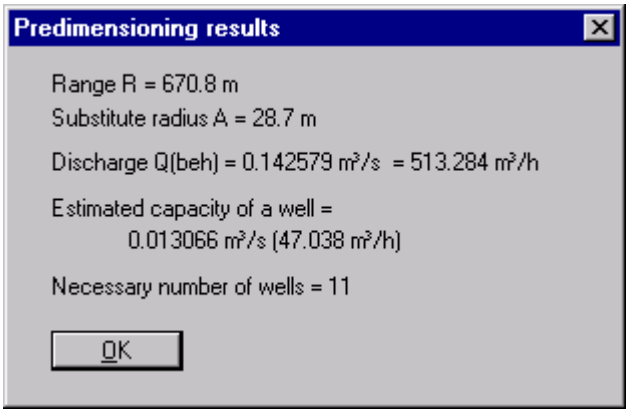

Press the "Rectangular" button. Then select the menu option "**Edit / Construction pit**".



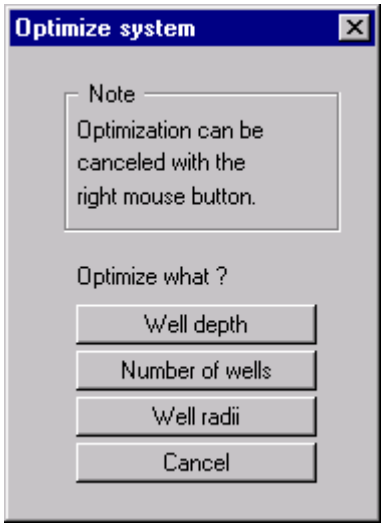

Enter the values into the dialog box. Confirm with “OK”. Then select the menu option “**Edit / Base data**”.



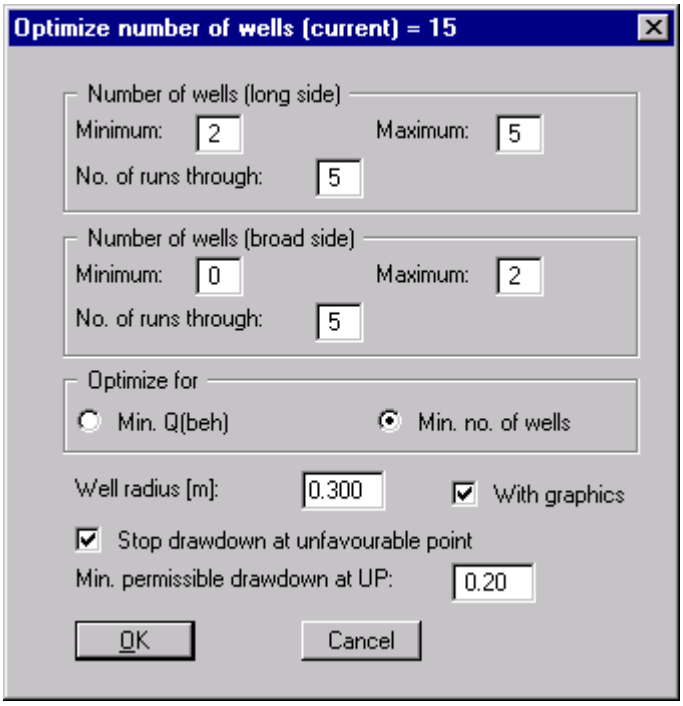

Enter the values into the dialog box. The input after “Wetted filter length h' (estimated) [m]” is only of importance for the predimensioning of the construction pit. From this, you get an idea of the necessary number of wells. Input does not influence the detailed dimensioning of groundwater maintenance, which follows later. Confirm with “OK”. You will get the results of a predimensioning of the installation.



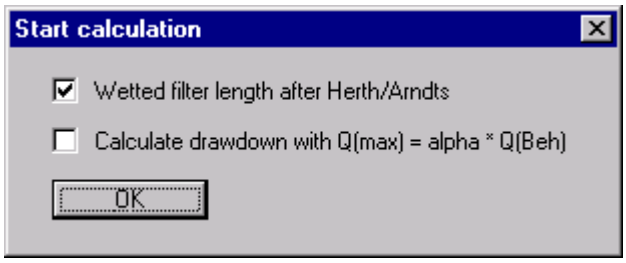

The predimensioning gives the necessary number of wells as “11”. The arrangement of the wells can be carried out in a variety of ways. The simplest method for you is to have this task done completely by the program. For this, select the menu option “**System / Optimise**”.



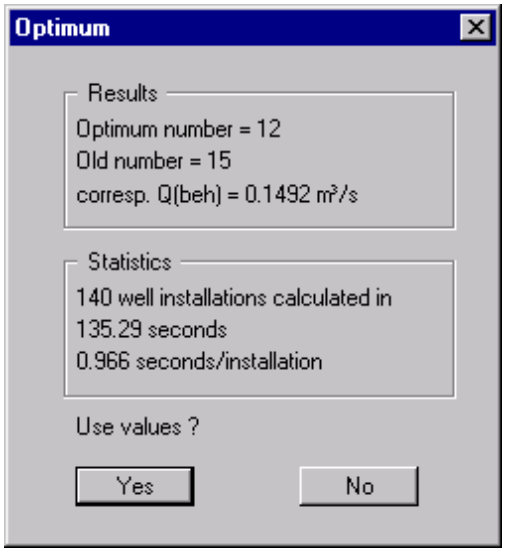

Press the “Number of wells” button.



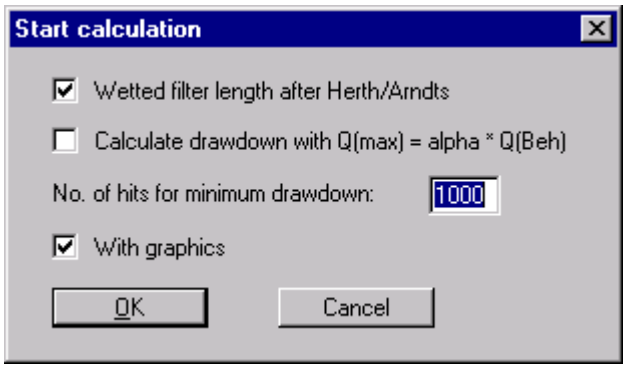

Enter the minimum and maximum number of wells, on the long and the broad side, to be investigated. With the input after “No. of runs through”, the variation of the position of the first and last well along each edge is controlled. In the “Optimise for” area, you can decide whether to optimise for minimum discharge or for minimum number of wells. Below this, you can enter the radius of the wells and determine whether or not a minimum drawdown at the unfavourable point is to be adhered to. After this, confirm your input with “OK”.

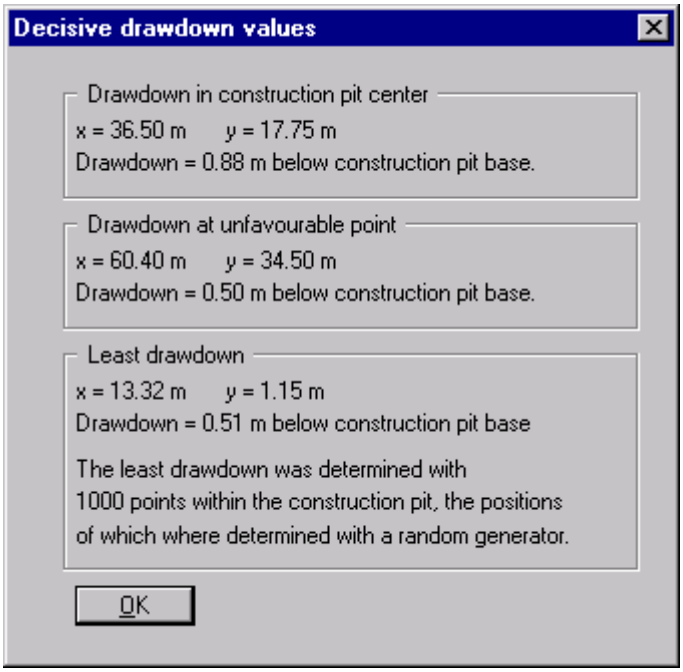

During optimisation the current number and position of the wells is graphically displayed. In the status bar at the bottom screen edge, information on the calculation results is displayed. A running optimisation can be cancelled with the right mouse button. Finally, you can decide whether or not to accept the optimisation results.

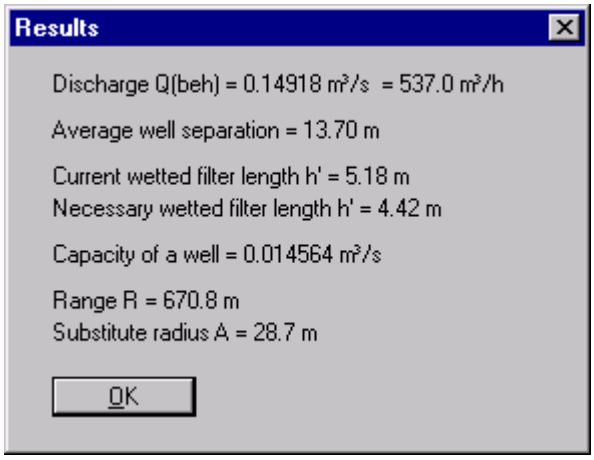



Confirm with “Yes”. Now the optimised installation must be recalculated. Select the menu option “**System / Calculate**”.

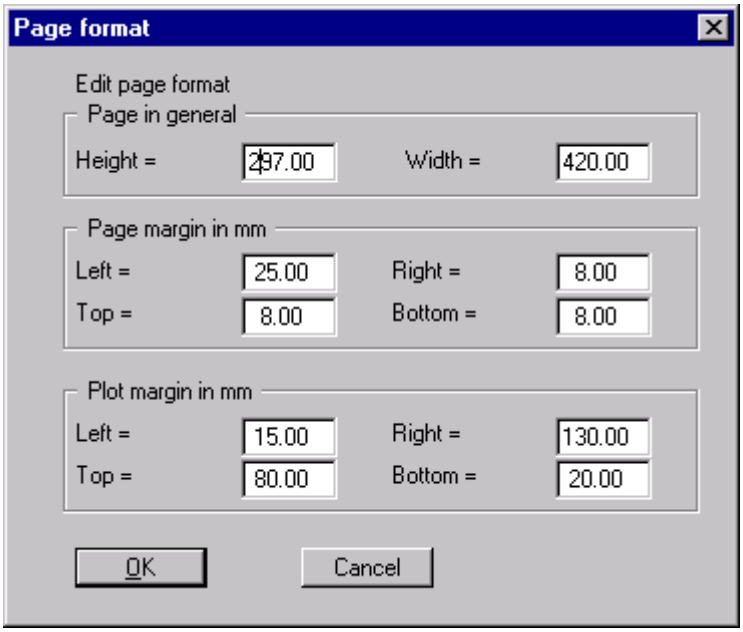



After calculations are complete, you will see information on the results, in several dialog boxes.



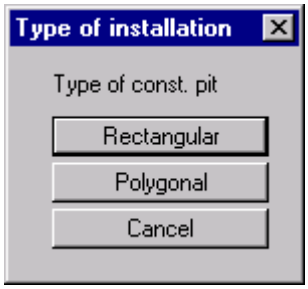




After the system has been calculated, a legend with the results will appear, as well as the input data legend. Additionally, a legend with a system section can be displayed. Position and format these legends according to your wishes (menu options “View / Result legend, etc.) and send the results to your printer (menu option “File / Start”). Save the installation, if wished, to hard drive (menu option “File / Save”). If the construction pit plan is to be presented on a smaller area of the page, select the menu option “Page / Page format”,



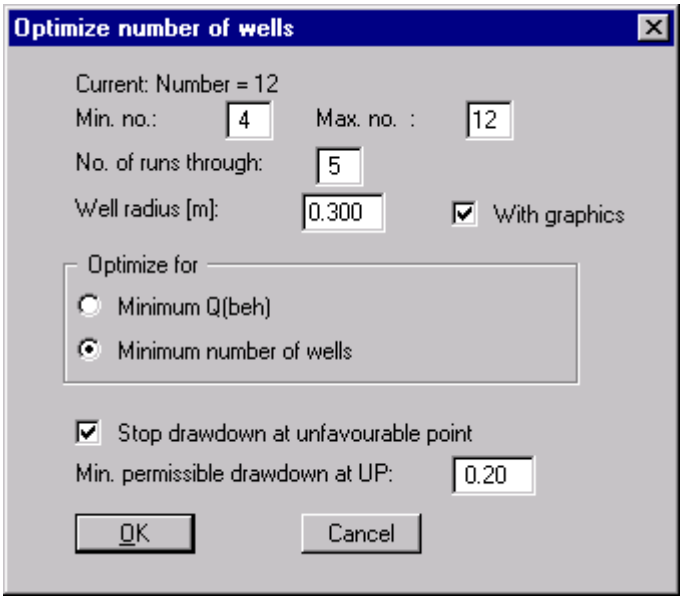

and enlarge the plot margins according to your wishes. It is also possible to set a different page format to A3.

For optimisation of rectangular construction pits, only an even number of wells can be created. Uneven numbers of wells are allowed for polygonal construction pits. For this reason, select the menu option "**File / New**" and

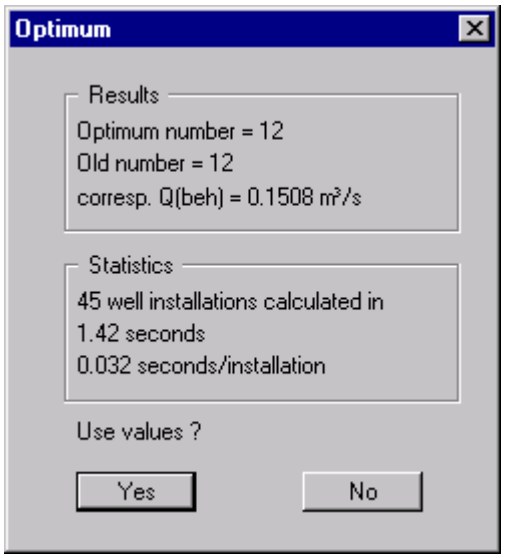



press the "Polygonal" button. Confirm the question


with "Yes". Now select the menu option "System / Optimise" again, and return to the optimisation of the number of wells.

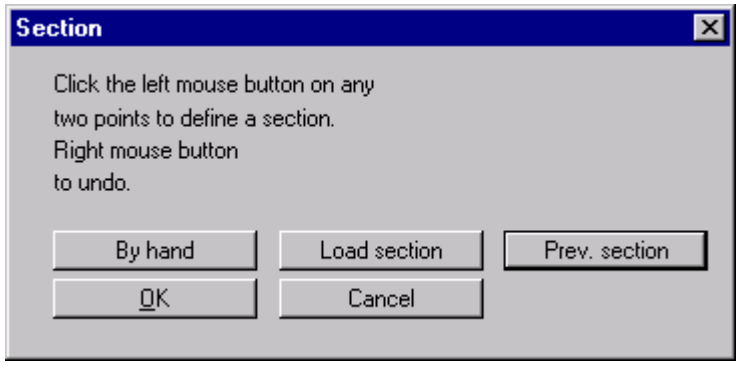



As, generally, there is no long and no broad side to construction pits bordered by polygons , the wells will be distributed around the pit with a constant distance to each other. The result of the optimisation is:

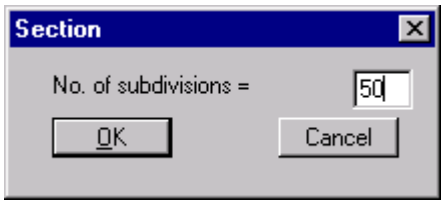



The number of wells has been reduced to “7”. Now the optimised installation must be recalculated. Select the menu option “**System / Calculate**”. The result legend will be displayed again.

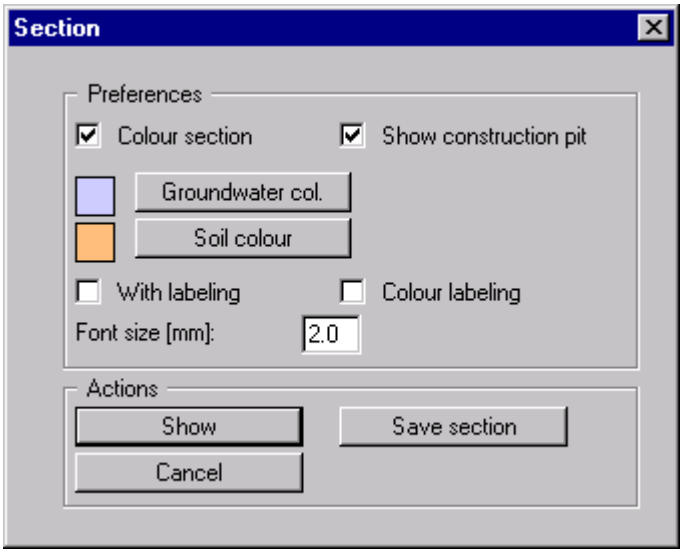
For further evaluation you can use the “Sections / Define straight section” menu option.



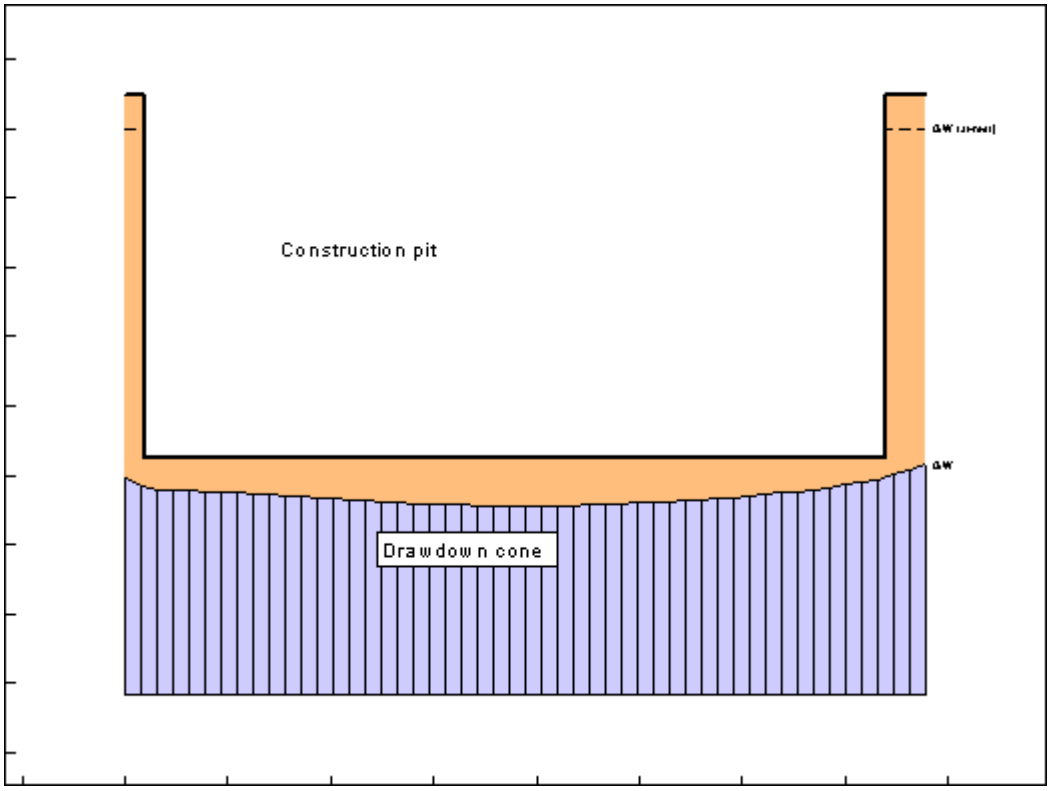

Click, with the left mouse button, on the start and end points of the desired section through the construction pit.




With the number of subdivisions you define the number of points along the line at which the program calculates and displays the drawdown.




Select the “Show” button and



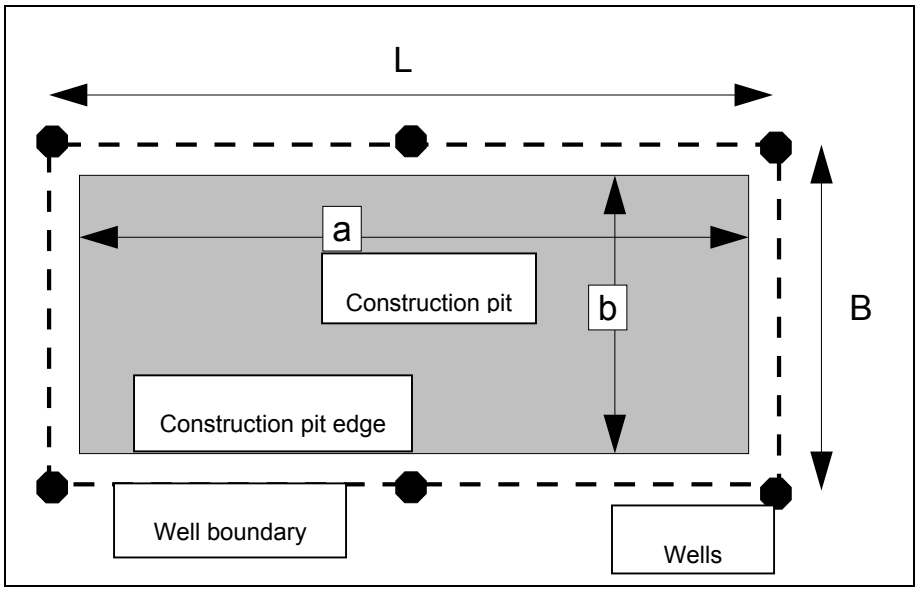

you will see the section through the construction pit. Additionally, a legend will now be shown, with the position of the section in plan.

This short description shows that only a few menu options need be selected for calculation of a multiple well system. All further menu options are mainly for data saving, layout and, if necessary, further evaluation of calculations.

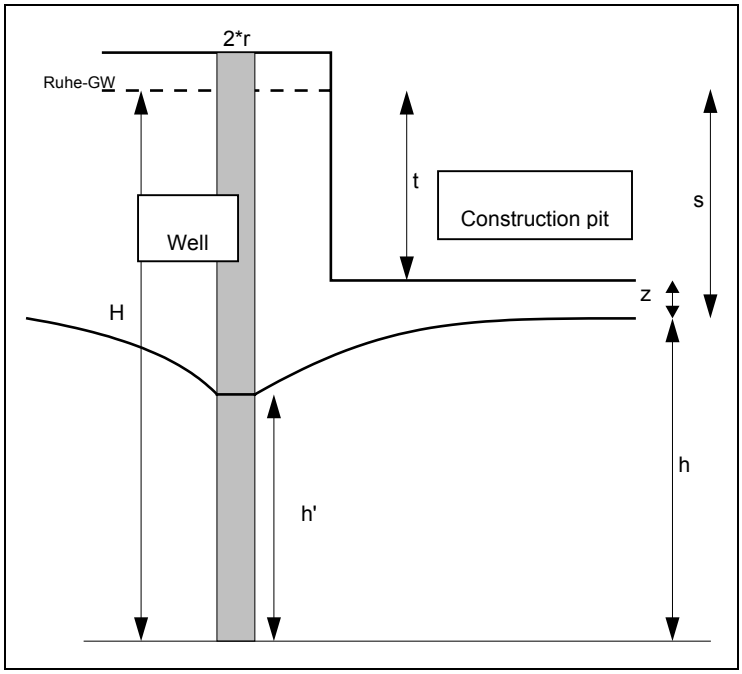
# 4 Theoretical principles

## *4.1 Rectangular construction pits*

The explanation will be for a rectangular construction pit. With reference to construction pits bordered with polygons, only minor deviations result, which will be handled in the following section. The main variables are contained in the following two figures.




**Designations (plan)**




**Designations (section)**

The range R can be defined in three different ways:

a) after Sichardt

$$R = 3000 * s * \sqrt{k} \quad (1a)$$

b) after Kussakin

$$R = 575 * s * \sqrt{k * H} \quad (1b)$$

c) as fixed, which you enter yourself.

For small k-values, small drawdown and large construction pits, a correction of the range R is necessary.

$$R_O = \sqrt{R^2 + A_{RE}^2} \quad (2)$$

($A_{RE}$ = substitute radius, see below)

It is your own decision as to when this correction should be used.

The drawdown value you wish to achieve is given with the values t and z. Together with the permeability k, the area of the construction pit (+ distance of wells from the construction pit edge) and the range R, the total discharge $Q_{max}$ (formula 20 or 93 in HERTH/ ARNDTS) results from this drawdown.

$$Q = \frac{\pi * k * (H^2 - h^2)}{\ln(R) - \ln(A_{RE})} \quad (3)$$

or, for a confined aquifer

$$Q = \frac{\pi * 2 * m * s * k}{\ln(R) - \ln(A_{RE})} \quad (4)$$

(m = thickness of aquifer)

The above two formulas are valid for values of

$$\ln(\frac{R}{A_{RE}}) > 1$$

For values smaller than “1”, instead of the expression

$$\frac{1}{\ln(R) - \ln(A_{RE})}$$

the relationship

$$2 * \frac{A_{RE}}{R} + 0{,}25$$

is used.

The value Q contains possible surcharges for a faster achievement of the drawdown target (after HERTH/ARNDTS generally 10 %) and for possible imperfect wells (after HERTH/ARNDTS generally 10 to 30 %, but see also the critical notes by RIESS in the Grundbautaschenbuch).

The value $A_{RE}$ is the so-called substitute radius. The program contains all known possibilities for calculating the substitute radius.

a) $A_{RE}$ is calculated from

$$A_{RE} = \sqrt{B * L}$$

b) From a suggestion of Weber's, $A_{RE}$ is calculated from

$$A_{RE} = \eta * L$$

(with $\eta = 0{,}2 * L/B + 0.37$)

c) $A_{RE}$ is calculated from L/3 for elongated construction pits, taking into account the drawdown at the centre of a row of wells.

d) $A_{RE}$ is calculated from L/5 for elongated construction pits, taking into account the drawdown at the end of a row of wells.

e) $A_{RE}$ is user-defined

To get an estimation of the necessary number of wells, enter an estimated wetted filter length h'. With this, the capacity of a well q is calculated (formula 77 in HERTH/ARNDTS).

$$q = 2 * \pi * r * h' * \frac{\sqrt{k}}{15} \quad (5)$$

An estimation of the necessary number of wells n results from Q/q. The actual number of wells necessary is achieved with the following detailed installation calculation. The estimated wetted filter length h' therefore has **no** influence on the calculation results.

After predimensioning, you must distribute the wells meaningfully around the construction pit. The calculation proper of the installation then takes place. First, a follow-up calculation of the proposed installation is carried out, to find the most unfavourable spot on the edge of the construction pit (see also HERTH/ARNDTS formula 18).

$$Q = \frac{\pi * k * (H^2 - h^2)}{\ln(R) - \frac{1}{n}\sum \ln(x)} \quad (6)$$

(with x = distance to well n)

or, for a confined aquifer

$$Q = \frac{\pi * 2 * m * s * k}{\ln(R) - \frac{1}{n}\sum \ln(x)} \quad (7)$$

or, for a semi-confined aquifer

$$Q = \frac{\pi * k * [(H^2 - h^2) - (H - m)^2}{\ln(R) - \frac{1}{n}\sum \ln(x)} \quad (8)$$

The program investigates the whole construction pit border in 0.2 m steps and determines from this the unfavourable point (UP). The above 3 formulas are valid for an installation with wells of equal diameter. If varying well radii are present, the expression

$$\frac{1}{n}\sum \ln(x)$$

is to be replaced by

$$\frac{1}{\sum q}\sum \ln(x^q) \quad (8a)$$

In which q is the capacity of the corresponding well.

$$q = 2 * \pi * r * h' * \frac{\sqrt{k}}{15}$$

In the program, to avoid complex iteration, it is assumed that all wells possess the same h'.

The actual water ingress to the construction pit results from formula (6), (7) or (8). From this new, possibly larger $Q_{max}$, together with the selected number of wells, the minimum necessary well capacity (q) results. After this, the program determines the average well separation b‘, and from this the actual wetted filter length of the wells $s_{eb}$ (formula 98 in HERTH/ARNDTS)

$$s_{eb} = h - \sqrt{h^2 - \frac{1{,}5 * q * (\ln(b') - \ln(r)}{\pi * k}}$$

(select the “Wetted filter length after HERTH/ARNDTS” switch) and/or the current capacity of the wells. Alternatively, you have the possibility ("Wetted filter length after HERTH/ARNDTS" not selected) of having the wetted filter length calculated for each well individually. The present wetted filter length then results from the well with the largest drawdown. Which of the two methods for calculation of wetted filter length is the theoretically correct one is disputed. In HERTH/ARNDTS all examples are calculated with the average well separation. In the “Grundbautaschenbuch” (1997) however, RIESS criticises the dimensioning practice of HERTH/ARNDTS and favours the second method.

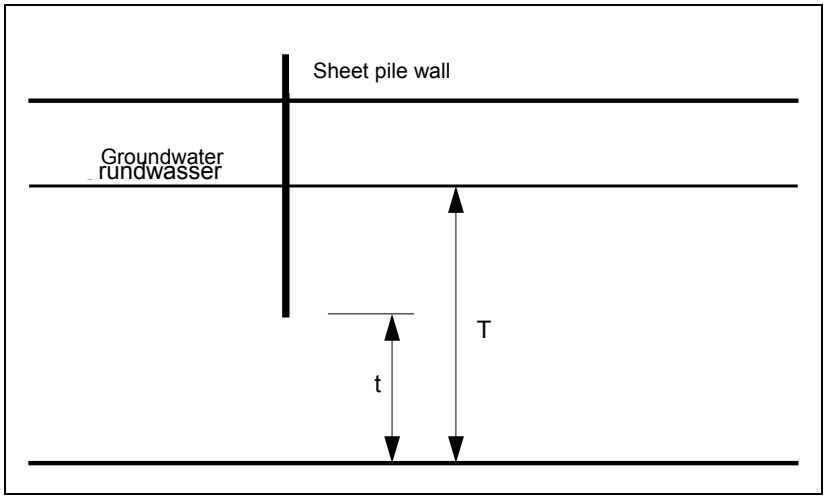
If the calculated wetted filter area is larger than, or equal to, the necessary wetted filter area (the capacity of a well results from this), the installation is sufficiently dimensioned. If this condition is not met, the program issues a warning message with notes on how to proceed further. You have the following possibilities:

- Enlarge well radius
- Enlarge well number
- Enlarge well depth

After successful installation dimensioning, the program calculates the drawdown in the individual wells and the drawdown in the centre of the construction pit or, for a polygonal construction pit, in the pit centroid. As, especially with polygonal pits, this is not the point with the least drawdown, an additional random generator is started, which then searches for the point with the least drawdown within the construction pit.

## *4.2 The influence of sheet pile walls*

The influence of sheet pile walls is taken into consideration via a reduction in water ingress according to HERTH/ARNDTS. The sheet pile wall is always outside of the well group.



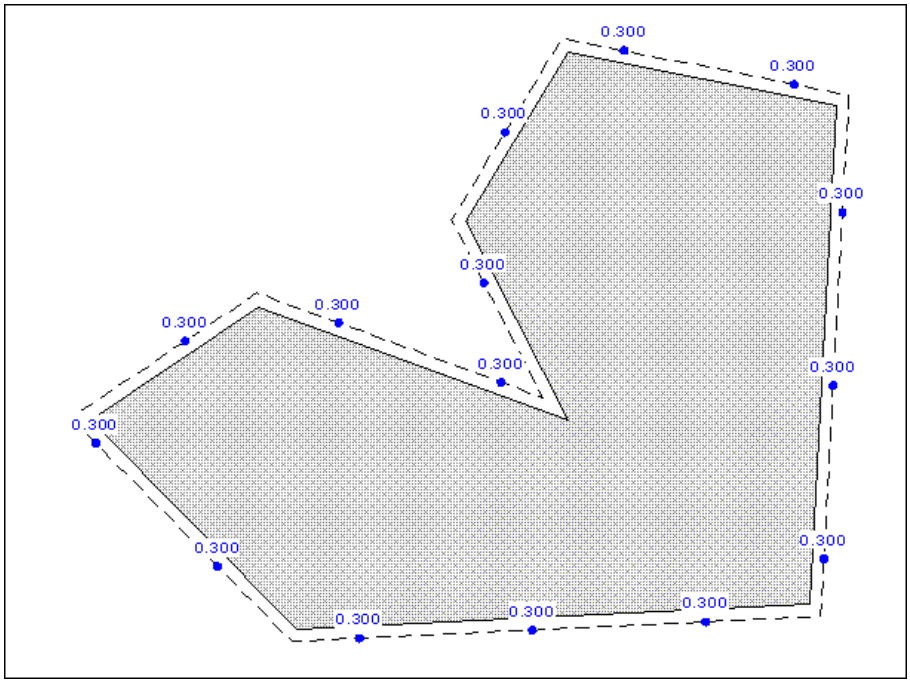

The reduction is dependent upon the ratio of t/T, and is shown in Figure 83 (HERTH/ARNDTS). In the program, you must give the position of the drawndown groundwater level in the area of the sheet pile wall, and define the penetration depth of the wall. Input of drawndown groundwater level is necessary, as the assumption that we have here the at-rest water level, with a small distance of the well from the sheet pile wall, would lead to unrealistically large reductions.

## *4.3 The influence of open water*

After RIESS (Grundbautaschenbuch 1997), for groundwater drawdown next to open water with a leaky base, the double distance from the centre of the construction pit to the water's edge is to be used, instead of the range. For elongated water, running parallel to the construction pit, the influence increases, in which case the single distance is to be used. This is realised in the program by defining the range as a fixed value in the menu option „Edit / Base data“ and then entering this fixed value (simple or double distance to waters edge) in the menu option “System / Calculate”, before starting calculations.

## *4.4 Polygonally bordered construction pits*

The procedure for polygonally bordered construction pits is analogous.




The only difference is in the calculation of the substitute radius. As a length and a breadth cannot always be defined, the only possibility is to define the substitute radius from the area A of the polygon which surrounds the wells (dashed line in the above figure).

$$A_{RE} = \sqrt{A}$$

Alternatively, you can also define a fixed value for $A_{RE}$.

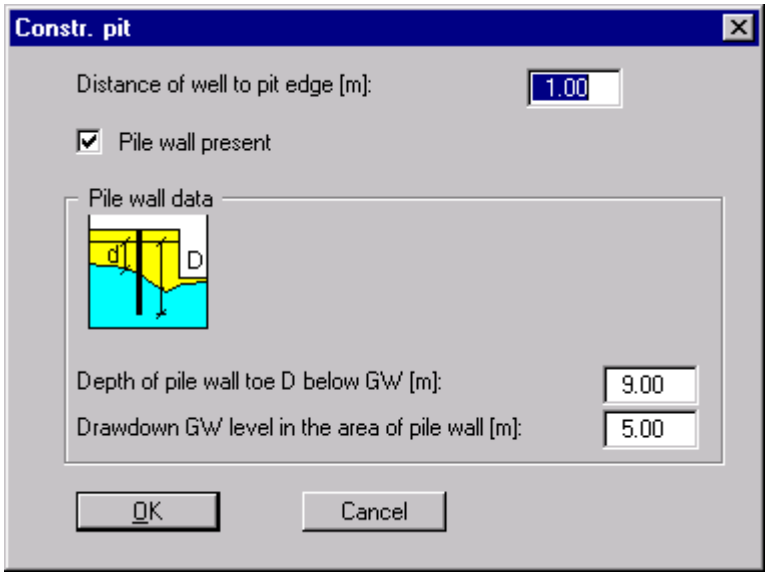
When arranging the wells, they need not be at the well boundary. However, the program always calculates the substitute radius from the area surrounded by the dashed line.

# 5 Program course

## *5.1 General*

After starting the program, an A3 page is shown, on which a construction pit (length = 64 m: width = 24 m) with 20 wells is displayed. The wells are arranged 1m from the construction pit edge.

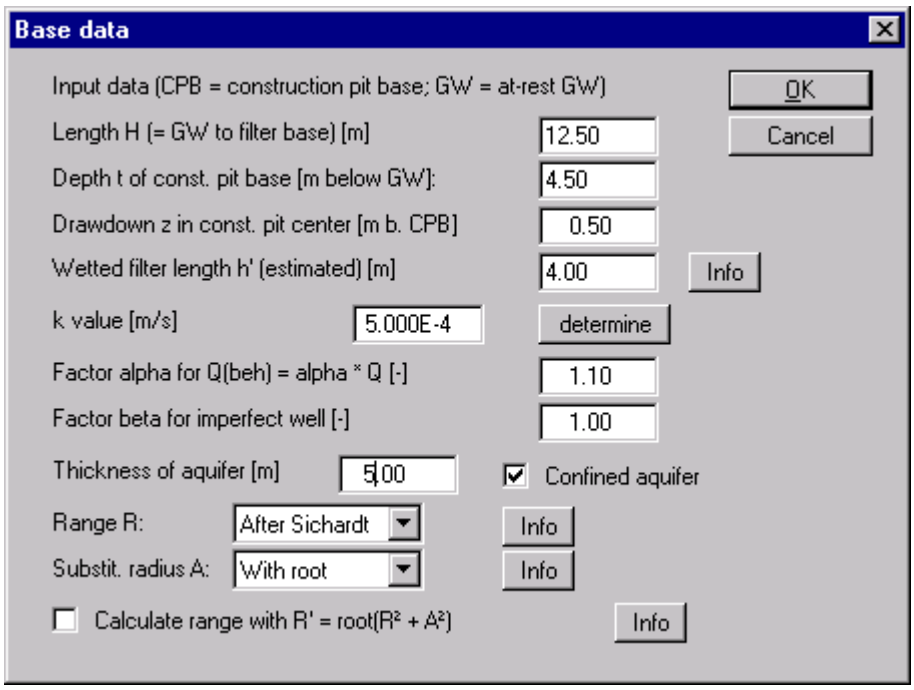
For input of construction pit dimensions, select the menu option “Edit / Construction pit”. You will see the following dialog box:




Enter the length and breadth of the pit, and the distance of the wells from the pit edge. Negative values are also allowed if, e.g., the wells are situated inside the pit. The pit boundaries are displayed on the screen as a continuous line. The program will look for the most „unfavourable point“ along the pit edge, for calculation of the actual discharge. The line upon which the wells theoretically lie runs parallel to the pit edge. This boundary is displayed with a dashed line. The wells need not necessarily be arranged on this line. However, this border will be used for calculation of the substitute radius independently of the actual position of the wells.

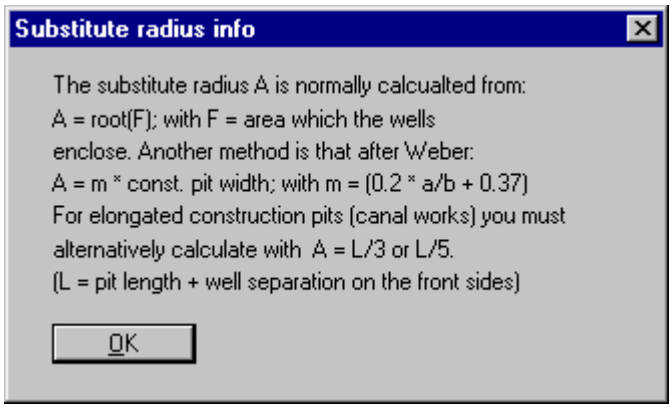
If, after editing the pit length or width, the screen display no longer shows the complete system, select the menu option “Page / Recalculate coordinates”, or press the “F9” key.

For input of system base data and for an estimation of the number of wells n, select the menu option “Edit / Base data”. You will see the following dialog box:



The variables are explained in the figures 1 and 2. Additionally, there are switches for the type of calculation of range, substitute radius, and for the type of aquifer.

With reference to the substitute radius, please see the info, which can be called up in a dialog box.




Further to this, you can select between a confined or an unconfined aquifer. By clicking the „Confined aquifer" switch, you can change to a system with a confined aquifer. When selecting a confined aquifer, you will also be asked for the thickness of the aquifer. The k-value can be determined after Hazen or Beyer. Select the „**determine**" switch to do this.

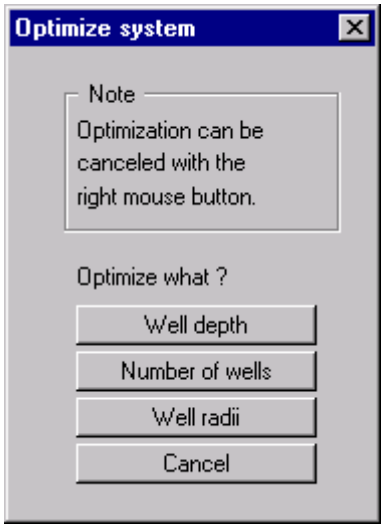
The entries in the dialog box can be edited using the keyboard. You can move on to each further dialog box using the "Tab" key or by clicking the left mouse button in each box. After editing the data, select the „OK" switch. A predimensioning of the necessary number of wells n will then be carried out. This predimensioning is based on the user-estimated wetted filter length h' of the wells. A faulty estimate will not influence the following calculations.

## *5.2 Well arrangement*

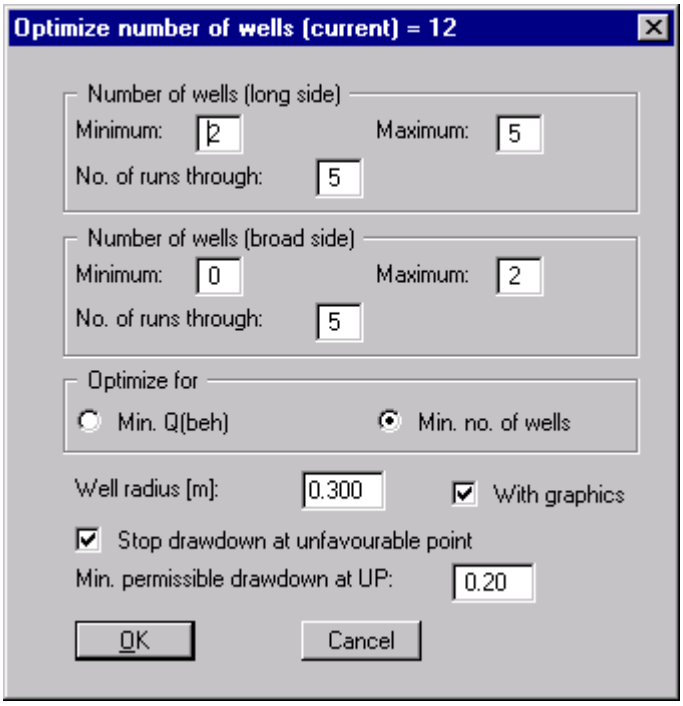
In order to position the wells sensibly around the edge of the pit, four alternative procedures are available.

### 5.2.1 "Method A" Optimise the number of wells

Method A is normally the simplest method for creating an optimum well arrangement. Select the menu option "**System / Optimise**"

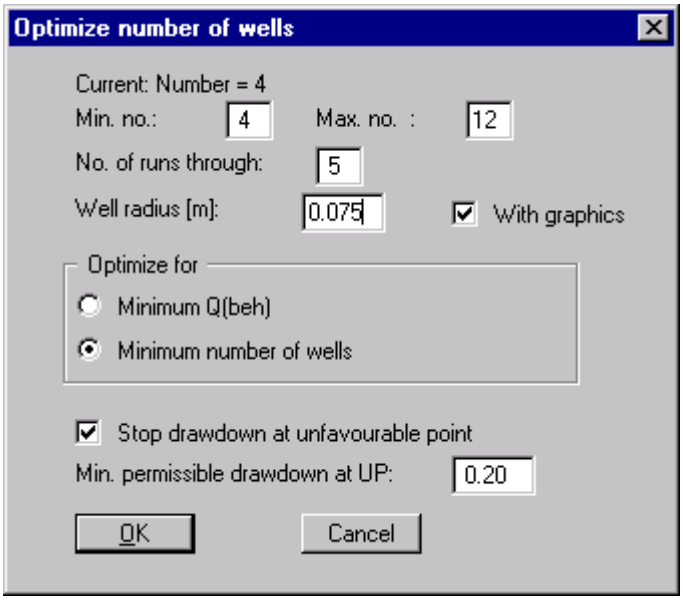



and then press the “Number of wells” button.




Set the minimum and maximum number of wells, on the long and the broad side, to be investigated. With the number after “No. of runs through”, the variation of the position of the first and last well along each edge is controlled. During the optimisation process the current positions of the wells will be displayed as an animation on the screen, allowing you to control your input. Further, select whether or not optimisation is to be carried out for a minimum discharge or for a minimum number of wells. If you activate the „Stop drawdown at unfavourable point” switch, the program will check the given value and refuse all well positions which do not conform with the condition. During the optimisation process, all new wells will be given a uniform diameter, which you must define in the dialog box.

If you are investigating a polygonally bound construction pit, a different dialog box appears:

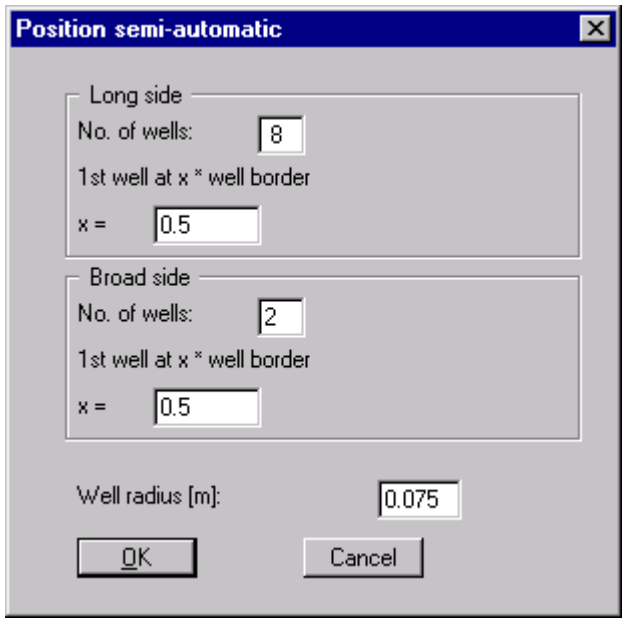



For polygonal pits, a differentiation between long and broad side can no longer be made. The wells will then be distributed with a constant distance to each other. Using "No. of runs through", the position of well no. 1 can be influenced.

If the program finds an optimum, you can decide whether or not to use these results. The optimised system must then be recalculated, in order to refresh the graphics.

### 5.2.2 "Method B" Semi-automatic well determination

Select the menu option "Semi-automatic" from the "Edit" menu item. The following dialog box appears:

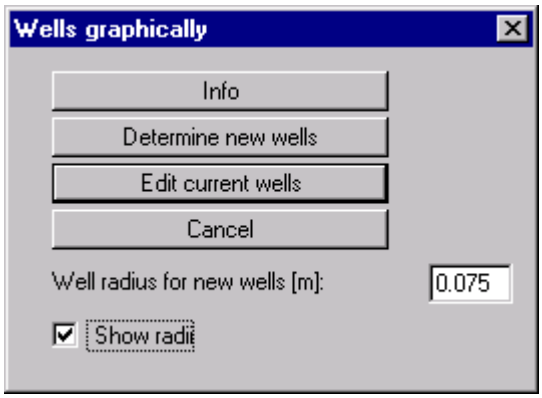



Enter into this dialog box the number of wells on the long and broad side of the pit, and the well radius. Additionally, you can determine the position of the first and last well from each edge as

multiples of the well separation. Then select the “OK” button. The construction pit system and the position of the wells will then be displayed on the screen. If you would like to alter the position of the wells further, select “Semi-automatic” again, or go on to method C.

### 5.2.3 “Method C” Graphic well determination

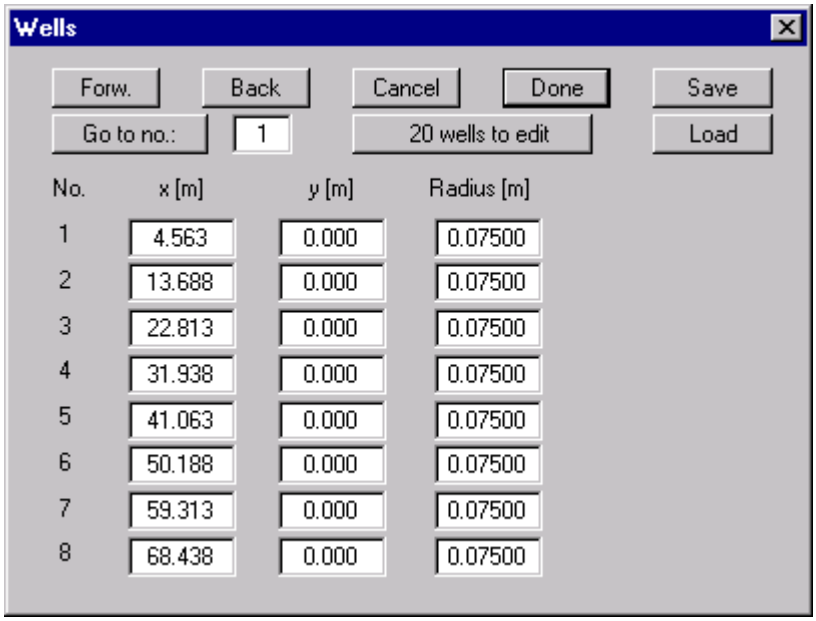
Select the menu option “Well positions (graphically)” from the “Edit” menu item. The following dialog box appears:




Select the „Info“ switch to see information on graphical determination of well positions. If you would like to edit a current well installation, which you may have created using semi-automatic determination, select the „Edit current wells“ switch. If you would like to delete current wells, select the „Determine new wells“ switch. You can then position new wells by clicking the left mouse button or, by clicking the right mouse button, delete current wells. With the „Show radii” switch, the well radii will entered in the graphical display.

### 5.2.4 “Method D” Determining wells by hand

You may also enter well positions in tabular form. For this, use the menu option “Edit / Wells by hand”.



If necessary, edit the number of wells with the „x wells to edit" button. Then enter the values into the table. With the „Forw." and "Back" buttons you can move through the table, if more than eight wells are present.

### *5.3 Result output*

After defining well positions, select the menu option "Calculate" from the "System" menu item. The program will then calculate the installation in accordance with the above described procedure.

At any editing stage of your problem, you can have the current screen contents printed. Select the menu option "Start" from the "File" menu item. A dialog box appears, in which you select the "Printer" button. If necessary, alter the printer alignment in the dialog box from "Portrait" to "Landscape" by clicking on the appropriate button. If you are using a printer which cannot take a complete A3 page, then click on the **"Fit in"** button. This will calculate a reduction factor (zoom factor), ensuring complete page output to the printer. Otherwise, several pages will be printed. After this, select the **„OK"** button, in order to start printer output. You will then get a graphic output of the well installation in submission quality.

As well as the system, several legends are displayed, containing input data, result data, etc. You may position the legends anywhere on the screen and enlarge or reduce their sizes. Further to this, you can also remove the legends completely from the display.

You can achieve result output as a protocol using the menu option „File / Print protocol".

# 6 Explanation of the individual menu items and options

Following, the individual menu items and corresponding menu options will be explained.

### *6.1 Menu item "File"*

#### 6.1.1 Menu option "New"

All input data will be deleted after a security request. After this, you can calculate a new multiple well installation.

#### 6.1.2 Menu option "Load"

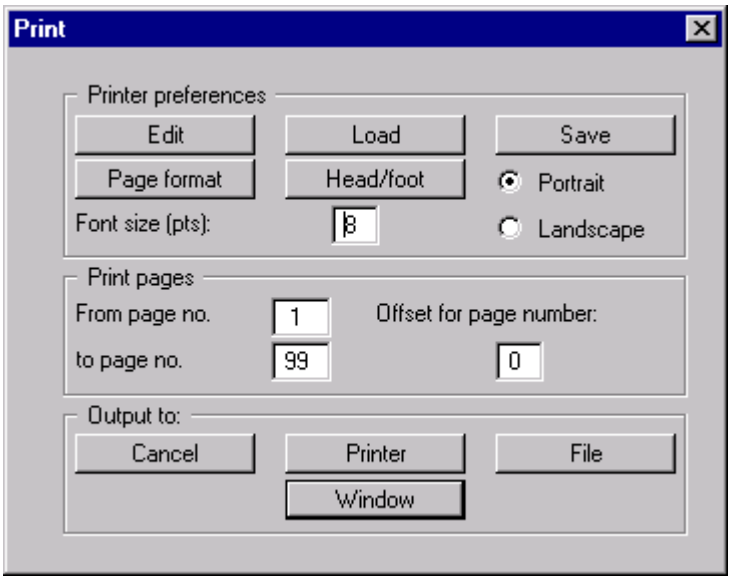
If, at a previous „sitting" at the computer, you have entered data, and saved these as described in the menu option "Save", you can reload them by selecting this menu option. It is then possible to edit these data according to your wishes.

#### 6.1.3 Menu option "Save" and "Save as"

You can save data entered during program use into a file, in order to have them available at a later date, or to archive them. It makes sense to use ".MBR" as file suffix, as this is the suffix used in the file requester for the menu option "Load", for reasons of transparency. If you do not enter a suffix when saving, ".MBR" will be used automatically.

### 6.1.4 Menu option "Protocol output"

You can have a result protocol of the current calculation results sent to the printer or to a file (e.g. for further processing with a word processor). Alternatively, you have the possibility of looking at the results in a separate window where they can also, if necessary, be edited. Output contains all information on the current state of calculations, including system data.



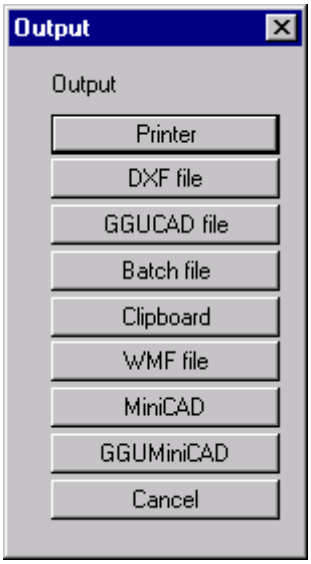

With the „Edit“ button, you can edit the current printer preferences or select a different printer. With the „Save“ button, you can save all preferences from this dialog box in a file, in order to have them available at a later sitting. If you select „MEBRU98.DRK“ as file name and save the file on the program level (default), the file will be automatically loaded at the next program start. With the „Page format“ button you can define, amongst others, the size of the left margin and the number of lines per page. With the „Head/Foot“ button you can enter a head and foot text for each page. If the „#“ sign appears within the text, the current page number will be entered during printing (e.g. ‘Page #’). If page numbering is not to begin at page “1”, an offset can be defined. This offset will be added to the current page number. The text size can be entered in pts. With the buttons at the bottom of the dialog box, output is sent to the “Printer” or to a “File”, the name of which must then be entered. If you select the „Window“ button, the results will displayed in an additional window. In this window editing is possible, as well as loading, saving and printing of text.

### 6.1.5 Menu option “Printer preferences”

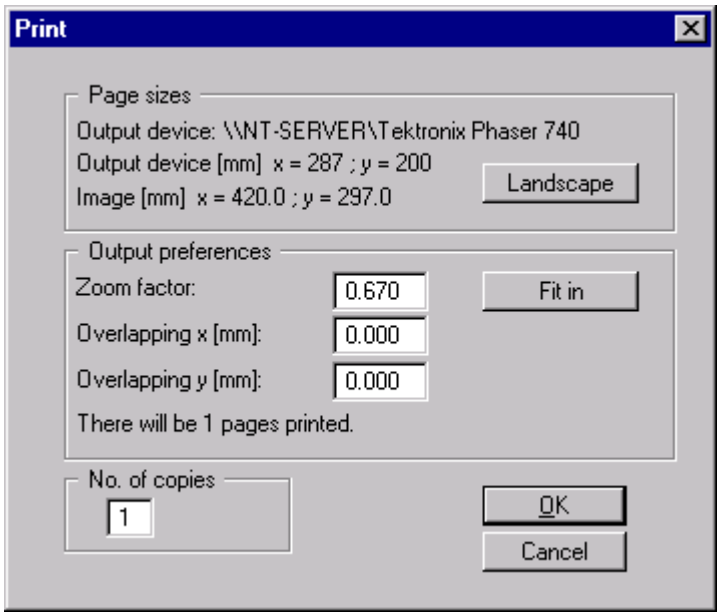
You can edit printer preferences or change printer in accordance with WINDOWS conventions.

### 6.1.6 Menu option “Start”

The following dialog box appears:




**"Printer"**
allows graphic output of the current screen contents to the WINDOWS standard printer or to a different printer, selected in the menu option "Printer preferences". For direct output, the following dialog box appears:




In the upper part of the dialog box, the maximum dimensions which the printer can accept are given. Below this, the dimensions of the image to be printed are given. If the image is larger than the output format of the printer, the image will be printed to several pages (in the above example, 1). In order to be better able to reconnect the image later, the possibility of entering an overlap for each page, in x and y direction, is given. Alternatively, you also have the possibility of selecting a smaller zoom factor, ensuring output to one page. The **„Fit in“** button will automatically calculate this zoom factor. With the „Portrait“ and „Landscape“ buttons you can change the orientation of the page to be printed.

**„AUTO-CAD file / GGUCAD file“**

allows output of the current screen contents to a file, in order to further process the image in a different program (e.g. AUTO-CAD, GGUCAD). AUTO-CAD output is in the so-called DXF format, which is standardised. With reference to the DXF format, please see the note in the menu item „View“, menu option „WINDOWS font”. Bitmap graphics and colour fill will not be exported to AUTO-CAD.

**“Clipboard”**

The current screen contents are copied to the WINDOWS clipboard. From there, they can be imported into other WINDOWS programs for further editing, e.g. into a word processor. The use of the Metafile format guarantees the best possible quality when transferring graphics.

### 6.1.7 Menu option „Quit“

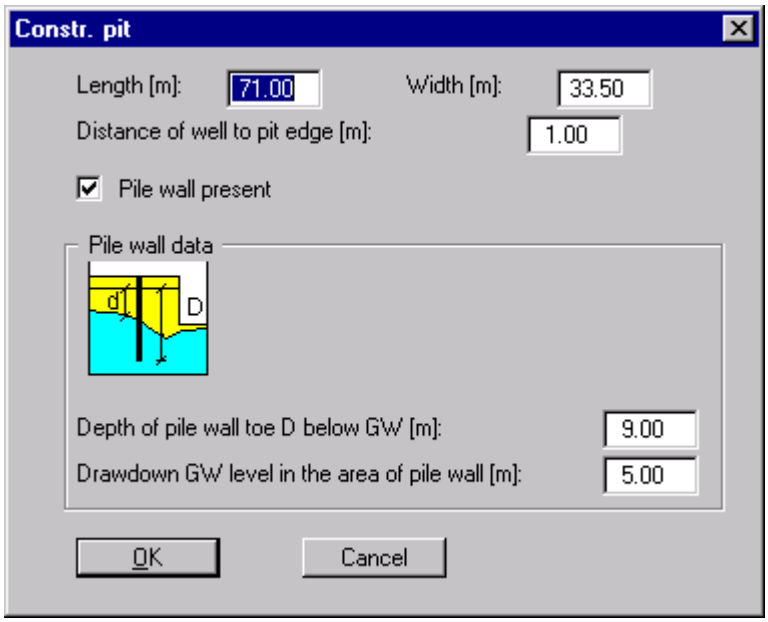
After a safety request, you can quit the program.

## *6.2 Menu item “Edit”*

### 6.2.1 Menu option “Data set designation”

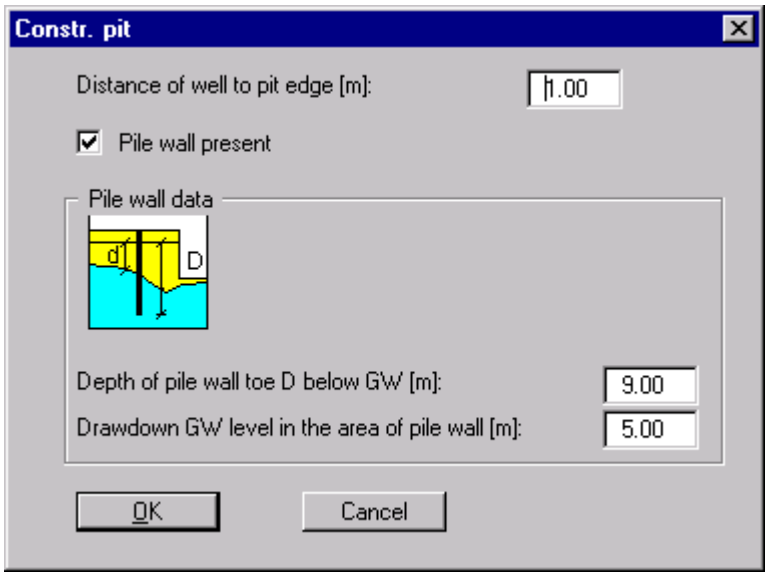

The text entered here appears in the „Results” legend and in the protocol.

### 6.2.2 Menu option “Construction pit”



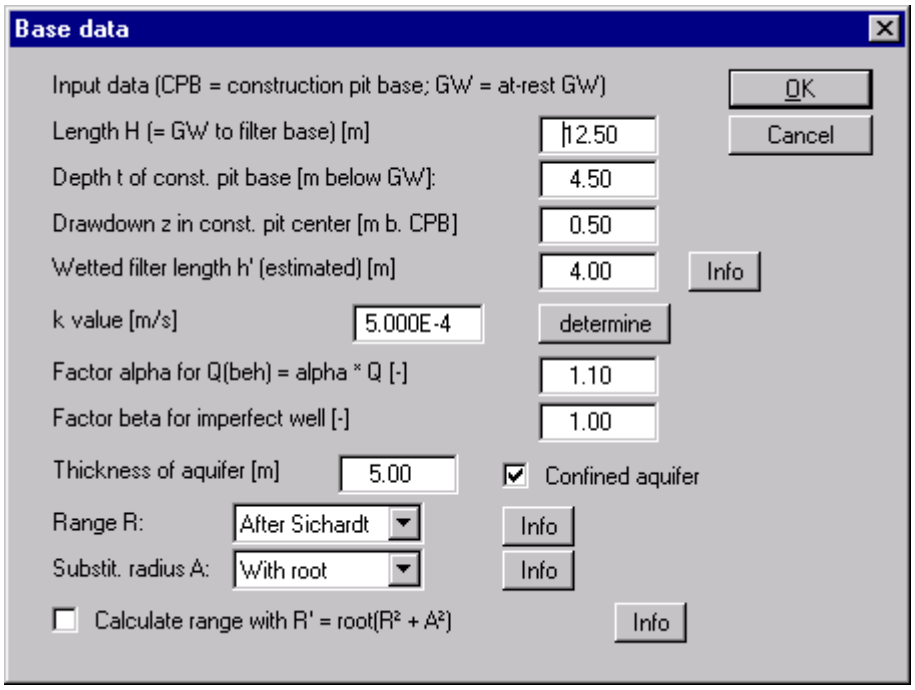

For rectangular construction pits, enter the length and breadth of the pit, and the distance of the wells from the pit edge. Additionally, the influence of any sheet pile walls may be considered. For this, activate the „Pile wall present“ switch and enter the depth of the sheet pile wall and the drawdown water level in the area of the pile wall. With the „Show system section“ menu option, you can get an overview on the position of the sheet pile wall.

For polygonally bounded construction pits, you only enter the distance of the wells from the well boundary. The shape of the construction pit is defined in the menu item „Construction pit polygon”.



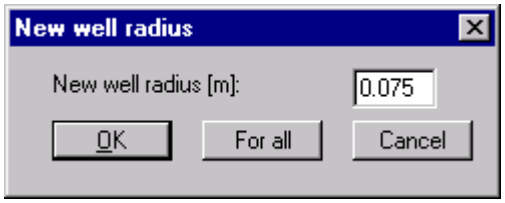
### 6.2.3 Menu option „Base data“

This is the central menu option of the program. Here you can enter almost all base data for the well installation. After clicking on this menu option the following dialog box (as an example) appears:




For an explanation of the input data see Section 4.

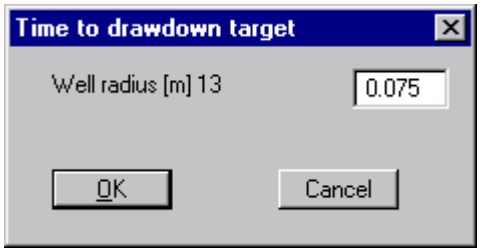
### 6.2.4 Menu option “Well radius”




You can edit the well radii. With the „For all“ button, all wells will be given a new radius. When graphically defining new wells, they will all be given the value defined here.

### 6.2.5 Menu option “Edit well radii”

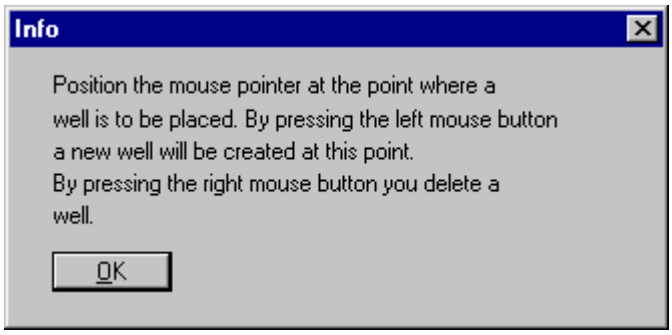

Click on the desired well with the left mouse button.




Enter the new radius.

### 6.2.6 Menu option „Well positions (graphically)“

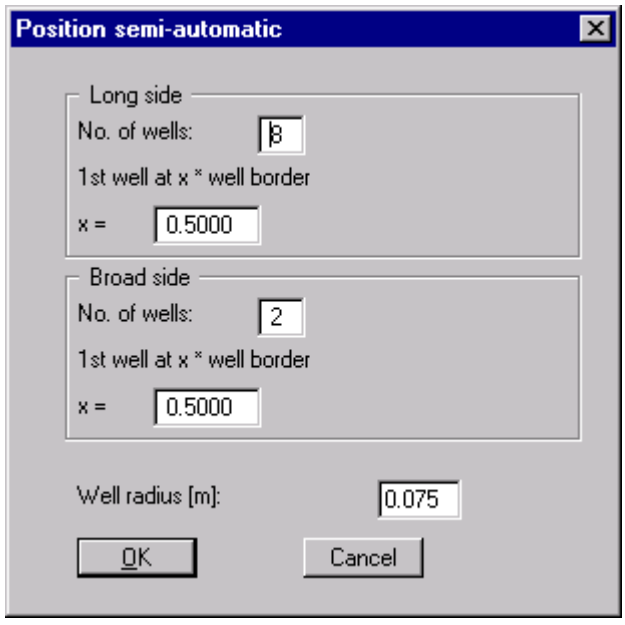
After selecting this menu option you can define well positions with the mouse.




If the screen display no longer shows the complete system, select the menu option “Page / Recalculate coordinates”, or press the “F9” key.

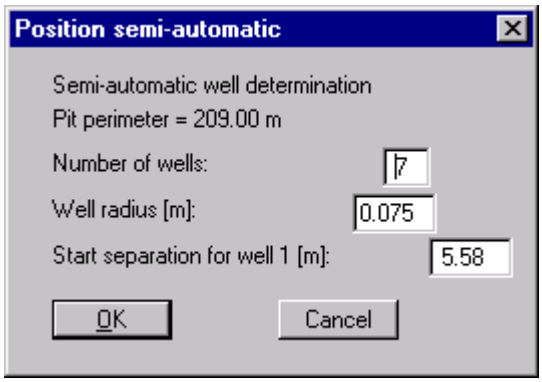
### 6.2.7 Menu option “Semi-automatic”

After selecting this menu option you can define well positions semi-automatically.



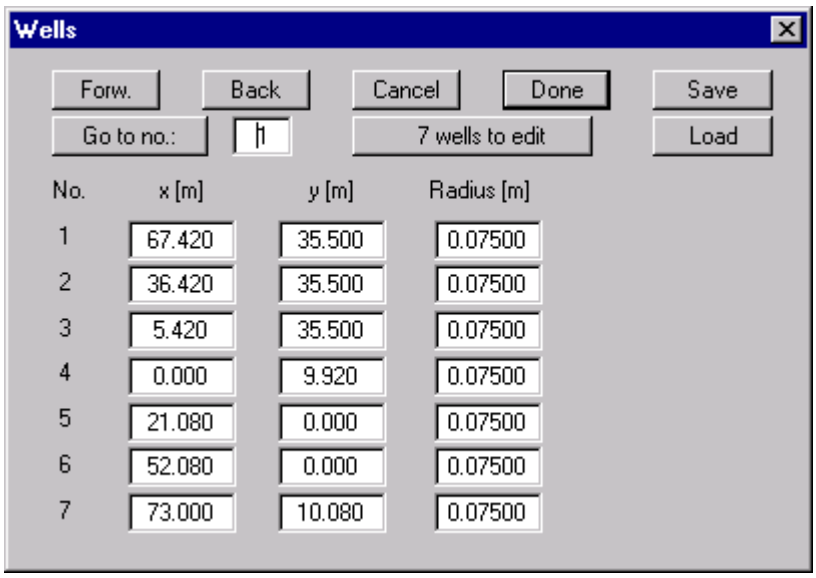
For rectangular construction pits you define the number of wells along the long and the broad side of the pit. With the input after „x =“ you control the separation of the first and last wells.

For polygonally bordered construction pits the dialog box is slightly different.




The defined number of wells will be arranged with equal spacing around the pit. By entering a start distance you can influence the position of the first well.

### 6.2.8 Menu option „By hand“




You can edit the x and y values and the radii of all wells. With the „x wells to edit” button you can redefine the number of wells. If more than eight wells are present you can move through the table with the „Forw.“ and “Back” buttons. You can save a well distribution or load one previously saved.

### 6.2.9 Menu option “Display”

If, after calculation of an installation, the screen presentation shows well drawdown (menu option “Evaluate / Display drawdown”), you can achieve a display with well radii or with numbers using this menu option.

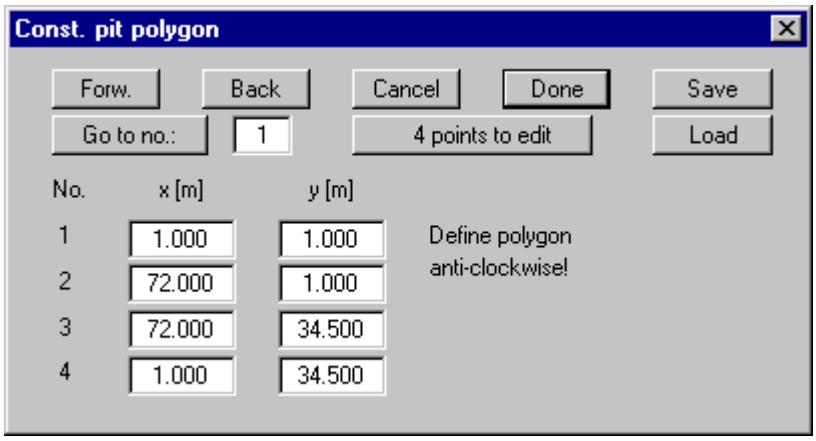
### 6.2.10 Menu option “Show system section”

The menu option „Show system section“ displays the well installation in section. The same graphics can be used as a legend in the plan view (menu option “View / System section”).

## *6.3 Menu item “Construction pit polygon”*

### 6.3.1 Menu option „By hand“

When editing a polygonally bounded construction pit, you can enter x and y coordinates for the polygon course here.

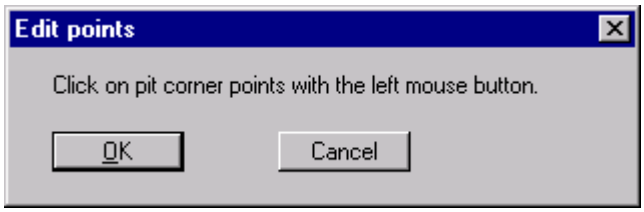



Please remember that the polygon course must be oriented anti-clockwise. With the „x points to edit” button you can redefine the number of points. If more than eight points are present you can move through the table with the „Forw.“ and “Back” buttons. You can save a polygon course or load one previously saved.

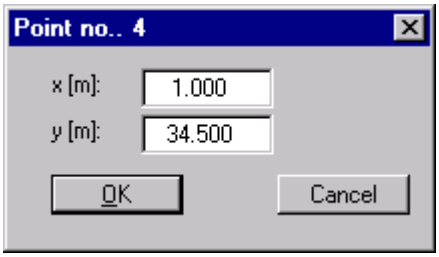
### 6.3.2 Menu option “Move”


Click on the desired polygon point with the left mouse button and move it by holding the left mouse button. An erroneous movement can be undone with the key combination [Alt] and [Back].

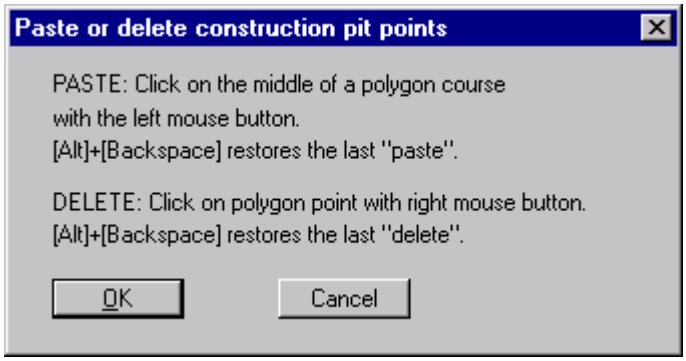
### 6.3.3 Menu option “Edit”




After clicking on a polygon point the coordinates can be edited by hand.

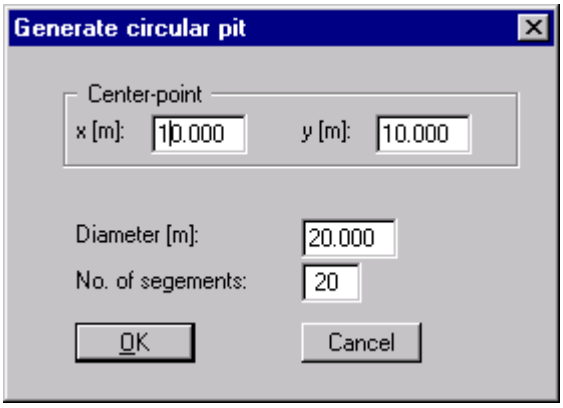



### 6.3.4 Menu option “Paste / Delete”




You may add polygon points or delete current points.

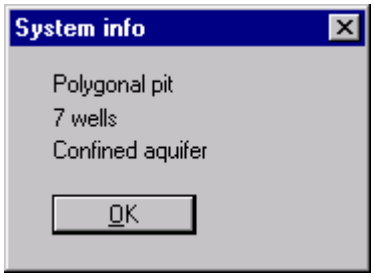
### 6.3.5 Menu option „Create circular construction pit“




You can create a circular construction pit by defining a mid-point and a radius. With „No. of segments“ you define subdivisions for the circle.

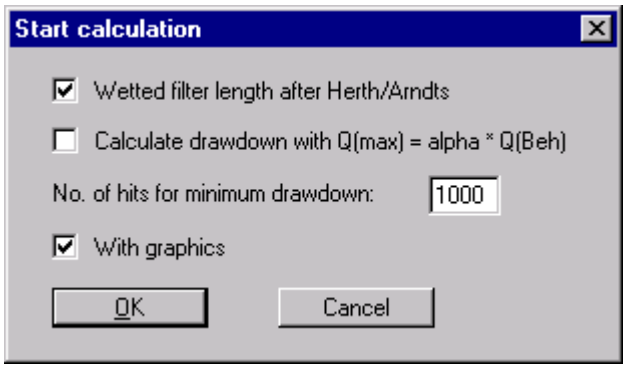
## 6.4 Menu item “System”

### 6.4.1 Menu option “Info”




### 6.4.2 Menu option “Calculate”

With this menu option you can begin calculating the installation. First, a plausibility control of the input data will be carried out. If necessary, you will see an error message, with an appropriate note on corrections. A dialog box then appears:



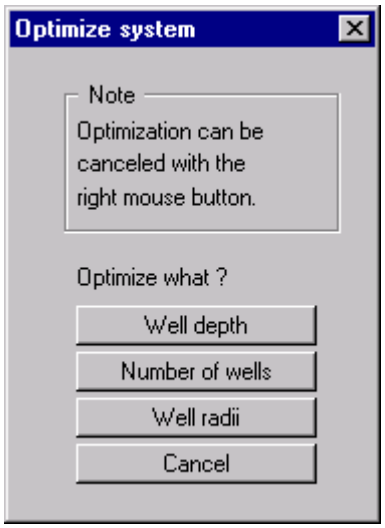

With which you can control the type of calculation of the wetted filter length. Further to this, you can select whether the drawdown, and with this the wetted filter length, is to be calculated with the surcharge alpha, for achievement of the equilibrium state.

Using a random generator, the program searches for the least drawdown within the construction pit. This is almost always at the well edge. But it also makes sense to search inside the pit, especially with polygonal pits and “strange” well installations. With „No. of hits“ you define the number of points to be searched for by the random generator, within the pit.

After selecting the “OK” button, the calculation of the installation takes place. If adequate dimensioning cannot be calculated, error messages will appear, with notes on recalculation.

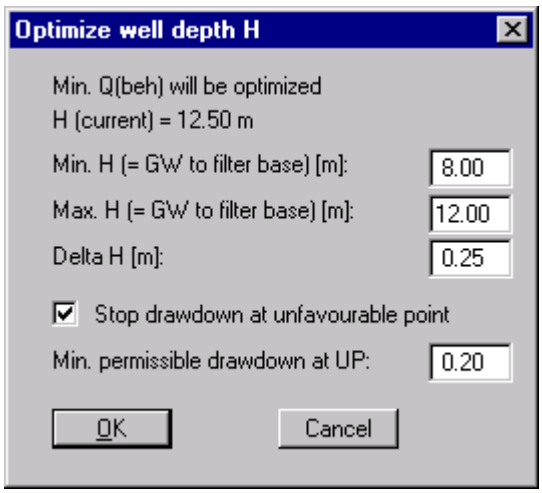
Otherwise, intermediate results will be shown on the screen, which will also appear in the result legend and in the protocol. After successful calculation, the drawdown in the wells and in the centre of the pit or, for rectangular pits, in the centroid, will be displayed graphically on the screen. Additionally, UP designates the unfavourable point.

### 6.4.3 Menu option “Optimise”




The program has optimisation routines for well number, well radius and well depth (H).

**Optimise well depth**



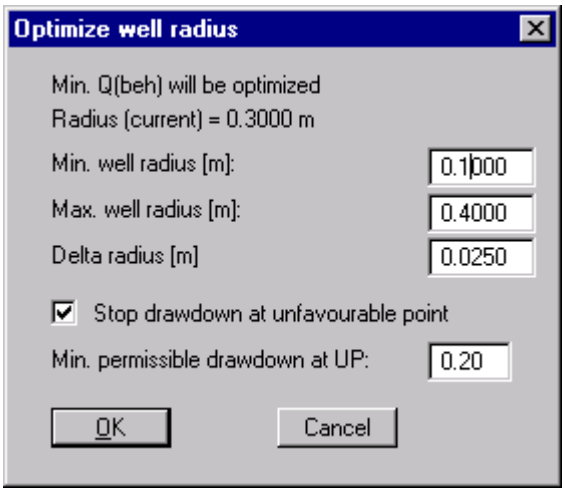

Enter a minimum and a maximum well depth H, between which the program is to vary. With the input for „Delta H“ you define the variation separation. Below this, you can determine whether or not a minimum drawdown at the unfavourable point is to be adhered to. Well depths which do not keep this condition when this switch is activated will not be accepted. After calculations are complete you will be shown the results.

Please remember that for well depth optimisation, no increase in the factor for the influence of an imperfect well will be carried out. After calculations are complete you should check this condition for yourself or, at the start of the optimisation process, define a large enough factor to take the influence of an imperfect well into consideration.

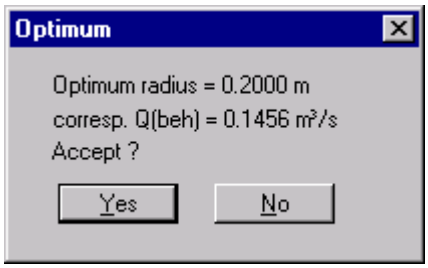
**Optimise the number of wells**

The procedure for optimisation of well numbers has been explained fully in the example (Section 4). Please refer to this section.

**Optimise well radii**

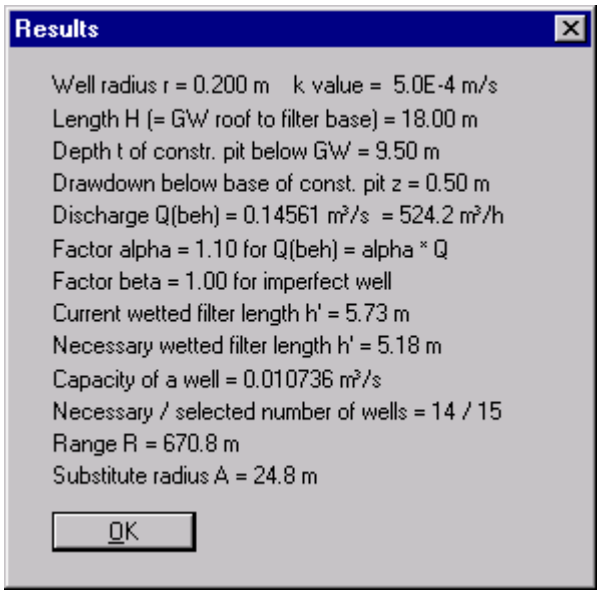



The optimisation of well radii is in complete analogy to the optimisation of well depth.

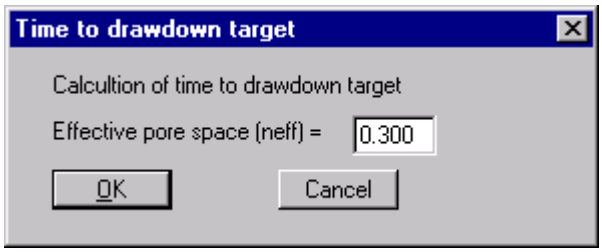



### 6.4.4 Menu option “Results”

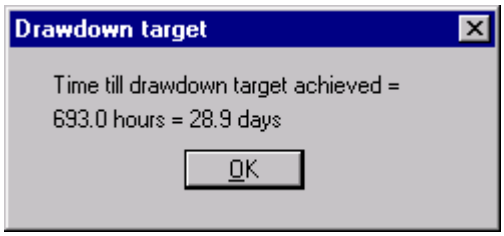
The calculation results are recapitulated in a dialog box.



### 6.4.5 Menu option “Time”

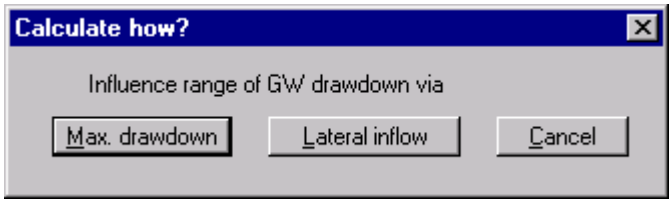



After input of effective pore space and confirmation with “OK” the time to drawdown target is calculated.



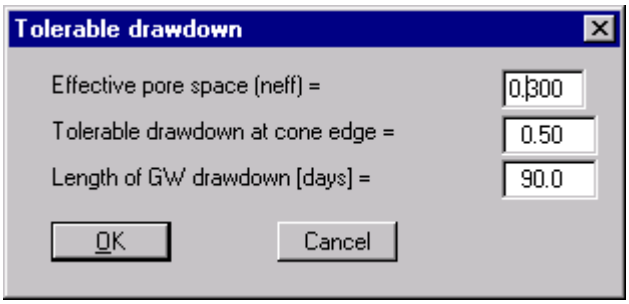

### 6.4.6 Menu option „Influence area“

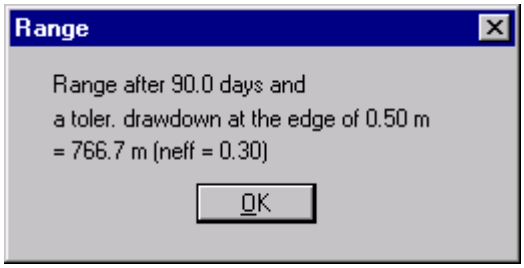
Using this menu option the drawdown range, as a function of drawdown time (days), is calculated.



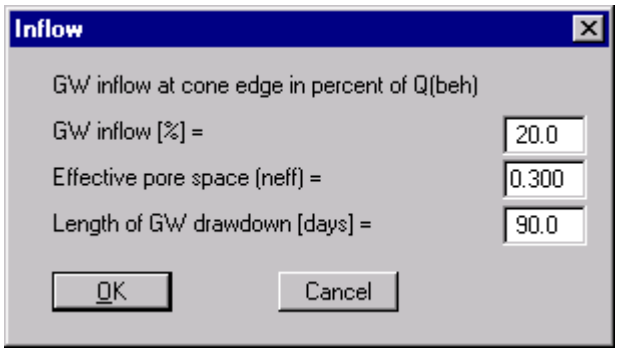

You can choose from two calculation methods. The effective pore space and the time must be given for both calculation types. The differences are as follows:

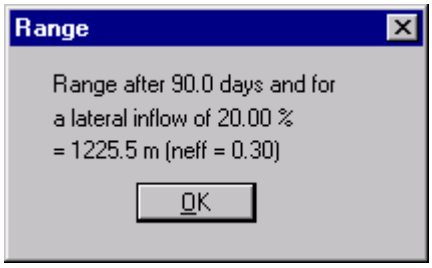
- Max. drawdown: Influence area as a function of the tolerable drawdown at the cone edge.






- Lateral inflow: Influence area as a function of groundwater ingress at the cone edge in [%] of $Q_{beh}$.




## *6.5 Menu item "Evaluation"*

### 6.5.1 Menu option "Display drawdown"

If the graphic display on the screen shows well numbers, you can achieve a presentation of well drawdown using this menu option. Select the type of drawdown.


### 6.5.2 Menu option "Calculate individually"

After calculation of the installation you can have any drawdown calculated, inside or outside of the construction pit. You need simply to click with the left mouse on the point for which you would like to calculate a drawdown. The drawdown will then be displayed on the screen. If the screen section is too small to display a drawdown outside of the pit, select the menu option "Page /

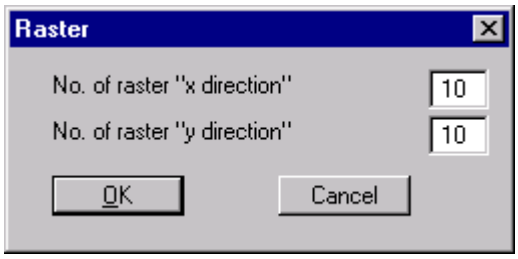
Coordinates by hand" and change the values to those wished for (see also further below). Drawdown above the base of the construction pit will be displayed as negative.

### 6.5.3 Menu option „Along a line“

This menu option supports calculation of drawdown along a user-defined line. The line is to be defined using the mouse. Two points must be given by clicking with the left mouse button. The user then enters the number of line subdivisions and with this, the number of drawdown points. If you use the menu option „Automatic“ after calculation, a drawdown cone will be displayed.

### 6.5.4 Menu option „In raster“

After calculation of the installation you can have any drawdown calculated, inside or outside of the construction pit. The difference to the previous menu option is that the four corners of a quadrilateral must be defined, instead of the end points of a line. After clicking on the fourth point with the left mouse button, you must enter the number of subdivisions for the "long" and the "broad" side.




After using the „OK“ button the drawdown at the raster points is calculated and then displayed.

### 6.5.5 Menu option "Save / Load"

You can save the x and y values for a freely defined drawdown in a file, in order to have these coordinates available at a later sitting.

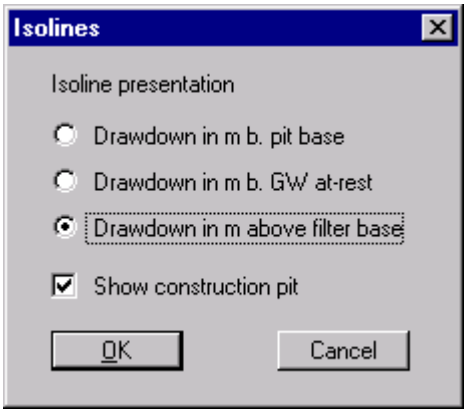
### 6.5.6 Menu option "Delete"

All freely defined drawdowns will be deleted.

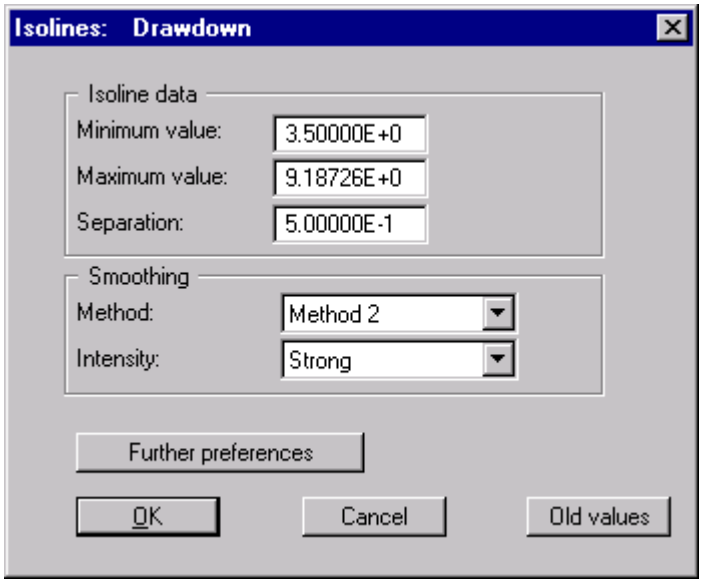
### 6.5.7 Menu option „Normal isolines“

The program carries out a triangulation with all calculated drawdowns and creates from this an interpolation grid, which then forms the basis for the isoline presentation. If you have not yet calculated any individual drawdown, you can do this using, e.g. the menu option "In raster".

First, enter the type of drawdown:




The triangulation then follows, which may take several seconds for a large number of points, and/or with a slow PC. The following dialog box appears:




The program supports two smoothing out procedures:

- Method 1 „strict“ Bezier spline
- Method 2 „loose“ Bezier spline

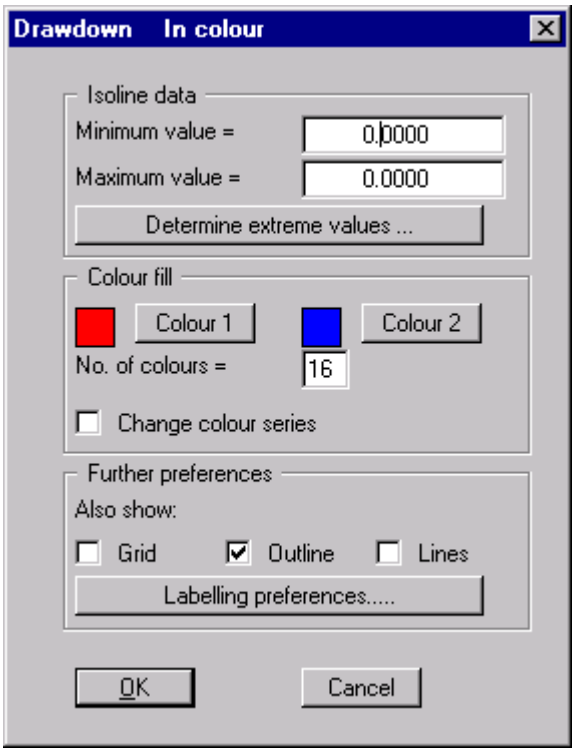
The expressions Minimum and Maximum values describe the boundaries of the drawdown to be presented. The expression separation describes the separation of two consecutive isolines.

With the „Further preferences“ switch, presentation parameters such as system boundaries, triangular grid, isoline labelling, font size, etc., can be determined. The handling of the dialog window is self-explanatory.

After pressing „OK“ the isoline graphics will be displayed on the screen.

### 6.5.8 Menu option „Coloured“

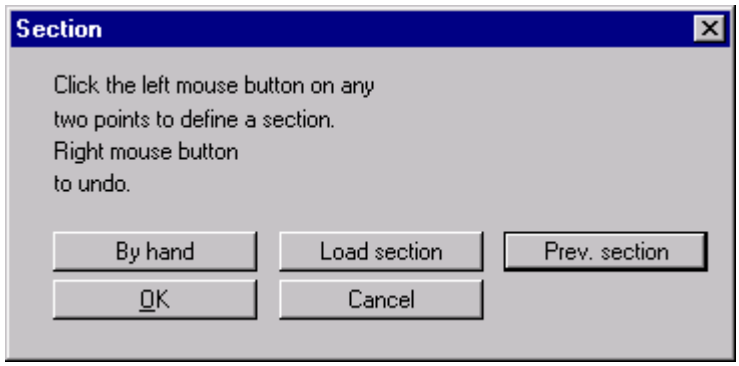
In analogy to the previous menu option, colour filled isolines can also be created. After selecting the type of drawdown the following dialog box appears:



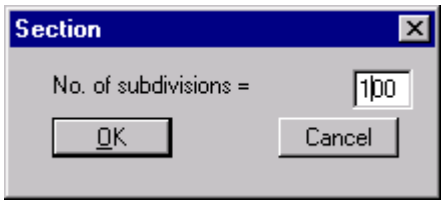

With the „Determine extreme values“ button, the minimum and maximum drawdown are calculated and entered into the corresponding input boxes. However, you need not keep these values, but may enter your own. The colour subdivision is controlled via the number of colours. In the above example 16 colour steps, between **„Colour 1“** and **„Colour 2“** have been selected. The default course runs from red to blue. These colours can be edited as wished after selecting the buttons „Colour 1“ and/or „Colour 2“. After confirming with **„OK“** the isolines will be displayed. A colour bar at the right screen edge serves to help in allocation of a colour to a particular drawdown value. If this bar is drawn into the right page margin then select a larger „Right plot margin“ from the menu item “Page”, menu option “Page format” (see 5.6.4).

## *6.6 Menu item “Sections”*

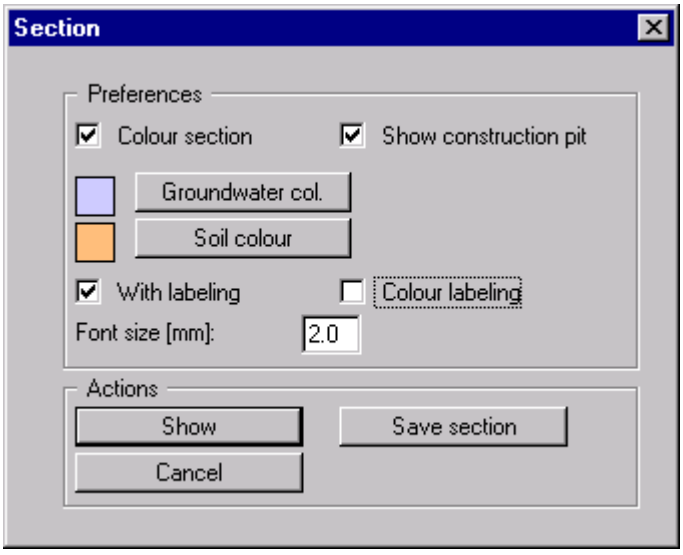
### 6.6.1 Menu option „Define „straight“ section“



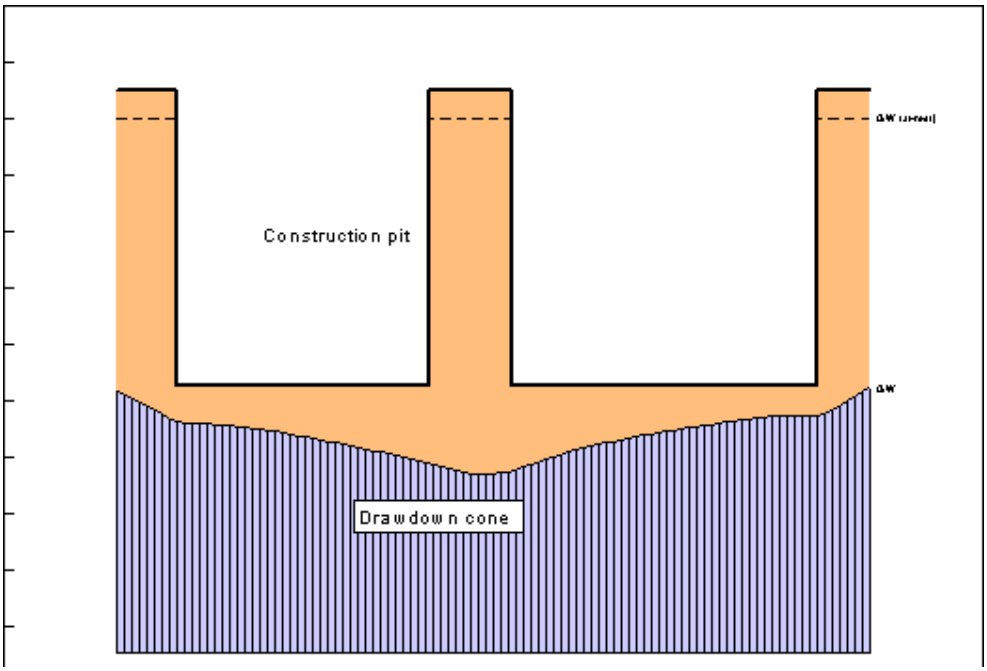
Click, with the left mouse button, on the start and end points of the desired section through the construction pit, or define the two points “by hand”.




With the number of subdivisions you define the number of points along the line at which the program calculates and displays the drawdown.

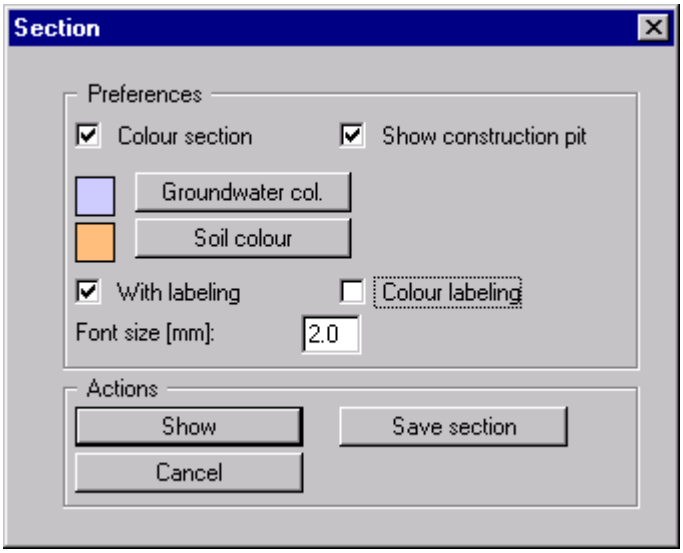



Select the “Display” button and:



you will see the section through the construction pit. Additionally, a legend will now be shown, with the position of the section in plan.

### 6.6.2 Menu option „„straight“ section preferences“




You can edit the default settings for the “straight section”. In this way an additional labelling of drawdown, e.g., can be created at the lower edge of the image.

### 6.6.3 Menu option „See“

The section course will be shown in plan. Is not really necessary, as this presentation is already in a separate legend in the graphics.

### 6.6.4 Menu option „Define „any“ section“

You can present any kind of drawdown cone with the GGU-MULTIWELL program. Using this menu option you can amalgamate calculated drawdowns to a single section by clicking on the drawdowns in the desired sequence with the left mouse button. Clicking with the right mouse button deletes the last selected drawdown from the section course. When the section is according to your wishes, select the menu option “Display”. The drawdown for the selected section will then be displayed.

### 6.6.5 Menu option „Define automatically“

Instead of amalgamating individual drawdowns by hand to a section, you can have a section course defined automatically with this menu option. The section will be defined according to the sequence of definition of the drawdowns. You can then have the drawdown presented in section using the “Display” menu option.

### 6.6.6 Menu option „See“

The section course will be shown in plan. Is not really necessary, as this presentation is already in a separate legend in the graphics.

### 6.6.7 Menu option „Display“

The selected drawdowns will be displayed in section. Additionally, a legend will be displayed in which the position of the section course in plan can be seen.

## *6.7 Menu item “View”*

### 6.7.1 Menu option “Refresh”

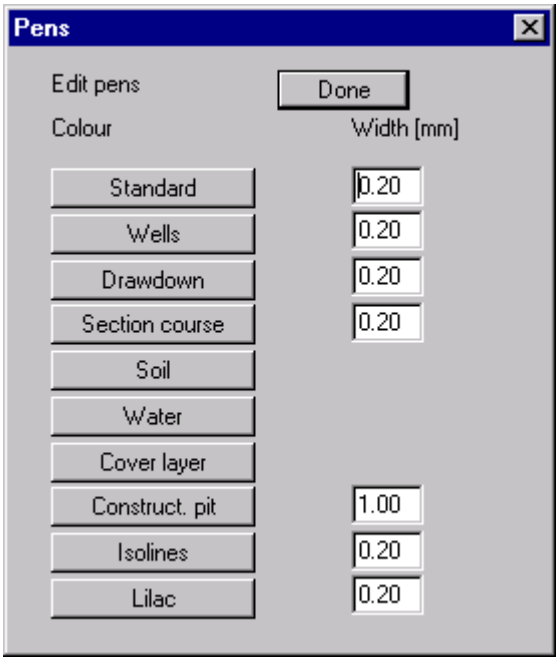
If, e.g., after using the zoom function (see below), only part of the image is visible, you can achieve an overview using this menu option. The zoom factor may be pre-set. It is much simpler, however, to get a complete overview (zoom factor = 1.0) using the [Esc] key. With the [F2] key you can refresh the screen without altering the zoom factor.

### 6.7.2 Menu option “Zoom”

You will see information on the zoom function.

### 6.7.3 Menu option “Pens”

You can adjust the colour presentation to suit your wishes.




### 6.7.4 Menu option “WINDOWS font”

For output to the screen or to an output device the program uses the WINDOWS specific true-type fonts, which guarantee an excellent presentation layout. In certain cases, however, it may be desirable to switch to a vector font. The vector font STANDARD.STZ is delivered with the program. You can switch to this font by clicking on this menu option. Clicking again switches back to the WINDOWS font. It is useful to switch to the vector font STANDARD.STZ if you would like to create an AUTO-CAD (DXF format) file of your image (see also menu option “File / Start”), as AUTO-CAD does not support WINDOWS fonts, and the file will then contain lines only.

### 6.7.5 Menu option “Mini-CAD and CAD for header data”

With these two menu options you can add free text to your graphics or equip them with additional lines, rectangles and bitmaps. For details please see the supplied “Mini-CAD” manual. The same dialog box appears for both menu options, the functions of which are explained in the „Mini-CAD” manual. There are the following differences between “Mini-CAD and CAD for header data”

- Drawing elements created with Mini-CAD are with reference to the coordinate system of the well installation, and will be displayed accordingly. This menu option should therefore always be selected when you wish to enter additional information in the area of the well installation (e.g. position of structures). All information in these Mini-CAD data will be saved with the file and reloaded with the next file opening.
- Drawing elements created with CAD for header data are with reference to the page format (in [mm]). They therefore always remain at the same position on the page, regardless of the coordinates of the well installation. You should always use this menu option when entering general information (e.g. company logo, report number, attachment number, stamp). When you save these so-called header data (see Mini-CAD manual), they can be reloaded into a completely different system (with different system coordinates). The thus saved header data will once again be at the same position on the page. This much simplifies creation and management of general page information.

### 6.7.6 Menu option “Font”

With this menu option you can switch to a different true-type font. All available true-type fonts are displayed in the dialog box.

### 6.7.7 Menu option „Status and symbol bar“

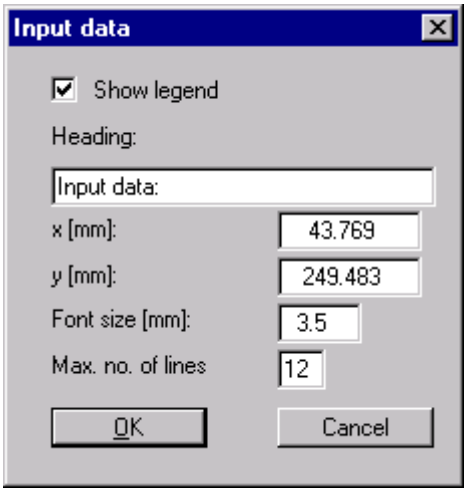
After program start-up a symbol bar appears at the top of the program window.

By clicking on these symbols (Smarticons) you can directly reach most of the program functions. If you would rather work with a pop-up window than with a horizontal bar, you can carry out the necessary alterations using this menu option. You can also switch off the symbol bar. The preferences will be saved, amongst others, in the “MEBRU98.ALG” file (see menu option “Save preferences”), and will be active at the next program start.

For Windows 95 and NT, the meaning of the symbols appears if you hold the mouse over the symbol for a moment.

### 6.7.8 Menu option „Input data legend“

After selecting this menu option a dialog box appears, allowing you to set preferences for a legend containing the most important input data.



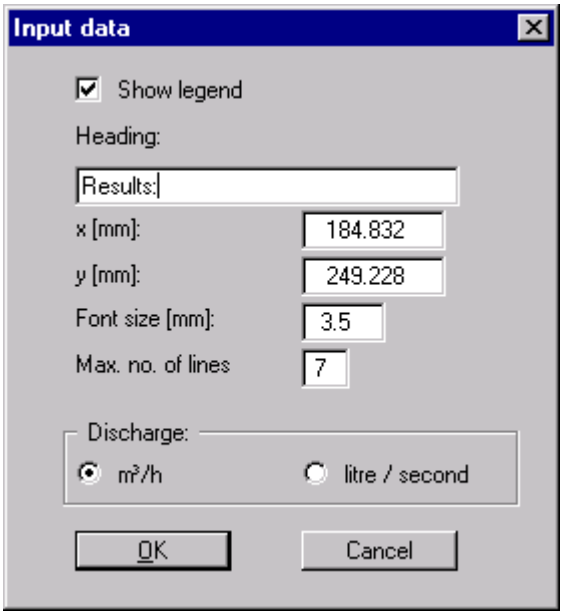

With the values for

- x value
- y value

you can alter the legend position. This is more simple using the mouse and the menu option „View / Move legends“. If you deactivate the „Show legend“ switch, the legend will not be displayed. With „Max. no. of lines” you can define the number of lines to be entered below each other. If necessary, presentation will be in several columns.

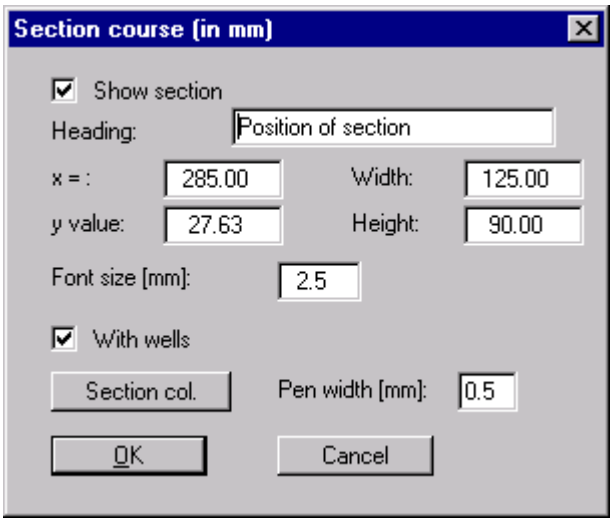
### 6.7.9 Menu option „Result data“

Handling is completely analogous to “Input data legend”.




Additionally, the discharge dimension can be selected.

### 6.7.10 Menu option „Section course“



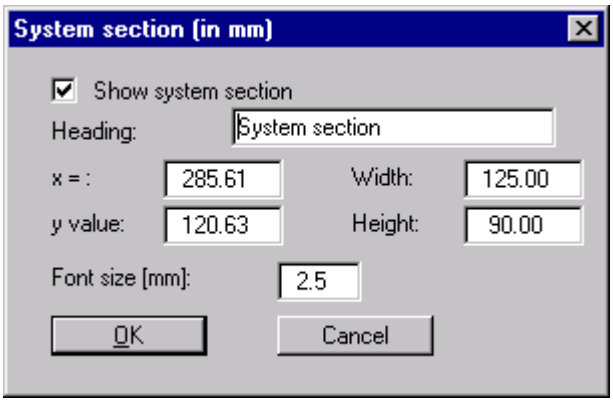

If a section course is displayed on the screen, this legend will be additionally displayed, with the position of the course in plan. With the values for

- x value
- y value

you can alter the legend position. Using the values for width and height you can determine the size of the legend. The other functions of the dialog box are self-explanatory.

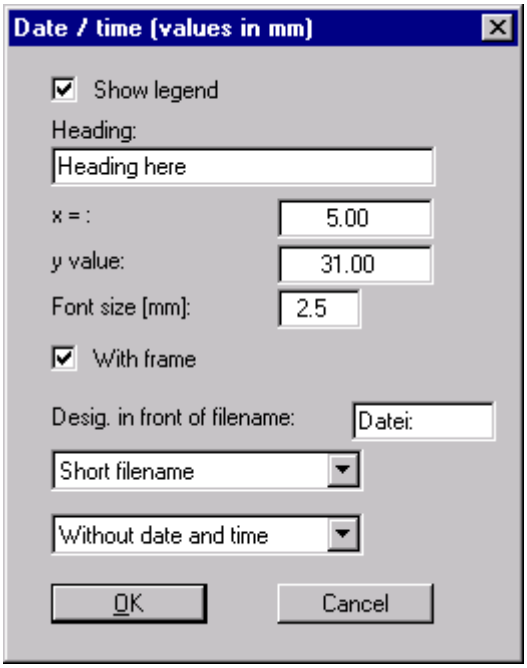
### 6.7.11 Menu option „System section“

You can have a legend containing a system section presented in the graphics. The shape and appearance of the legend can be edited.




### 6.7.12 Menu option „File name,…“

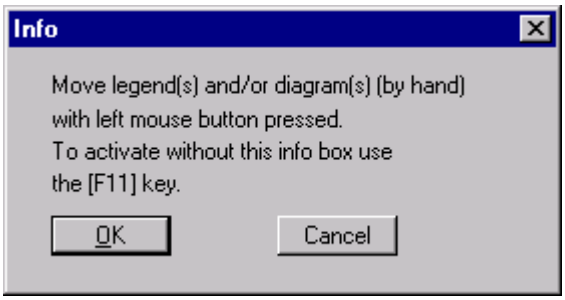
You can have a legend containing the file name, date and time presented in the graphics. The shape and appearance of the legend can be edited.




### 6.7.13 Menu option “Load preferences”

You can load a file into the program, which was saved using the previous menu option. Only the corresponding data will be refreshed.

### 6.7.14 Menu option “Move legends”




### 6.7.15 Menu option “Save / Load preferences”

All data entered with the three previous menu options can be saved to a file. If you select MEBRU98.ALG as file name, and save the file on the same level as the program, the data will be automatically loaded at the next program start and need not be entered again.

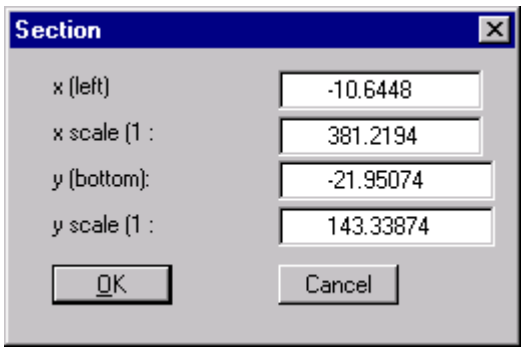
## *6.8 Menu item “Page”*

### 6.8.1 Menu option “Recalculate coordinates”

If you have altered the image coordinates during use of the program, e.g. by creating sections, you can have the coordinates for a complete overview recalculated using this menu option.

### 6.8.2 Menu option „By hand“

In the dialog box




you can alter the image coordinates by direct number input.

### 6.8.3 Menu option “Graphically”

you can alter the image coordinates graphically with the mouse. An info box explains the possibilities.

### 6.8.4 Menu option “Zoom”

You can reduce the graphical screen presentation by any factor. The initial size can be restored using the menu option „Recalculate coordinates”.

### 6.8.5 Menu option “Page format”

When starting the program an A3 page is set as default. If you would prefer different page formats you can define them in this dialog box.

### 6.8.6 Menu option “Font sizes”

You can edit font sizes for image labelling.

## *6.9 Menu item “?”*

### 6.9.1 Menu option “Copyright”

You will see a copyright message and information on the program version number.

### 6.9.2 Menu option “Maxima”

You will see information on the default program maxima.

### 6.9.3 Menu option “Help”

You will see this manual as Windows Helpfile.

# Index