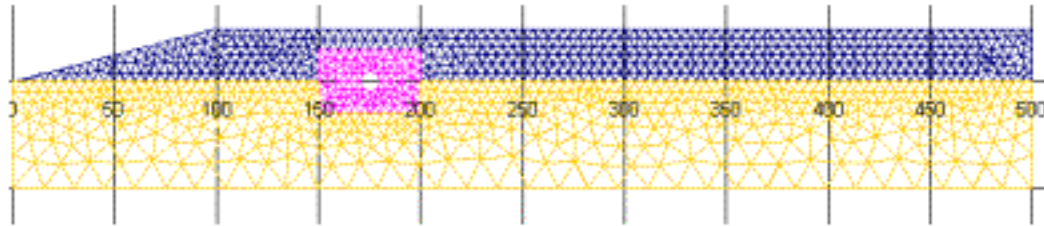


# Mndrain on-line manual



Mndrain – by [volle001@umn.edu](mailto:volle001@umn.edu), Civil Engineering, University of Minnesota.  
Minnesota Local Research Board and Minnesota Department of Transportation

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Problems or Comments Contact  
[V.R. Voller at volle001@umn.edu](mailto:V.R. Voller at volle001@umn.edu)

# Mndrain Purpose

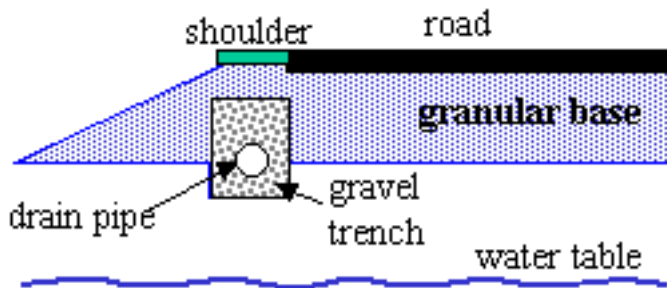
## Purpose and Objective

Mndrain is a suite of codes, embedded in a Microsoft Excel windows environment, directed at the evaluation of the effectiveness of edge drains.

The objective of Mndrain is to provide a user friendly environment in which the consequences of an edge drain design decision can be investigated. Mndrain should be regarded primarily as tool for assessment of design decisions as opposed to a tool that explicitly provide design decisions.

## Background

Edge drains consist of pipes that run along the length of a road. The pipes are placed in a high permeability gravel trench below the shoulder/road surface, see schematic



Schematic of edge drain cross-section (NOT TO SCALE)

The objective of the edge drain is to remove moisture from the granular base of the road system. The rate at which moisture is removed will depend on the geometry and materials used in the base and soil type in the sub-grade. The FHWA defines the quality of drainage obtained based on how long an edge drain will take to reduce an initially saturated (100% moisture) base down to a moisture level of 85%, see Table

Table 5.4. Pavement rehabilitation manual guidance for time to drain from 100 to 85 percent saturation (ERES 1987; FHWA 1994).

Quality of Drainage	Time to Drain
Excellent	Less than 2 hours
Good	2 to 5 hours
Fair	5 to 10 hours
Poor	Greater than 10 hours
Very Poor	Much greater than 10 hours

In the Mndrain code users can

1. Choose from 3 basic scenarios
  - a. An initially saturated base, drain trench, and edge drain on a permeable sub-grade with an adjustable water table height.
  - b. An initially saturated base on a permeable sub-grade with an adjustable water table height. NO drain or drain trench is present.
  - c. An initially saturated base and fouled edge drain on a permeable sub-grade with an adjustable water table height. This case accounts for the drain trench BUT does not allow water to enter the drain pipe.
2. Select material types and adjust geometries for each scenario
3. Calculate the moisture removal vs. time curve over a two-hour drainage time.

The numerical engine that sits at the heart of Mndrain is a Control Volume Finite Element (CVFE) solution of the Richard equation

$$\frac{\partial \theta}{\partial t} = \nabla \cdot (K(h) \nabla h) + \frac{\partial K}{\partial z}$$

$h \rightarrow$  pressure head (units of length,  
– ve in unsaturated region)

$\theta \rightarrow f(h)$  moisture content

$K \rightarrow g(h)$  hydraulic conductivity

for variably saturated flow in a porous media. It is noted that commercial codes are available for this type of calculation. In particular

Hydrus 2D goto <http://www.usssl.ars.usda.gov/models/hydrus2d.htm> and

SEEP/W goto <http://www.geo-slope.com/products/seepw.asp>

among others, have been successfully used to simulate edge drain performance.

There are however two distinct advantages offered by the development of the Mndrain code

1. The commercial codes are primarily intended as multi-purpose research tools and they include many sophisticated features which are not required in an evaluation of an edge drain performance. As a result there is a steep learning curve required to master the operation of these codes. Such codes are ideal for use in a central research facility but are less than ideal for distribution among field engineers. In contrast the Mndrain code only has one feature, the ability to solve unsaturated flow in layered media. This lack of general utility allows for a well-focused user

interface that promotes rapid acquisition of the skills required to run the code. The ability to learn the code operation rapidly is enhanced by the fact that the code is embedded in a Microsoft Excel interface, a tool that is well used and familiar to a large section of the engineering community.

2. The code in Mndrain is freeware. This means that all of the source software is freely available. Hence can be readily reconfigured do that further applications can be readily achieved

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# System Requirements

## System Requirements

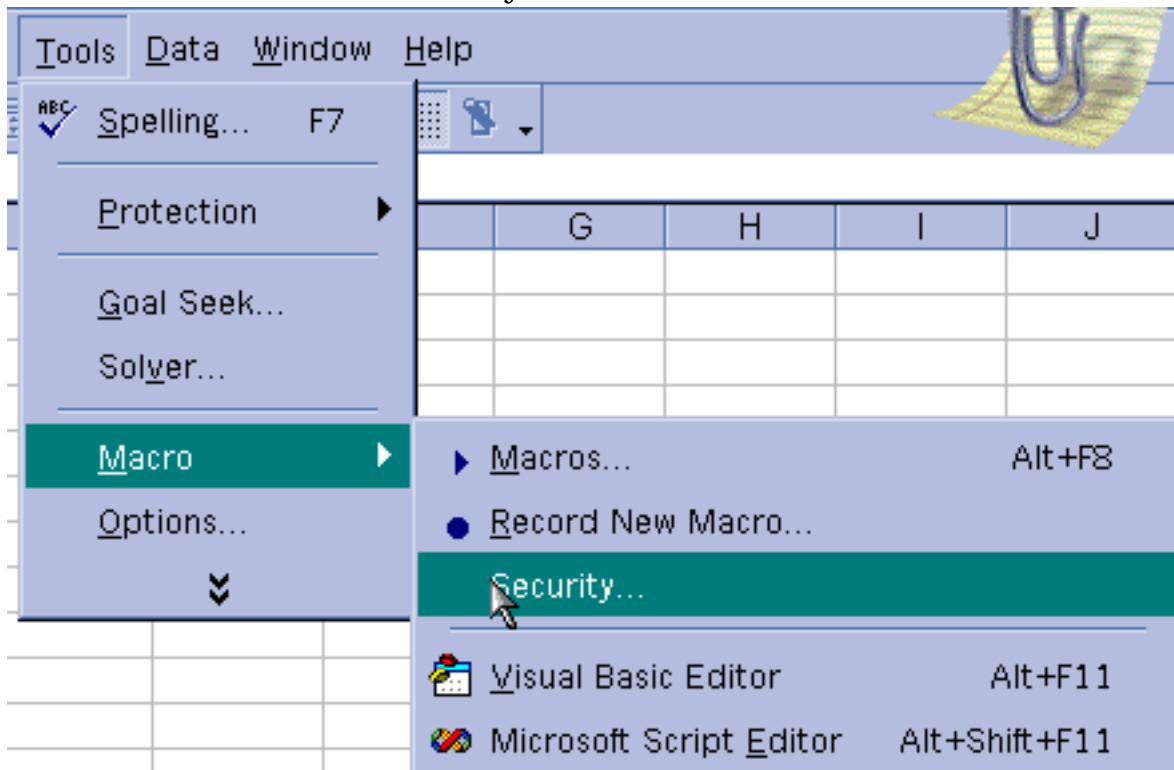
- A windows based personal computer running windows 98 or higher
- A copy of Microsoft Excel 2000 or higher must be installed
- NOTE:  
A current installed copy of Netscape or Explorer is helpful BUT not required.

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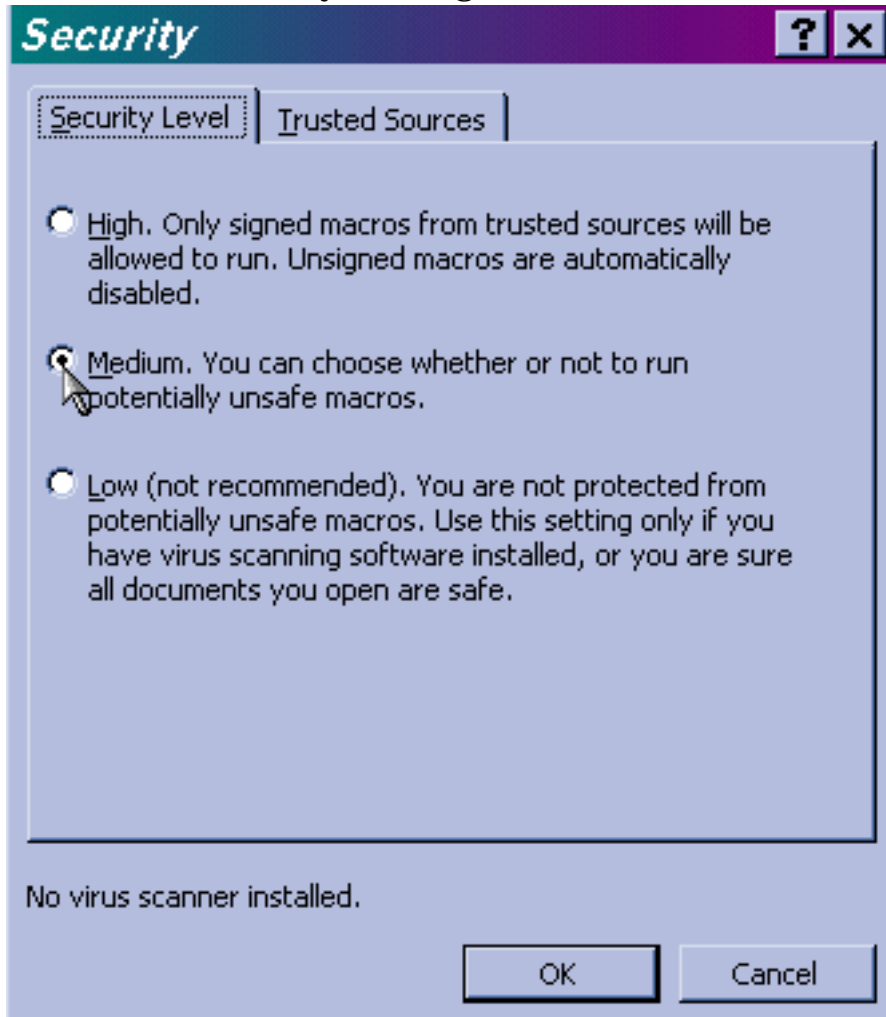
# Security Setting in Excel

The Excel software on the machine where Mndrain will run needs to be set up to allow the user to enable macros. In some setups of Excel a high security setting is in place and all macros embedded in a given Excel file are automatically disabled. To run Mndrain the Excel security needs to be set to medium. This is done with the following 5 steps

1. Open Ecell on your machine
2. Choose Tools-Macro-Security



### 3. Make sure security setting is Medium



### 4. Press the OK button in the above Dialog

### 5. Exit from Excel

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# Downloading Mndrain

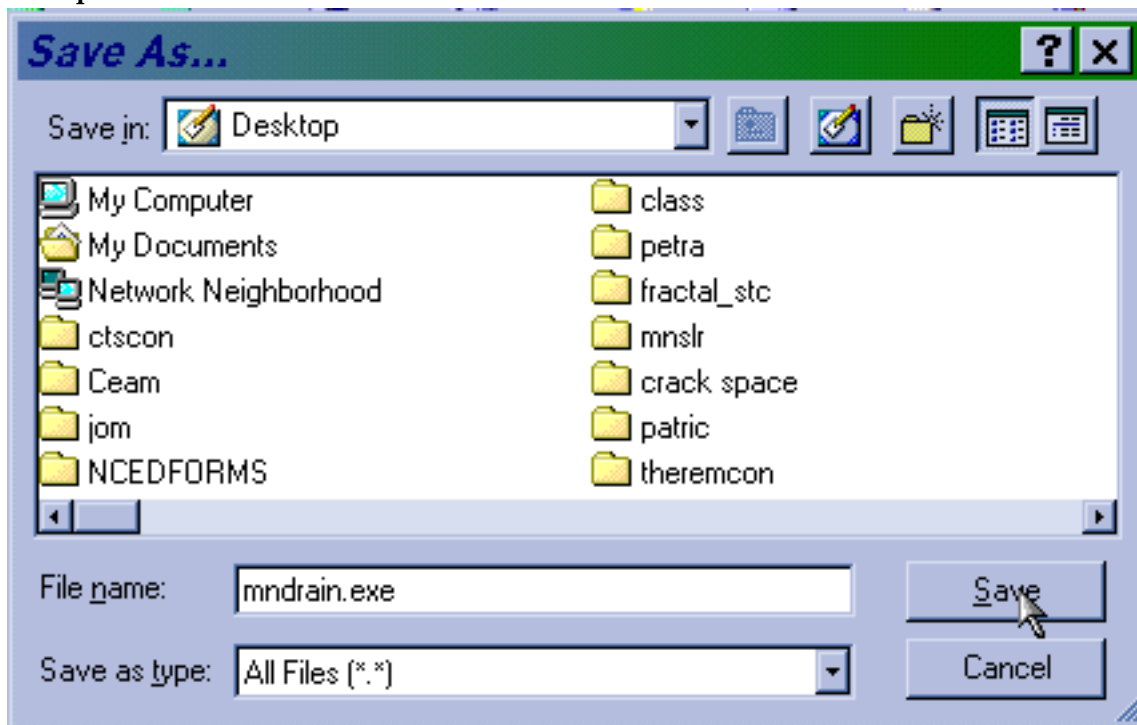
The Mndrain code is available as a self extracting executable file at [http://www.ce.umn.edu/~voller/voller\\_research/task5/mndrainrequest.html](http://www.ce.umn.edu/~voller/voller_research/task5/mndrainrequest.html)

To get this code

1. Go to [http://www.ce.umn.edu/~voller/voller\\_research/task5/mndrainrequest.html](http://www.ce.umn.edu/~voller/voller_research/task5/mndrainrequest.html)
2. In this page find the link to the Mndrain executable code--

**file [mndrain.exe](#) 2.8**

3. Double click on this link and save the file to the desktop of your windows based computer



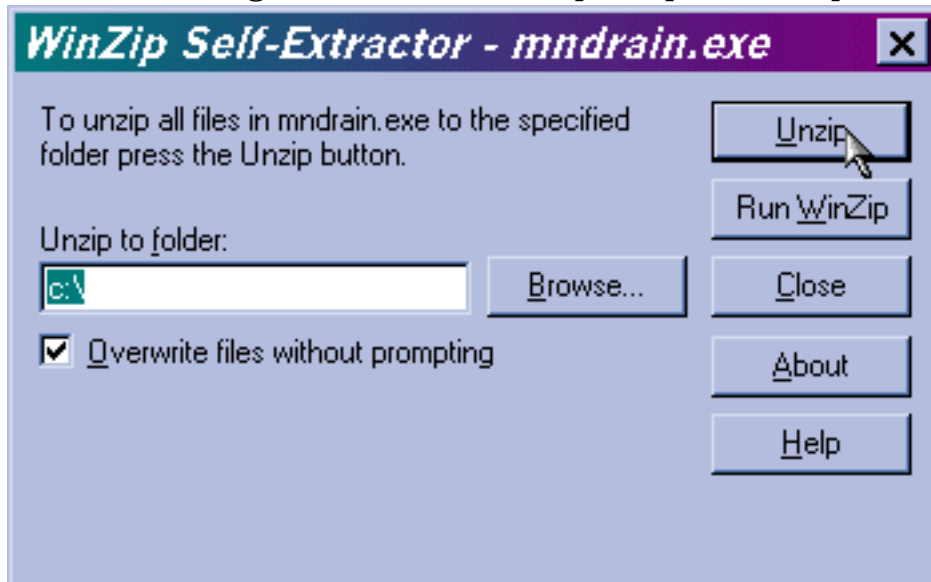
4. After the save. Find the icon



on the desktop of your windows machine



5. Double clicking on this icon will open up an un-zip dialog box



Unzip the files. DO NOT change the default drive from c:\  
The unzip operation will create the windows directory

c:\mndrain

This directory and its sub-directories will contain all the implementation and documentation files for using Mndrain.

6. After completion of the unzip operation look for the icon



on your desktop.

**DOUBLE CLICKING THIS ICON WILL START THE MNDRAIN CODE**

## NOTE

1. THERE IS NO NEED TO MODIFY ANY FILE IN THE DIRECTORY `c:\mndrain`  
The running of the Mndrain code SHOULD ALWAYS be initiated by clicking the desktop icon



2. If you wish, after the files are unzipped, you can delete the program



from your desktop OR move it to another directory in your computer.

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## Starting Mndrain

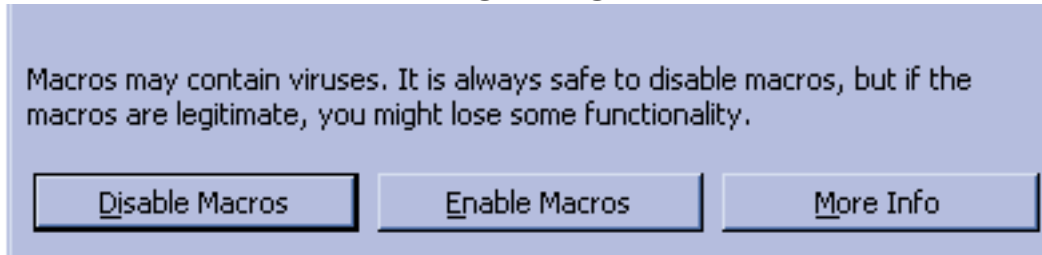
1. After completion of the [unzip operation](#) The icon



should be on your desktop.

2. DOUBLE CLICKING THIS ICON WILL START THE MNDRAIN CODE
3. This will open up a Microft Excel File--- master.xls--

4. You should see the following dialog box



You MUST HIT the Enable Macros Button to be able to run Mndrain

5. If the above Enable Macro Dialog DOES NOT APPEAR then you need to change the security setting in your copy of Excel
  - o Exit from Excel by closing the window
  - o Follow the [security setting instructions](#) in the Mndrain on-line help manual.
  - o When a medium security level has been set in Excel repeat the above open instructions.

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# The Main Mndrain Page

When the Mndrain code has been successfully opened the user will be located on the Main Mndrain Page.

## MNDRAIN -- Software for analysis of Edge Drains

Vaughan R. Voller (volle001@umn.edu)

Civil Engineering, University of Minnesota

For Minnesota local Road Research Board and Minnesota Department of Transportation

(Automatic meshing routine EasyMesh provided by Bojan Niceno, University of Delft, <http://www-dinma.univ.trieste.it/~nirftc/research/easymesh/> )

Note Material Properties Last Updated on October 25, 2002

See

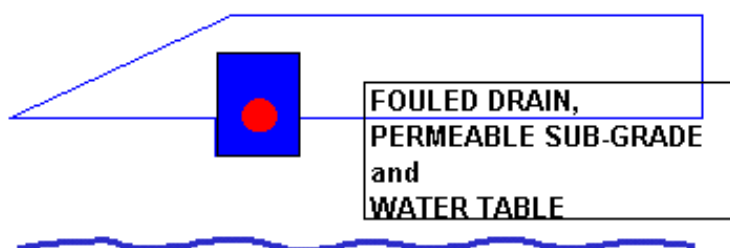
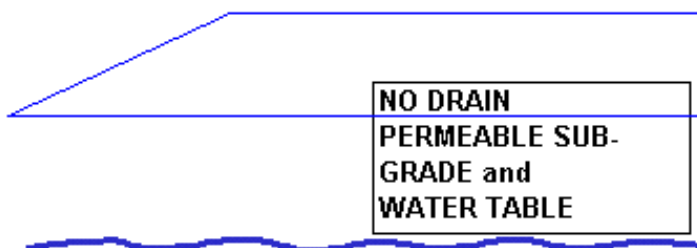
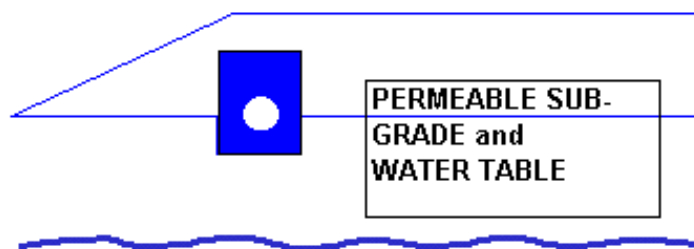
[http://www.ce.umn.edu/~voller/voller\\_research/task6/database\\_m.htm](http://www.ce.umn.edu/~voller/voller_research/task6/database_m.htm)

CLOSE  
MNDRAIN

If your are connected to the web  
Refresh Property Data by clicking here

Click to open on-line  
manual in PDF

Click on Desired cross-section of drain to begin



On this page the user can

1. If a web connection is active update material data from a remote database
2. Choose a particular simulation scenario to investigate.
3. Close the application

These functions are examined in subsequent help pages.

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# Updating Material Properties

Appropriate material properties are hard coded into the Mndrain software. These properties are stored in an Excel sheet that is hidden from the user. In addition a master table of material properties is stored on the secure web site [http://www.ce.umn.edu/~voller/voller\\_research/task6/database\\_m.htm](http://www.ce.umn.edu/~voller/voller_research/task6/database_m.htm) It is expected that as more information become available the material data in this master list will be updated. If the user is running Mndrain on a computer connected to the world wide web then clicking the button

**Note Material Properties Last Updated on October 25, 2002**

**See**

**[http://www.ce.umn.edu/~voller/voller\\_research/task6/database\\_m.htm](http://www.ce.umn.edu/~voller/voller_research/task6/database_m.htm)**

If you are connected to the web  
Refresh Property Data by clicking here

found on the Main Mndrain Page, will update the data stored in the local Excel sheet.

## Detailed Information on Material Properties

To carry out an unsaturated flow calculation (i) a relationship between the hydraulic conductivity and pressure or moisture content and (ii) a relationship between the pressure and the moisture content is required. In the current version of Mndrain the Brookes Corey relationships

$$K = K_{sat} \left[ \frac{\theta - \theta_{res}}{\theta_{sat} - \theta_{res}} \right]^{\lambda_2}$$

$$\theta = \begin{cases} (\theta_{sat} - \theta_{res})(h/h_d)^{-\lambda_1} + \theta_{res}, & \text{for } h < h_d \\ 0.0001(h - h_d) + \theta_{sat}, & \text{for } h \geq h_d \end{cases}$$

are used, where

$\theta$  → moisture content,  $\theta_{\text{sat}}$  → saturated moisture content

$\theta_{\text{res}}$  → residual moisture content

$K$  → hydraulic conductivity,  $K_{\text{sat}}$  saturated hydraulic conductivity

$h$  → pressure head,  $h_d$  → pressure head at air entry ( $\leq 0$ )

The current (as of 25<sup>th</sup> October, 2002) material properties used in these equations are

25-Oct-02	$\lambda_1$	$\theta_{\text{sat}}$	$\theta_{\text{res}}$	$h_d$	$K_{\text{sat}}$	$\lambda_2$
Gravel	0.2	0.45	0.03	-0.5	0.1	13
Granular Base A	0.2	0.45	0.03	-1	5.00E-04	13
Granular Base B	0.5	0.45	0.03	-2	2.00E-04	7
Granular Base C	1	0.45	0.03	-5	0.001	5
Loamy Sand	0.474	0.401	0.035	-8.7	1.70E-03	7.22
Loam	0.22	0.434	0.027	-11.15	3.67E-04	12.1
Silt Loam	0.211	0.486	0.015	-20.75	0.000189	12.48
clay	0.131	0.385	0.09	-37.31	1.67E-05	18.267
Impermeable	1	0.4	0.1	-5	1.00E-20	5

## NOTE

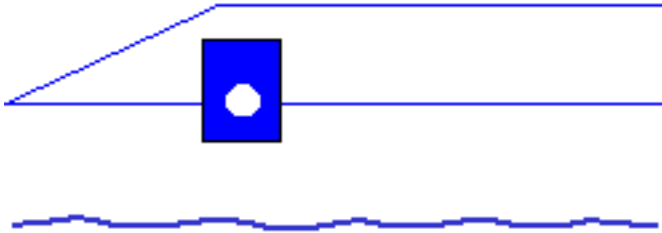
1. It would be possible to modify the Mndrain code so that other material relationships or tabular data can be used in place of Brookes Corey.
2. The definition of the moisture-pressure relationship assumes a small compressibility of the liquid in the saturated region,  $h > h_d$ . This step allows for an accurate and smooth transition between the saturated and unsaturated zones.
3. The current data for the Granular materials is chosen to be representative of the range that might be expected. Specific values for a given granular base still need to be defined.
4. The current data for the sub-base is taken from the Hydrus-2D data base.

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# Opening a Scenario Page

On the Main Mndrain Page the user is presented with 3 basic scenarios from which to choose. These are

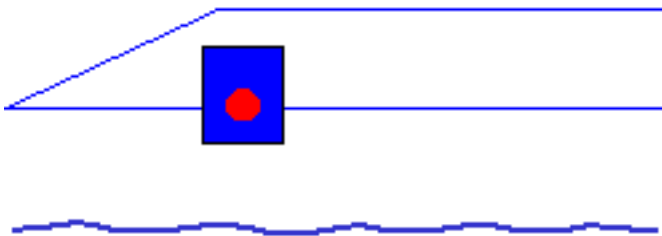
1. An initially saturated base, drain trench, and edge drain on a permeable sub-grade with an adjustable water table height.



2. An initially saturated base on a permeable sub-grade with an adjustable water table height. NO drain or drain trench is present.



3. An initially saturated base and fouled edge drain on a permeable sub-grade with an adjustable water table height. This case accounts for the drain trench BUT does not allow water to enter the drain pipe.



The user can choose the desired scenario by simply clicking on the associated schematic

Assuming the appropriate Excel security setting have been made the following dialog box will appear

Macros may contain viruses. It is always safe to disable macros, but if the macros are legitimate, you might lose some functionality.

[Disable Macros](#)

[Enable Macros](#)

[More Info](#)

Select the "Enable Macros" button. This will open up a Scenario Page where the user can choose material properties and make geometry changes to the basic scenario chosen.

If the above Enable Macro Dialog DOES NOT APPEAR then you need to change the security setting in your copy of Excel

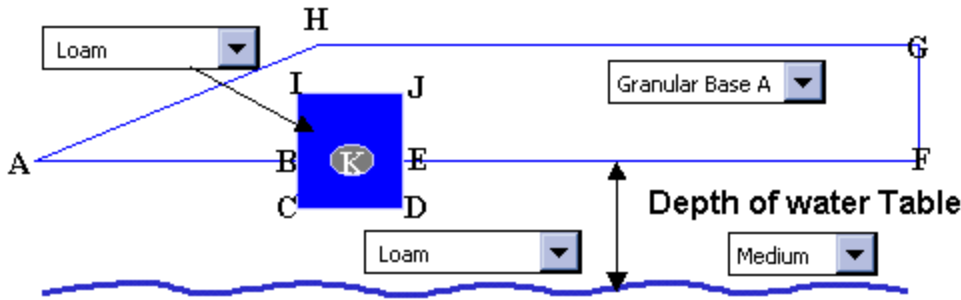
- Exit from Excel by closing the window
- Follow the [security setting instructions](#) in the Mndrain on-line help manual.
- When a medium security level has been set in Excel repeat the above choose scenario instructions.

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# The Scenario Page

A successful open of the Scenario Page will give



Hit Here To RSET Data

close and return to master

This will terminate the current example  
You will be asked if you would like to save current sheet say YES

Enter Data (cm) - in shaded areas

Simulation Time (s) 7200

	X	Z
A	0	0
B	150	0
C	150	-15
D	200	-15
E	200	0
F	500	0
G	500	25
H	100	25
I	200	15
J	150	15

K center point of drain

	X	Z
	175	0

Drain Radius 5

Run Codes

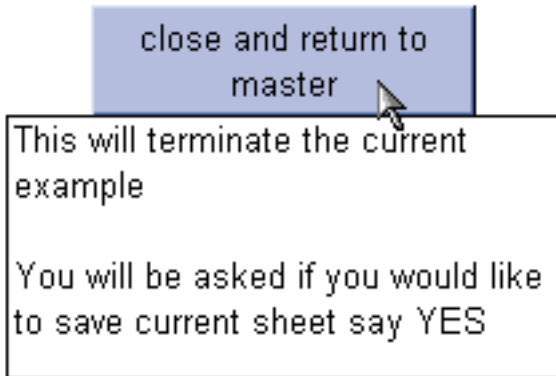
You will be asked to run a suite of codes aimed at predicting drain time

On this page the user can set material properties and geometry.  
If a new run is to be undertaken the first task is to RESET the data  
See next help page for details.

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# Close Scenario

The button



will close the current scenario and return to the Main Mndrain Page

When clicked the user may be asked if they would like to save the changes made. Unless the user feels that serious set up errors have been made it is recommended that user allows for the saving of changes.

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# Reset Properties

When you arrive at the Scenario Page If you are starting a brand new run then it is a good idea to reset the the material and geometry data to the base case setting. This is done by finding and clicking the button



Hit Here To RSET Data

Failure to do this may mean that incorrect data will be used in subsequent runs.

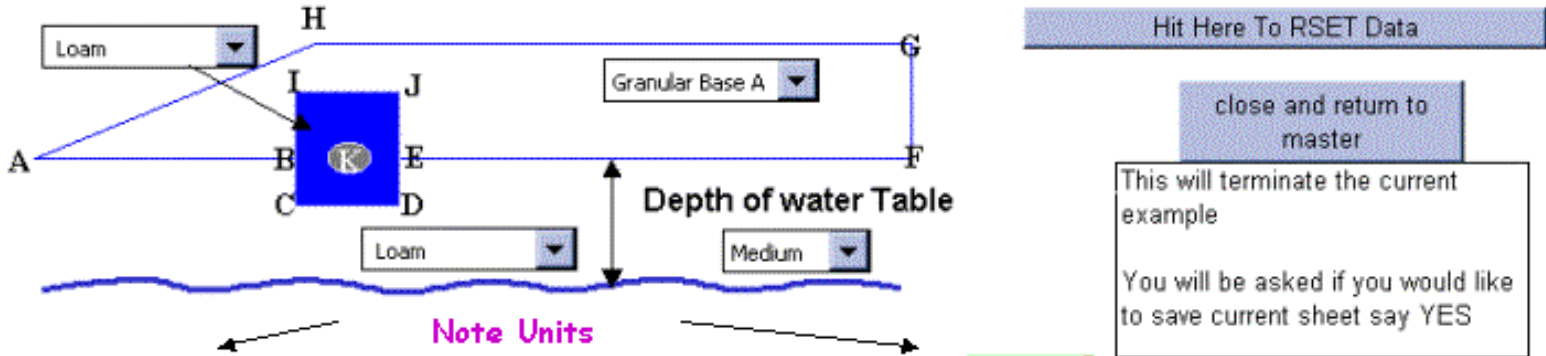
In some cases you may be returning to a previously saved run and wish to continue inputting data. In such cases the "reset button" does not need to be activated.

Note: The "reset button" Can also be used as a "start over button" in cases where the user is encountering errors in setting up a given run.

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# Setting up geometry

The opening page of a given scenario includes a representative image of the geometry and a table giving the x,z positions of key points on that geometry



Enter Data (cm) - in shaded areas

	X	Z
First point should ALWAYS be origin $x = 0, z = 0$	A 0	0
Match the letters in the table with diagram and enter location in cm	B 150	0
	C 150	-15
	D 200	-15
	E 200	0
	F 500	0
	G 500	25
	H 100	25
	I 200	15
Ensure morphology of geometry remains the same	J 150	15
	K center point of drain	
	X 175	Z 0
Drain Radius	5	

Simulation Time (s) 7200

Hit Here To RSET Data

close and return to master

This will terminate the current example

You will be asked if you would like to save current sheet say YES

Run Codes

You will be asked to run a suite of codes aimed at predicting drain time

Make sure drain center is in trench and at least two radii removed from edge

The geometry is changed by overwriting the x,z coordinates in the table that correspond to the points in the image identified by uppercase letters. The user can also change the simulation time.

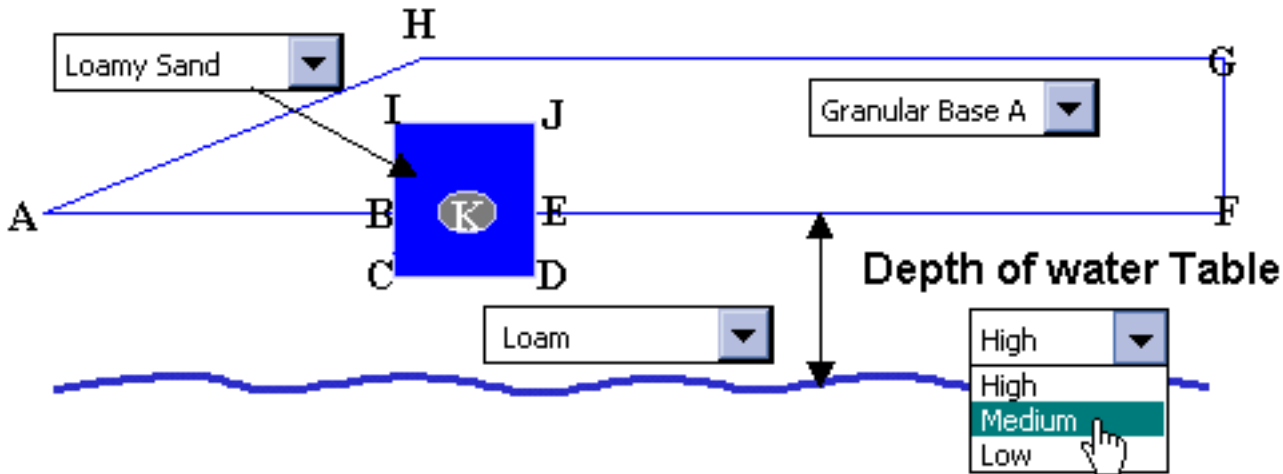
## NOTE

- The first point should always be the origin (0,0). All other points are positioned relative to this location.
- Length measurements are in cm and time in seconds
- The onus is placed on the user to ensure that the revised geometry fits the morphology shown in the image (i.e., The relative location of one point to another MUST remain the same). The image on the page will NOT update as the points are modified. There is, however, a place later on in the setup where the user can get a visual check on the geometry.
- It is also left to the user to ensure that the drain location is in the trench.
- The finite element gridding will break down if the drain is "too-close" (less than two radii distances) from the edge of the trench.

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# Choosing material properties

The opening page of a given scenario includes a representative image of the geometry. This image has up to three (3) material identified on it and may also include a water table position



The user can select the material type for each of the identified material regions and the position of the water table by making a selection from the scrolling menus.

Note:

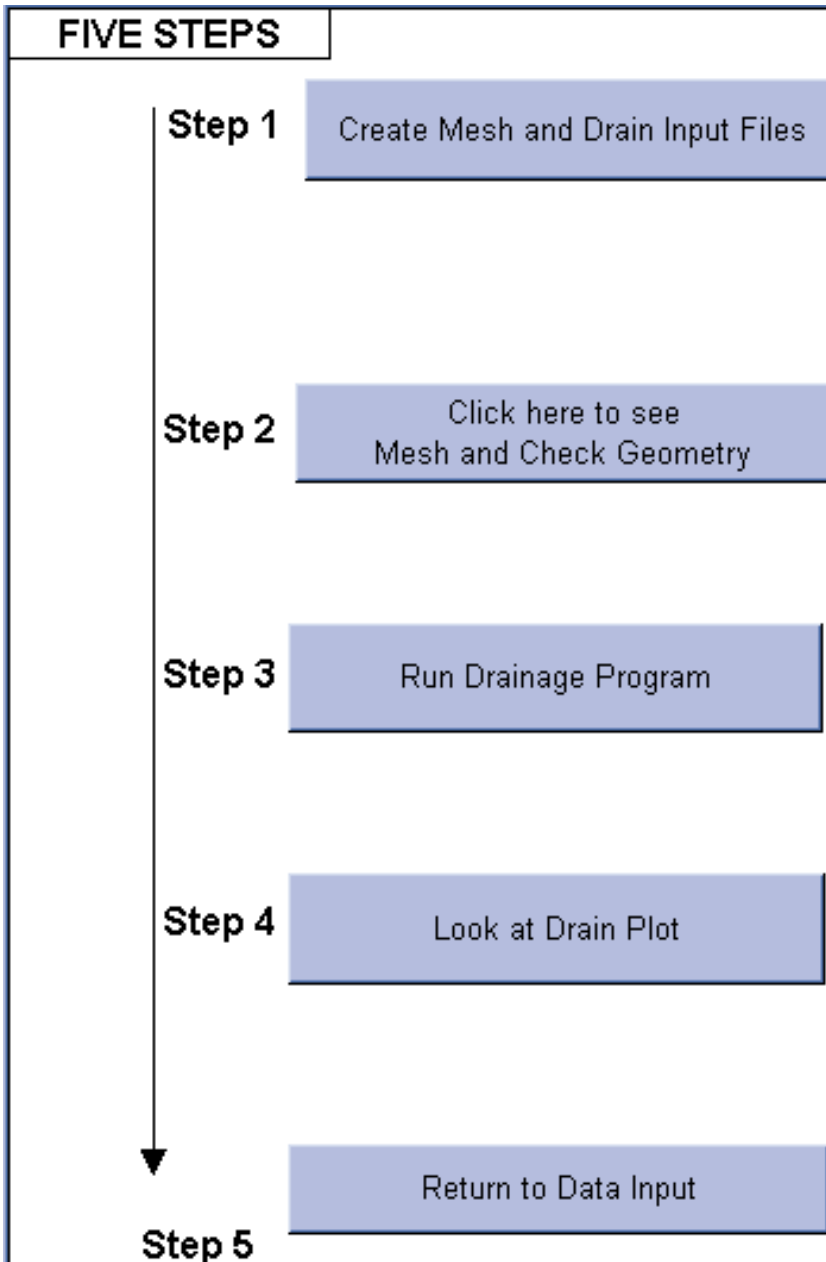
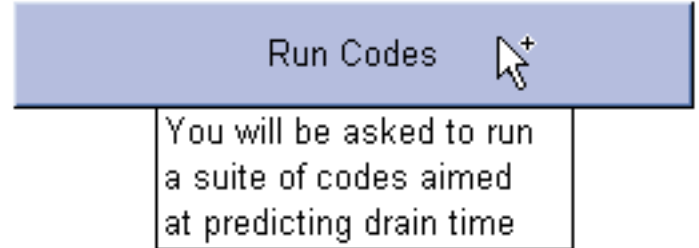
- The selection of a given material type will provide a pointer to the corresponding position in the material property data base.
- A selection of Impermeable for the sub-grade will effectively result in a no flow condition along the bottom of the granular layer.
- The selections for the water table height are "low" (1 meter below origin), "medium" (50cm below origin) and "high" (25 cm below origin).
- In the case of "high" water table setting the user should ensure that there is at least a 5 cm gap between the bottom of the trench and the water table.

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# The Run Page

After the geometry and material properties have been set in the Scenario Page Clicking the button, on the right, will lead the user to the Run Page where the programs that make up Mndrain are run.

This page consists of the following set of buttons



IN EVERY case these buttons **MUST** be clicked in the order shown to run the Mndrain code.

The Function of these buttons is described in the next set of help pages

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# Preparing the Input

The First button on the Run Page

**Step 1**

Create Mesh and Drain Input Files

Is used to

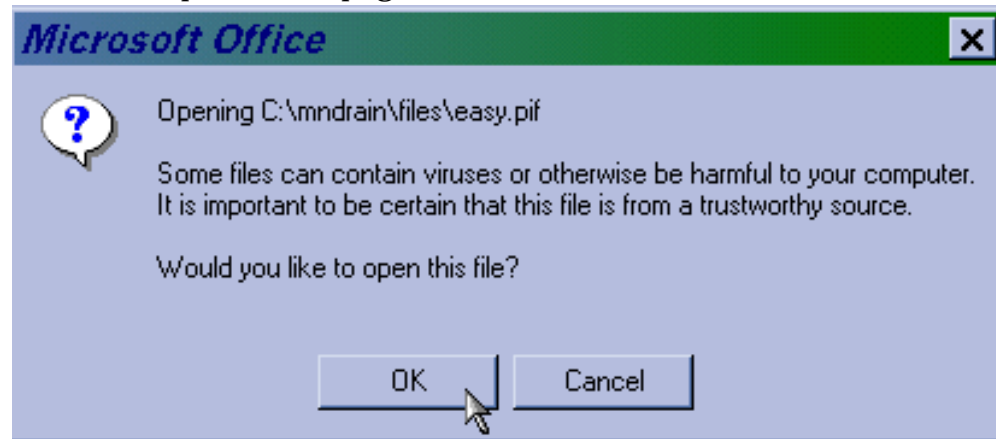
1. Create the Finite Element Grid for the programs
2. Set up the input data for the Mndrain programs

When this button is clicked Two Programs are run

The first program is an external DOS program for creating the finite element mesh based on the geometry data provided by the user. This program is a compiled version of the public domain software easymesh see the web site

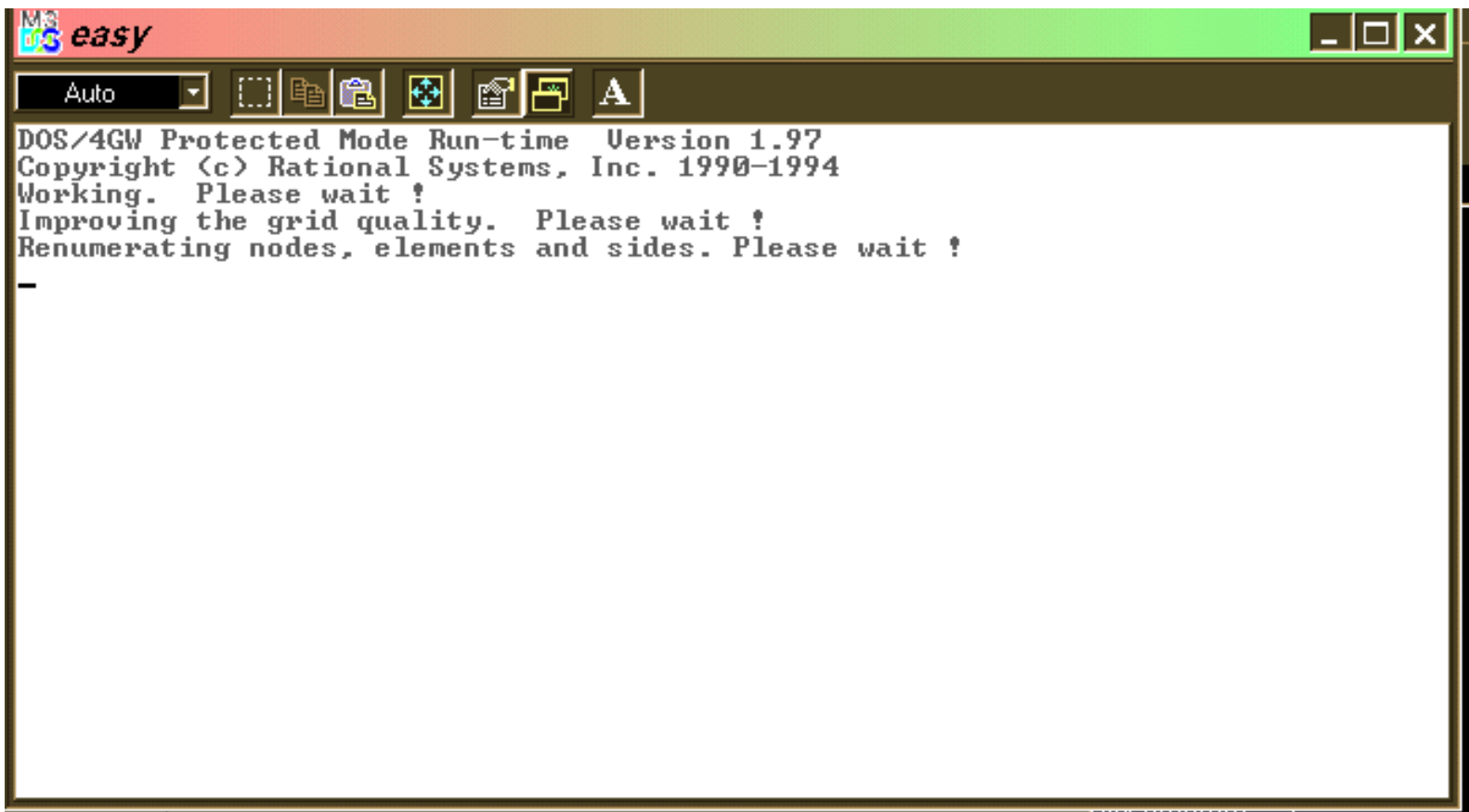
<http://www.dinma.univ.triests.it/~nirftc/research/easymesh>  
for deatils.

In order to run the easymesh code the user has to authorize the running of an external application from the open Excel page



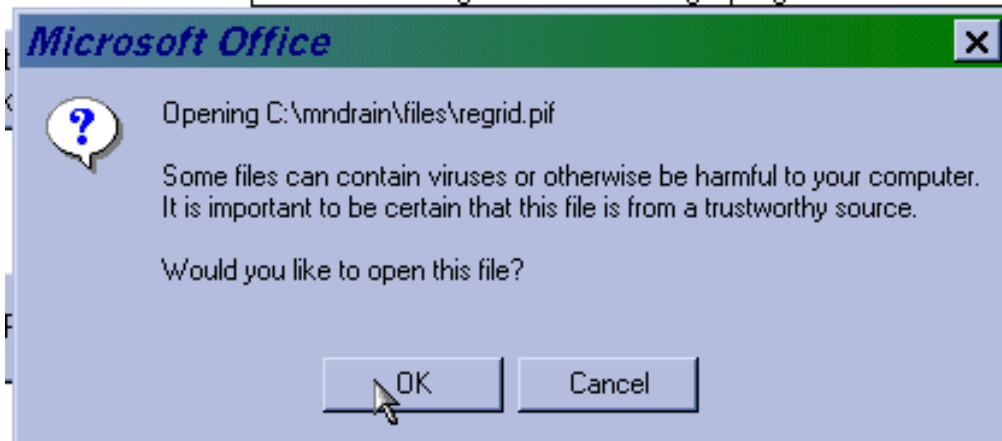
This action will open up a DOS window on the computer----

see next page---



This window will remain on the screen until the easymesh program has finished running ~ 1 minute.

When easymesh is finished the user will be asked to OK the external running of the program regrid



This program, written as part of Mndrain, reformats the output from easymesh in a form suitable for the Mndrain programs. The program also runs in a Dos Window. On completion The user can take the option of looking at the domain geometry and grid. See the next help page.

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# Looking at the Mesh

The Second button on the Run Page

Click here to see  
Mesh and Check Geometry

An image of the mesh and geometry color coding material types will be shown.

If mesh or gemoetry look wrong return to data input

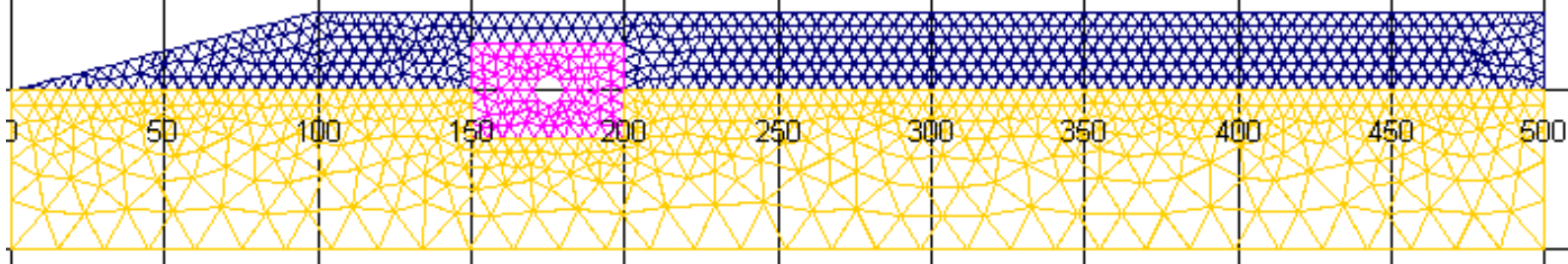
Return to Data  
Input

Is used to look at the mesh. Clicking this button. AFTER the first button on the Run Page has been clicked and the associated programs run, will provide a plot of the current drain geometry and mesh, e.g.,

This is the mesh that will be used in the calculation  
Check out dimensions and regions

Return to User

Automatic meshing routine **EasyMesh** provided by Bojan Niceno, University of Delft, <http://www-dinma.univ.trieste.it/~nirftc/research/easymesh/>



It is always recommended that user looks at the mesh. This is an excellent place to check that a consistent geometry has been applied.

If the geometry looks wrong the user has the option at this point to return to the Scenario Page

Note the "Return to User" Button in the mesh plot will return the user to the Run Page

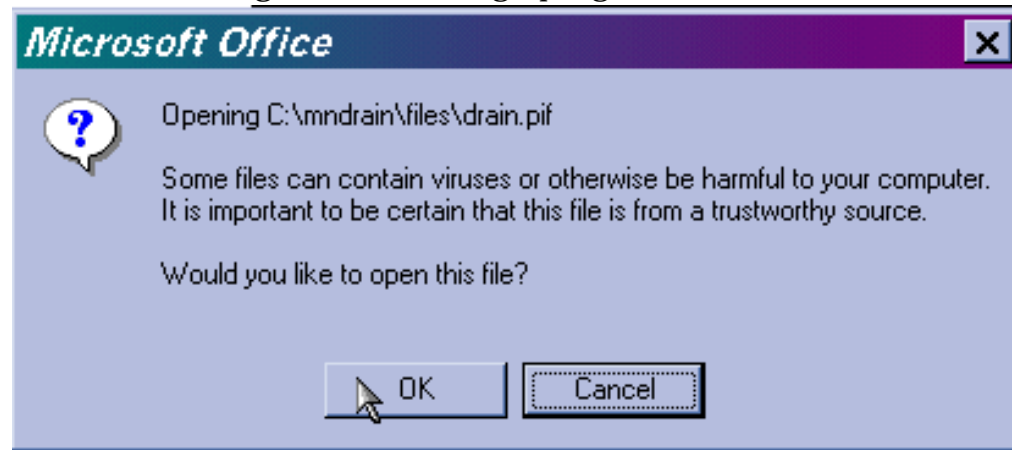
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# Running the drain calculation

The Third button on the Run Page

**Step 3** Run Drainage Program

Is used to run the drainage calculation. Clicking this button will request the user to authorize the external running of the drainage program



When authorised a DOS window will open in which the drain program will run

A screenshot of a DOS window titled "DRAIN". The window has a menu bar with "Auto" and several icons. The main area displays the following text:

```
PROGRAM RUNNING please wait

time(sec) -- degree of Saturation-cm^2 moist gran base   convergence~e-4
0.000000      1.000000      5369.30      0.000000
120.000      0.982174      5273.59      0.806988E-03
240.000      0.972434      5221.29      0.492515E-04
360.000      0.965166      5182.27      0.405237E-04
480.000      0.959160      5150.02      0.474613E-04_
```

The columns in this output are explained on the next page

1. Column 1: Is Time in seconds
2. Column 2: Degree of Saturation  
(Volume of Moisture in Granular Base/Pore Volume in Granular Base)
3. Column 3: Total Moisture (cm<sup>2</sup>) in the granular base at the given time.
4. Column 4: Convergence. A measure of the mass error. A value of 10<sup>-4</sup> is very good. Values of 10<sup>-3</sup> are acceptable provided they do not prevail for too many time steps.

For a two hour simulation time the drain program will take about 2 minutes to run. At the end of the operation the program will signify successful completion and pause until the user hits a key

The screenshot shows a window titled "DRAIN" with a menu bar containing "Auto" and several icons. The main area displays a table of data with four columns: Time (s), Degree of Saturation, Total Moisture (cm<sup>2</sup>), and Convergence. The data rows range from 4680.00 to 7200.00 seconds. Below the table, the text "Program Successfully Terminated" and "Press Enter to Continue." is displayed.

4680.00	0.820036	4403.02	0.442160E-04
4800.00	0.816875	4386.05	0.494760E-04
4920.00	0.813790	4369.48	0.451564E-04
5040.00	0.810786	4353.35	0.410875E-04
5160.00	0.807860	4337.64	0.654564E-04
5280.00	0.805020	4322.39	0.415807E-04
5400.00	0.802325	4307.93	0.423565E-04
5520.00	0.800004	4295.47	0.439993E-04
5640.00	0.797807	4283.67	0.381055E-04
5760.00	0.795729	4272.51	0.475000E-04
5880.00	0.793750	4261.89	0.414868E-04
6000.00	0.791859	4251.73	0.450328E-04
6120.00	0.790031	4241.92	0.470600E-04
6240.00	0.788250	4232.35	0.214773E-03
6360.00	0.786520	4223.06	0.385330E-04
6480.00	0.784839	4214.04	0.368156E-03
6600.00	0.783206	4205.27	0.435910E-04
6720.00	0.781627	4196.79	0.485388E-04
6840.00	0.780102	4188.60	0.448307E-04
6960.00	0.778629	4180.70	0.393494E-04
7080.00	0.777210	4173.07	0.444776E-04
7200.00	0.775842	4165.73	0.490766E-04

Program Successfully Terminated  
Press Enter to Continue.

At this point the data has been stored and as detailed in the next help page the user can interrogate this data using standard Excel methods.

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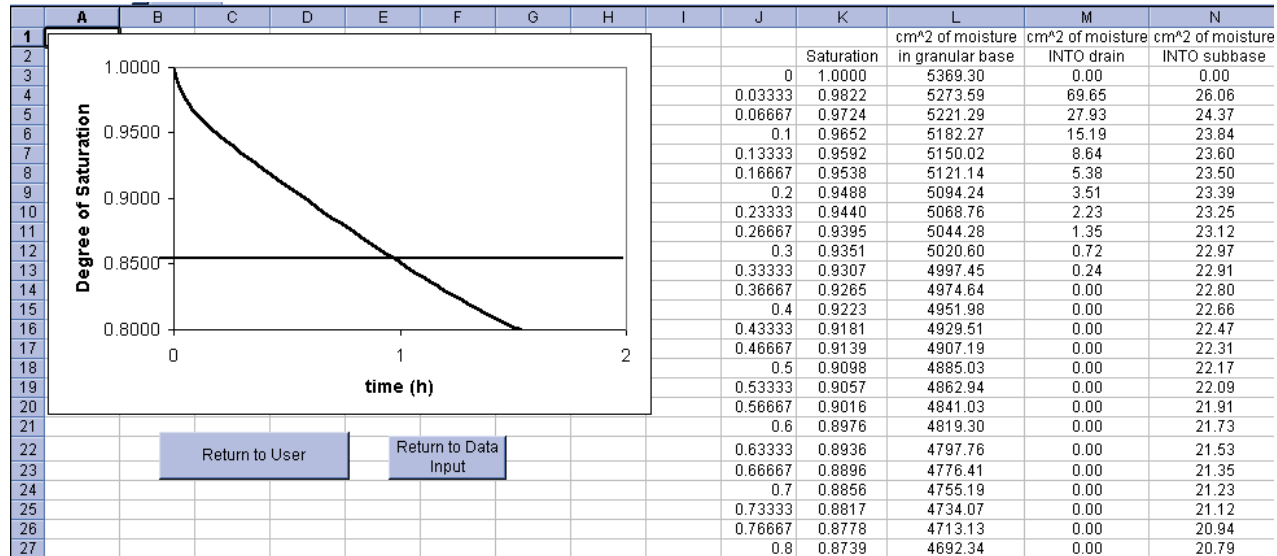
# Working with the results

The Fourth button on the Run Page

**Step 4**

Look at Drain Plot

is used to look at the results. Clicking this button will take the user to an Excel page which contains a graph and output.



The graph of Saturation vs. time includes the 85% cut off.

The data for the graph and additional data is also tabulated on this page. The three additional data columns are:

1. The amount (cm<sup>2</sup>) of moisture in the granular base at a given time
2. The amount (cm<sup>2</sup>) of moisture entering the drain pipe in the current time step
3. The amount (cm<sup>2</sup>) of moisture entering the subbase (subgrade) in the current time step

In a study to compare different designs it is recommended that, using basic Microsoft Excel features, this data is "cut" and "pasted" into an Excel spreadsheet under the control of the user.

The user is RESPONSIBLE for saving the data generated.

Note the results page contains button to

- Take the user back to the Run Page ("Return to User")
- Take the user back to the Scenario Setup Page ("Return to Data Input")

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# Closing the Run Page



Return to Data Input

close and return to master

The Fifth and Sixth buttons on the Run Page **Step 5**

are used to

- Return to the Scenario page ("Return to Data Input") where the material properties and geometry for a new run can be set up
- Or close the current Scenario and return to the Main Page ("close and return to master") where a new scenario can be chosen. Note the user will be asked if they would like to save.

To close the entire program the user needs to return to the Main Page

## MNDRAIN -- Software for analysis of Edge Drains

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Civil Engineering, University of Minnesota

For Minnesota local Road Research Board and Minnesota Department of Transportation

(Automatic meshing routine EasyMesh provided by Bojan Niceno, University of Delft, <http://www-dinma.univ.trieste.it/~nirftc/research/easymesh/>)

Note Material Properties Last Updated on October 25, 2002

See

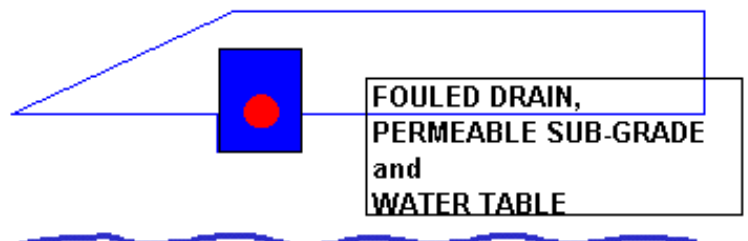
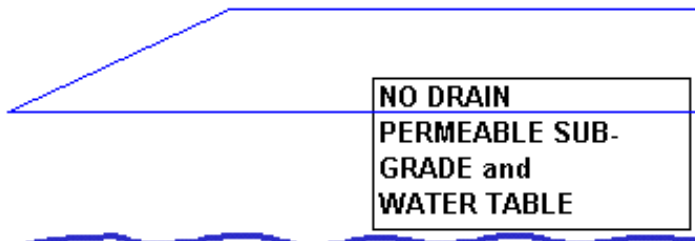
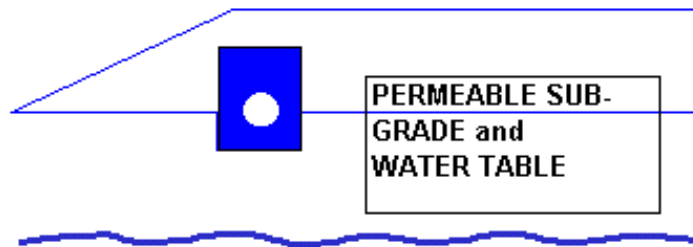
[http://www.ce.umn.edu/~voller/voller\\_research/task6/database\\_m.htm](http://www.ce.umn.edu/~voller/voller_research/task6/database_m.htm)

If your are connected to the web  
Refresh Property Data by clicking here

CLOSE  
MNDRAIN

Click to open on-line  
manual in PDF

Click on Desired cross-section of drain to begin




and click the "Close Mndrain" Button

This will return the user to the desktop. It is recommended that the user OK's any save request that are made during this operation. ----- [BACK to Help Index](#)

# Checking Implementation

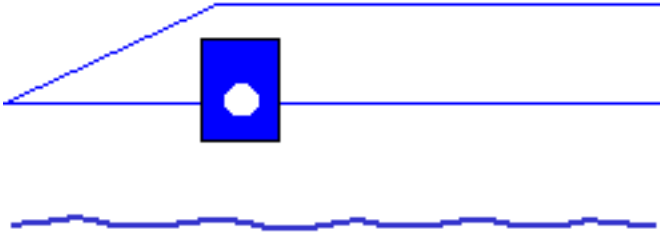
The downloading and operation of Mndrain can be checked by running each one of the three scenarios with its base settings and then comparing the drainage predicted (Saturation vs. Time) with the data given on the following pages.

**REMEMBER:** The Reset Button must be used before each run is set up



Hit Here To RSET Data

CASE 1: Initially saturated base on a permeable sub-grade with an adjustable water table height.



The results for the first hour of simulation should match

Time	Saturation
0	1
0.033333	0.982174
0.066667	0.972434
0.1	0.965166
0.133333	0.95916
0.166667	0.953781
0.2	0.948771
0.233333	0.944025
0.266667	0.939467
0.3	0.935056
0.333333	0.930745
0.366667	0.926497
0.4	0.922276
0.433333	0.918091
0.466667	0.913935
0.5	0.909807
0.533333	0.905693
0.566667	0.901612
0.6	0.897565
0.633333	0.893554
0.666667	0.889578
0.7	0.885625
0.733333	0.881692
0.766667	0.877792
0.8	0.873921
0.833333	0.870086
0.866667	0.866281
0.9	0.862502
0.933333	0.858741
0.966667	0.855003
1	0.851291

CASE 2: Initially saturated base on a permeable sub-grade with an adjustable water table height. NO drain or drain trench is present.

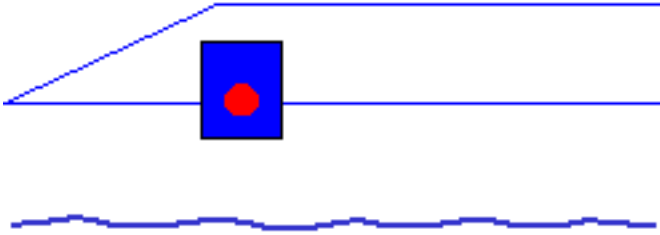


The results for the first hour of simulation should match

Time	Saturation
0	1
0.033333	0.995241
0.066667	0.990597
0.1	0.986026
0.133333	0.981507
0.166667	0.977008
0.2	0.972527
0.233333	0.968077
0.266667	0.963658
0.3	0.959269
0.333333	0.954891
0.366667	0.950535
0.4	0.946218
0.433333	0.941939
0.466667	0.937689
0.5	0.933461
0.533333	0.929247
0.566667	0.925064
0.6	0.920921
0.633333	0.916807
0.666667	0.912735
0.7	0.908682
0.733333	0.904646
0.766667	0.900633
0.8	0.896654
0.833333	0.892719
0.866667	0.888824
0.9	0.884954
0.933333	0.881086
0.966667	0.877253
1	0.873433



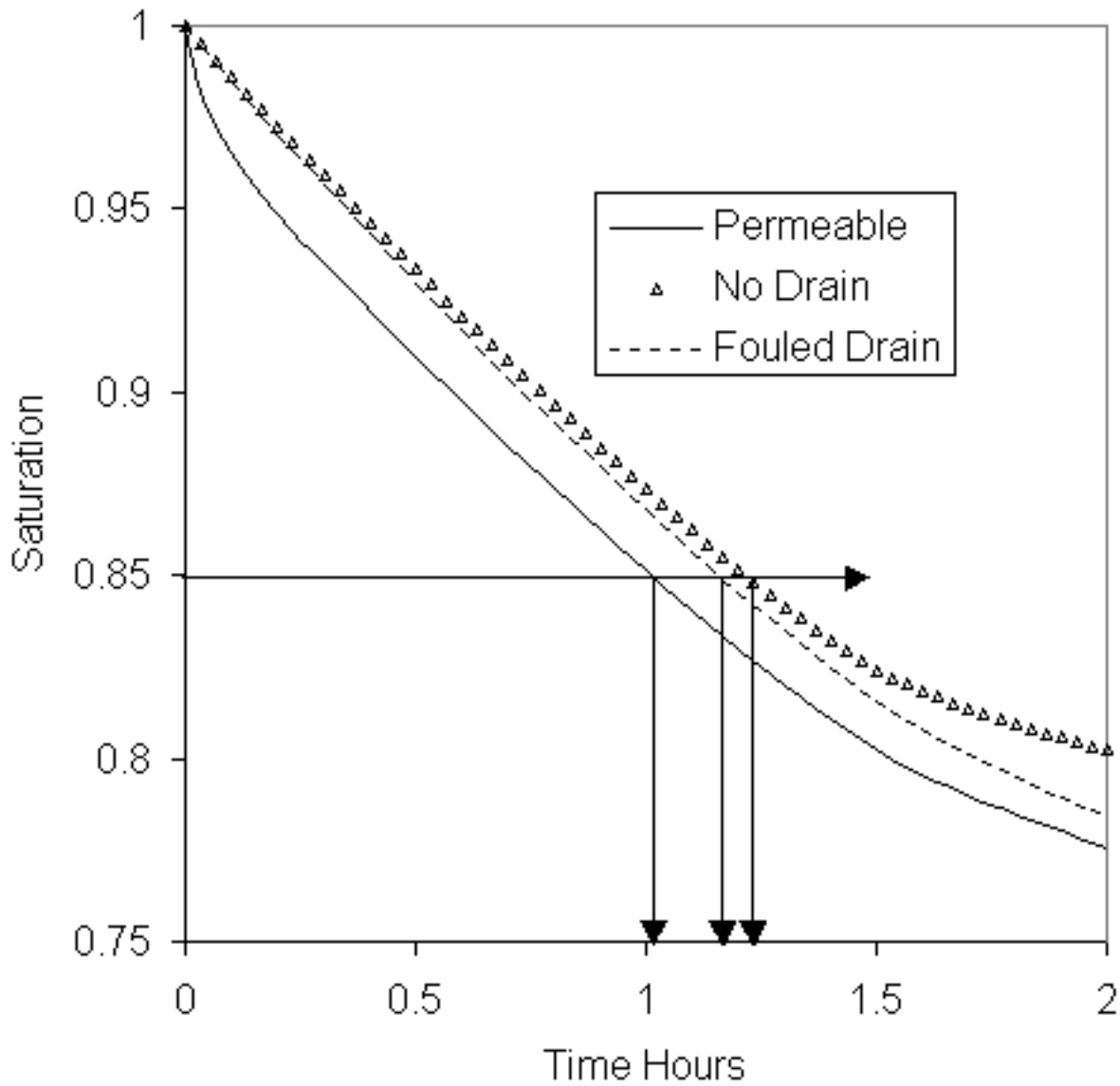
CASE 3: Initially saturated base and fouled edge drain on a permeable sub-grade with an adjustable water table height.



The results for the first hour of simulation should match

Time	Saturation
0	1
0.033333	0.994535
0.066667	0.989566
0.1	0.984733
0.133333	0.979971
0.166667	0.975254
0.2	0.97058
0.233333	0.965933
0.266667	0.961312
0.3	0.956719
0.333333	0.952146
0.366667	0.947604
0.4	0.943096
0.433333	0.938631
0.466667	0.934213
0.5	0.929836
0.533333	0.925473
0.566667	0.921144
0.6	0.916848
0.633333	0.912591
0.666667	0.908372
0.7	0.904186
0.733333	0.900029
0.766667	0.895906
0.8	0.891813
0.833333	0.887758
0.866667	0.88374
0.9	0.879751
0.933333	0.875791
0.966667	0.871869
1	0.867975

A graph of the above three runs, through two hours, is



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