SHETRAN Windows Worked Example

This worked example takes you through running SHETRAN. It is based on a 2 month period of data for the Gais Gill (1 km^2) catchment in the upper Eden, which has undergone intensive monitoring as part of CHASM project. It uses a 50m DEM and catchment mask file.

Upper Eden, Gais Gill is in the SW corner.

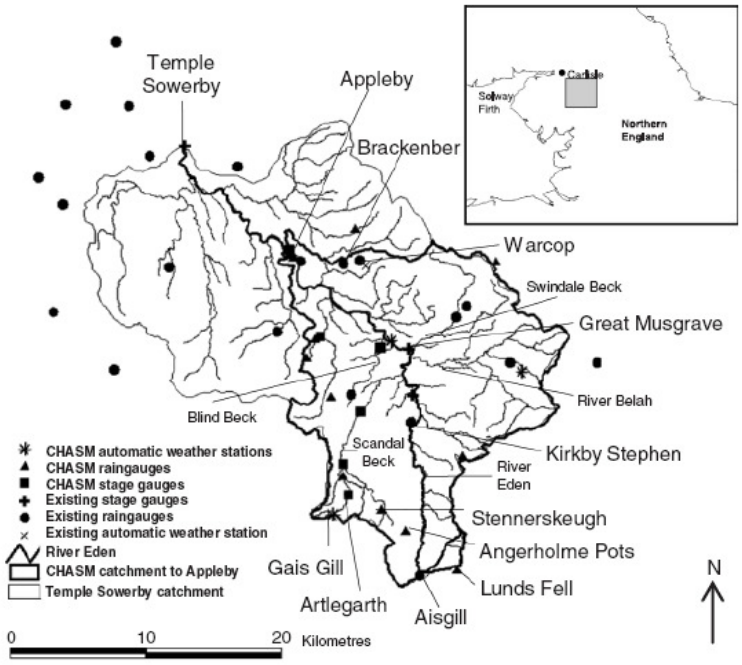

Fig. 1. Location map of the Upper Eden study catchment. CHASM, Catchment Hydrology and Sustainable Management.

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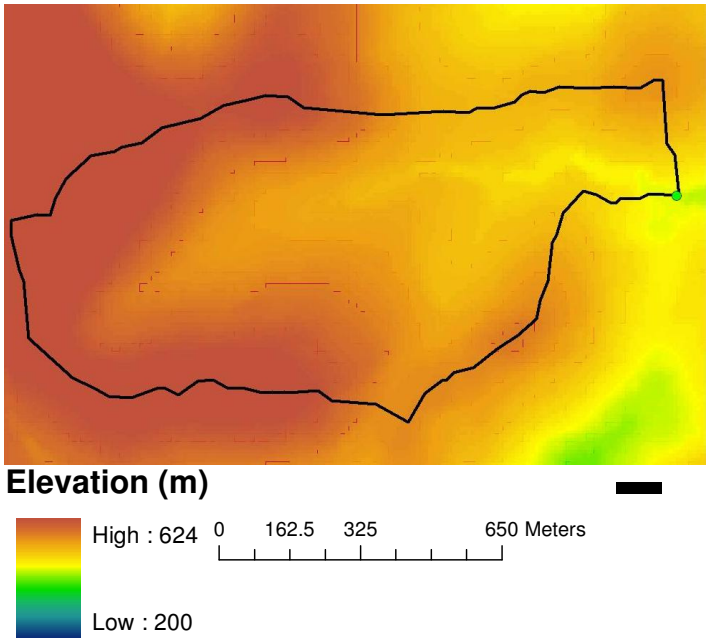
Gais Gill catchment (1.0 km^2)



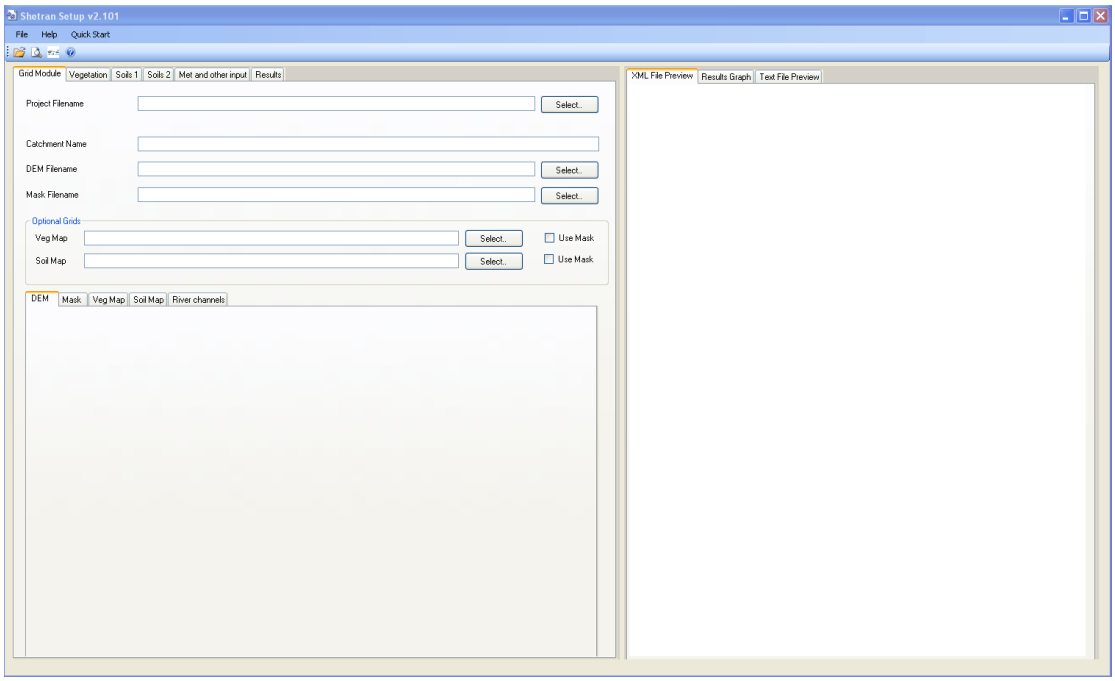
There are four parts to this worked example.

1) SHETRAN simulation of forested catchment
2) Changing vegetation type
3) Changing soil layers and type
4) Changing river network

Section 1 – SHETRAN Simulation of Forested Catchment

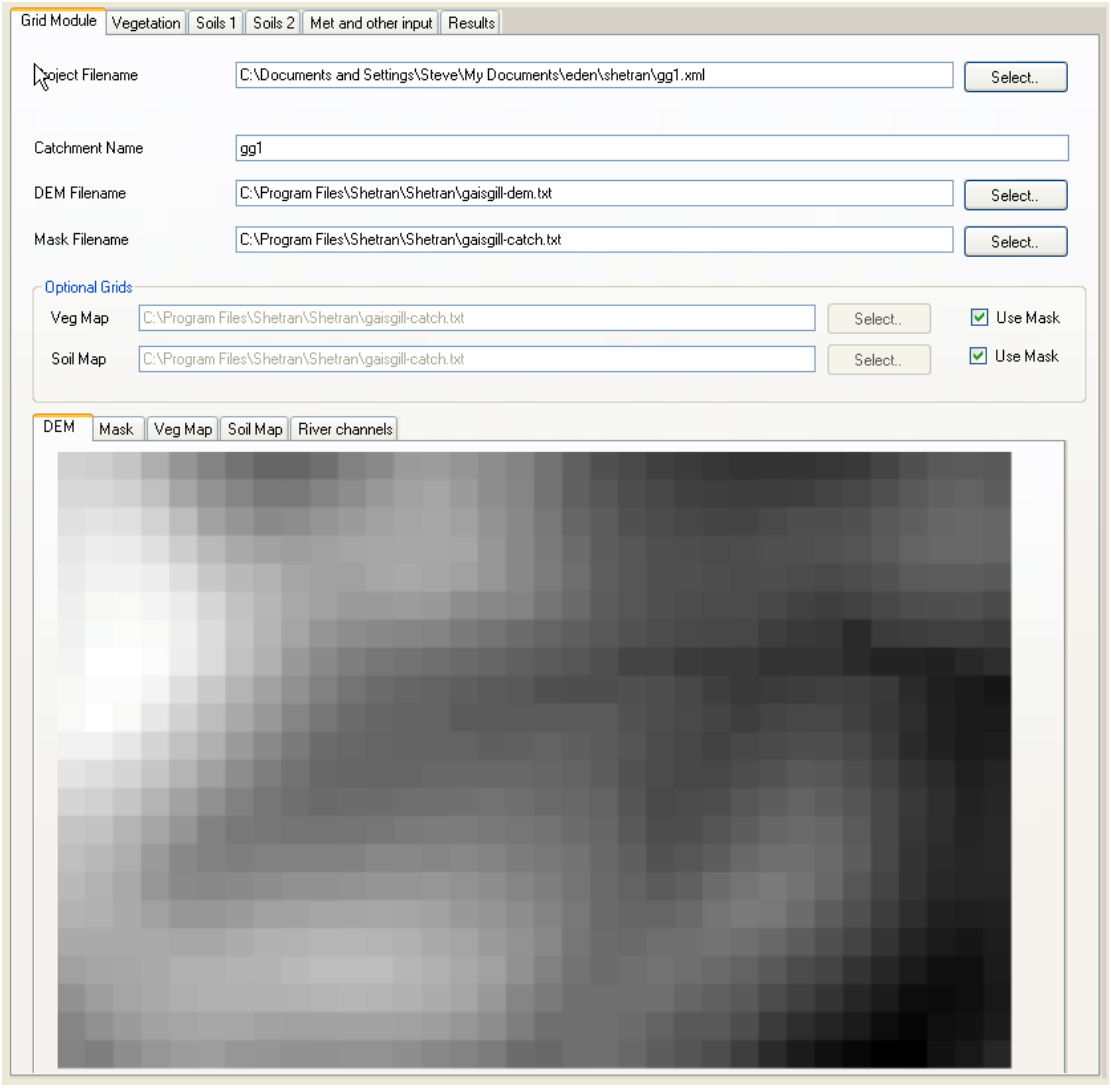
Start SHETRAN. Go to **Start | All programs | shetran | Shetran**

The screen below will appear. There are six tabs on the left: **Grid Module** (which is the visible tab)**, Vegetation, Soils 1, Soils 2, Met and other input** and **Results.** On the right are three tabs: **XML File Preview, Results Graph** and **Text File Preview**

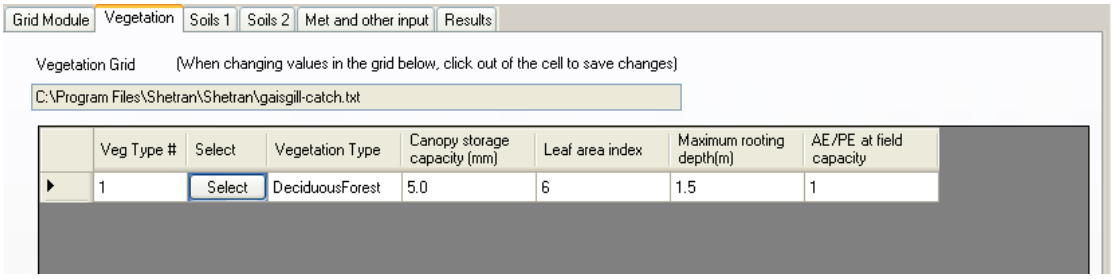


Fill in the **Grid module** as below with:
Project filename (click on **Select**, go to a suitable drive and folder, e.g. c:\Documents and Settings\Steve\My Documents\eden\shetran, and type in filename e.g. gg1)
Catchment Name (type in the catchment name)
DEM Filename (click on **Select**, go to the correct folder and choose the correct file. e.g. c:\Program Files\shetran\shetran\gaisgill-dem.txt). You will need to change the **Files of Type** to **Text Files (*.txt)**
Mask Filename (click on **Select**, choose the correct file)
For the **Veg Map** and **Soil Map** tick on **Use Mask**. For simplicity in this practical this assumes there is only one soil type and vegetation type over the entire catchment.

The tabs **DEM** and **Mask** display the data being used.



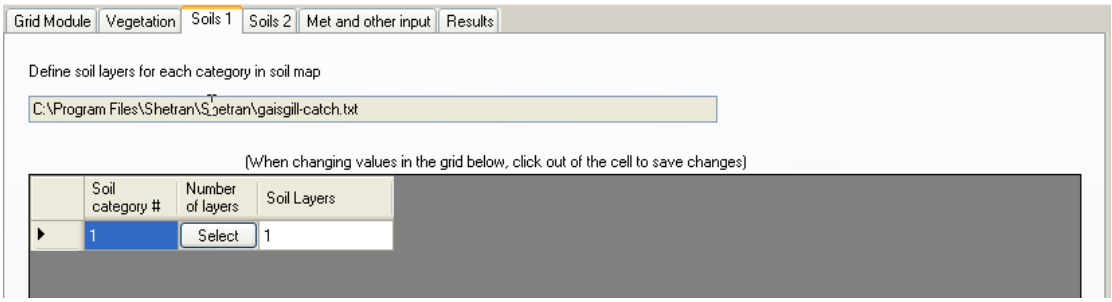
Click on the **Vegetation** page. The default vegetation is **Grass**
Select Deciduous Forest as below (i.e. click on **Select** and choose **Deciduous Forest** from the list of vegetation types)



If a red warning symbol appears ( )on the left put mouse pointer over the symbol and an error message will appear.

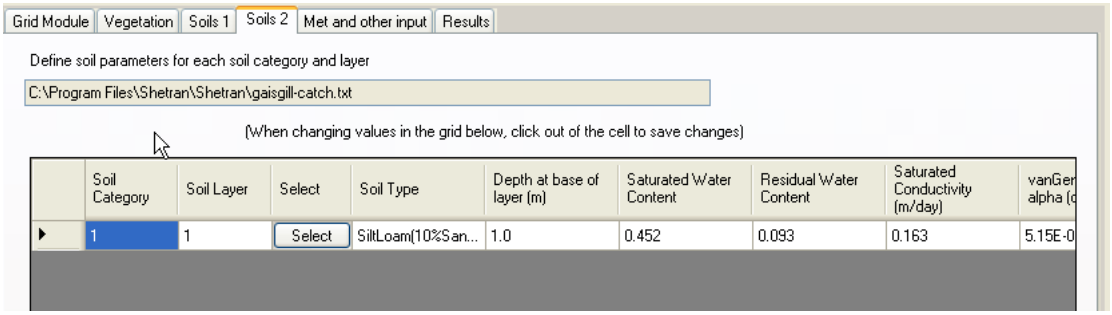
Click on the **Soils 1** page

Up to 3 soil layers can be defined for each soil category. The default is that there is a single soil later. Leave the default as it is for the moment



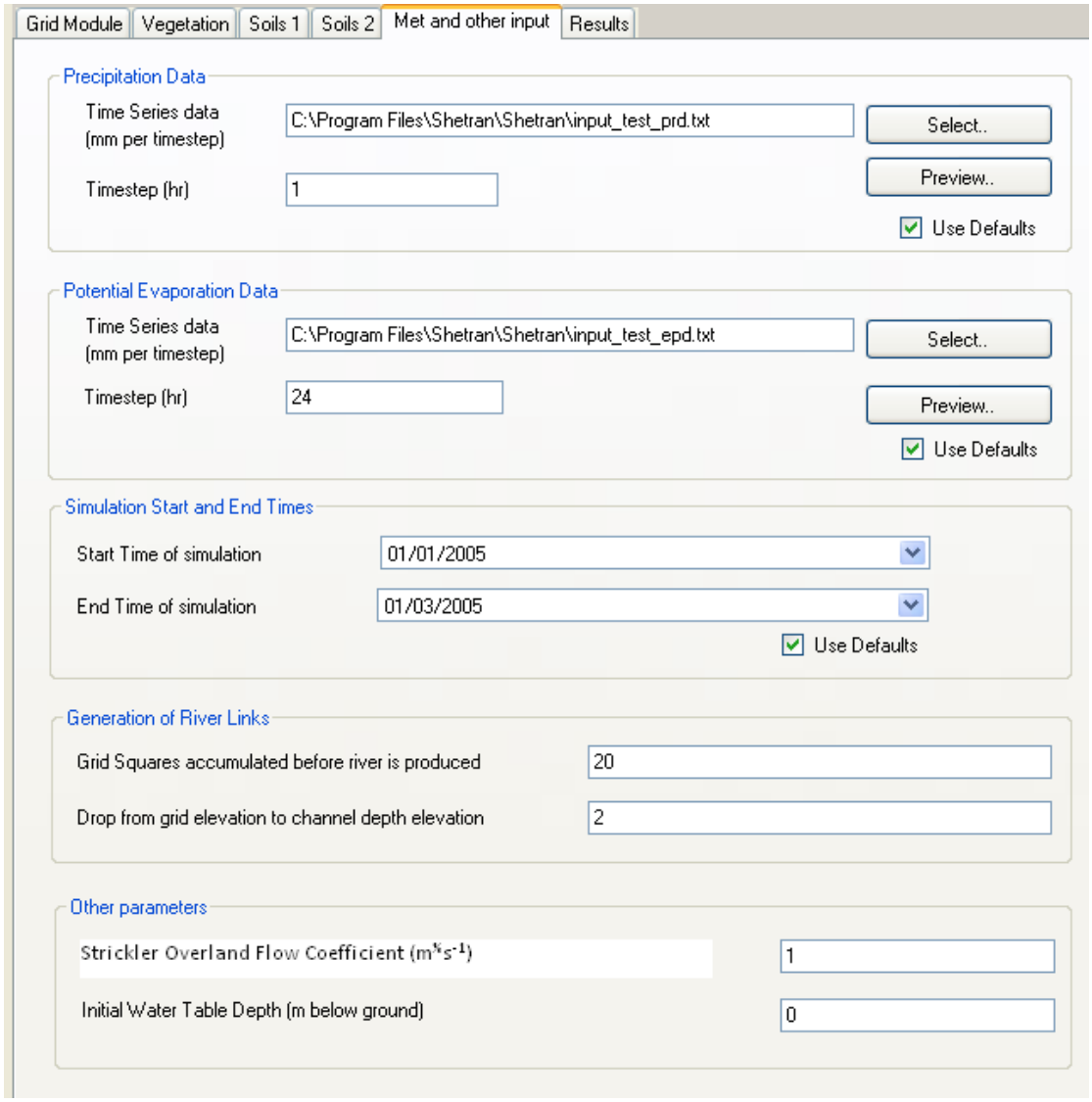
Click on the **Soils 2** page

The default is a SiltLoam soil as below. Leave the default as it is for the moment

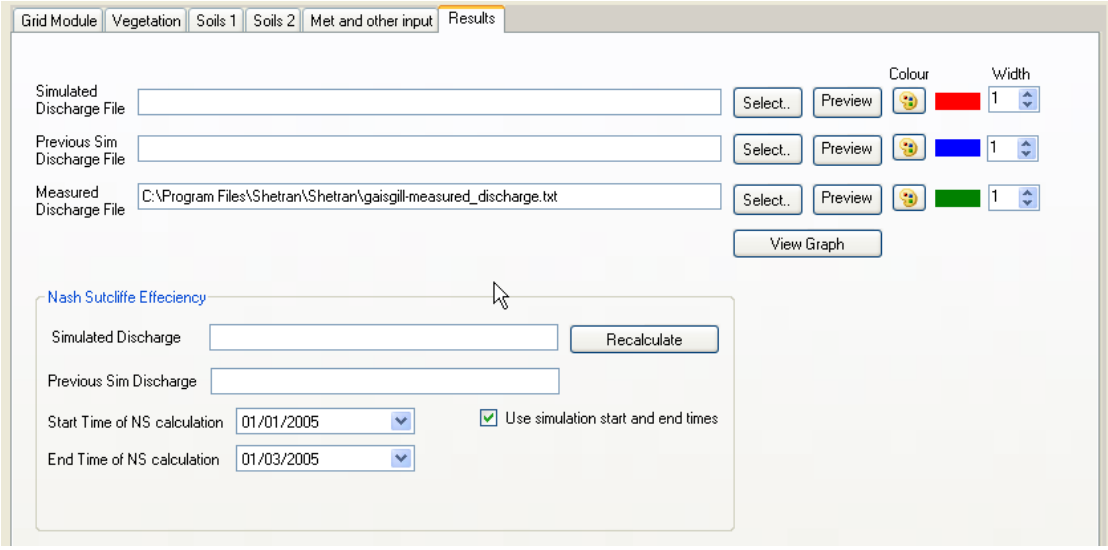


Click on the **Met and other input** page.
Some of the defaults do not need changing, some do.
Change the following as below:
Start time of Simulation
End time of Simulation
Note, the dates can be in United Kingdom format (i.e. day/month/year) or American (i.e. month/day/year). In the example shown here they are in United Kingdom format

Preview displays a time series of precipitation and potential evaporation data



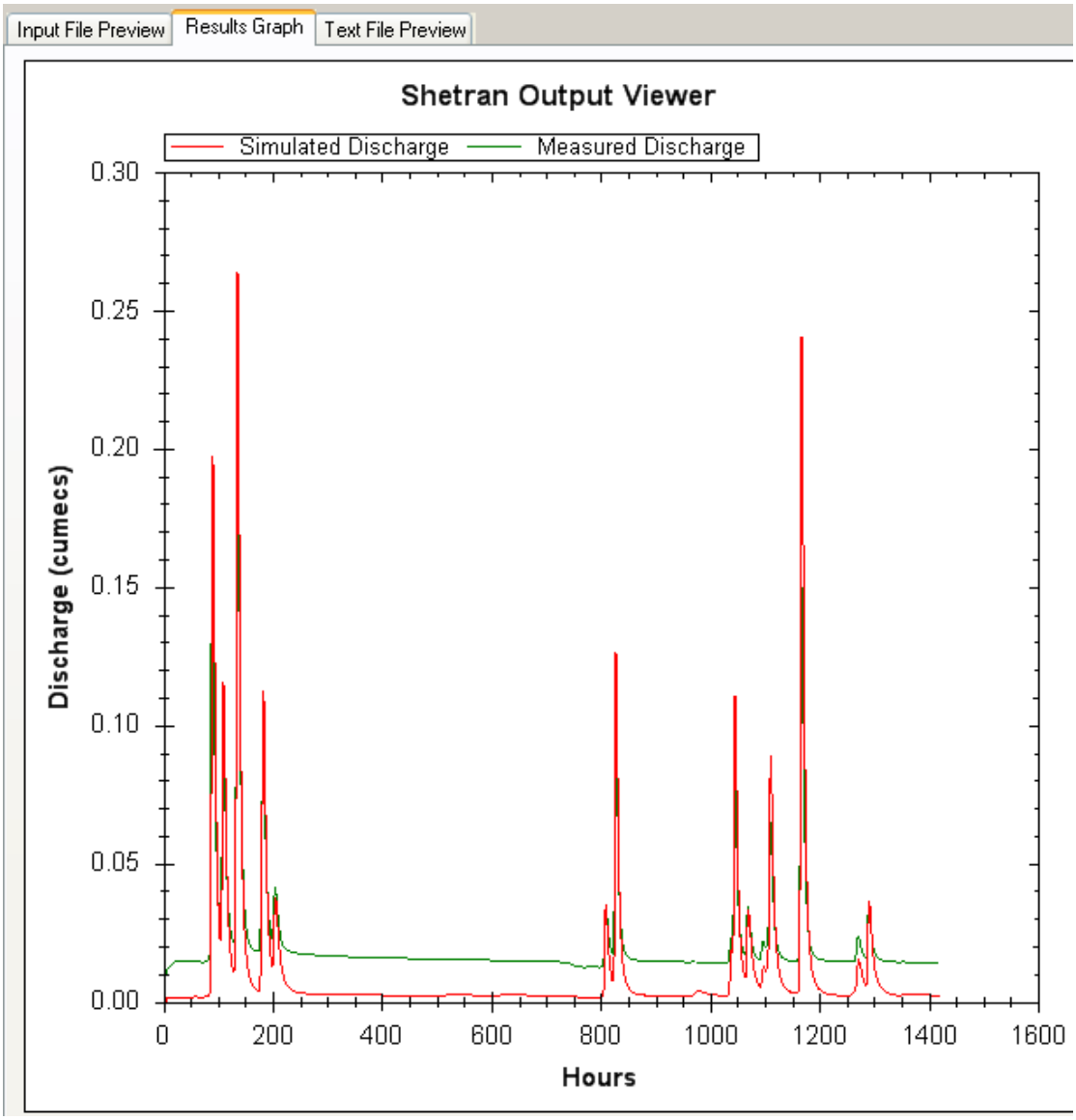
Click on the **Results** page
Change the **Measured Discharge File**
The text for the **Simulated Discharge File** is automatically filled in
On the **Nash Sutcliffe Efficiency,** tick the **Use Simulation start and end** times so that that the times correspond to those on the **Met and Other input** page.

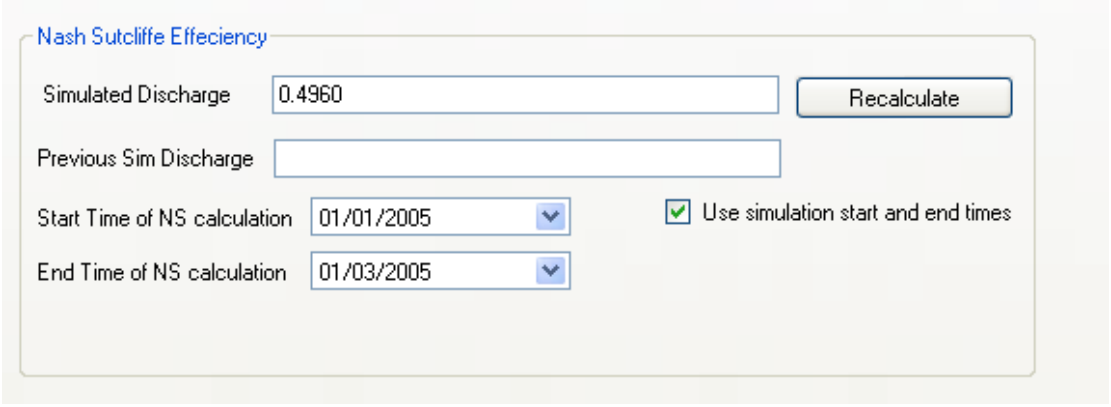


Run Shetran

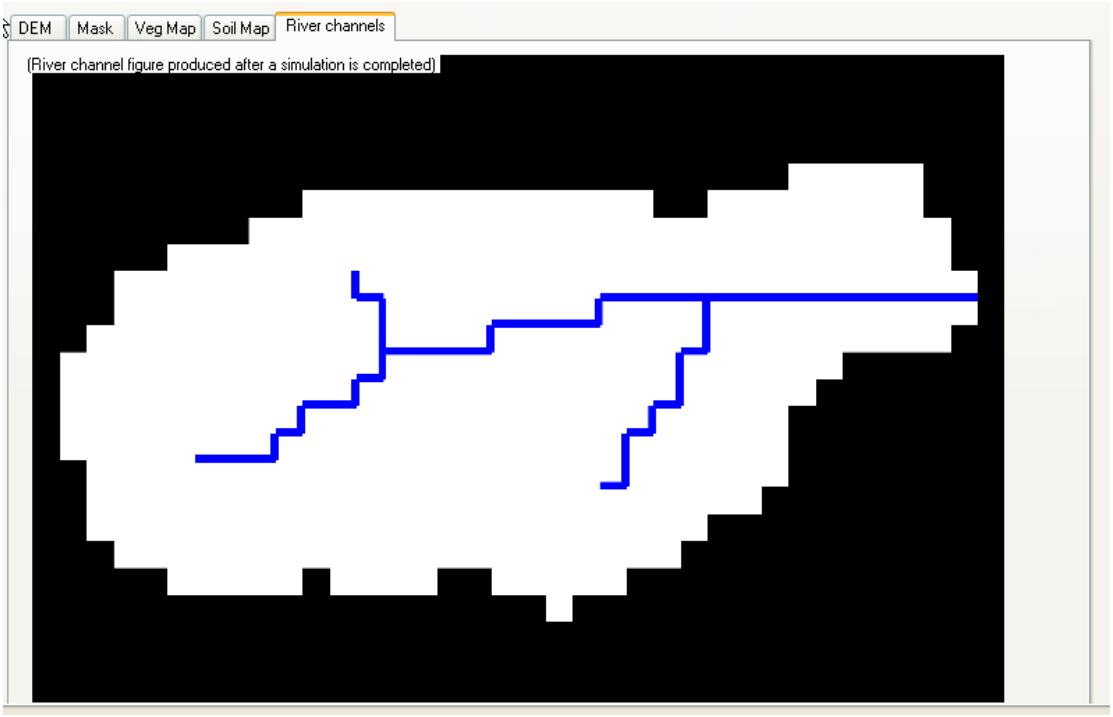
To run Shetran click on **Run Shetran executable** icon (). This will prepare the Shetran input files and then run Shetran. The time through the simulation (hours) will scroll down the screen in a command window. When completed (after two months) or 1416 hours the text **Normal Completion of SHETRAN Run** will appear briefly (this should take a couple of minutes depending on the machine). A box with the text **Run complete – SHETRAN exited normally**.will appear. Click on **OK**. The Figure below should appear. This shows the simulated and measured time series of discharge at the outlet (m^3/s).

The Nash Sutcliffe efficiency will also appear as below. This gives an idea of the quality of the simulation – a value of 1 is a perfect fit and a value of zero means the simulation is equivalent to the mean of the measured discharge.



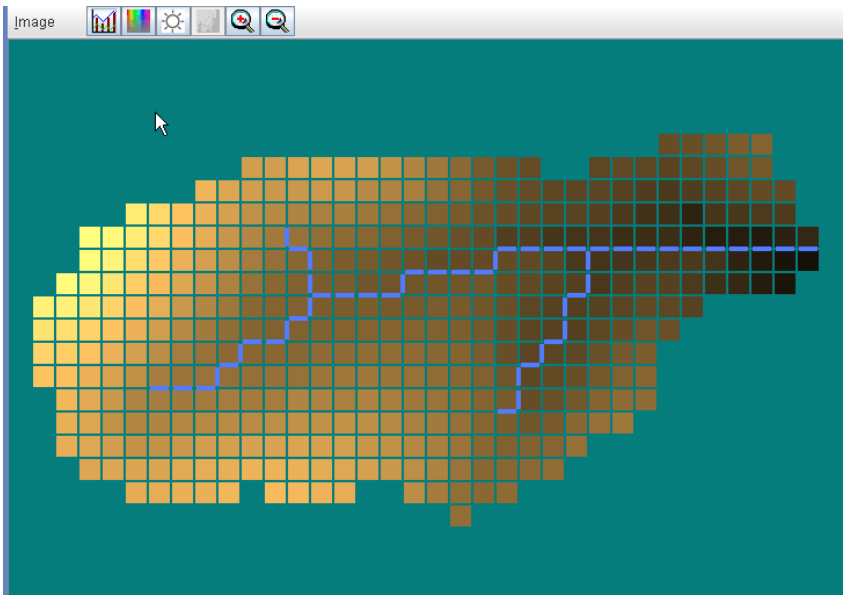


Go back to the **Grid Module** page. The **River channels** tab is now visible and the river channels automatically generated depending on where the flow accumulates are shown



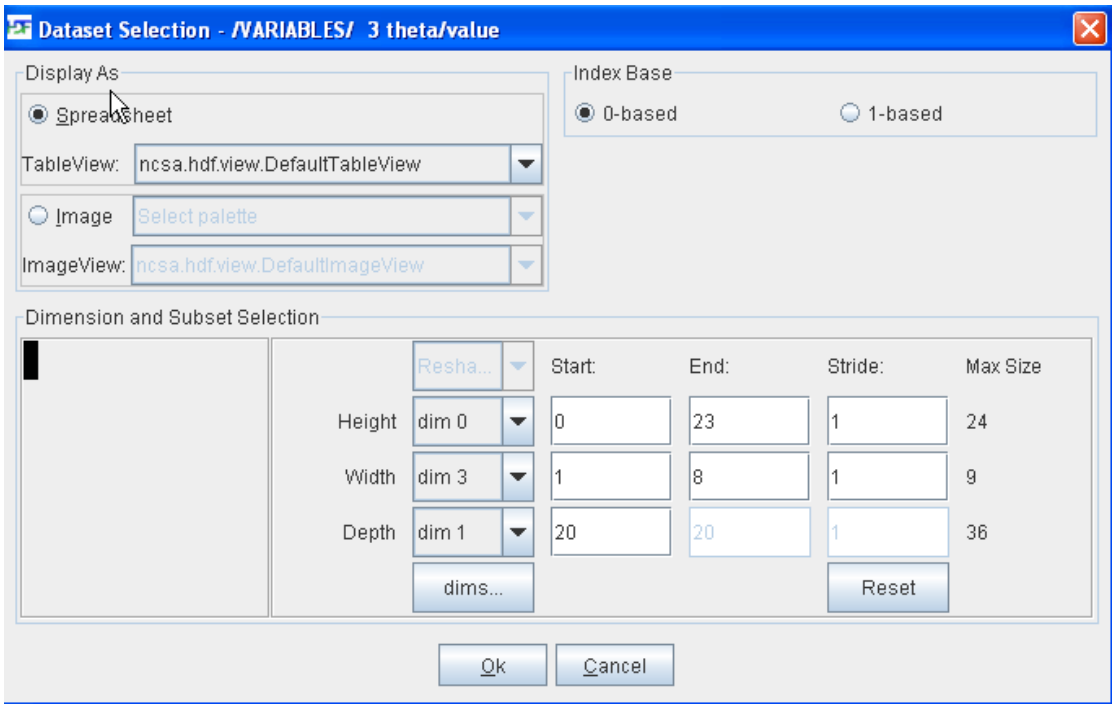
View additional SHETRAN Output

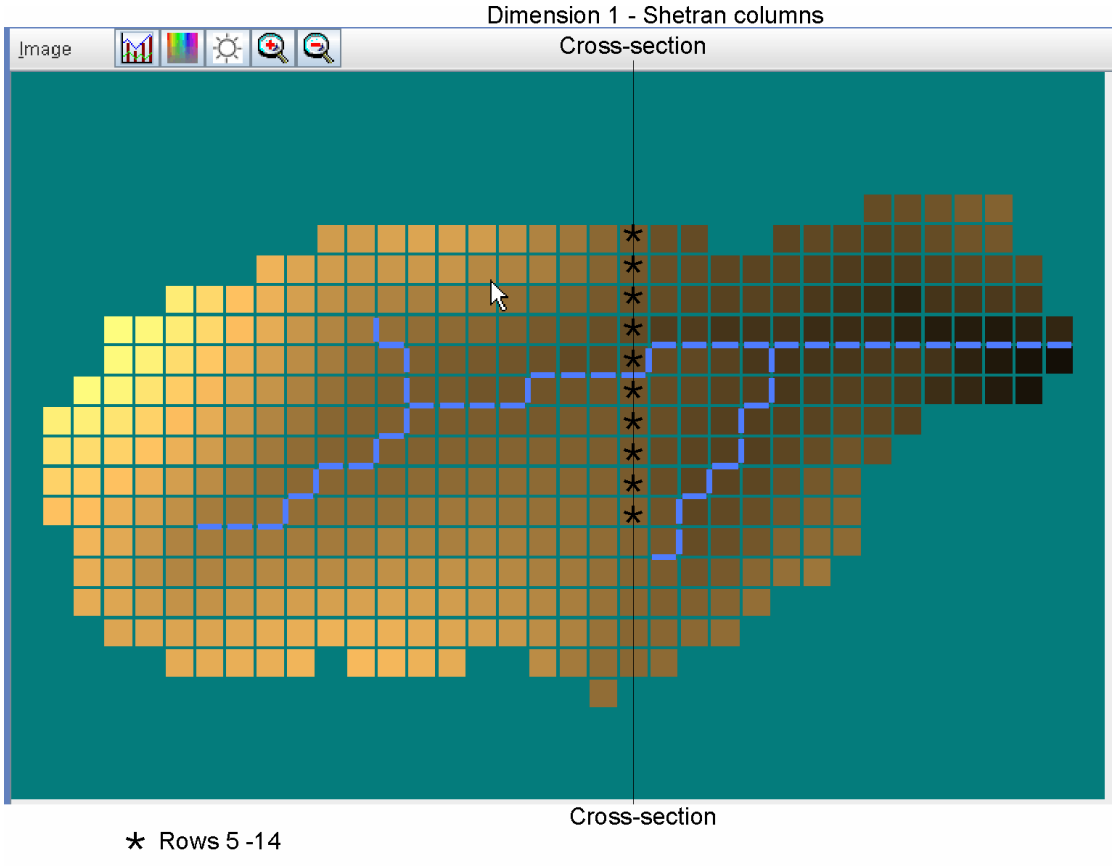
Using windows go to c:\Documents and Settings\Steve\My Documents\eden\shetran \output_gg1_shegraph.h5. Double click on this file to start HDFView (this assumes that the free HDFView has been installed). Double click on **CATCHMENT_MAPS** and double click on **SV4_elevation**. The screen below should appear. This shows the DEM with the rivers automatically generated depending on where the flow accumulates. The rivers are in the same location as those in the **River Channels** tab in the GUI



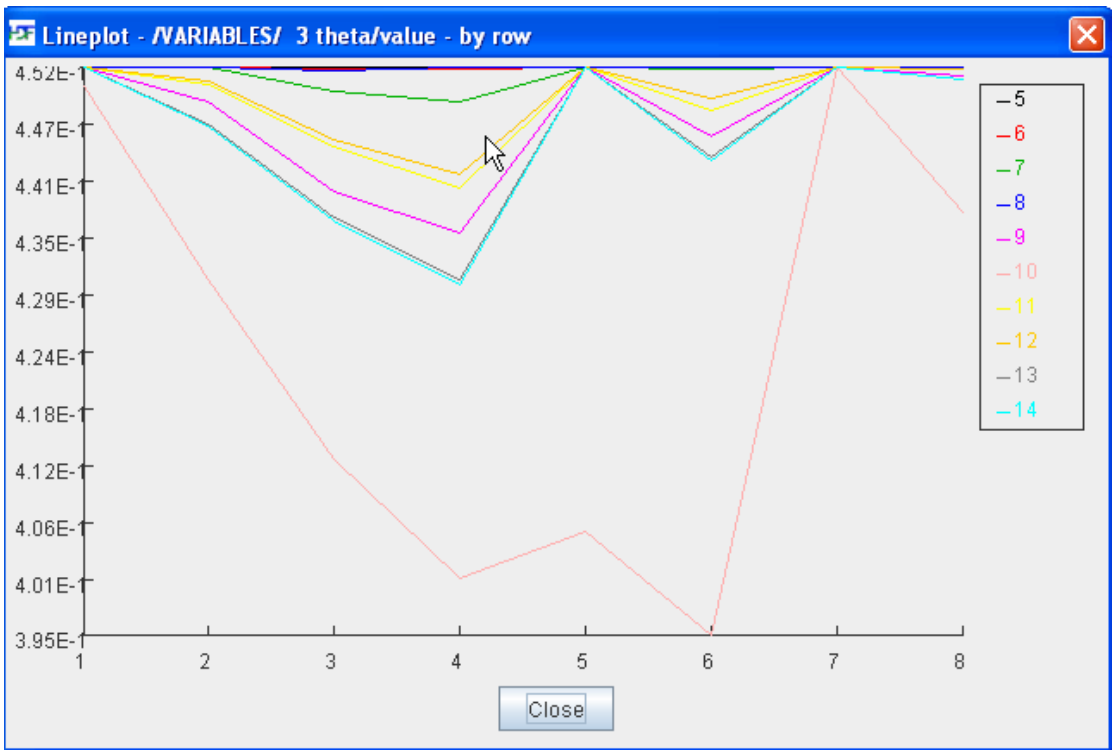
Double click on **Variables** and on **Theta.** Right click on **Value** and Select **Open_As.** This is now a bit confusing as you need to think in 4 dimensions!! Dimension 0 is the SHETRAN row and Dimension 1 the SHETRAN columns. Dimension 2 is the Shetran layers in a soil column or the z direction, layer 0 is the top layer of the soil column which also includes the ground surface. Dimension 3 is the time dimension; this can be found by clicking on **Dims**.

Select the values as below. The **width** (time through the simulation) starts at 1 as the values at time 0 are all zero. Click on **OK** and this produces a spreadsheet, which shows the values for a vertical cross-section through the catchment and how they vary in time.





Selects rows 5 to 14 in the spreadsheet. Click on the **Line plot** icon (). Click on **Row** and **OK.** The figure below should be produced. For the top layer in the 10 highlighted grid squares this shows a time series of how the soil moisture content varies over the two month simulation, with values produced every week.



Open the file: c:\Documents and Settings\Steve\My Documents\eden\output_gg1_mb.txt in NotePad, WordPad or Excel. The values on the final line are for the end of the simulation and these are.

Spatially Averaged Totals (mm) over the simulation

Time(Hours),	Cum Prec.,	Cum. Can. Evap.,	Cum. Soil Evap.,	Cum. Trans,	Cum. Discharge,	Subsurface Stor.
1416.625,	86.700,	21.505	2.524,	4.786,	58.397,	449.038

Section 2 – Changing Vegetation

We will now run the simulation again but with a changed vegetation. Go back to the **Grid module** screen. This time select the following:

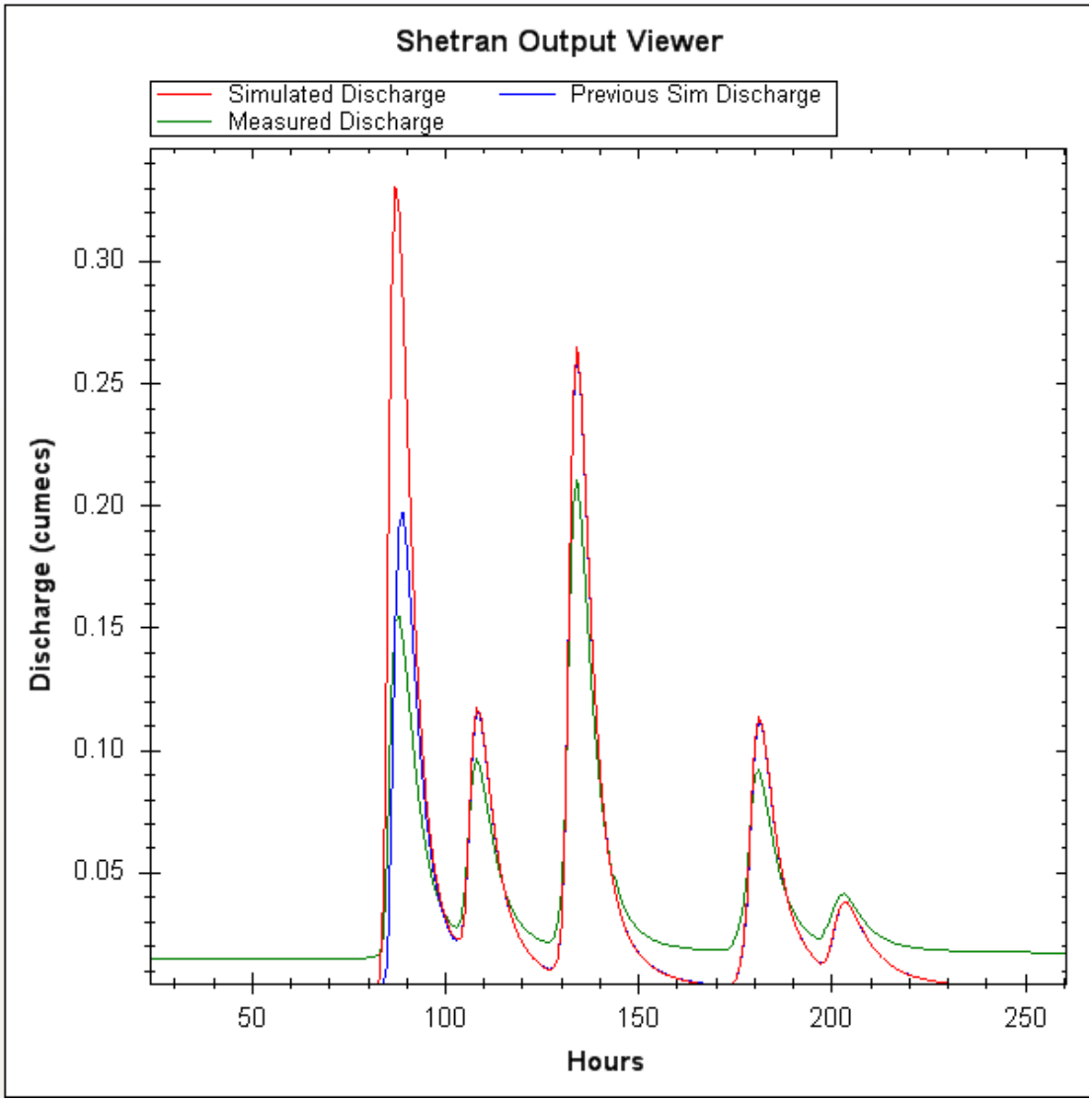
Project name:
c:\Documents and Settings\Steve\My Documents\eden\shetran\gg2.xml
Catchment name: gg2

Leave the other values. Go to the **Vegetation** screen.
Change the following values for **Deciduous forest**
Canopy storage capacity is reduced from 5 to 1.5
Rooting depth is reduced from 1.5m to 1m
AE/PE ratio at field capacity is reduced from 1 to 0.6

Leave the **Soils 1** and **Soils 2** screens and go to the **Results** screen

In **Previous Sim Discharge File** select
c:\Documents and Settings\Steve\My Documents\eden\shetran\output_gg1_discharge_sim_hourly.txt.
(this makes discharge from the first simulation visible in the viewer so the effect of changing the vegetation can be easily seen).

Run SHETRAN as before. The Results Graph shows the new simulation in red, the previous simulation in blue and the measured discharge in green. It is hard to see what is happening so with the left mouse button select a rectangle containing the first set of peaks (up to 250 hours). The zoomed in graph can be seen below. This shows the simulated discharge for the first peak has gone up but for the other peaks it is similar. The Nash Sutcliffe efficiency has gone down from 0.4960 to 0.2274.



Open the file:
c:\Documents and Settings\Steve\My Documents\eden\shetran\outut\pej2-mb.txt in NotePad, WordPad or Excel. The values on the final line are for the end of the simulation and these can be seen below. The main difference from the previous simulation is the canopy evaporation has gone down and as a result the discharge is higher. Some of the energy used to evaporate water from the canopy is now used for transpiration and to evaporate water from the soil surface and so these are now slightly higher than before.

Spatially Averaged Totals (mm) over the simulation

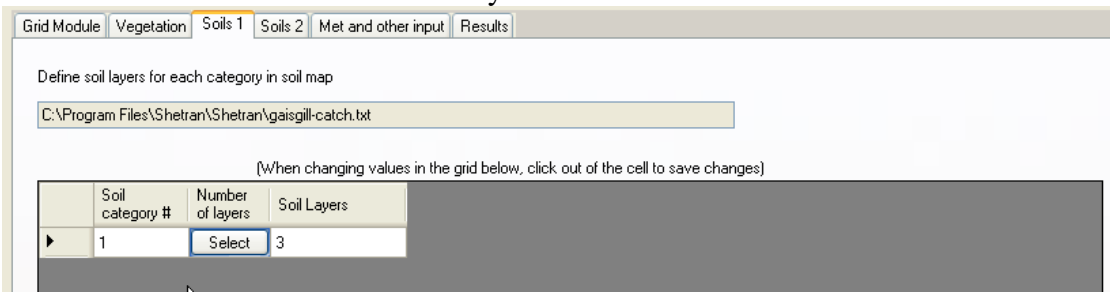
Time(Hours),	Cum Prec.,	Cum. Can. Evap.,	Cum. Soil Evap.,	Cum. Trans,	Cum. Discharge,	Subsurface Stor.
1440.573,	86.700,	16.617 ,	3.874,	6.538,	63.060,	449.119

Section 3 – Changing Soil

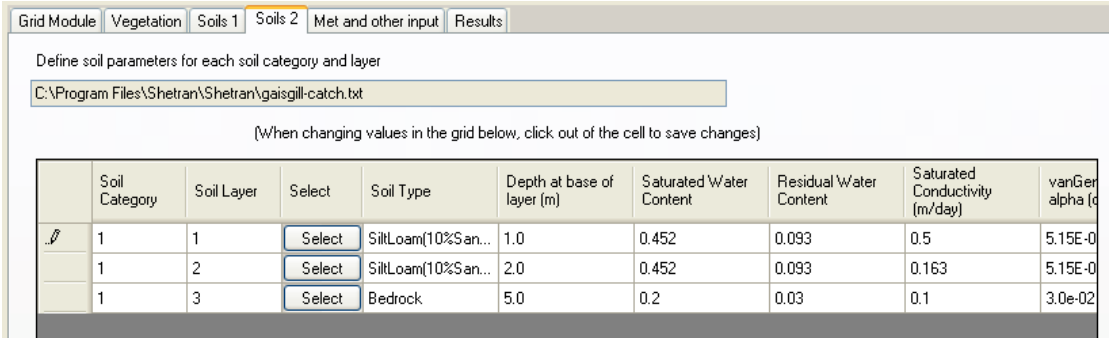
We will now run the simulation again but with different soils. Go back to the **Grid module** screen. This time select the following

Project name:
c:\Documents and Settings\Steve\My Documents\eden\shetran\gg3.xml
Catchment name: gg3

On the **Soils 1** screen **Select 3** Soil Layers



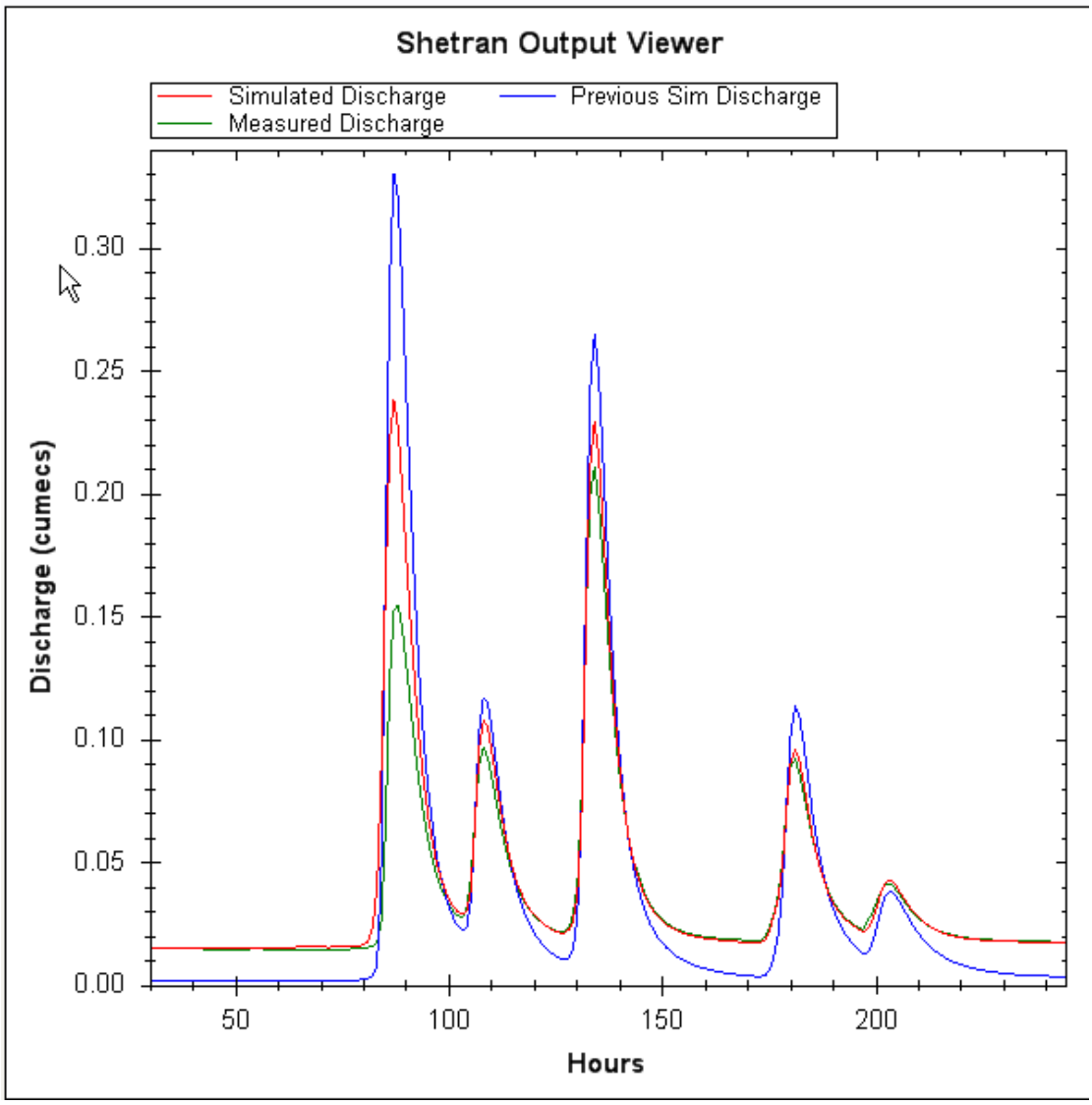
The default values are a SiltLoam down to 1.0m, another SiltLoam down to 2.0m and some bedrock down to 5.0m. Change the **Saturated Conductivity** in **Soil Layer 1** from 0.163 m/day to 0.5 m/day. This parameter is often hidden you may need to scroll along to the right (Look at the bottom of the **Soils 2** screen)



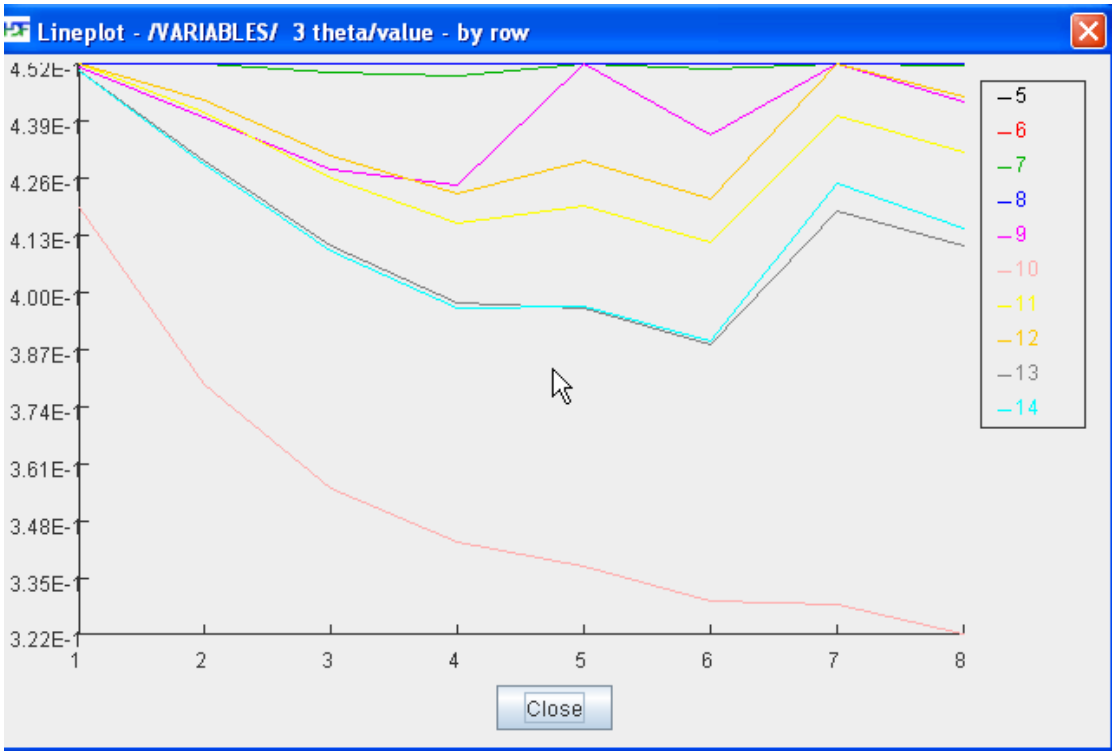
In the **Results** screen change the **Previous Sim discharge File** to:
c:\Documents and Settings\Steve\My Documents\eden\shetran\output_gg2_discharge_sim_hourly.txt.

Run SHETRAN as before.

The screen below will appear if we consider only the discharge up to 250 hours (to see the entire series right click on the graph and select **Undo All Zoom/Pan**) . The new simulation (shown in red) is much more similar to the measured discharge (shown in green). The Nash Sutcliffe efficiency is now 0.8860. In particular, the base flow in the measured and simulated discharges are very close, as a result of the simulation having 3 soil layers down to 5m below ground.



As before use Windows to open c:\Documents and Settings\Steve\My Documents\eden\shetran\output_gg3_shegraph.h5 to view the soil moistures. Overall, the deeper soils have made the top soil layer (shown below) much drier than before.


Lineplot - /VARIABLES/ 3 theta/value - by row
4.52E-1
4.39E-1
4.26E-1
4.13E-1
4.00E-1
3.87E-1
3.74E-1
3.61E-1
3.48E-1
3.35E-1
3.22E-1
1
2
3
4
5
6
7
8
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6
7
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9
10
11
12
13
14
Close

Section 4 - Changing river network

This time we will change the number of river links/channel used in SHETRAN. Go back to the **Grid module** screen. This time select the following

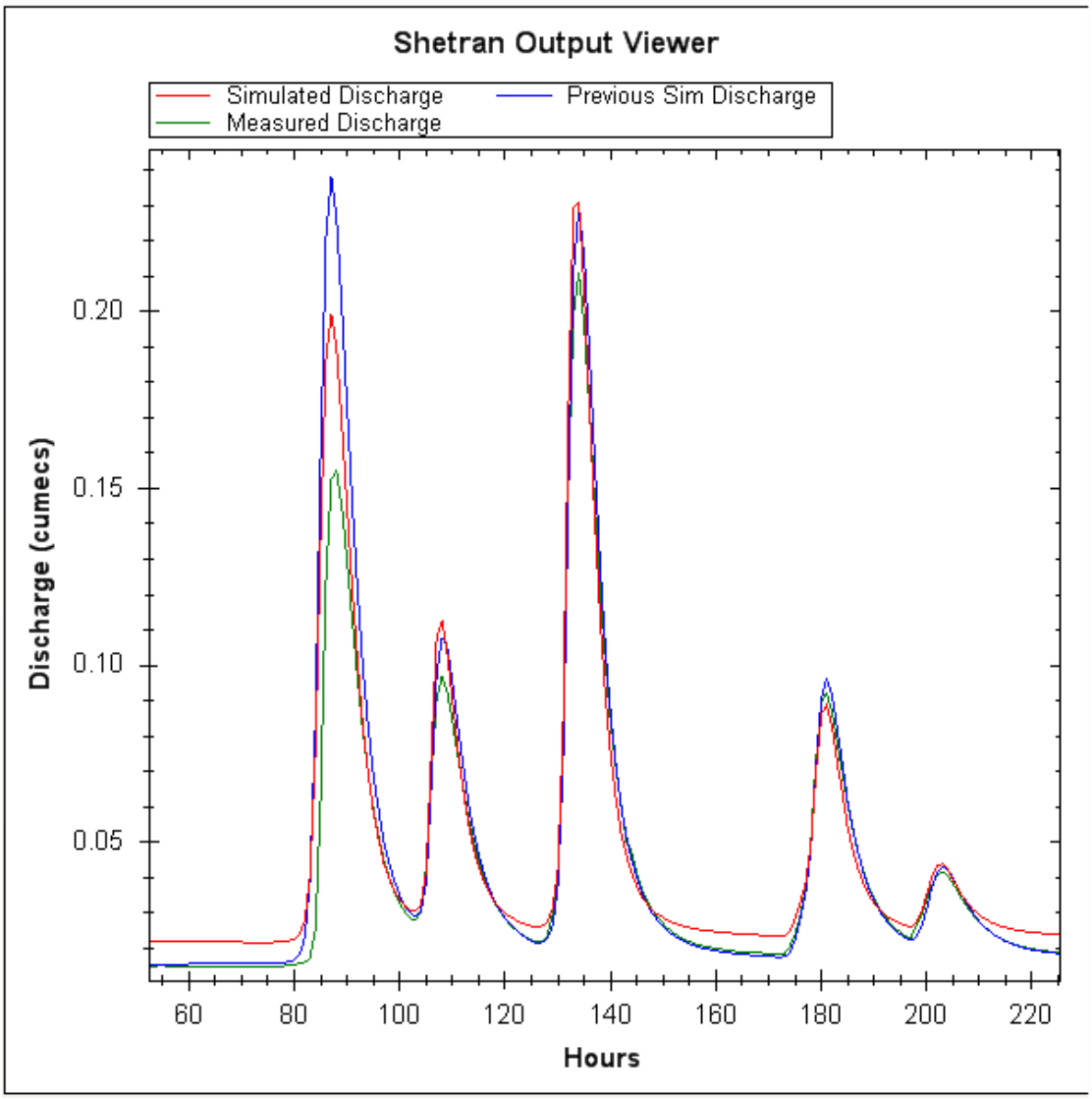
Project name:
c:\Documents and Settings\Steve\My Documents\eden\shetran\gg4.xml
Catchment name: gg4

On the **Met and other input** screen in **Generation of river links** change **Grid squares accumulated before a river link is produced** from 20 to 5. This parameter now produces a river link if the upstream contributing area is greater than 5 grid squares.
Reducing the value from 20 to 5 will produce a lots more river channels. The main ones will still be in the same place but there will be more small ones further up into the catchment.

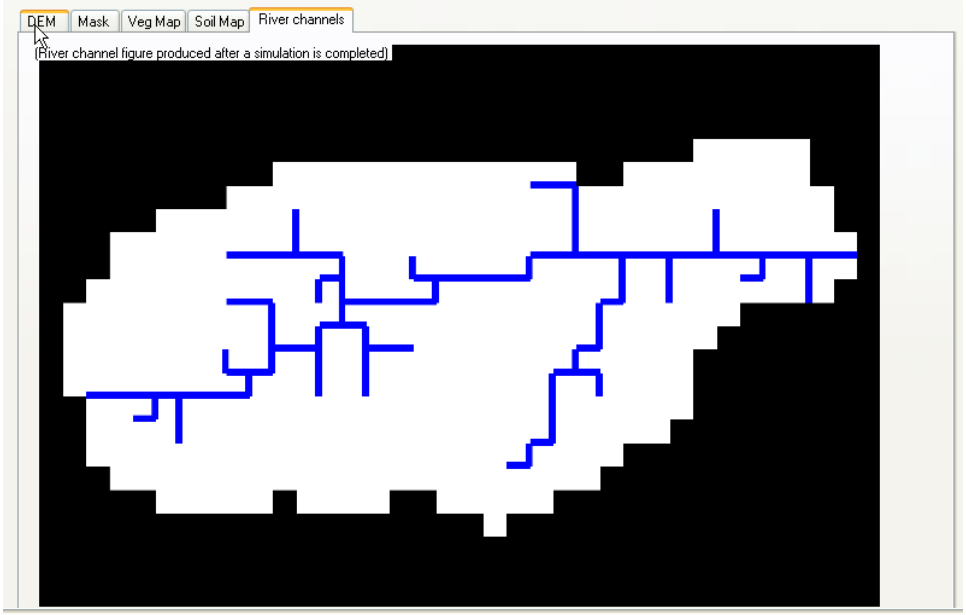
On the **Results** screen change the **Previous Sim discharge File** to:
c:\Documents and Settings\Steve\My Documents\eden\shetran\output_gg3_discharge_sim_hourly.txt

Run SHETRAN as before.

If you zoom in (point the mouse over the graph and select the appropriate rectangle) the screen below will appear. The previous simulation with fewer river channels is shown in blue and the new simulation with more river channels in red. There is a complex response here. More channels produce a higher baseflow, but some of the peaks are higher and some lower.


Shetran Output Viewer
Simulated Discharge
Previous Sim Discharge
Measured Discharge
Discharge (cumecs)
0.20
0.15
0.10
0.05
60
80
100
120
140
160
180
200
220
Hours

Go back to the **Grid Module** page. The **River channels** tab is now visible and the river channels automatically generated depending on where the flow accumulates are shown. Comparing it to the previous simulation shows that there are more river channels.



This can also be seen by looking in c:\Documents and Settings\Steve\My Documents\eden\shetran \output_gg4-shegraph.h5. As before double click on **CATCHMENT_MAPS** and double click on **SV4_elevation**. The screen below should appear. This shows the DEM with the rivers automatically generated depending on where the flow accumulates.