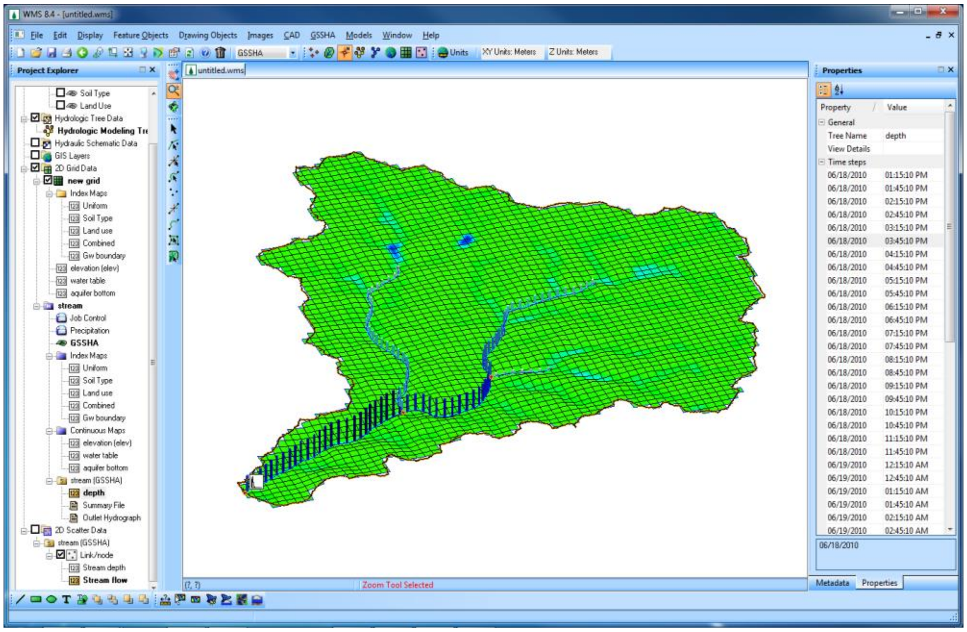
v. 10.1

WMS 10.1 Tutorial

GSSHA – Groundwater – Groundwater Modeling in GSSHA

Setup a basic groundwater model using GSSHA



Objectives

Learn how to set up a groundwater model from a basic GSSHA long term model.

Prerequisite Tutorials

- GSSHA – Applications – Long Term Simulations in GSSHA

Required Components

- Data
- Drainage
- Map
- Hydrology
- 2D Grid
- GSSHA

Time

- 30-60 minutes

1 Introduction

This tutorial teaches how to set up a groundwater model in GSSHA. Begin with an existing long term simulation project with all the parameters for a basic surface water simulation already defined.

2 Open an Existing GSSHA Project

Open a GSSHA project file for the Eight Mile Creek watershed.

1. In the ***2D Grid Module*** select ***GSSHA | Open Project File…***
2. Locate the ***GSSHA Distributed Hydrologic modeling*** folder in the files for this tutorial. If needed, download the tutorial files from www.aquaveo.com.
3. Browse and open the file ***\GSSHA Distributed Hydrologic modeling\Groundwater\Base.prj.***
4. Save the project with a different name as ***\GSSHA Distributed Hydrologic modeling\Personal\ Groundwater\GW.prj***
5. In the *Project Explorer*, toggle off the display of all the map data and toggle the *GSSHA* coverage on.

3 Creating Groundwater Datasets

To simulate groundwater in a GSSHA model, the following index maps and tables need to be defined:

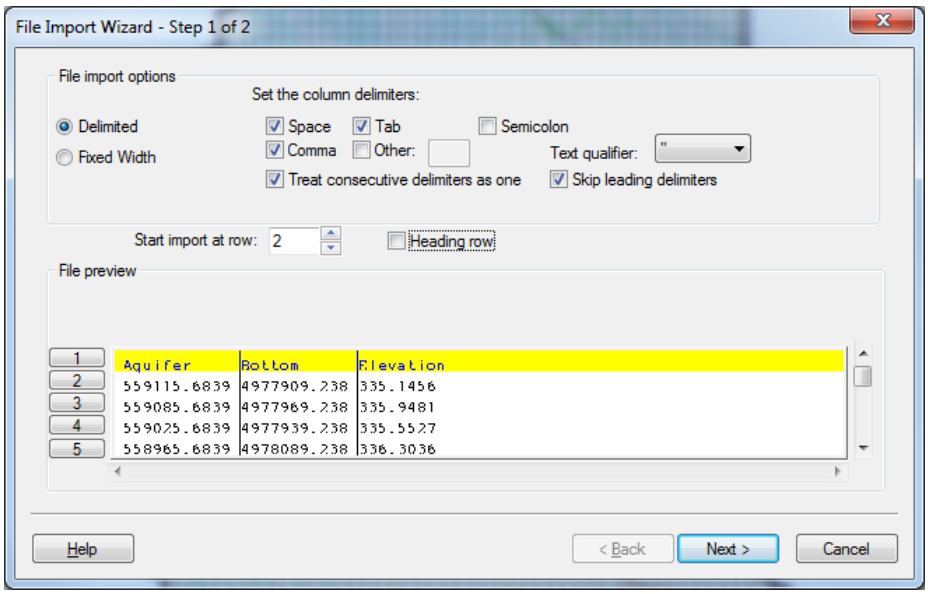
- Aquifer bottom map,
- Initial water table elevation map,
- Boundary condition map
- Subsurface hydraulic conductivity map
- Subsurface porosity map.

Create the aquifer bottom and water table elevation maps from x, y, z points stored in a .csv file. These points were derived from borehole logs. The hydraulic conductivity and porosity inputs will be developed using a geology shape file.

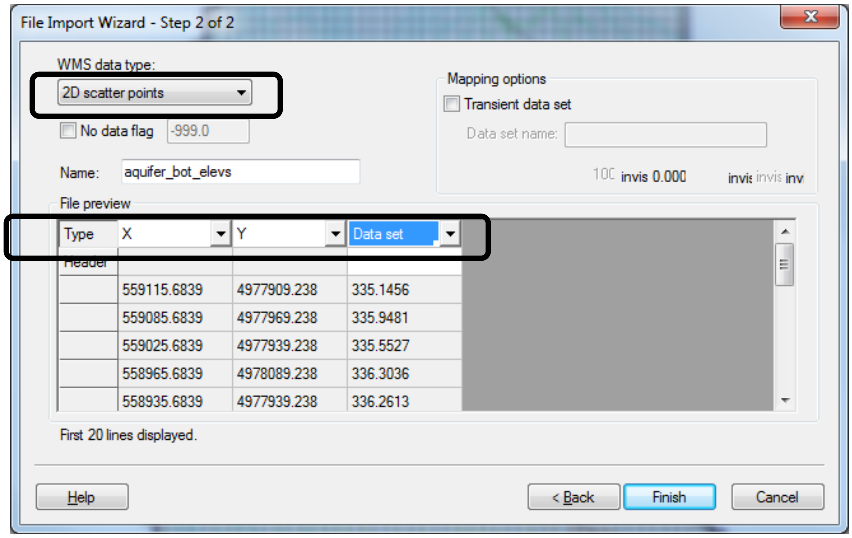
3.1 Aquifer Bottom

The aquifer bottom map is created from XYZ data of the aquifer bottom. These data can be derived from borehole data that contain information about depth to different layers in the subsurface.

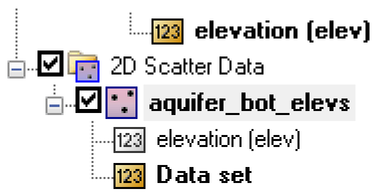
1. Select ***File* | *Open*** in the WMS window, browse and open file ***\GSSHA Distributed Hydrologic modeling\RawData\Groundwater\ aquifer_bot_elevs.csv.***
2. In the *File Import Wizard*, change the *Start import at row* value to 2. Do not turn on the *Heading Row* toggle.



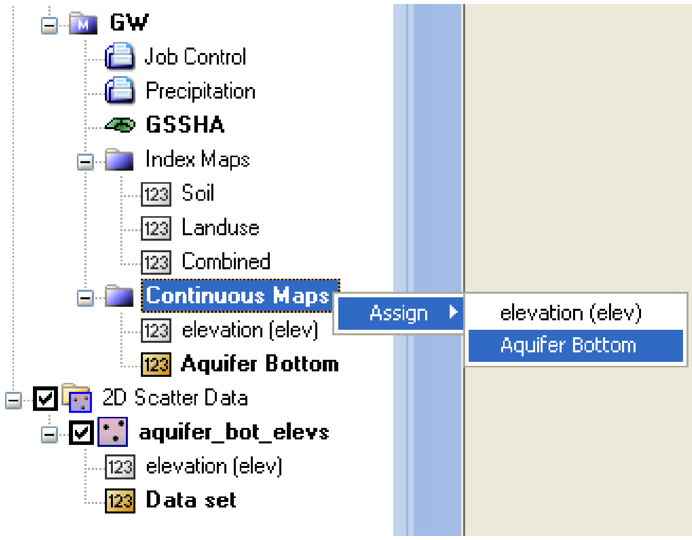
3. Make sure the Comma delimiter is toggled on and click *Next*.
4. Make sure the WMS data type is set to *2D Scatter Points*.
5. Make sure the first column is mapped to *X*, the second column to *Y*, and the third column to *Data set*.



6. Click *Finish* to import the dataset as a 2D Scatter Point dataset
7. A new scatter point dataset named *aquifer_bot_elevs* should appear in the *Project Explorer* and the points are plotted.



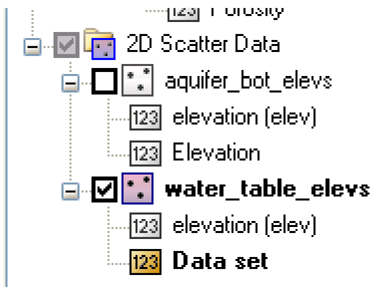
8. Make sure *Data set* is selected as the active dataset.
9. Right click on the *aquifer_bot_elevs* scatter set and choose *Interpolate->...To Grid.*
10. Change the interpolated data set name to *Aquifer Bottom*. DO NOT toggle on the option to *Map elevations*.
11. Click OK to create a new grid data set from the aquifer bottom scatter points.
12. A new continuous map named *Aquifer Bottom* should be visible among the other continuous datasets for the grid.
13. Right click on the *Continuous Maps* folder underneath the *GW* folder in the 2D Grid Data section of the *Project Explorer*.
14. Select *Assign-> Aquifer Bottom*



3.2 Initial Water Table Elevations

Ideally, there will be observation well data from which to derive an initial representation of the water table. These xyz data can be interpolated to the grid to develop the required continuous map in the same way the aquifer bottom map was created. In lieu of measured values, develop an initial water table by assuming an initial water table and running GSSHA to derive a water table map. In this example, use xyz data that represent well water surface elevations scattered throughout the domain.

1. In the WMS window select ***File | Open***, browse and open file ***\GSSHA Distributed Hydrologic modeling\RawData\Groundwater\ water_table_elevs.csv.***
2. In the *File Import Wizard*, change the *Start import at row* value to 2. Do not toggle on the *Heading row* toggle. Make sure the Comma delimiter is toggled on and click *Next.*
3. Make sure the *WMS data type* is set to *2D Scatter Points*. Map the first column to *X*, the second column to *Y*, and the third column to *Data set*.
4. Click *Finish* to import the dataset as a 2D Scatter Point dataset.
5. A new scatter point dataset named *water_table_elevs* should appear in the *Project Explorer* and the points are plotted.



6. Select the *Data set* data set (under *water_table_elevs*) to make sure it is selected as the active dataset.
7. Right click on the *water_table_elevs* scatter set and choose *Interpolate->...To Grid.*

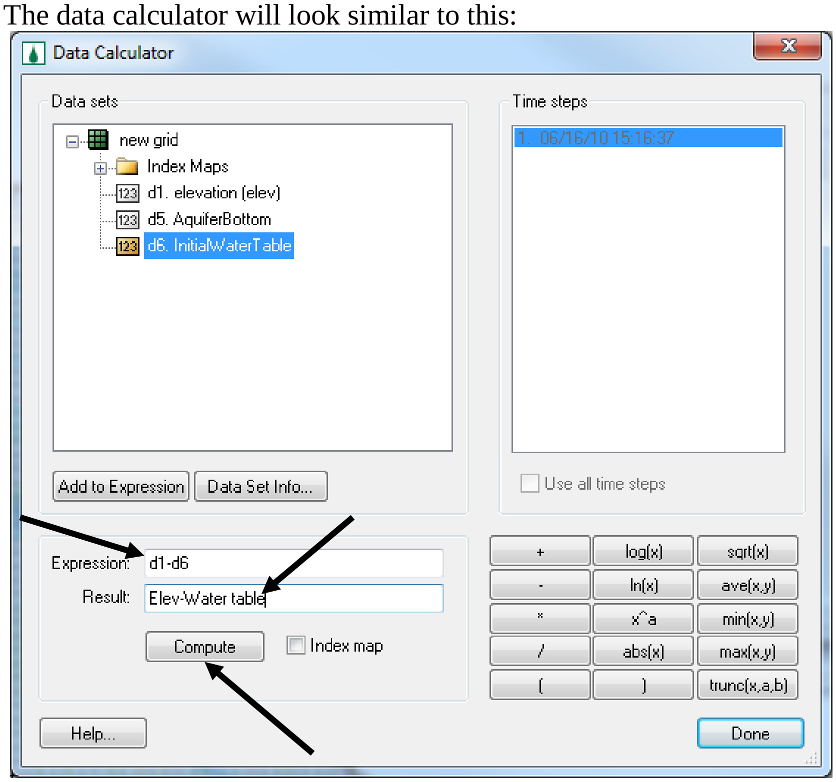
8. Change the interpolated data set name to *InitialWaterTable*. DO NOT toggle on the option to Map elevations.
9. Click *OK* to create a new grid data set from the water table scatter points
10. Notice the new continuous map named *InitialWaterTable* among the other continuous datasets of the grid.

3.3 Checking Water Table Elevation Data

After interpolating the water table XYZ data to define the water table elevation map, the water table elevation at some locations could be higher than the ground elevation or lower than the aquifer bottom which is not desirable. Be sure to check this and fix any anomalies before using the water table elevation map with the model.

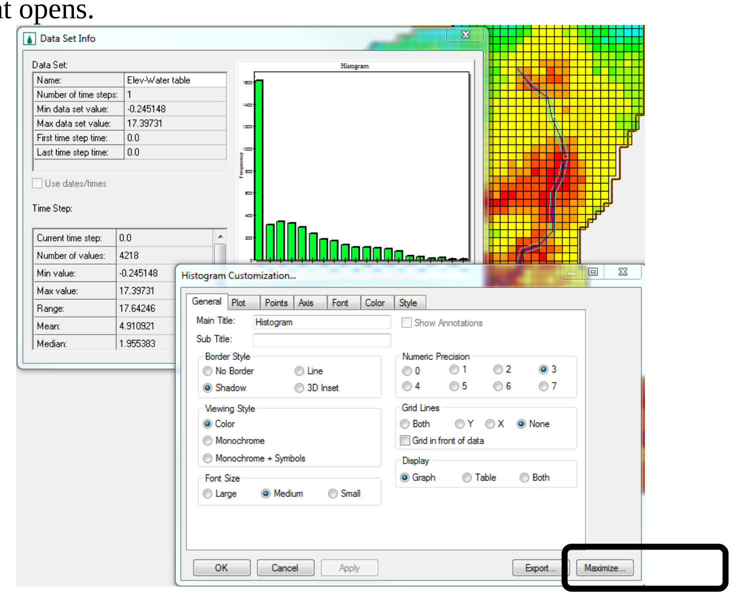
One of the easiest ways to check this is to use the data calculator to subtract the water table map from the elevations map or subtract the aquifer bottom from the water table elevations.

1. In the *2D Grid* module, select *Data* | *Data Calculator*.
2. Double click *elevation (elev)* data which will insert a dataset symbol such as *d1* in the *Expression* box. Note that the dataset symbol might be different in this case.
3. Then click the - (minus) button or type it from the keyboard.
4. Double click the *InitialWaterTable* dataset. Type *Elev-Water table* in *Result* field.
5. Do NOT select the toggle *Index Map.*
6. The data calculator will look similar to this:

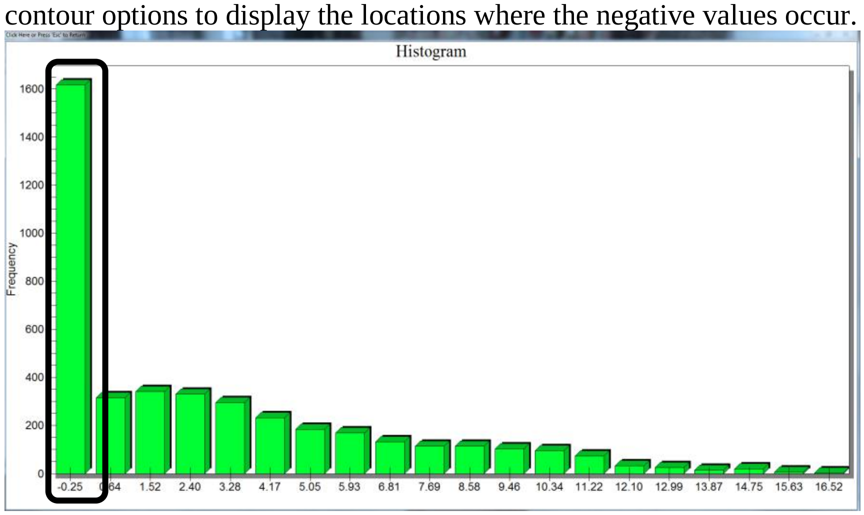


7. Click *Compute* and then *Done*.

8. Right click on the *Elev-Water Table* map in the *Project Explorer* and select *Properties.*
9. This will open the *Data Set Info* dialog. Notice the Histogram of the values in the data selected.
10. Double click on the plot area and select the maximize button in the other dialog that opens.



11. In the maximized histogram plot, check to see if there are any negative values. This example has a negative value. This means that the water table elevation is greater than the ground elevation at these cells. Change the contour options to display the locations where the negative values occur.



12. Similarly, use the expression *InitialWaterTable - Aquifer Bottom* in the data calculator to see if any cells have a water table elevation that is below the aquifer bottom. Then view the properties of the new data set to see if there are any negative values. There are negative values in this case which means that, for some cells, the water table elevation is lower than the aquifer bottom.

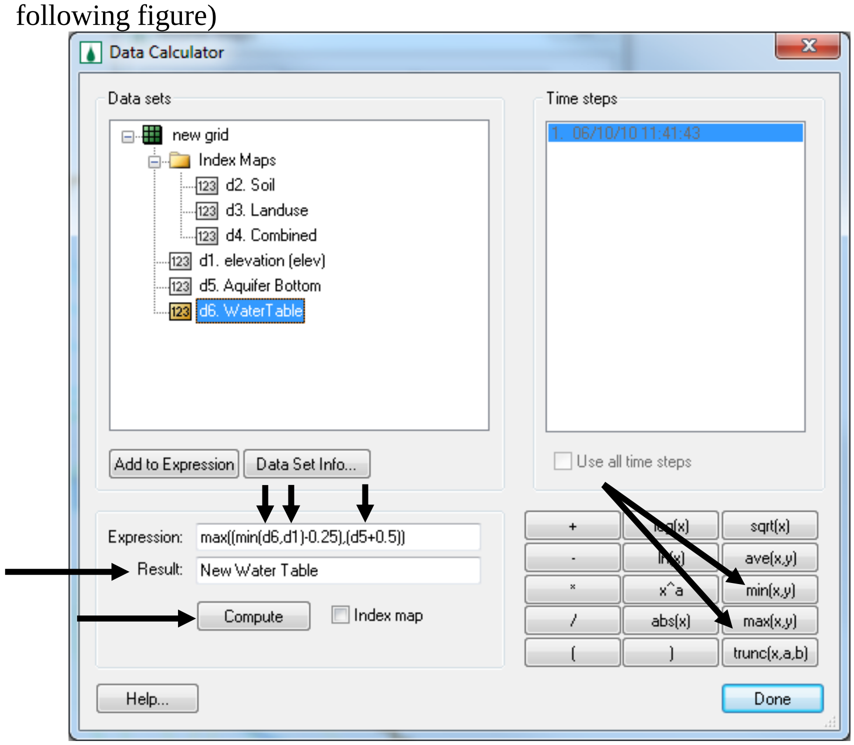
3.4 Adjusting the Water Table Elevation Data

There are different ways to get around this issue. In this exercise, use the *max(x, y)* and *min(x, y) functions* available in the data calculator. These functions pick the maximum and minimum value from two datasets and assign them to the new dataset.

1. The water table dataset should be adjusted so it is:
   - At least 0.25m below the ground surface
   - At least 0.5m above the aquifer bottom
2. To do this, first use the *'min' function* to select the lesser of the water table and the ground surface elevation values. Then, subtract 0.25m from this so that the water table is at least 0.25m below the ground surface.
3. Then use the *max function* between the result from the previous step and the aquifer bottom and add 0.5m to it. This ensures that the water table is at least 0.5m higher than the aquifer bottom.
4. Create a new water table dataset for each step or use the following formula directly:

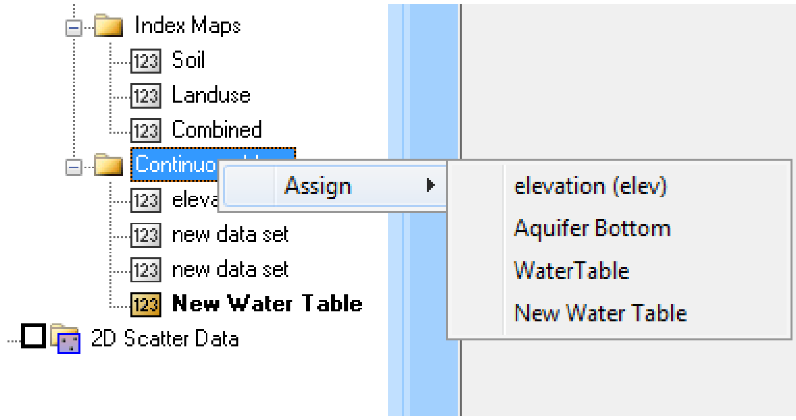
   Max((**min**(*InitialWaterTable*, *ground elevation*)-0.25), (*aquifer bottom* +0.5))

5. Open the data calculator.
6. Type the modified water table equation in the *Expression* field as shown in the figure below.
7. Enter *New Water Table* in the *Result* field. Click *Compute.* (See the following figure)



Once the updated water table map is computed, it should automatically get associated with the current GSSHA model. If *New Water Table* is listed under the *Continuous Maps* folder under the GSSHA model *GW*, then it is already assigned. If it is not listed follow the following steps:

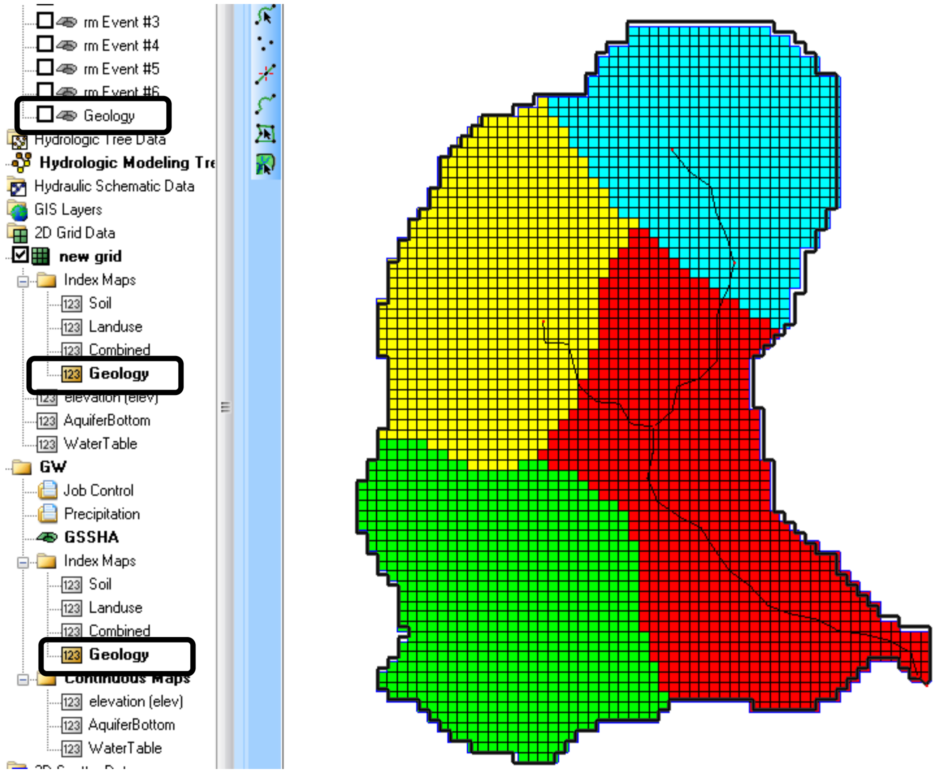
1. Right click on the *Continuous Maps* folder underneath the *GW* folder in the 2D Grid Data section of the *Project Explorer*.
2. Select *Assign-> New Water Table*



3.5 Hydraulic Conductivity and Porosity

To define the hydraulic conductivity and porosity, use a geology shapefile which has information about the underground soil type distribution. In GSSHA, hydraulic conductivity and porosity are used to derive the values of transmissivity and storage.

1. In the *Project Explorer*, right click on *Coverages* and select *New Coverage.*
2. Select *Soil Type* for *Coverage type.*
3. Change the name to *Geology* and select *OK*. This will add a coverage named *Geology* under the *Coverages* folder.
4. Select ***File | Open*** and browse to open the following shape file: ***\GSSHA Distributed Hydrologic modeling\RawData\Groundwater\Geology.shp.***
5. Make sure that the *Geology* coverage is selected and *Geology.shp* is active.
6. In the *GIS Module*, select ***Mapping | Shapes -> Feature objects.***
7. Click *Yes* to use all the polygons.
8. In the *GIS to feature object wizard*, use the default mapping and click *Finish* on the wizard.
9. Once done mapping, feel free to delete the shape file from the *Project Explorer* and turn off the display of *Geology* coverage. Select the *GSSHA* coverage to make this coverage active.
10. In 2D Grid module, select ***GSSHA | Maps***
11. Select *Geology* as the input coverage and *Texture* as the coverage attribute.
12. Change the index map name to *Geology*.
13. Select "*Coverages->Index Map*". When the index map is finished, click *Done* to close the *GSSHA Maps* dialog.



4 Groundwater Job Control

1. In the GSSHA *Job Control* ***(GSSHA | Job Control)***, toggle on the *Groundwater* option and click the *Edit parameter* button. This will open the *GSSHA Groundwater* dialog.

Note: When turning on the groundwater option, a groundwater boundary condition index map named *Gw boundary* is created automatically in the Project Explorer. Also, GSSHA assumes a no-flow groundwater boundary condition around the perimeter of the watershed.

2. In the *GSSHA Groundwater* dialog, set the *Aquifer bottom* Data Set to *AquiferBottom* and the *WaterTable* Data Set to *New WaterTable*. Define the *Hydraulic Conductivity* and the *Porosity* Data in the groundwater mapping table in the next step.
3. Set the Time Step to be 600.
4. Make sure the LSOR direction is set to horizontal.
5. Make sure the LSOR convergence is 0.00001.
6. Make sure the Relaxation coefficient is 1.2.
7. Make sure the Leakage rate is set to 0.0.
8. Click OK to close *GSSHA Groundwater* dialog.
9. Click OK to close the *Job Control* dialog.

5 Groundwater Map Table

The hydraulic conductivity and porosity maps have not been defined for groundwater model yet. Use the geology index map to define these values in a groundwater mapping table.

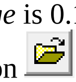
1. Select the ***GSSHA | Map Tables…*** menu command. In the *GSSHA Map Table Editor* switch to the *Groundwater* tab.
2. Select *Geology* as the index map and generate IDs. Notice the four different IDs. Enter the values as shown in the following table:

Parameter	Loamy Sand	Sandy Loam	Loam	Silt Loam
Hydraulic Conductivity	5.98	2.18	1.32	0.68
Porosity	0.437	0.453	0.463	0.501

3. Once finished entering the values, select the *Done* button to close the *GSSHA Map Table Editor* dialog.

6 Verifying Long Term Simulation Data

Before running the groundwater model, make sure that the long term simulation is setup correctly.

1. In the GSSHA *Job Control* dialog, click *Edit parameters* for the *Long term simulation.*
2. Make sure the *Latitude* is 44.81, *Longitude* is 267.83, *GMT* is -6 hours, *Minimum Event Discharge* is 0.1 cms, and *Soil Moisture depth* is 0.25 m.
3. Click on the browse button  for the *HMET Data file*. Browse and select ***\GSSHA Distributed Hydrologic modeling\Groundwater\HMETData.txt***.
4. Make sure continuous simulation format is set to *WES*. Click *OK*.
5. Select *OK* in the Job Control dialog.

7 Setting Output Control

1. In GSSHA *Job control*, click on the *Output Control* button.
2. Turn off the toggle next to *Surface Depth* and toggle on the *Groundwater elevations* and *Cumulative groundwater recharge*.
3. Change the *Write frequency* to be 180 minutes for the grid data and leave the *hydrograph write frequency* as it is.
4. Select *OK* and *OK*.

8 Saving and Running the GSSHA Model

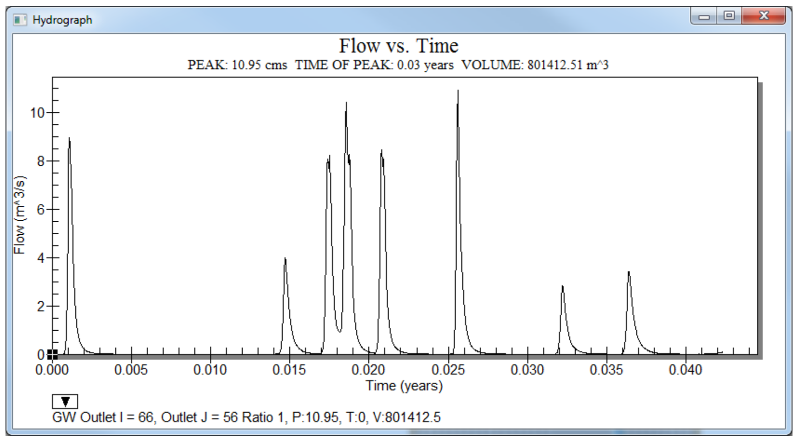
The project is now ready to be saved, and the GSSHA model can be run.

1. Save the project as ***\GSSHA Distributed Hydrologic modeling\Personal\Groundwater\GW.prj***
2. Select ***GSSHA| Run GSSHA***

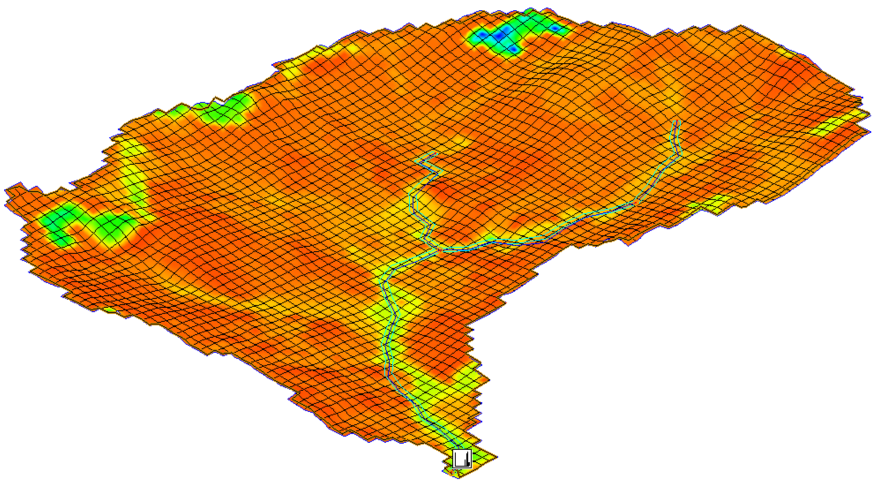
The model should take about 10-15 minutes to run, depending on the capacity of the computer. To view the solution without waiting for the model to run to completion, click the *Abort* button, select ***GSSHA | Read Solution***, and open the solution located at ***\GSSHA Distributed Hydrologic modeling\ Groundwater\GW.prj***.

9 Viewing Groundwater Model Results

1. Once the model has finished running, close the model wrapper to read the solution.
2. Visualize the outflow hydrograph. Copy and Paste the outflow hydrograph ordinates to the *Data* sheet under the *Basic GW Model* column of ***\GSSHA Distributed Hydrologic modeling\Groundwater\GWResults.xls***.



3. Open the summary file and scroll down to find the *SIMULATION TOTALS* at the end of the file. Copy the information in the SIMULATION TOTALS section of the file to the *Simulation Totals* sheet under the *Basic GW Model* column of ***\GSSHA Distributed Hydrologic modeling\Groundwater\ GWResults.xls***.
4. Select the g*roundwater_head* data set in the *Project Explorer* and toggle through the time steps to see how the groundwater head varied with time.
5. Similarly, select *gw_recharge_cum* (Cumulative groundwater recharge) dataset and toggle through the time steps to see the amount of recharge in various parts of the watershed as the simulation progresses.



10 Exporting a Hot start file for next case

Using the output dataset from one model as an input to another model is called a hot start in GSSHA. In the coming workshop, the final groundwater elevation in this workshop will be used as a hot start as the starting groundwater head of next model.

To export the final groundwater head data and so it can be imported later in another model, do the following

1. Select the g*roundwater_head* data set in the *Project Explorer* and select the final time step in the properties window.
2. With the last time step selected, right click on g*roundwater_head* in the project explorer and select *Export Dataset.*
3. Select the file format to be *GRASS ASCII grid file* and click OK.
4. Save the file as ***\GSSHA Distributed Hydrologic modeling\Personal\Groundwater\GWHotStart.ggd.***

