
***Introduction to the US Army Corps of
Engineers Spatial Hydrologic Modeling
System with GSSHA and WMS***

***GSSHA Using the Watershed Modeling
System***

Tutorials – Volume 1

WMS BASICS

WMS 8.4 Compatible – Volume 1

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TABLE OF CONTENTS

1	LOADING DEMS, CONTOUR OPTIONS, IMAGES, AND COORDINATE SYSTEM	1-1
1.1	INTRODUCTION	1-1
1.2	GETTING AROUND THE WMS INTERFACE	1-2
1.3	IMAGES	1-4
1.4	GEOTIFF FILES	1-4
1.5	OVERLAYING IMAGES	1-8
1.6	WORLD FILES	1-10
1.7	REGISTERING IMAGES	1-10
1.8	GIS SHAPEFILES	1-16
1.9	MAPPING SHAPEFILES TO WMS COVERAGES	1-20
2	WATERSHED DELINEATION USING DEMS AND 2D GRID GENERATION	2-1
2.1	INITIATING WMS	2-1
2.2	IMPORTING THE DEM DATA	2-1
2.3	COMPUTING FLOW DIRECTION AND FLOW ACCUMULATION	2-4
2.4	DELINEATING THE WATERSHED	2-5
2.5	2D GRID GENERATION	2-6
2.6	TASK	2-7
3	CREATING FEATURE OBJECTS AND MAPPING THEM TO 2D GRID	3-1
3.1	MAPPING GIS SHAPE FILES TO WMS COVERAGE	3-1
3.2	CREATING 2D GRID	3-4
3.3	CREATING INDEX MAPS	3-4
3.4	EXPLORING MAPPING TABLES	3-7
3.5	SAVING A GSSHA PROJECT	3-10
3.6	TASK	3-11

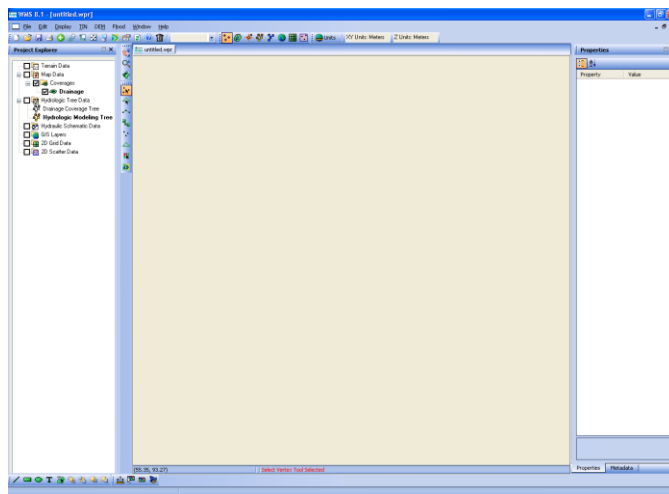
Loading DEMs, Contour Options, Images, and Coordinate System

Loading DEMs, Contour Options, Images, and Coordinate Systems

In this first exercise you will get familiar with the WMS interface and the help system using data from the Park City, UT area.

1.1 Introduction

We will learn the basic layout of WMS and get acquainted with the interface.




The left most portion of WMS window is called Project explorer, the central part is the display window and the right part is the properties window which changes with context.

1.2 Getting Around the WMS Interface

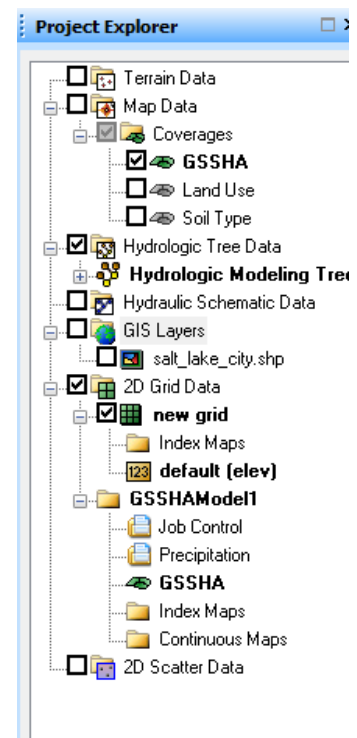
The WMS Help file has a section on some of the basic elements of the WMS graphical user interface (GUI).



1.2.1 Self-Guided Tour




The WMS Help file is located at <http://www.xmswiki.com> and documents the important elements of the GUI. In this section you will practice on your own to become familiar with the interface, but you can always refer back to the help file on the wiki as needed.

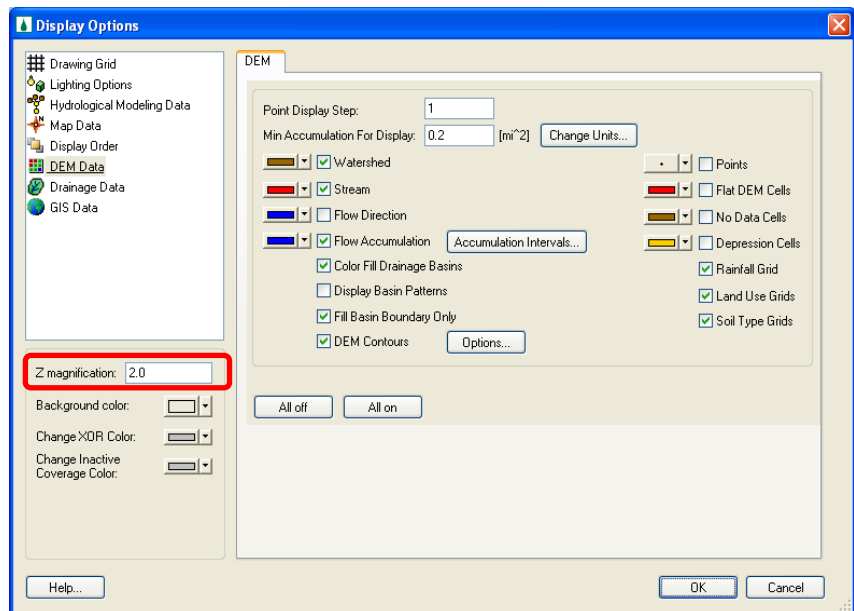
1. Start WMS
2. Select **Help / WMS Help**
3. Take a couple of minutes to review the WMS Help wiki and then close the help page
4. Different operations like spatial data reading/editing, hydrologic modeling or grid generation etc. are done using different modules. Switching from one module to the other can be done by clicking the corresponding module icons  in the menu bar. As you do, you will notice menus and tools change according to the available options. Change the module several times and note how the menus and tools change according to the currently active module. When you are done be sure the Terrain Data module is active (the first one from the left).




5. If you look at WMS project explorer, you can see that there is a folder in the project explorer to contain the data associated with each module (the drainage module shares data from the terrain and map modules).
6. The default behavior of the project explorer window is to switch modules as these folders or data contained in them are selected. For eg, if you click on *GIS Layers* folder, *GIS Module* will be selected, if you click on *Coverages* folder, map module will be selected.
7. WMS 8.4 projects are saved as *.wms files. Project files save all necessary files and the saved project can be reopened.
8. You can control which objects are displayed by selecting and unselecting different data elements in the Project Explorer window. Detailed control and



style of elements drawn are set using the *Display Options* , *Contour Options* , and other macros.

9. Select **File / Open**  Browse and open file *C:/Training/Images /BaseProj.wms*
10. Select the *Contour Options*  macro and experiment with changing some of the contouring options such as the *Contour Methods*, *Contour Interval* and *Color Ramp*.
11. Controlling what and how objects are visually displayed can be set through the display option. Select *Display / Display options* or by simply clicking the display options button  on the menu bar.
12. In the *Display Options* dialog box enter 2.0 for *Z magnification*. You can also access the DEM contours from the display options by selecting the DEM Data object in the upper left window and then Options button next to DEM Contours. Make sure the DEM contours are *Color Filled* and click OK twice.



13. Select the *Rotate Tool*  and drag your watershed so that you can better visualize the watershed relief.
14. Select the *Contour Options*  macro and set the *Contour Options* to *Linear* Select OK, and then select *Plan View*  to reset the drawing of the DEM from the changes you made with the rotate tool.

1.3 Images

Images are an important part of most projects developed using WMS. An image is comprised of a number of pixels (picture elements), each with its own color. The resolution, or size, of the pixels will determine the amount of area and detail represented in the image. Images are used in WMS to derive data such as roads, streams, confluences, land use, soils, etc. as well as providing a base map for your project. In order to make use of images they must be georeferenced. Georeferencing an image defines appropriate x and y coordinates so that it can be overlaid spatially with other data. Because images are commonly used in Geographic Information System (GIS) programs like WMS, data developers often store the georeferencing information as either part of the image file (a geotiff file for example), or in a separate file commonly referred to as a “world” file.



In this section we will experiment with JPG and TIFF image files. We will also see how an image without spatial information can be georeferenced.

1.4 Geotiff Files

Geotiff images are files that embed the georeferencing information. This means that you do not have to specify coordinates when you read in the image.

1.4.1 Scales

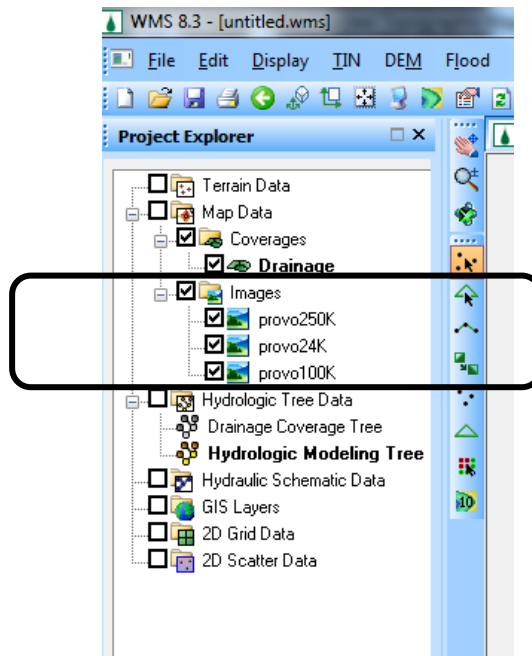
In this section we will see how the scale of an image affects the display. We will use some of the images for Provo, Utah.

1. Select **File/New** or click on macro icon  to open a new instance of WMS.
2. Select **File / Open** 
3. Browse the folder **C:\Training\Images** and open the following images:
 - a) **provo24K.tif**
 - b) **provo100K.tif** and
 - c) **provo250K.tif**


Click No if/when prompted to convert to jpg


Note: These are the topographic maps of Provo, UT area. The three images are of different scales (1:24000, 1:100000 and 1:250000 respectively).

4. Once these files are open, you can see them listed in the project explorer (see the following figure).



5. Turn the display of the images on and off by checking them on and off in the project explorer. Leave them all on when you are done experimenting.

6. Select the Zoom Tool  and draw rectangle over the image to zoom into the area of your preference.



Zooming Tips: with the zoom in tool  selected, if you press and hold the Shift key in the keyboard, the zoom in tool turns to zoom out tool



You can use the scroll wheel of your mouse to zoom in and out with any tool or module selected.

7. Zoom into the same location in the three different images and see the difference in resolution, area covered by the images, details captured etc.

1.4.2 Tiling Images

In this section we will see how properly georeferenced images tile automatically in WMS.

1. Select **File/New** or click on macro icon  to open a new instance of WMS.
2. Select **File / Open**  and browse the folder **C:\Training\Images**. Open file **provo24K.tif**. If prompted, do not convert the TIFF file to JPEG.
3. Then open **orem24K.tif**

4. Similarly open *springville24K.tif*
5. You should have noticed how these images tiled to the proper location.
6. Use the *Zoom* tool  to have a closer look at the image.
7. Select the *Frame* macro 



1.4.3 Converting Images from TIFF to JPG and Building Pyramids

WMS 8.4 provides the option of building pyramids when each image file is opened. When pyramids are built, multiple files of varying resolutions are saved by WMS so that when a large area of an image is viewed a lower, or coarser, resolution image is displayed. A higher, or finer, resolution image is displayed as you zoom in to view a smaller portion of the image. This is similar to an automatic resampling process. On the other hand, when image pyramids are not built, only the original resolution image is displayed.

The advantages of building pyramids include faster and crisper display of an image. Image display is faster due to lower resolution images being displayed for larger areas and higher resolution images being displayed for smaller areas. The clarity of the image display improves in situations when the image resolution exceeds the display resolution of the screen, which often occurs as you view a large portion of a high resolution image.

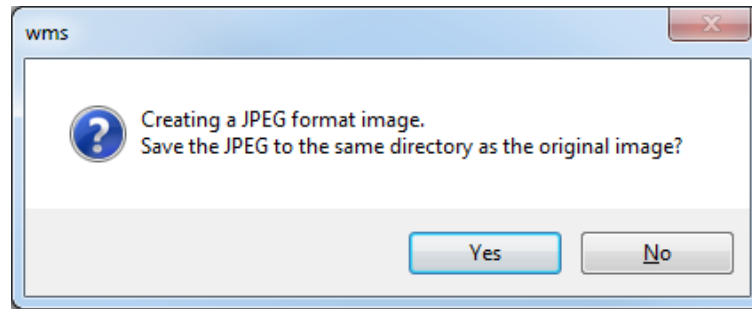
Because WMS can only build pyramids using JPEG images you must convert TIFF images to the JPEG format in order to build pyramids. Image conversion can be performed by WMS either as you open the image or after opening the image. By default, WMS always builds pyramids when a JPEG image is opened or created through conversion. Nevertheless, this setting can be changed.

We will open a TIF image, convert it to JPG and build pyramids. We will then compare the differences.

1. Select *File/New* or click on macro icon  to open a new instance of WMS.
2. Select *File / Open*  and browse the folder *C:\Training\Images*. Open file *provo24K.tif*.
3. Select Yes when prompted to convert the TIF image to JPEG.

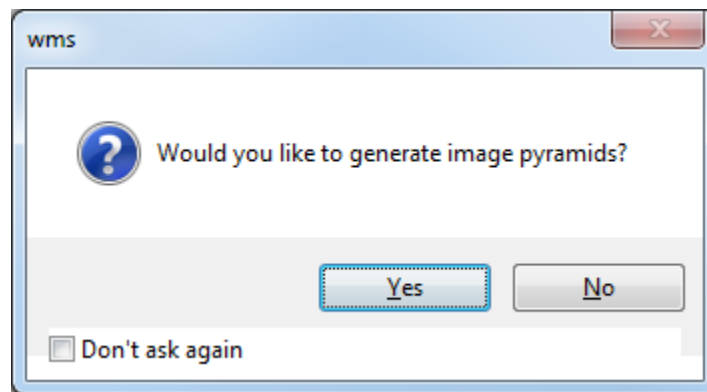


4. Select Yes to save the image in the same directory.



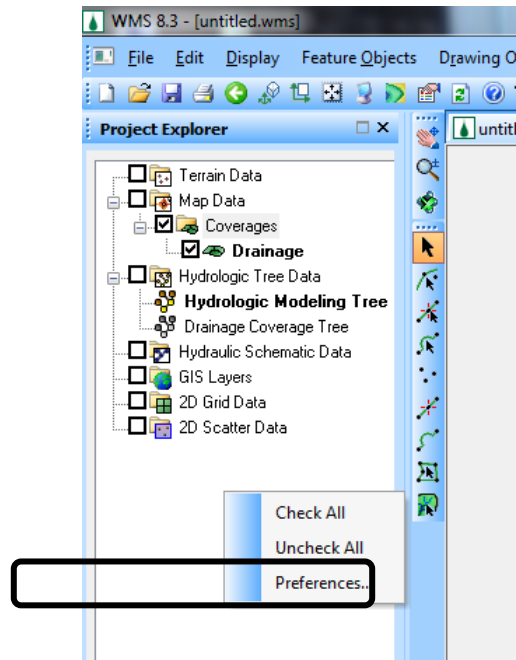
The conversion process might take a while depending upon the size of the image and speed of your computer.

5. Select Yes to build pyramids.



Note: if WMS did not prompt you to convert to JPG or build pyramid, follow the these steps to turn the option on.

- a) In the project explorer, right-click on the image that was opened without the pyramid built and delete it (this will remove the image from WMS display but the original copy of the image will not be deleted)
- b) Right-click in the Project Explorer below the tree contents and select **Preferences** in the pop-up menu that appears (or select **Edit / Preferences**)



- c) Select the *Image Preferences* tab in the Preferences dialog
 - d) Under Image Pyramids, select *Prompt for Each Image*
 - e) Under TIFF->JPEG Conversion, ensure that Convert to JPEG is set to *Prompt for Each Image*
 - f) Select *OK*
 - g) Select *File / Open* and browse the folder *C:\Training\Images* and open the image *provo24K_xms.jpg*. This image was created when you converted the TIF image to JPG.
6. Now you can see a JPG image listed in the project explorer and the image displayed.
 7. Minimize the WMS window with the image and open another instance of WMS
 8. Open the same JPG image (*C:\Training\Images\provo24K_xms.jpg*). This time select No when prompted to build pyramids.
 9. Zoom in and out into the picture
 10. Compare the differences in the two instances or WMS one with the pyramids built and another without the pyramids.

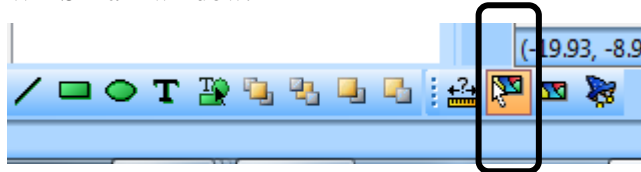
1.5 Overlaying Images

Here we will see how different types of images can be overlaid together.

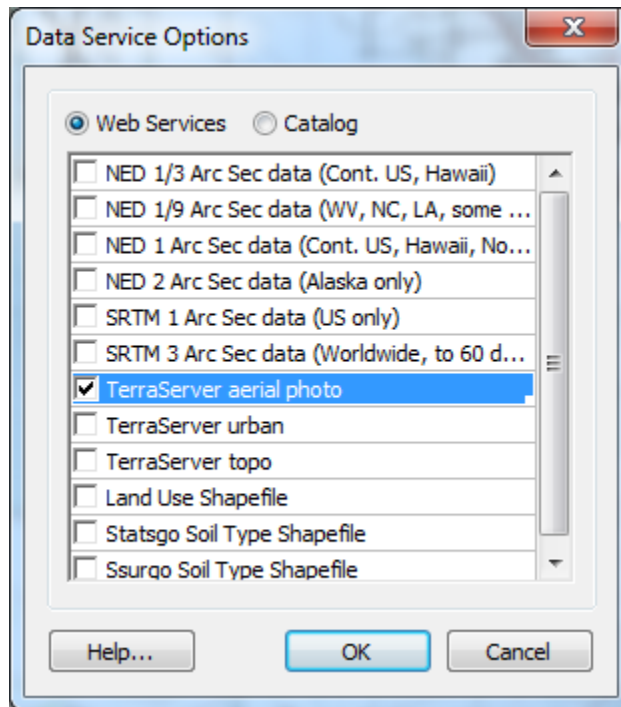
1. In the new instance of WMS, browse and open image *C:\Training\Images\provoTStopo.jpg*. This is a topographical map of Provo area

obtained from Terraserver (<http://www.terraserver.com/>). This image is already georeferenced.

2. Select the *Get data tool*  located at the lower left corner of the WMS main window.



3. Then draw a rectangle with the mouse pointer around the jpg image that you opened previously, which will open *Data Service options* dialog. Select *Terraserver aerial photo* option as shown in the following figure.



4. Select OK and browse folder *C:\Training\Personal\Images* and enter name *provoTsaerial* and click Save.
5. Select Yes to create the files.
6. WMS will suggest a suitable resolution for the image based upon the size and coverage of the image. You can change the resolution, but here let us use the suggested resolution. Click OK.
7. This will take a moment for WMS to use the web services and download the data from the server.
8. Once done, you will be prompted to build pyramids, select OK.
9. You can see both the topo map and the aerial photo listed on the project explorer.

10. Right click *provoTsaerial* in the project explorer and select *Set Transparency*.
11. Move the slider to 40% and click OK. You should be able to see the aerial photo over the topo map.
12. You may also turn the display of one or the other image from the project explorer and compare the two images.

1.6 World Files

Many image files do not contain georeferencing information. For example JPEG files do not have georeferencing “tags” in the file like TIFF images may have. Most organizations that make images available for use distribute world files containing the georeferencing information along with the image files. These world files usually have the same name as the corresponding TIFF or JPEG file, but with the extension .tfw (for JPEG files the extension is .jpw, .jgw, or .jpgw). If you download a world file and are asked to supply a name for it, follow this naming convention.

Use the following procedure to view the information contained in the world file.

1. Select *File / Edit File*
2. Browse and open *C:\Training\Images\provoTStopo.jpgw*

```
16.0  
0.0  
0.0  
-16.0  
436056.0  
4455767.9999999
```

Because there is a world file named *topo.jpgw*, the image is automatically registered. If a world file for an image is not named with the .tfw (or, for a JPEG, it is not .jpw, .jgw or .jpgw), you would have the option of importing the world file from within the registration dialog demonstrated below.

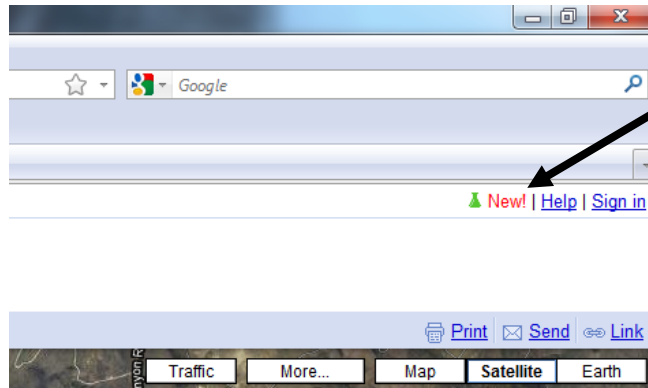
1.7 Registering Images

Sometimes you will not be able to obtain a geotiff image or an image with a world file. In this case, you can download a background image common image sources such as scanned paper maps, or Google maps or Google Earth images etc and geo-reference the image manually. To do this, you will need to know the coordinates of three points on the image. These coordinates can be in a projected or geographic (latitude-longitude) system. Before you scan your paper image, or download an image from the Internet, you will want to mark the three points you have selected so that you can easily find the points on the image when you register the image in WMS.

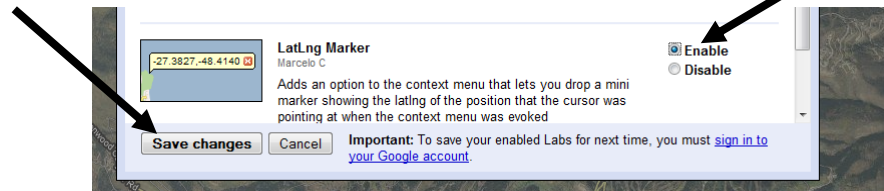
1.7.1 Downloading image from Google Maps

As an example we will see how an image can be imported from Google maps and get it georeferenced so that the image can be used in WMS.

1. Open a web browser and go to <http://maps.google.com/> . Turn the satellite map on.
2. On the top right corner of the map click *New*.



3. Enable *LatLng Marker tool* and select *Save Changes*.



4. Enter Park, UT in the search box and click *Search Maps*. This will zoom into the area where our watershed is located.



5. Right click approximately near the locations as shown in the following figure and select *Drop LatLng Marker* which will put the coordinates marker at each of the locations you specify, See the following figure.





6. You may zoom in more to have larger scale of the image but make sure that all the three markers are still within the visible extent.
7. Now press PrintScreen key on the keyboard. Open *Paint* from Start menu in the computer and paste the image. If you want, you may crop only the portion of the image you need.
8. Once done, save the image as *C:\Training\Personal\Images\ParkCity.jpg*.
9. If you have trouble downloading the image, there is one already downloaded in *C:\Training\Images\ParkCity.jpg*.


1.7.2 Geo-referencing image in WMS

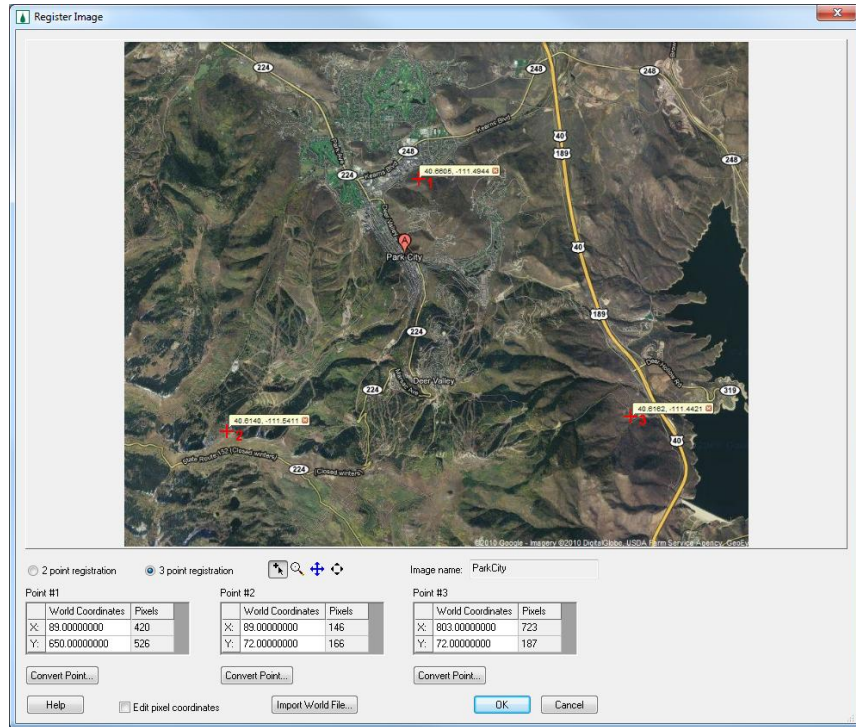
We will use the Goggle Maps image that we downloaded for Park City watershed and define the coordinates so that it lines up with the watershed.

1. Open the WMS project file for Park City *C:\Training\Images\Baseproj.wms* to see how the image overlays over the watershed .
2. Open the image you downloaded in previous step located at *C:\Training\Personal\Images\ParkCity.jpg*.
3. If you had trouble downloading the image, there is one already downloaded in *C:\Training\Images\ParkCity.jpg*.
4. Click Yes to build pyramids.

The image will appear in the Register Image dialog. Three latlng markers are also displayed. There are also three plus signs with the numbers 1, 2, and 3 by them (much larger and visible). You need to place the numbered plus signs over the tip of the place markers and enter the appropriate coordinates in order to register the image.

- Use the *Point Selection* tool  to drag each red + over the corresponding X as shown in the following figure. You may wish to place them close and then zoom  in on the area for more accuracy.

Once you zoom in there is a *Frame* tool  that you can use to re-center the image so that you can zoom in on another registration point. Do your best to move each plus mark over the pins in the image.




The coordinates for the three points are known in geographic (latitude/longitude) and so we will register using these coordinates and then convert to the projected UTM coordinates afterwards. In order to properly register, the coordinates must be decimal degrees.

- Using the values shown in the respective *latLng* markers, enter the appropriate x (longitude) and y (latitude) values for the three points.

Note that longitude values west of the prime meridian should be entered as negative.

Also notice that Longitude or Easting is the X-coordinate and Latitude or Northing is the Y-Coordinate.

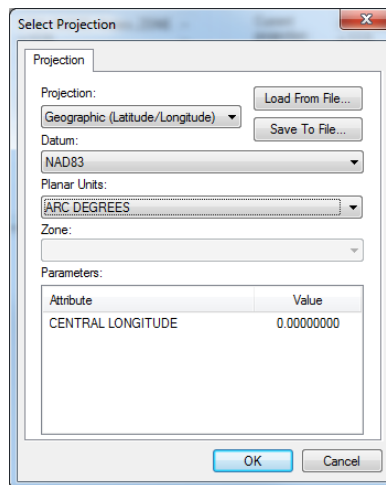
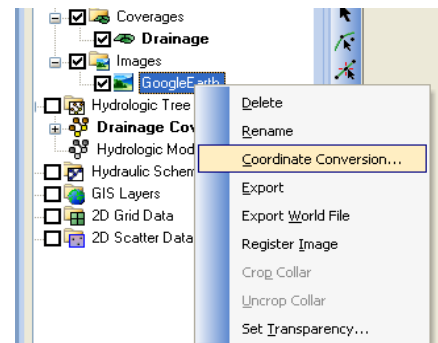
- When you have correctly entered the three coordinates select *OK* in the Register Image dialog
- Select the *Frame* macro 
- Click *OK*.

You might have seen just a yellow dot in the screen. The image is not showing up because the coordinate system of the delineated watershed does not match with the coordinates of the image you just registered. Proceed to the following section to learn how to convert the coordinate system of a dataset so that the image overlays the watershed.

1.7.3 Converting the Coordinates to UTM

Geographic coordinates are commonly used on maps because they provide a global reference for any point in the world. However, for engineering work a planimetric system is necessary. The Universal Transverse Mercator (UTM) projection is commonly used so we will convert the coordinate system from geographic to UTM.

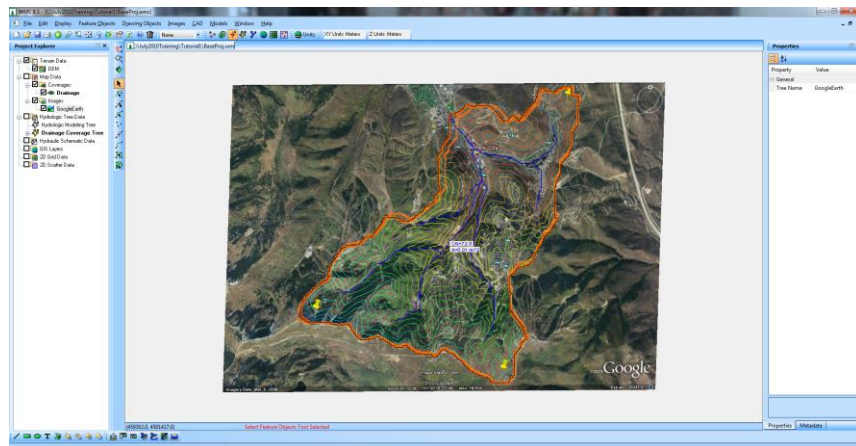
1. Right-click on the *GoogleEarth* image icon in the Project Explorer and choose the *Coordinate Conversion* option
2. Select the *Global Projection* radio button in the *Object Projection* section in the *Reproject Object* dialog
3. Select *Set Projection*
4. Select *Geographic (Latitude/Longitude)* from the *Projection* drop down box
5. Select *NAD 83* from the *Datum* drop down box



6. Select *OK*
7. Set the Vertical System projection to *NADV 88(US)* and units to *Meters*
8. Toggle on the *Specify* check box in the *Project Projection* in the *Reproject Object* dialog

9. Select the *Global Projection* radio button
10. Select *Set Projection*
11. Set *Projection* to *UTM*, *Datum* to *NAD 83*, *Planar Units* to *Meters*, and *Zone* to *12 (114°W - 108° W – Northern Hemisphere)*
12. Select *OK*
13. Set the Vertical System projection to *NAVD 88(US)* and units to *Meters*
14. Select *OK*

There might be some distortion in the image as it is converted from geographic to UTM because a degree of longitude has a shorter distance the farther north you are, but this is normal. Any measurements taken now, or data created from the image, will have meters for coordinate values.



1.7.4 Exporting a World File

Once you have georeferenced an image, you can then export a world file so that you can use it for future use.

1. Right-click on the *GoogleEarth* image in the Project Explorer and select *Export World File*.

If you save the world file with the same name as the image but with an extension *.jpw*, then next time you open the image, it will open properly georeferenced. But, if it is saved with a different name, you will have to import the world file. We will see how it works here.

2. Save the file as *C:\Training\Personal\Images\ParkCity.jpw*, the same as what WMS defaults to. Click *Save*.
3. In the WMS project explorer, delete the image we have been working so far by right clicking on the image and selecting *Delete*.
4. Select *File / Open* and select file *C:\Training\Personal\Images\ParkCity.jpg*. This will open the image properly georeferenced.

Note: But, as already discussed, if the image and the world file are at different locations or if they have different names or if there is no world file, opening an image will bring the *Image Registration* dialog.

To import a world that is saved at different location or with a different name, click *Import World File* button at the lower end of the *Registration* dialog. Browse and open the world and click OK. The image will georeference properly.

1.8 GIS Shapefiles

GIS shapefiles are another data source frequently used in developing models with WMS. In this section we will see how commonly used shape files for land use and soils can be obtained and used in WMS.

1.8.1 Geospatial data acquisition

There are several sources to get the geospatial data. The XMS wiki has a special geospatial data acquisition page which has tutorials and tips on downloading these data from the most convenient sources for use in WMS, SMS or GMS. We will download a shapefile with land use data and open it in WMS.

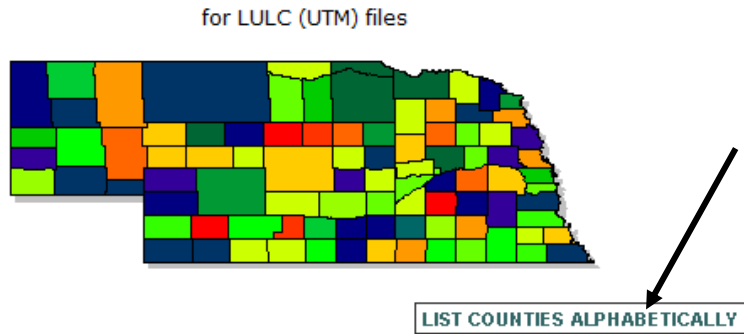
1. Initiate a web browser and type the following link <http://www.xmswiki.com/xms/GSDA:GSDA> which will take you to the Geo-Spatial Data Acquisition Home page.
2. Under *Surface Characteristics* select *Land Use*.
3. Select *WebGIS*




4. Under *Land Use* select *Shapefile (UTM)*



5. We will get the land use data for Omaha. In the US map, select Nebraska.
6. Click on *List Counties Alphabetically*



7. In the list that displays, select *Douglas County*
8. Select *Omaha* on the top of the list.

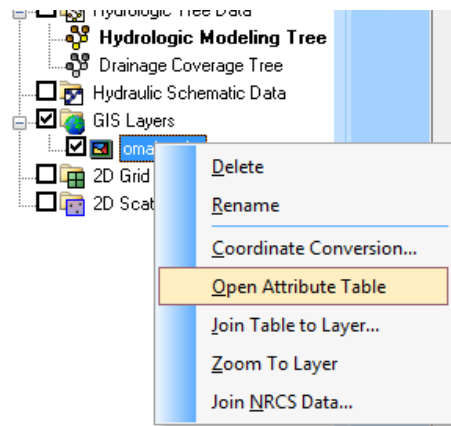


DOUGLAS - Nebraska
LULC Data (UTM)

NAME	MIN X	MAX X	MIN Y	MAX Y	ZONE
FREMONT	584041	748468	4539198	4654179	14
OMAHA	247597	417187	4543002	4650411	15

[Back to Top](#)

9. Save the archive that pops out to *C:\Training\Personal\Images*
10. Outside of WMS, browse the folder and extract the zip.
11. In WMS, open an aerial photo for Omaha as *C:\Training\Images\Omaha\AerialPhoto.jpg*
12. Now, in the project explorer, right click on *GIS Layers* and select *Add Shapefile Data...*
13. Browse and open the land use shapefile that you downloaded (*C:\Training\Personal\Images\omaha\omaha.shp*)
14. Now you can see the land use shape file overlaying the aerial photo for the city of Omaha.
15. Right click *omaha.shp* on the project explorer and select *Open Attribute Table*. This will open the attribute table for the land use shape file. You should be able to see *LUCODE* as one of the attributes which is the USGS land use code. We will be using this attribute to define overland roughness values and other surface characteristics in later tutorials.



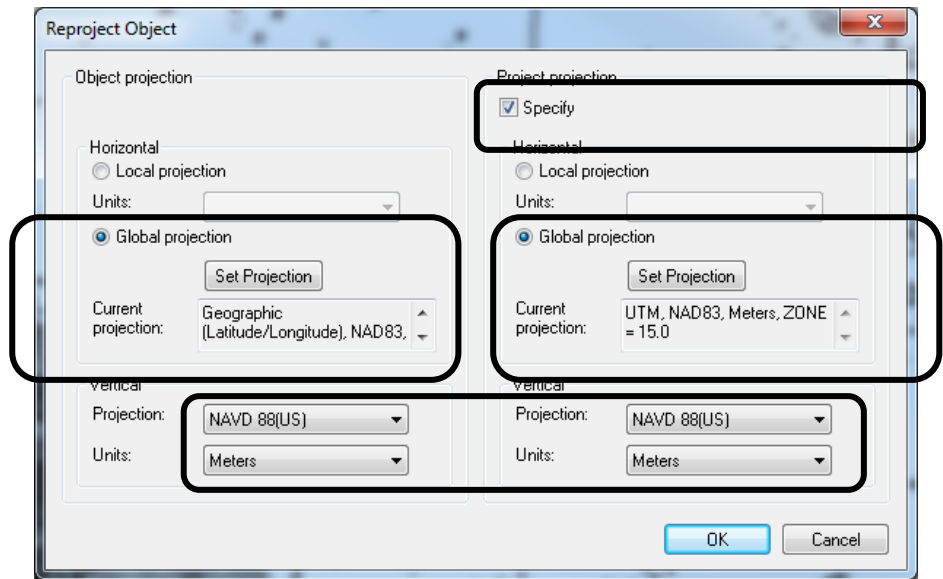
16. This shape file is still in the GIS format. We will have to convert it to a WMS coverage data format so that it can be used for hydrologic and hydraulic calculations. We will do this in a later section.
17. Do not close WMS, we will keep working with this data in the following section.

1.8.2 Geospatial data processing

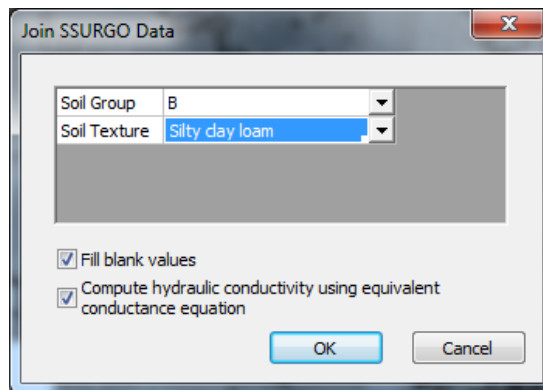
Some of the GIS data are not 'ready to use' like the land use shapefile we used in the previous section. We need to process these data before they can be used. In this section we will see how some of these tools can be used in WMS with a soils shapefile.

We will open SSURGO soilshape file for Omaha and process it so that it can be used for defining infiltration and other soils-derived properties of our GSSHA models.

1. Right click *GIS Layers* in the project explorer. Browse and open file *C:\Training\Images\Omaha\Soil\Spatial\soilmu_a_ne055.shp*.
2. Why do these data not overlay with our current modeling data? It is because the soils data are in geographic coordinates while the other data are already in the projected UTM coordinate system.
3. You can change the coordinate system of the soils file by right clicking on *soilmu_a_ne055.shp* in the project explorer and selecting *Coordinate Conversion*.
4. Set the *Object Projection* to *Geographic NAD83* if it isn't already.
5. Select *Specify* option for *Project projection*. Then select *Global projection* and click *Set Projection* button.
6. Select UTM NAD83 Zone 15 and click OK.
7. Make sure the *Vertical Projection* is set to *NADV 88(US)* for both fields.



8. Click OK. This will convert the coordinates for the soil data to UTM NAD 83 and it will overlay properly with the land use data and aerial photo.
9. Once the soils data are properly opened, right click on *soilmu_a_ne055.shp* and open its attribute table. You can see in the attributes table that there are only some key values as attributes which do not have any meaning for soils properties.
10. Close the attribute table and right click on *soilmu_a_ne055.shp* in the project explorer. Select *Join SSURGO Data*.
In SSURGO data, the attributes are stored as separate tables and they need to be linked with the shapefile before you can use them.
11. In the *Join SSURGO Data* dialog select both check boxes and leave the Soil Group and Soil Texture fields as they are. See the following figure:



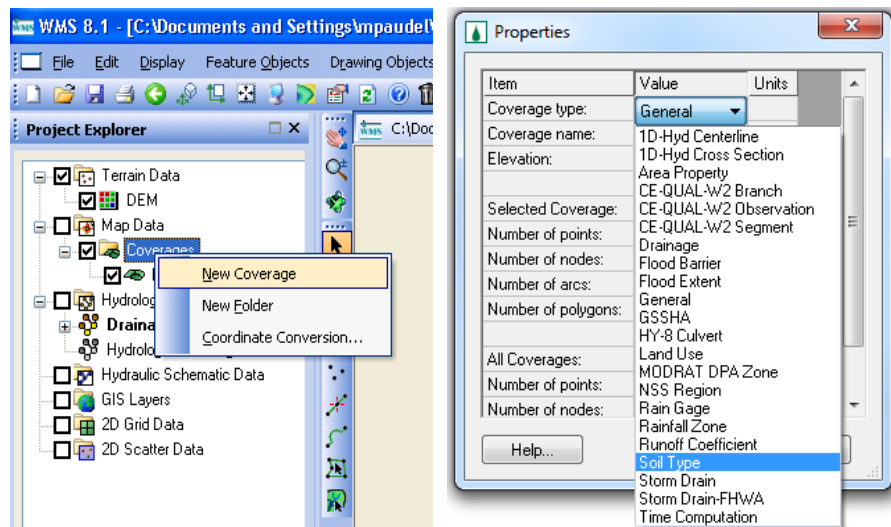
12. Click OK.


- Right click on the soils shape file and open the attribute table again. This time you will see that several soils properties have been added as attributes.

1.9 Mapping Shapefiles to WMS coverages

The SSURGO shapefile that we processed in the previous step is still in GIS format that WMS cannot use directly. In order to use it the polygons overlapping our watershed need to be copied to a WMS Soil Type coverage. This is done from the GIS module.

- In the project explorer (left side of WMS main window), right click on “Coverages” and select “New Coverage”



- Select the coverage type to be *Soil Type* and click *OK*. This will create a new soil type coverage in the project explorer. Note that WMS creates a Drainage coverage automatically as soon as WMS is opened. Whenever you create a GSSHA grid, the drainage coverage is converted to a GSSHA coverage.
- Click on the new soil type coverage in the Explorer window to make it active.
- Click on the *soilmu_a_ne055.shp* (under GIS layers) to make it active and change to the GIS module as we are going to map the data from the shapefile to the soil type coverage.
- Click on the “*Select shapes tool*”  and drag a rectangle around your watershed area to select all land use polygons that overlap the basin. Do not worry if you select few polygons that are outside the watershed boundary, WMS will use the watershed boundary to clip the land use polygons.

6. Select **Mapping | Shapes** -> **Feature objects**, click “Next” and make sure that the fields are mapped properly. for eg Texture field should be mapped to TEXTURE, HYDGRP should be mapped to HYDGRP and so on. Click “Next” and click “Finish”.
7. The soil type data is now converted and stored in WMS data format and we no longer need the GIS data once it is mapped to a coverage. You may delete the shape file under GIS layers (Right click on *soilmu_a_ne055.shp* and select delete).

Watershed Delineation using DEMs and 2D Grid Generation


2.1 Initiating WMS

1. Open a new instance of WMS if it is not already open.

2.2 Importing the DEM Data

DEM data can be obtained from a variety of sources. If you already have a DEM stored on your computer, you can just open it in WMS. Alternatively, you can download DEM data from the USGS seamless server (<http://seamless.usgs.gov/>)

WMS has a web services tools that links directly to the seamless server data and can help you download DEM data. We will use this feature in this workshop.

1. Click on the *Hydrologic Modeling Wizard*  button at the lower left corner of the WMS main window.



2. In the *Hydrologic Modeling Wizard* dialog, browse for the folder *C:\Training\Personal\WatershedDel* and enter the project name to be *JudysBranch.wms*.

2-2 GSSHA Modeling Using WMS – Volume 1

3. Click the *Save* button.
4. Click *Next*
5. Click the *Define* button under the *Project Coordinate System*. Select the *Set Projection* option and enter the following information and click OK and then OK again.

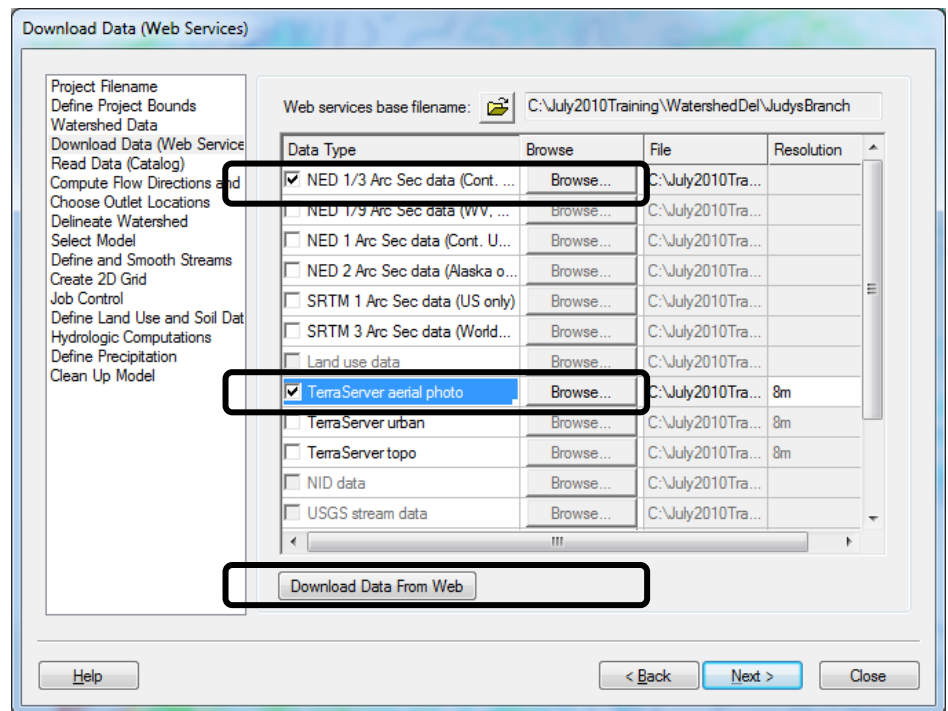
Attribute	Value
CENTRAL MERIDIAN SCALE FACT...	0.999600000
CENTRAL MERIDIAN	-87.0000000
ORIGIN LATITUDE	0.0000000
FALSE EASTING (m)	500000
FALSE NORTHING (m)	0

6. Typically you would select the *Define* button to define the project bounds which opens a virtual earth map locator and lets you navigate to your project area and sets the project bounds from the map. However, because it is difficult to instruct users to consistently zoom to the same area, we will enter the bounding coordinates directl.
7. Enter the following coordinates in the *Define Project Bounds* dialog.

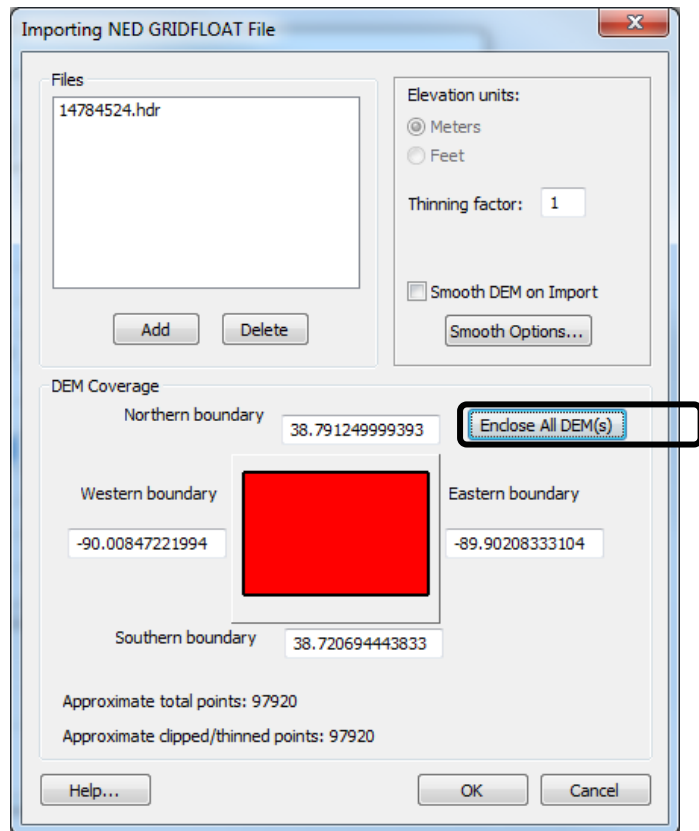
Boundary	Coordinate Value
X Minimum (Western)	759834.27
Y Minimum (Southern)	4290028.98
X Maximum (Eastern)	769088.24
Y Maximum (Northern)	4297864.13

Boundary	Coordinate Value
X Minimum (Western)	759834.27
Y Minimum (Southern)	4290028.98
X Maximum (Eastern)	769088.24
Y Maximum (Northern)	4297864.13

8. Click *Next* and make sure that the *Use web services* option is toggled on.
9. Click *Next* and select *NED 1/3 Arc Sec Data* and *TerraServer aerial photo*. Then click *Download Data From Web*.





10. WMS will download both the DEM and background aerial photo for the watershed (there are times when the web services may be down so if it does not download the data directly you may have to do so outside of WMS).
11. Once the DEM downloads, the *Importing NED GridFloat File* dialog will open. Select the *Enclose All DEM(s)* button and click OK.

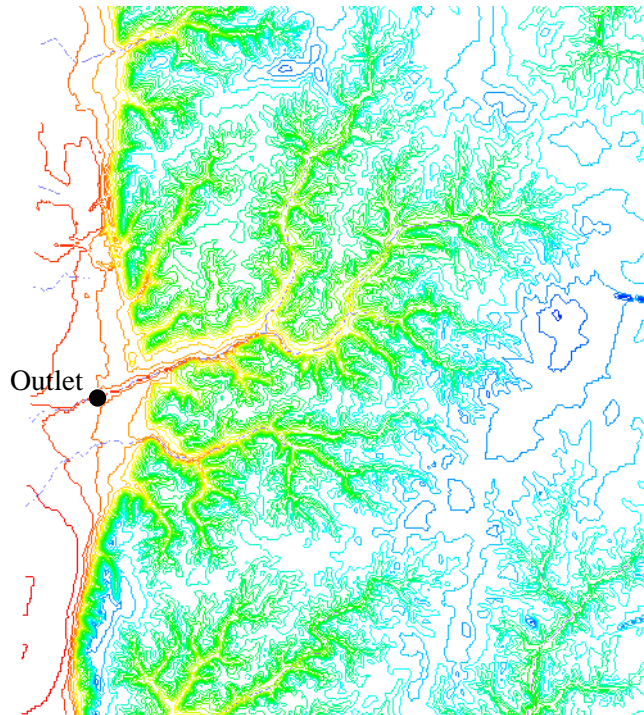


12. WMS will now download the aerial photo from TerraServer. Select Yes to generate pyramids when prompted.
13. Now you can see both the DEM contours and the aerial photograph opened up.
14. Close the *Hydrologic Modeling Wizard* dialog.


2.3 Computing Flow Direction and Flow Accumulation

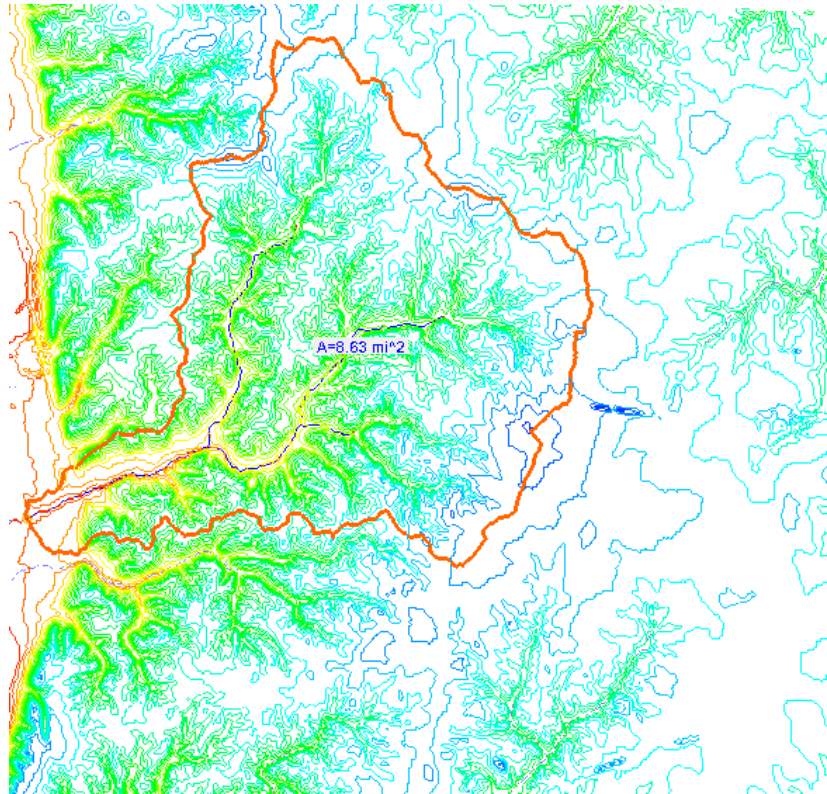
1. To delineate a watershed you should be in the *Drainage Module*. Click  to select the drainage module.
2. Select **DEM / Compute TOPAZ Flow Data** and Click *OK* twice. TOPAZ will compute the flow direction and accumulation and infer the streams based on the DEM data.
3. Click on “Close” after computations are complete. It will probably take 10-15 seconds to finish, but you can know it is done when the last line of text in the model wrapper reads “Normal Program Termination”.
4. You can now see light blue lines representing the streams added to the display (these are the areas where flow accumulates on the DEM, or the stream channels).

5. You need to create an outlet point to delineate a watershed. Select the “Create Outlet Point” button . Locate the point where you want the outlet for the watershed to be. See following figure for the approximate location of outlet (you can use the middle scroll button of mouse to zoom in or out).



2.4 Delineating the Watershed



1. Select DEM | DEM -> Stream Arcs... and make sure the stream threshold value is 1 sq. mile. Click OK.
2. Select DEM | Define Basins
3. Select DEM | Basins -> Polygons
4. Select DEM | Compute Basin Data. Click OK.
5. Click on “Frame” button . Your watershed should look somewhat like the following figure.



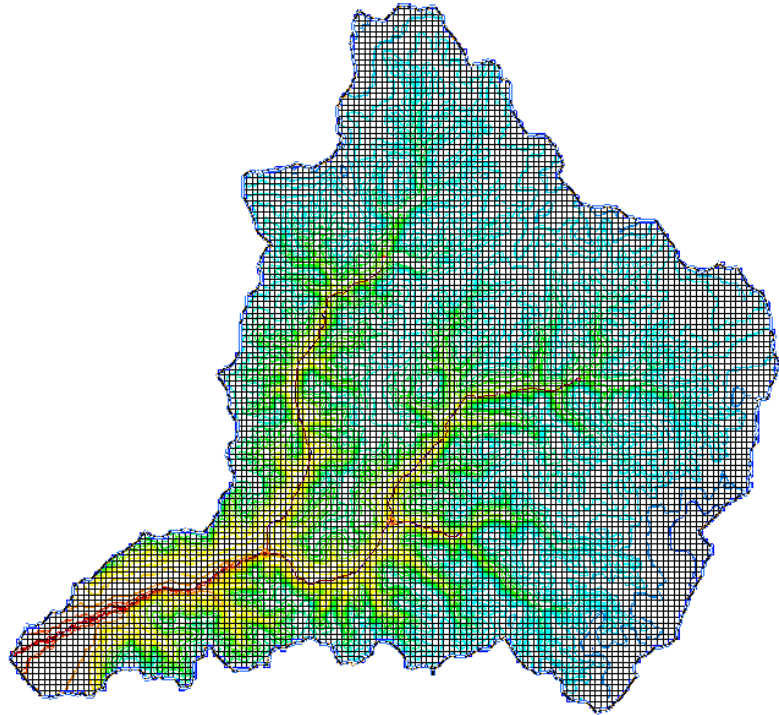
6. Save your WMS project by selecting *File / Save*.  Save it as *C:/Training/Personal/ WatershedDel /JudysBase.wms*

2.5 2D grid generation

To develop a GSSHA model, you will need to generate a two-dimensional finite difference grid.

1. Switch to the *Map Module* .
2. Click on the *Select Feature Polygon Tool*  and right click anywhere within the watershed polygon. Then select *Create Grid* in the popup menu that appears.
3. Select *Yes* to confirm that you are creating GSSHA grids.
4. Make sure the *Base Cell Size* option is checked on and enter **50m** as the cell size and click *OK*.
5. Click *OK* to interpolate grid cell elevation from the DEM, and select *NO* when prompted if you want to delete the DEM data.
6. You can now see grid cells over the watershed. You should have also noticed that under the *Coverages* in the data tree, the *Drainage* coverage has been now changed to *GSSHA*.

7. Do NOT save WMS project (we do not want to save the grid at this moment)




2.6 Task

1. Repeat this tutorial with your own data.

Creating Feature Objects and mapping them to 2D Grid

In order to develop a grid into a GSSHA model, several attributes such as surface roughness, infiltration, porosity, moisture content, and others will need to be defined for each cell. This tutorial focuses on the development of these hydrologic parameters for GSSHA grids using commonly available land use and soils GIS data.

Since GSSHA uses spatially varying parameters, it would be impossible to enter such parameters for each grid cell one by one. So, we will define the parameters by aggregating cells of like soil and/or landuse properties using Index Maps. If there are only 5-6 different soils in a watershed then we need only define 5-6 different infiltration properties which will be mapped to all like cells, rather than having to define the values separately for each cell. In this tutorial we will learn how these Index Maps are created in WMS.

1. We will continue working with the Judys Branch watershed delineated in previous workshop. If you have saved the delineation, go ahead and open the project in WMS from *C:/Training/Personal/WatershedDel/JudysBase.wms*. If you do not have a copy, you can open *C:/Training/WatershedDel/JudysBase.wms*.
2. Select *File | Save As*  and save the project with new a name *C:/Training/Personal/FeatureObjects/JudysParam.wms* so that the original project will not be overwritten.

3.1 Mapping GIS shape files to WMS Coverage

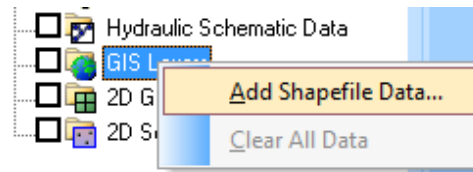
You should have remembered from previous workshops how some of the important GIS data can be obtained. If there is any confusion, refer to Section 1.8.1.

3-2 GSSHA Modeling Using WMS – Volume 1

In the previous workshops, you learned about various WMS data types and their sources. In this section you will use these data to set up GSSHA modeling parameters.

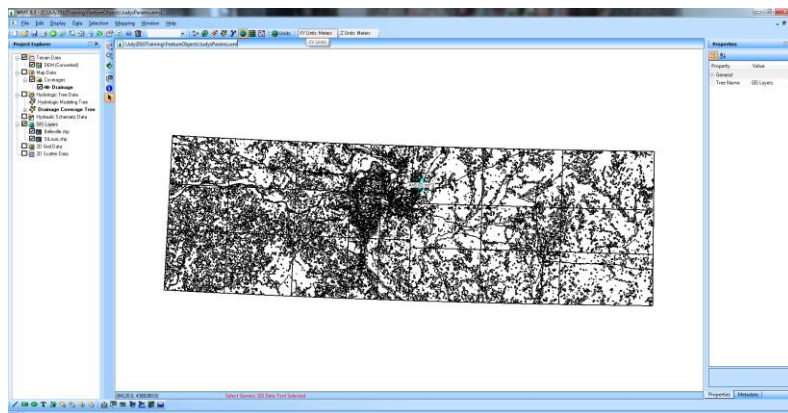
3.1.1 Adding Land Use Coverage

1. In the project explorer, right click on *GIS Layers* folder and select *Add Shapefile Data*.

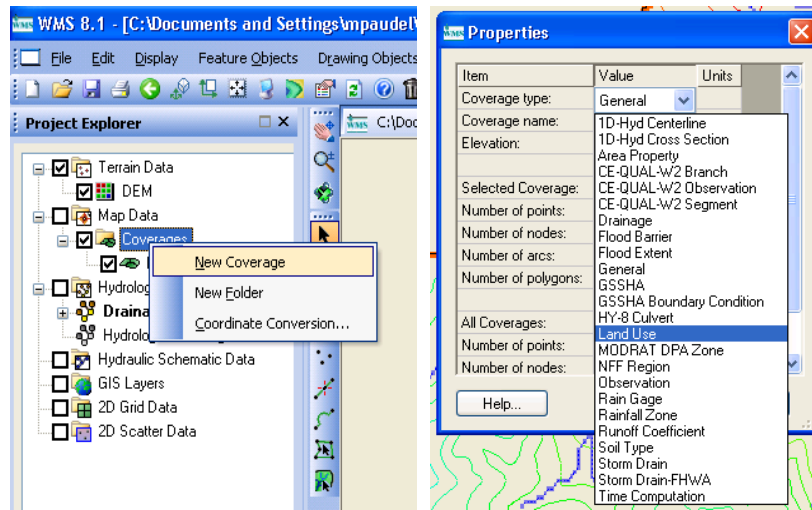



2. Browse *C:/Training/RawData/JudysBranch/Landuse* and open *Belleville.shp* and *StLouis.shp*. These are the two land use shapefiles that are necessary to cover out watershed.

Two shapefile layers are added to the project explorer under GIS layers. If the coordinate is matching the land use extent will overlay your watershed. Your project will now look somewhat like the following figure.



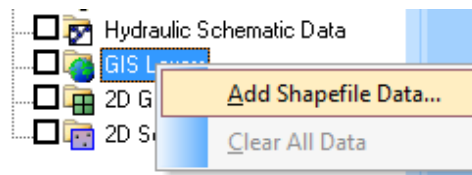
3. Right click the shapefiles and look at the attribute table. You should be able to see the USGS land use code (LUCODE).
4. In order to use the land use data, the polygons overlapping our watershed need to be copied to a WMS land use coverage. This is done from the GIS module.
5. In the project explorer, right click on *Coverages* and select *New Coverage*.



6. Select the coverage type to be *Land use* and click *OK*. This will create a new land use coverage in the project explorer.
7. Click on the new Land use coverage in the Explorer window to make it active.
8. Press Shift key in the key board and click on both *Belleville.shp* and *StLouis.shp* (under GIS layers) to make them active which also switch you to the GIS module as we are going to map the data from the shapefile to the land use coverage.
9. Click on the “*Select shapes tool*”  (should be selected by default) and drag a rectangle around your watershed area to select all land use polygons that overlap the basin.
10. Select *Mapping | Shapes* → *Feature objects*, click *Next* and make sure that LUCODE is mapped to Land use. Click *Next* and click *Finish*.
11. WMS no longer needs the GIS data once it is mapped to a coverage. You may delete the shape file under GIS layers (Right click on the shapefiles *Belleville.shp* and *Stlouis.shp* and select delete).

3.1.2 Adding Soil Type Coverage



12. In the project explorer, right click on *GIS Layers* folder and select *Add Shapefile Data*.



1. Browse *C:\Training\RawData\JudysBranch\SSURGOSoil\Raw\Spatial\soilmu_a_i1119.shp* to open SSURGO soil shapefile.

2. This data is as it was downloaded and needs to be processed to join the attributes.
3. Join the attributes for the shapefile you added. Right click the shapefile and select *Join NRCS Data*. Refer to section 1.8.2 of this tutorial for detail about joining the attribute table to SSURGO shapefile.
4. Create a new coverage, change the type to *Soil Type*.
5. Map the polygons from the soil shapefile that overlap the watershed to the newly created soil type coverage. (Similar to how you mapped land use data, see section 3.1.1)
6. Once you have mapped the soil polygons delete the SSURGO shapefile from the project explorer.

3.2 Creating 2D grid


1. Switch to the *Map Module* by clicking .
2. Click on the *Select Feature Polygon Tool*  and right click anywhere within the watershed polygon. Then select *Create Grid* in the popup menu that appears.
3. Select *Yes* to confirm that you are creating GSSHA grids.
4. Make sure that *Base Cell Size* option is checked on and enter **50m** as the cell size and click *OK*.
5. Click *OK* to interpolate grid cell elevation from the DEM, and select *YES* when prompted if you want to delete the DEM data.

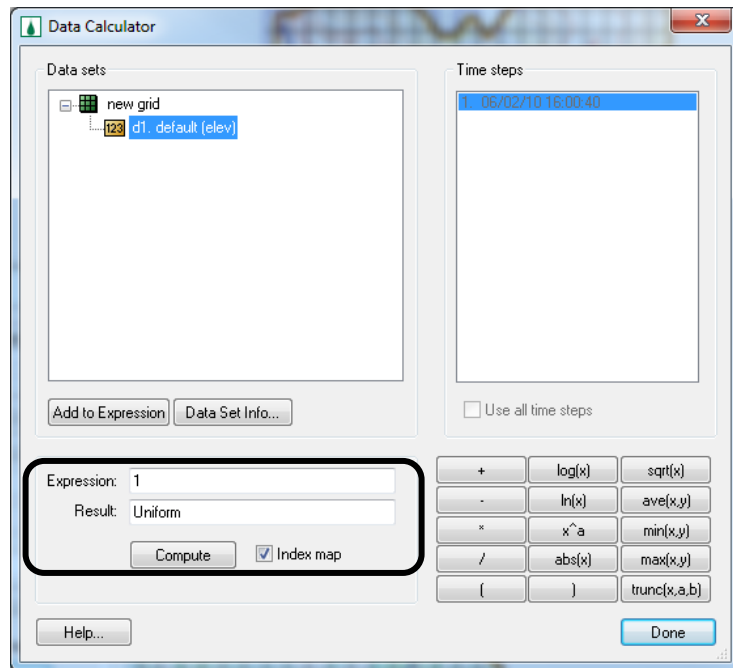
You will be using the land use and soil data to create index maps which are based on this grid.

3.3 Creating Index Maps

WMS has an interface to automatically generate an index map. Here you will create uniform, land use and a soil index maps.

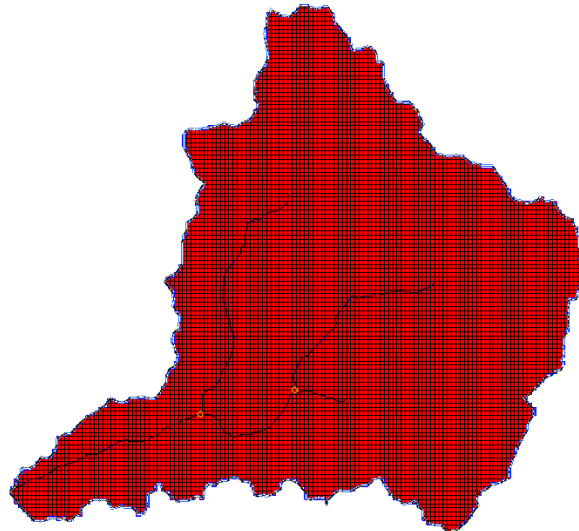
3.3.1 Creating Uniform Index Map

1. Switch to the *2-D Grid module* by clicking the grid module  button.
2. Select *GSSHA / Maps...*
3. Click the *Data Calculator* button.
4. In the *Data Calculator* dialog enter 1 for the *Expression* and enter *Uniform* for the *Result* field. Check on the *Index Map* toggle and click *Compute*.



5. Click *Done*.

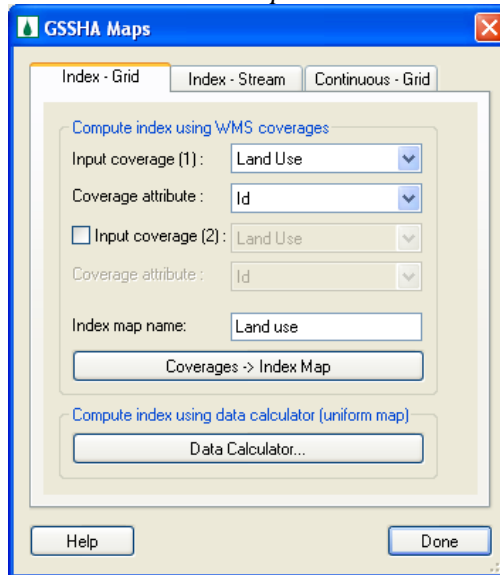
This will create an index map that has the same ID value (1 in this case) in each grid cell. A uniform index map is used to define a parameters which are uniform over the watershed domain. For example if you assume uniform overland roughness in the watershed, then a uniform index map can be used to define the roughness for the whole watershed.




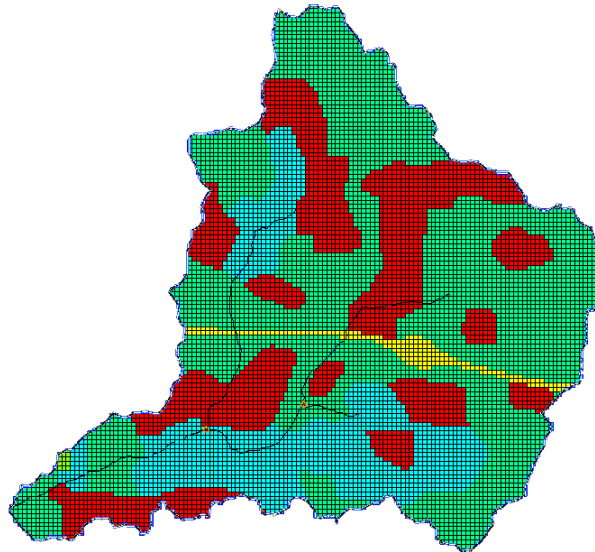
3.3.2 Creating a Land Use Index Map

3-6 GSSHA Modeling Using WMS – Volume 1

1. In the *GSSHA Maps* dialog, select *Land use* for *Input Coverage(1)*. Enter the name *Land Use* for the *Index Map Name*.



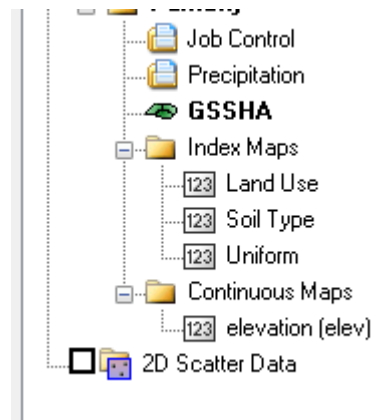
2. Click on the *Coverages -> Index Map* button. Click *Done* when completed.
3. You may now turn off the display of the *Land use* coverage by turning off its check in the project explorer. Make sure that the display of the *GSSHA* coverage and *2D Grid Data* are turned on.
4. Click the “*Frame*” button .
5. You can now see colored grid cells where each color represents a different land use code.



3.3.3 Creating a Soil Type Index Map

1. In the *GSSHA Maps* dialog, select *Soil type coverage* for *Input Coverage(1)*. Enter the name *Soil Type* for *Index Map Name*.
2. Click *Done* to close *GSSHA Maps* dialog.

- At this point your project should have three index maps and the project explorer will look something like the following figure

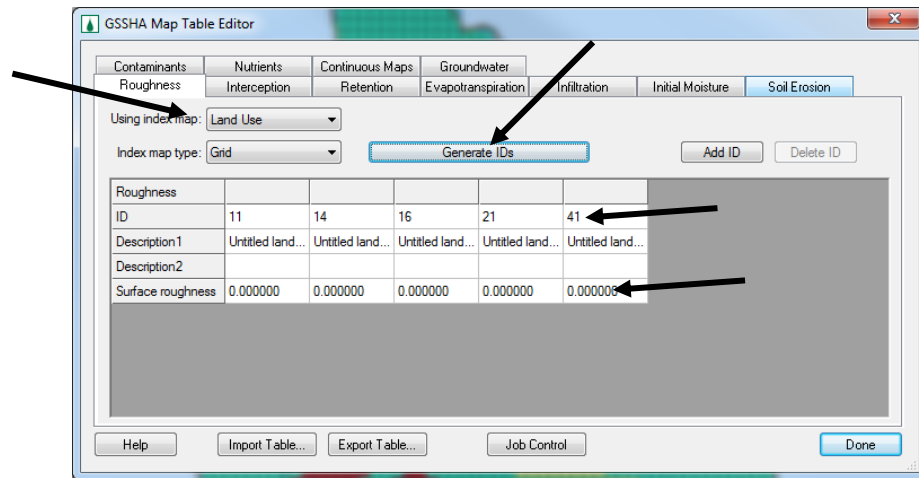


3.4 Exploring Mapping Tables

The index maps are created so that the land or soil characteristics can be correlated with *GSSHA Map Tables*. Map tables are used to enter the hydrologic and hydraulic parameters for the grid cells.

- Select **GSSHA / Map Tables** which will bring up the *GSSHA Map Table Editor* dialog.
- The *Roughness* tab is selected by default. Currently, this tab does not have any information but we can use the index maps to create IDs.
- Select *Uniform* from the dropdown box for *Using Index Map* field and click *Generate IDs*. This will create one Land Use ID field. If you recall the step you created *Uniform* index map, you had entered value 1 for all the grid cell. Because of which you have only one ID here. This index map can be used to create *Roughness* IDs if you are assuming a uniform surface roughness for the entire watershed.
- However, in the real world, the surface roughness varies over the watershed domain. If you want to create a GSSHA model that uses distributed surface roughness, you will have to use *Land use* index map to create the *Land Use IDs*.
- Select *Land Use* from the dropdown box for *Using Index Map* field and click *Generate IDs*. Select Yes if prompted to delete existing IDs. This will create different Land Use IDs for each unique land use that is present in the land use shape file or now in the index map.

3-8 GSSHA Modeling Using WMS – Volume 1



- You should now enter the roughness values for each of these IDs. The IDs seen in the spreadsheet are USGS Standard Land use codes which helps you identify which land use it is, see a portion of this table below:

Classification Code	Land Use Description
11	Residential
12	Commercial Services
13	Industrial
14	Transportation, Communications
15	Industrial and Commercial
16	Mixed Urban or Built-Up Land
17	Other Urban or Built-Up Land

- Map tables are created for other hydrologic and hydraulic characteristics of watershed using different index maps. You may switch through different tabs in *GSSHA Map Table Editor* dialog.
- As you click on other tabs in the map table dialog, WMS will prompt you if you want to turn on that option. For eg, if you have not turned the infiltration ON but you selected *Infiltration* tab in the map table, WMS will prompt you if you want to turn the infiltration On and so forth.

3.4.1 Understanding the Mapping (.cmt) File

The parameter values you entered in the *GSSHA Map Table Editor* dialog are saved in a mapping file in the GSSHA project directory that has a *.cmt extension. GSSHA uses the .cmt file as a lookup table to find defined values for GSSHA parameters from the corresponding index map.

- Select **File / Edit File** in WMS. Browse and open *C:\Training\gsha.cmt*
- This will open a sample .cmt file in a text editor. You can go through different sections of this file and see how they are stored. The roughness values in this file are obtained from standard text books relating to the USGS land uses.

Similarly, the infiltration parameters are obtained from Rawls and Brakenseik's table which provide Green and Ampt infiltration parameters based upon the soil texture. This is why we had soil texture imported while processing SSURGO data in previous sections.

The USGS land use files and SSURGO soils files use consistent IDs and texture classifications. So that we do not have to define the roughness and infiltration values each time we create a new GSSHA model, we have created a "master" mapping file that has roughness values defined for each USGS land use code and infiltration parameters for each SSURGO soil texture from the literature as mentioned above. This table can be found in *C:\Training\gssha.cmt*. These values are not intended to be absolute for every project, but will define a reasonable starting point.

3. It is important to note that WMS creates a .cmt file each time you create a GSSHA model which is saved in the same folder where the GSSHA project is saved. But this .cmt file might not have all the parameters listed as you saw in the master .cmt file found in *C:\Training\gssha.cmt*. WMS will save out only those parameters for the IDs that are present in your index map.
4. Close the .cmt file
5. Instead of typing the parameters for roughness or infiltration etc, you can import a .cmt file that already has these values listed like the one you just viewed. To import a .cmt file, click *Import Table button* in *GSSHA Map Table Editor* dialog and browse for the .cmt file with proper values.

3.4.2 Combined Index Map Concept

The values of infiltration parameters obtained from Rawls and Brakenseik's table are for bare earth conditions where the soils are assumed to be exposed. But in a natural watershed, the land cover will change the infiltration characteristics of the soil. For example sand with grassland as land use will have significantly different infiltration characteristics from sand covered with crops or asphalt.


Because of this, it is advisable to create a combined index map which generates unique IDs for each different land use-soil type combination within the watershed. Once, you have your soil and land use data mapped to respective WMS coverages, a combined index map can be generated.


1. In the *2D Grid Module*, open the *GSSHA Maps* dialog. Then check the toggle to use second input coverage.
2. Select Soil Type for the first input with Texture as attribute and Land use for second input with ID as the attribute.
3. Change the name to *Combined* and create an index map by selecting the *Coverages->Index Map* button.
4. This combined index map can now be used in the *GSSHA Map Table* to generate IDs for Infiltration parameters.

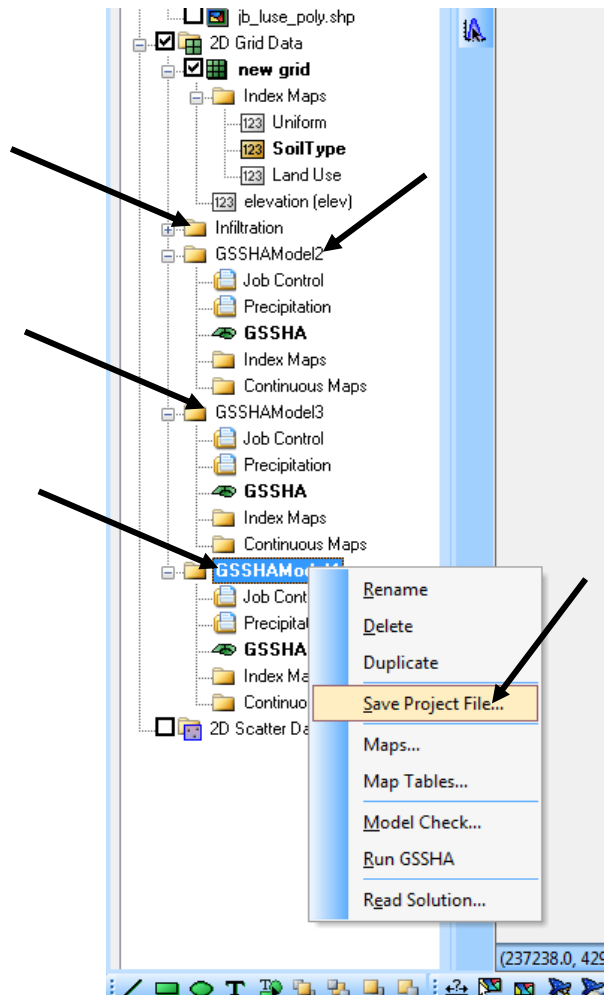
One thing to note here that when you import a standard .cmt file to fill in the infiltration parameters, the parameter values are obtained from Rawls and Brakenseik's table and as we already discussed these values are for bare earth

condition. You will have to manually adjust the parameters during calibration if you are using a combined index map to generate infiltration parameters.

3.5 Saving a GSSHA Project

There are two different save operations as you create a GSSHA model in WMS. If you select **File / Save** or use the save button  you will save a WMS project. This does not save the index map or the GSSHA project. You save a GSSHA project separately.

1. To save a GSSHA project, switch to *2D Grid module*  and select **GSSHA / Save Project File**.
2. In later workshops, it is possible that you might have more than one GSSHA model based on the same grid (scenario modeling workshops). In that situation when you choose **GSSHA / Save Project File** the GSSHA project which is currently selected in your project explorer will be the project that is saved.
3. As an alternative you can save a GSSHA project by right clicking on the GSSHA model in the project explorer you wish to save and selecting **Save Project File**. See the following figure.



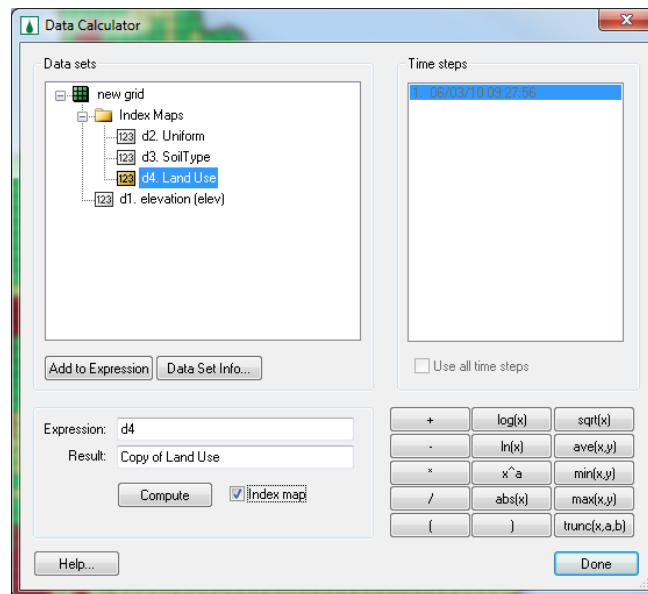
In the above figure, there are four GSSHA projects namely *Infiltration*, *GSSHAModel2*, *GSSHAModel3* and *GSSHAModel4*. The screenshot shows the saving of *GSSHAModel4*.

3.6 Task

3.6.1 Copying an index map

There might be some situations when you need a copy of an index map.


1. In the *2D Grid Module*, open the *GSSHA Maps* dialog.
2. Open the *Data Calculator* by clicking the *Data Calculator* button.
3. In the data calculator, double click the index map you want to copy. Doing this will put a formula in the *Expression* field.
4. Check the *Index Map* toggle on and enter an appropriate name.
5. Click *Compute* which will create a copy of the index map you selected.
6. You can see an index map added in the project explorer.

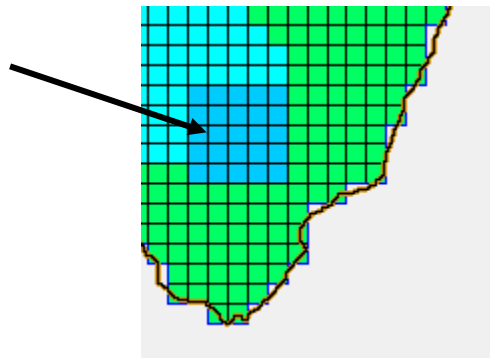
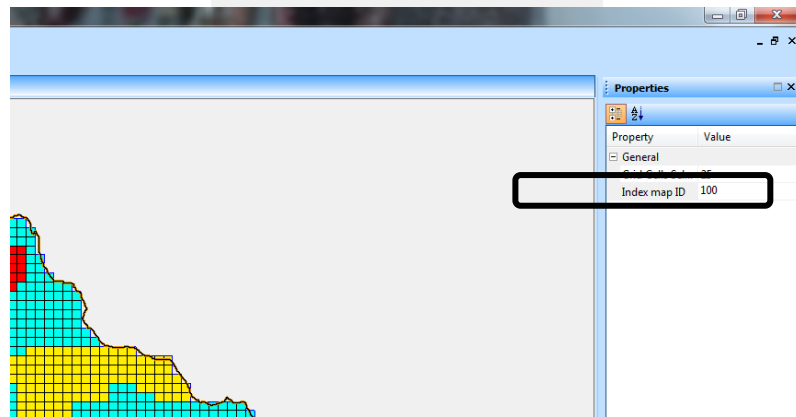
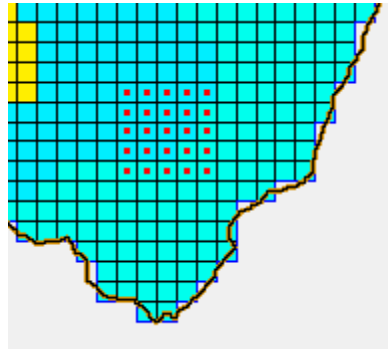



7. In this figure, the data calculator is set to create a copy of the *Land use index map*.

3.6.2 Editing an Index Map

Sometimes you will have to modify an existing index map. Editing an index map cell means assigning it a different ID (overriding what was mapped from a coverage). For example you have a land use change index map but, you notice that a certain portion of the land has been converted to a built up area. You can modify the index map for these few cells to incorporate the change.

1. In the project explorer, select the index map you created a copy of in the previous step.
2. Select the *Select Grid Cell Tool*  and drag a box to select the grid cells you wish to change ID's for.
3. In the WMS properties window you can edit the ID's of the selected cells. Go ahead and assign the *Index Map ID* to be 100.
4. This will update the index map and because it is a different value it will now display as a different color.



5. If the area you want to change the ID is not rectangular, then with the *Select Grid Cell Tool*  selected, you can press and hold Shift Key in the Keyboard and click on the cell(s) you want to select.
6. Alternatively, you can select the grid cells with a polygon. Select *Edit / Select with Polygon*. Then draw the polygon to include the cells you want to select.