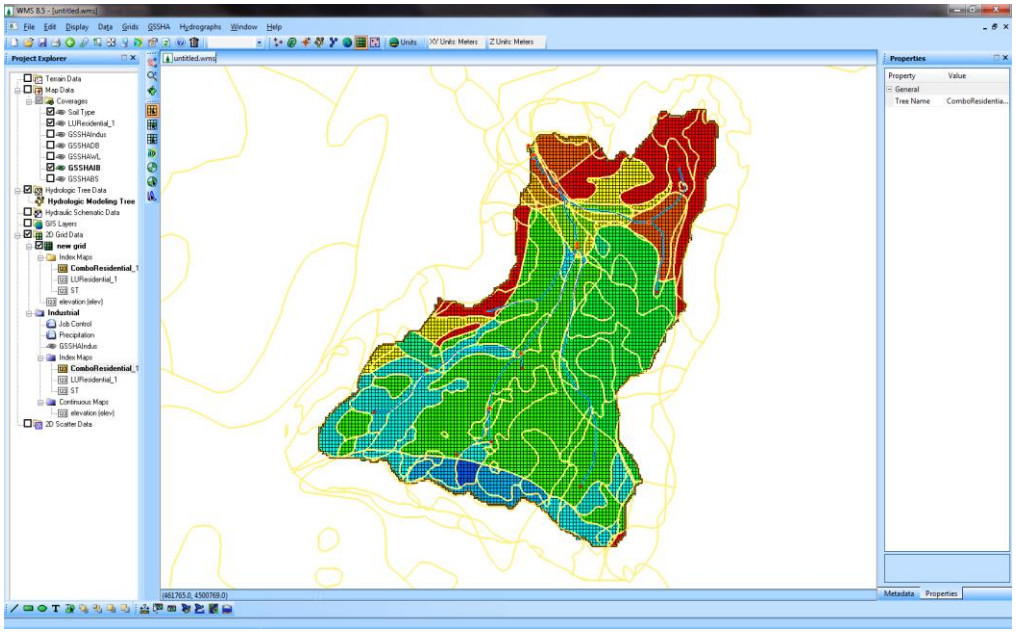
WMS

v. 10.1

WMS 10.1 Tutorial

GSSHA – Applications – Analyzing the Effects of Land Use Change (Part - II)

Understand how to include the effects of runoff abatement measures in GSSHA models



Objectives

This tutorial teaches how to add the effects of runoff abatement measures such as detention basins, wetlands, infiltration basins, and buffer strips in a GSSHA model. It also instructs how to manage several different model scenarios in a single set of GSSHA project files.

Prerequisite Tutorials

- GSSHA – Modeling Basics – Developing a GSSHA Model Using the Hydrologic Modeling Wizard in WMS

Required Components

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

Time

- 30-45 minutes

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1 Contents

2 Introduction

Changing the land use in a certain portion of the watershed can cause an increase in the peak flow at the watershed outlet. This situation is often undesirable as natural streams and various hydraulic structures like culverts and channels downstream of the new development become undersized.

In this workshop, add abatement measures to the *Industrial* GSSHA model so the effects of land use changes added in the previous workshop are minimized.

Simulate the effects of following abatement measures:

- Add a detention basin
- Add a wetland
- Add an infiltration basin

3 Open an Existing Project

First open *Industrial.prj*. This is one of the land use change scenarios created in the previous workshop.

1. In 2D grid module, select ***GSSHA|Open Project File...***
2. Locate the ***Personal***, ***Scenarios***, and ***Tables*** folders in the files for this tutorial. If needed, download the tutorial files from www.aquaveo.com.

3. Browse and open the project ***Scenarios\BaseModel\Industrial.prj.*** This is the same project that was created in the previous workshop.
4. Save the project as ***Personal\Scenarios\Abatement\ Industrial.prj***

4 Adding a Detention Basin

To mitigate the problems of flooding, introduce a detention basin in the watershed.

4.1 Creating a new GSSHA Project for the Detention Basin

Creating a new GSSHA Coverage

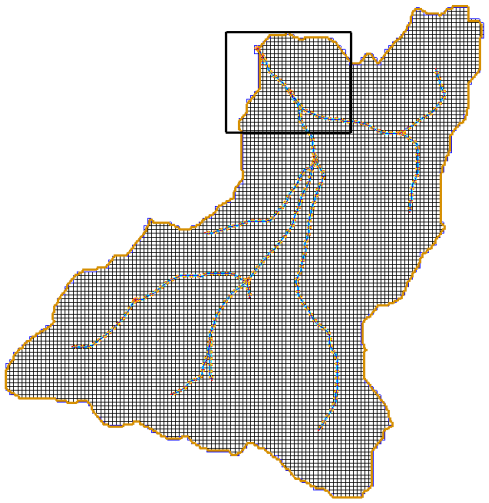
1. In the project explorer, under *Coverages*, right-click *GSSHAIndus* coverage and select *Duplicate*.
2. Rename the new GSSHA coverage as *GSSHADB.*

Creating a new GSSHA Project

1. In the project explorer, under ***2D Grid Data***, right-click on GSSHA project named ***Industrial*** and select *Duplicate.* This will create a new GSSHA project with name ***Industrial (2).***
2. Under ***2D Grid Data***, ***e***xpand ***Industrial (2)***. Right-click on *GSSHAIndus* and *assign GSSHADB.*
3. Right-click on project ***Industrial (2)*** and select ***Save Project File….*** Save it as ***Personal\Scenarios\Abatement\DetBasin.prj.*** This will also rename the project.

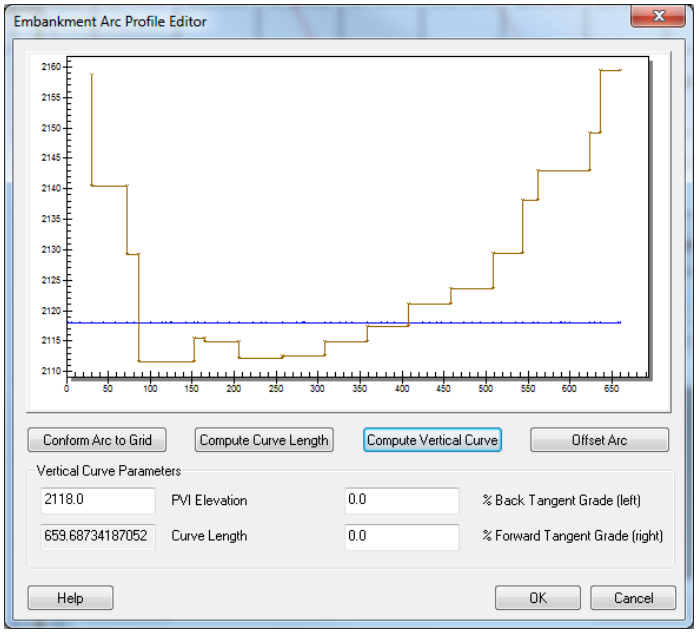
4.2 Defining the Detention Basin Parameters

1. Open a background image which will be used as a guide to draw an embankment arc as well as insert a node. Browse and open file ***Scenarios\Images\DetBasin.jpg***.
2. In the *Project Explorer*, turn on the display of all the 2D grid data by checking it on.
3. Zoom into the area as shown in the following figure.
4. If unable to see the background image, it might be because on one of the index maps is turned on. In that case, select the *elevation (elev)* dataset under *2D grid Data* to make it active.
5. Select the *DetBasin* model under *2D Grid Data* to make this the active GSSHA model.



To define a detention basin, define an embankment arc at the downstream end of the detention basin. This arc represents the detention basin's downstream embankment. When the embankment arc is created, the grid edges defined by the embankment arc must be downstream from the detention basin's outlet point. Define an outlet point by adding a feature point along the stream at the downstream end of the detention basin. Define one or more outlet structures and a detention basin in the point attributes for this feature point.

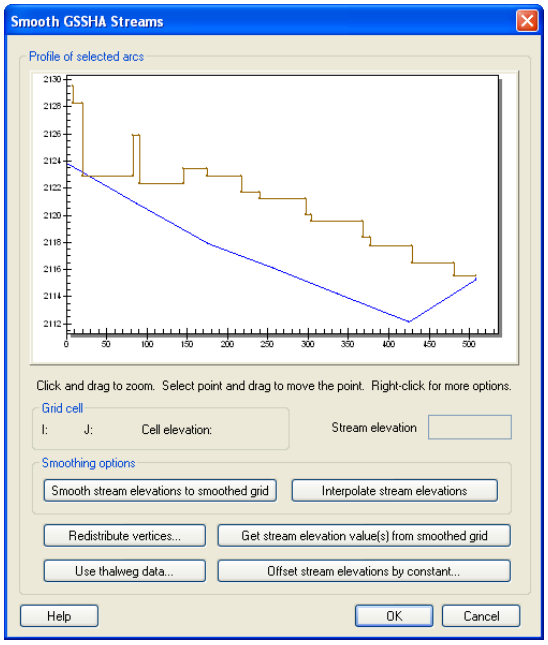
6. In the *Project Explorer*, turn off the display of all coverages except *GSSHADB.* Select the *GSSHADB* coverage.
7. Select the *Create Feature Point* tool .
8. Insert a node at the location shown in the background map by clicking on the stream at this location.
9. Select the *Create Feature Arc* tool and draw an embankment arc as shown in the background image. **Make sure to not click on the stream or boundary arcs while drawing the embankment arc. Doing so will end the arc at the intersection. In other words, define the embankment as a single arc with only two nodes. Multiple vertices can define the geometry of the detention basin embankment between the nodes.**
10. In the *Project Explorer*, turn the display of the *DetBasin* background image off.
11. Click on the *Select Feature Arc* tool and double-click on the embankment arc. Change the type to *Embankment* and click on the (...) button under the *Embankment* attribute.
12. Enter a PVI Elevation of 2118 and click on the *Compute Vertical Curve* button. After clicking this button, notice the plot of the embankment arc and the grid elevations as shown in the following figure.



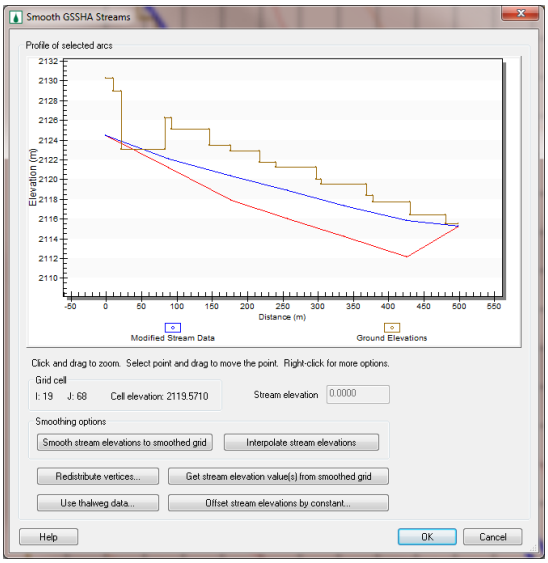
13. Click *OK*, then *OK* again.

The arc created to define the embankment is not directly used by GSSHA. In GSSHA, the embankment is represented by grid cell edges. WMS uses the arc and finds the nearest cell edges to represent the embankment in GSSHA.

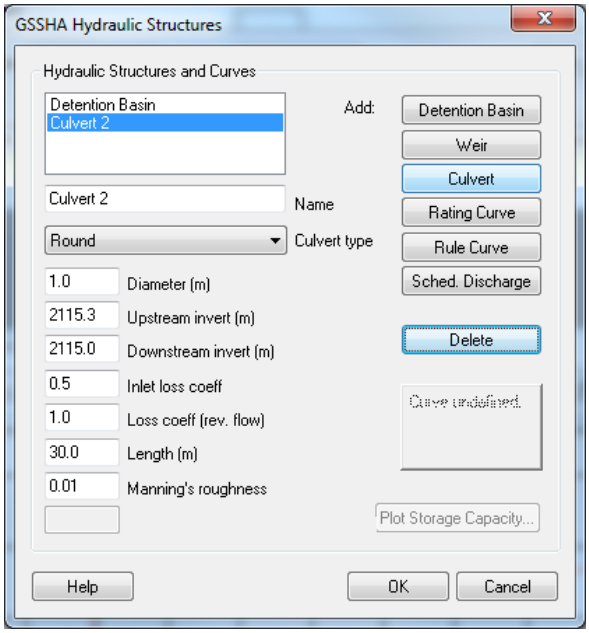
14. In *Display Options*, switch to *2D grid data* and turn on the display of *Embankment Edges*.
15. This will display the edges of grid cells designated as embankment edges in a different color than the regular grid cell edges. If the node inserted in the stream (step 8) is downstream from this line representing the embankment edge, need to move the node so it is upstream of the embankment edge. The edge defining the location of the embankment needs to be downstream from the node where the detention basin is defined.
16. In the *2D grid module*, check the elevation of the grid cell at which the node is located. The cell elevation should be about 2115.53.
17. In the *Project Explorer*, select the *GSSHADB* coverage. Click on the *Select Feature Point/Node Tool* and click on the node. See the elevation of the node on the properties window to the right side. The node elevation is about 2110 (it might be little different in this case as it depends on the location of the node).
18. Edit the node elevation in the properties window so it is 2115.3. Do not let the elevation of this node be too far below the grid. After changing the elevation of the node, the stream arc profile needs to be re-interpolated so that there is no adverse gradient along the flow direction.
19. Select the model to be *GSSHA* in the model selection drop down box.
20. Click on the *Select feature Arc* tool and select the stream arc which is just upstream of the node.
21. Select ***GSSHA | Smooth Stream Arcs***. The profile of the stream arc will be as shown in the following Figure:



22. Drag the vertices along the stream arc upward (towards the grid) so that there is no adverse gradient and until it similar to the following figure. **Do not click on *Interpolate stream elevations* button since doing that will change the most downstream node elevation.**

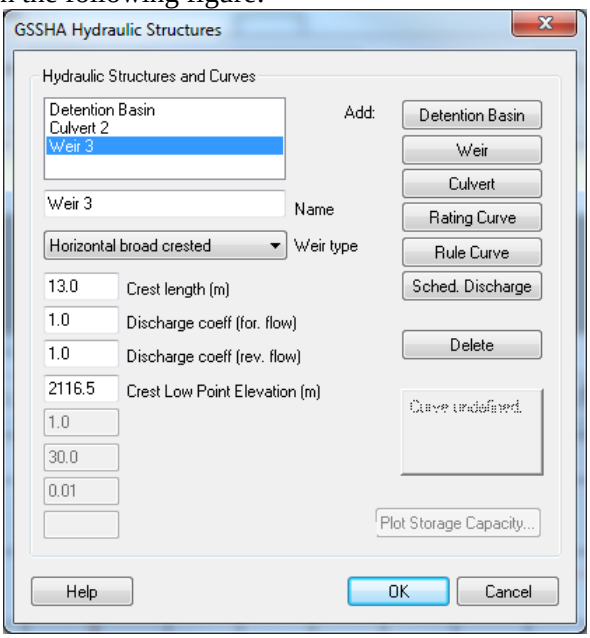


23. Click *OK*
24. Click on the *Select Feature Point/Node* tool  and double-click on the node representing the outlet of the detention basin. This will open the *Properties* dialog. Click on the (...) button under *Hydraulic Structures*.
25. Insert a ***Detention basin*** by clicking on the *Detention Basin* button. Enter 2115.5 for Minimum, 2115.5 for Initial and 2117.0 for the Maximum water surface elevations.
26. Then insert a ***Culvert*** by clicking on *Culvert* button. Enter the parameters for the culvert as shown in the following figure:



The node elevations of the stream arc where the culvert is being inserted is used for the upstream elevation of the culvert. The length and diameter of the culvert are governed by the flow rate and site condition.

27. Insert a ***Weir*** by clicking on *Weir* button. Enter the parameters for the weir as shown in the following figure:



28. Click *OK* and then *OK* again.

4.3 Redistribute Stream Vertices

GSSHA pours water from the grid cells to the stream at specific locations. Since the spacing changed on some of the stream vertices, redistribute the vertices.

1. Click on *Select feature line branch* tool  and click at the most downstream stream arc to select all of them.
2. Select ***Feature Objects | Redistribute*** and enter 85 for *spacing.*
3. Click OK.

4.4 Save the Scenario

1. In the *Project Explorer*, right-click on ***DetBasin*** and select ***Save Project File…*** Save the project file as ***Personal\Scenarios\Abatement\ DetBasin.prj***
2. Save the GSSHA group as ***Personal\Scenarios\Abatement\Abatement.ggp*** selecting the GSSHA projects listed (there should be Industrial and DetBasin).

This completes the detention basin setup to be modeled.

5 Adding a Wetland

A detention basin might not always be the best flood mitigation method. As an alternative add a wetland in the watershed and compare how it reduces the flood. Restoring a wetland helps maintain an ecological balance in the watershed and this type of solution could be preferable over a structural solutions.

5.1 Creating a New GSSHA Project for the Wetland

Creating a new GSSHA Coverage

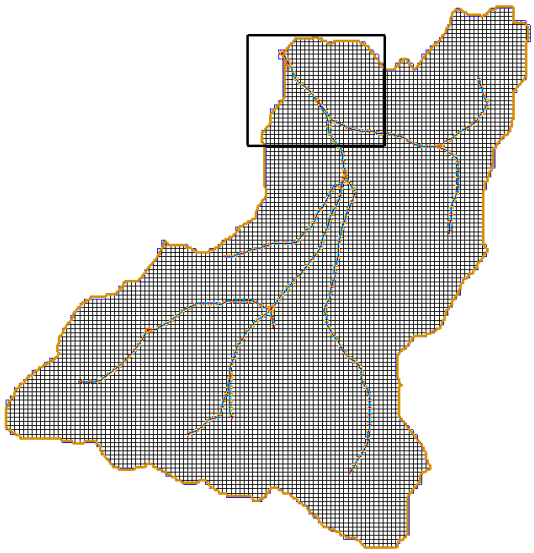
1. In the project explorer, under *Coverages*, right-click *GSSHAIndus* coverage and select *Duplicate.*
2. Rename the new GSSHA coverage as *GSSHAWL.*

Creating a new GSSHA Project

1. In the project explorer, under ***2D Grid Data***, right-click on GSSHA project named ***Industrial*** and select *Duplicate.* This will create a new GSSHA project with name ***Industrial(2).***
2. Under ***2D Grid Data***, ***e***xpand ***Industrial(2)***. Right-click on *GSSHAIndus* and assign *GSSHAWL.*
3. Right-click on project ***Industrial(2)*** and select ***Save Project File….*** Save it as ***Personal\Scenarios\Abatement\WetLand.prj.*** This will also rename the project.

5.2 Defining the Wetland Parameters

1. Open the background image which will be a guide of the location of the wetland. Browse and open file ***Scenarios\Images\Wetland.jpg***
2. Zoom into the area as shown in the following Figure.

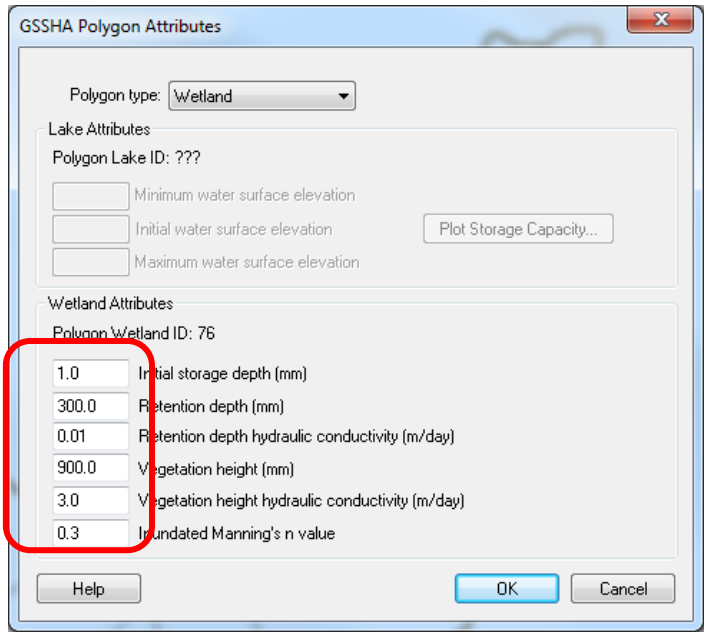


To define a wetland, draw a polygon and define it as the wetland.

3. Make sure *GSSHAWL* is turned on and is active (currently selected).
4. Switch to the ***Map Module*** and click on the "*Create Feature Arc Tool"*. Then draw a polygon as shown in the background image. **NOTE: While drawing the arc, make sure to not click on or near the stream arc at any location.**

In this exercise the wetland is inserted such that the stream passes through it, but GSSHA can model the wetland both on and away from the stream arc.

5. Once done drawing the arc, turn off the display of background image.
6. Select the Select Feature Arc Tool .
7. Select the arc and choose the ***Feature Objects | Build Polygon*** option.
8. Click on the "*Select Feature Polygon Tool"* double-click inside the polygon. This will open the *GSSHA Polygon Attributes* dialog.
9. Select *Wetland* for the Polygon Type and define the following attributes for the wetland.



10. Click *OK*.
11. On the data tree, right-click on ***WetLand*** GSSHA model and select ***Save Project File…*** Save the project file as ***Personal\Scenarios\Abatement\ WetLand.prj***
12. Save the GSSHA group selecting all the three GSSHA models.

6 Adding an Infiltration basin

This is another abatement measure that can be used as a flood control measure. An infiltration basin is a designated area in the watershed which has a very high infiltration rate. Modify one of the existing GSSHA project in order to define the Infiltration basin.

6.1 Creating a New GSSHA project for the Infiltration Basin

Creating a new GSSHA Coverage

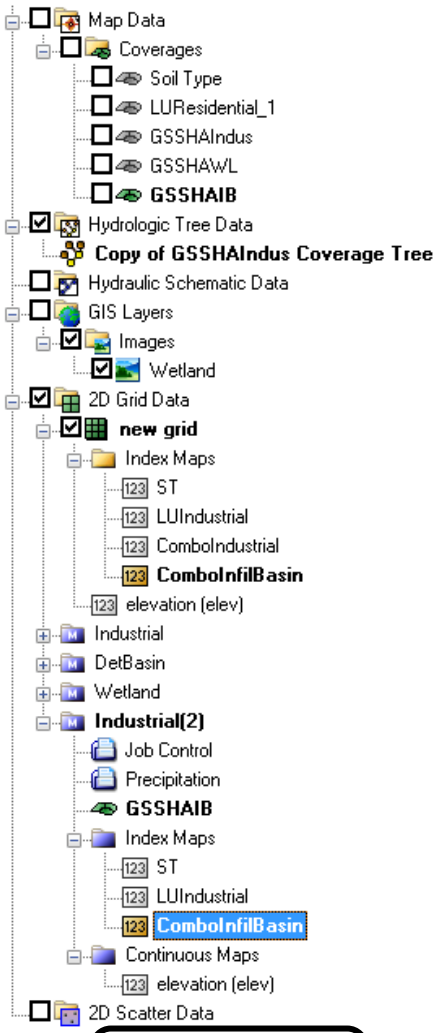
1. In the project explorer, under *Coverages*, right-click *GSSHAIndus* coverage and select *Duplicate.*
2. Rename the new GSSHA coverage as *GSSHAIB.*

Creating a new GSSHA Project

1. In the project explorer, under ***2D Grid Data***, right-click on GSSHA project named ***Industrial*** and select *Duplicate.* This will create a new GSSHA project with name ***Industrial (2).***
2. Under ***2D Grid Data***, ***e***xpand ***Industrial (2)***. Right-click on *GSSHAIndus* and assign *GSSHAIB.*

Creating a new Index map

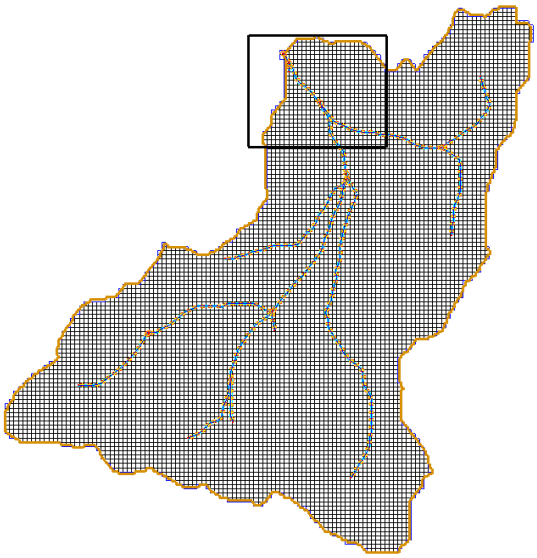
Here instead of modifying the polygons in a coverage and creating an updated index map, directly modify an existing index map. So that the index maps associated with other GSSHA models do not change, create a copy of the *ComboIndustrial index map* and modify it for an Infiltration basin.



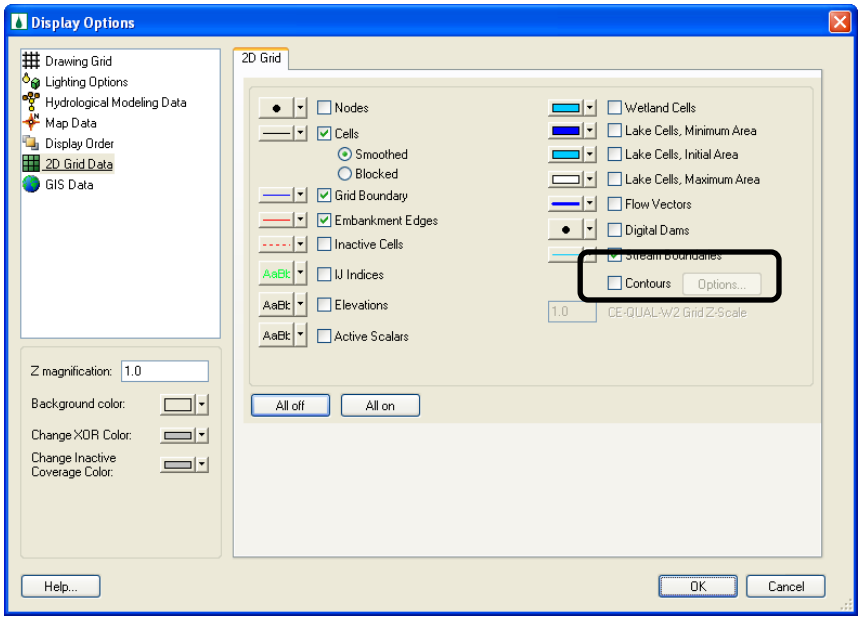
1. Right-click on project ***Industrial (2)*** in the project explorer and select *Maps.*
2. In *GSSHA maps* dialog, click on *Data Calculator* button.
3. In Data calculator, double-click on the *ComboIndustrial* dataset. This will put a symbol (something like 'd4') in the *Expression box.*
4. Enter *ComboInfilBasin* in *Result* field.
5. Toggle the *Index Map* option on (**This is very important!**).
6. Click *Compute.* Click *Done* and *Done* again. This should have added a new index map in the project explorer.
7. Right-click and remove the *ComboIndustrial* index map from this GSSHA project. The data tree should look something like the figure to the right.
8. Right-click on project ***Industrial (2)*** and select ***Save Project File….*** Save it as ***Personal\Scenarios\ Abatement\InfilBasin.prj.***

6.2 Defining the Infiltration Basin Parameters

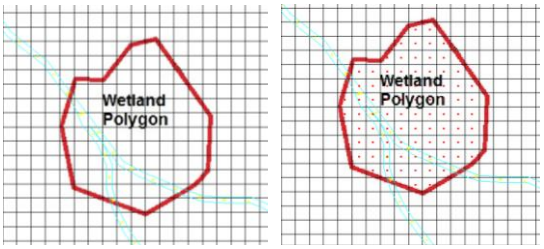
1. Turn on the display of the *Wetland* background image to create an infiltration basin at the same location as the wetland. If having removed the image, open it from ***Scenarios\Images\Wetland.jpg***
2. Zoom into the area as shown in the following Figure.



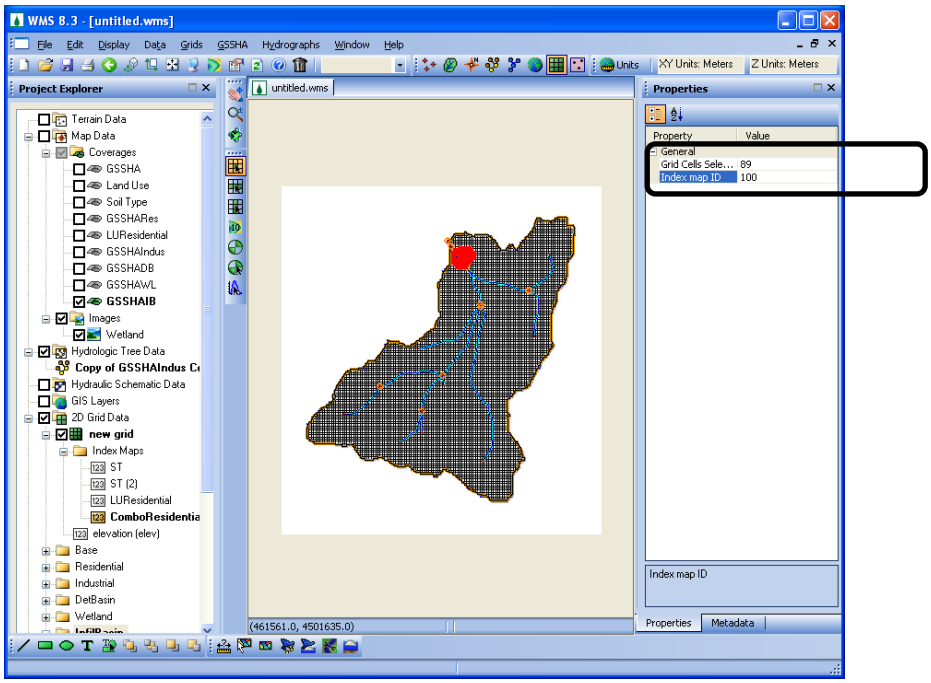
3. Now update the index map properties for the cells that lie within the polygon shown in the background image.
4. In the data tree turn on the display of *GSSHAIB* coverage and make it active.
5. In the data tree under ***2D Grid Data***, select ***InfilBasin*** GSSHA project
6. Click on *ComboInfilBasin* index map to select it. This will make the background image disappear, because the grid contours are color filled. So select ***Display|Display Options***. In the *2D Grid Data* tab, check off the option for grid contours (See the following figure).



7. In *2D grid Module*  , click on *Select Grid Cell* tool  .
8. Then select ***Edit|Select with Polygon…***Click OK.
9. Now, trace the polygon as seen in the background image and at the end double-click. This will select all the grid cells that are within the polygon.



Once the cells are selected, change the *Index Map ID to* **100**. This is done by changing in the properties window on the right hand side of the screen, see the following figure:



A different Index Map ID was defined for these cells so that these will be displayed as different field in the mapping table. Increase the infiltration rate for these cells.

10. Now turn the 'contour color fill' back in. Select ***Display|Display Options.*** In the *2D Grid Data*, check the option to display contours. Zoom in to the area and see if the cells that are within the infiltration basin are colored differently. If not, change the Index Map Id of that cell to 100 again.
11. In the project explorer, under *2D Grid Data*, right-click ***InfilBasin*** project and select ***Map tables...***
12. Switch to the *Infiltration* tab. Select *ComboInfilBasin* as the index map and Click on *Generate ID* button. Select NO. This will add a new field at the end of the list with ID 100.
13. Enter the following values for this field:

Hydraulic Conductivity	23.56
Capillary Head	4.95
Porosity	0.437

Pore Index	0.694
Residual Saturation	0.02
Field Capacity	0.091
Wilting Point	0.1

14. Click Done.
15. On the project explorer, right-click on ***InfilBasin*** and select ***Save Project File.*** Save the project file as ***Personal\Scenarios\Abatement\ InfilBasin.prj***
16. Save the GSSHA group selecting all four GSSHA models.

7 Adding a Buffer Strip

A buffer strip is generally characterized by very high surface roughness because it offers resistance to the overland flow.

7.1 Creating a New GSSHA Project for the Buffer Strip

Creating a new GSSHA Coverage

1. In the project explorer, under *Coverages,* right-click *GSSHAIndus* coverage and select *Duplicate.*
2. Rename the new GSSHA coverage as *GSSHABS.*

Creating a new GSSHA Project

1. In the project explorer, under ***2D Grid Data***, right-click on GSSHA project named ***Industrial*** and select *Duplicate.* This will create a new GSSHA project with name ***Industrial (2).***
2. Under ***2D Grid Data***, ***e***xpand ***Industrial (2)***. Right-click on *GSSHAIndus* and assign *GSSHABS.*

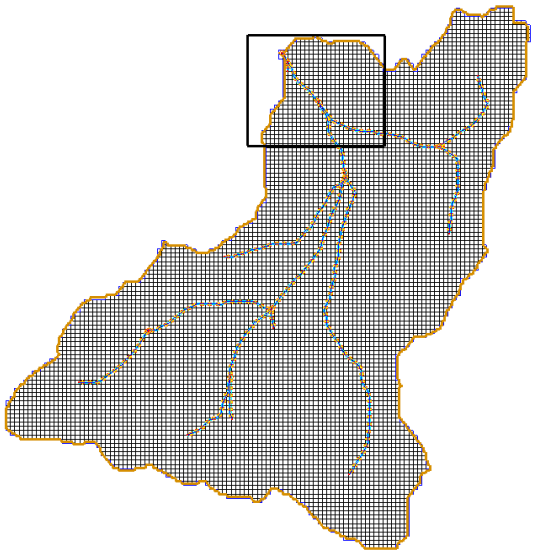
Creating a new Index map

Create a copy of existing index map and modify its IDs to define a buffer strip. Create a copy of the *LUResidential_1 index map* and modify it for the buffer strip.

1. Right-click on project ***Industrial (2)*** in the project explorer and select *Maps.*
2. In *GSSHA maps* dialog, click on *Data Calculator* button.
3. In Data calculator, double-click on *LUIndustrial* dataset which will put a symbol (eg d3) in the *Expression box.*
4. Enter *LUBufferStrip* in *Result* field.
5. Toggle *Index Map* option on.
6. Click *Compute.* Click *Done* and *Done* again. This should have added a new index map in the project explorer.
3. Right-click and remove the *LUIndustrial* index map from this project.
4. Right-click on project ***Industrial (2)*** and select ***Save Project File….*** Save it as ***Personal\Scenarios\Abatement\BufferStrip.prj.***

7.2 Creating the Buffer Strip

1. Change the display option of the *2D Grid Data* to turn off contour color fill.
2. Open the background image which shows the location of the buffer strip to insert. Browse and open file ***Scenarios\Images\BufferStrip.jpg***
3. Zoom into the area as shown in the following Figure.



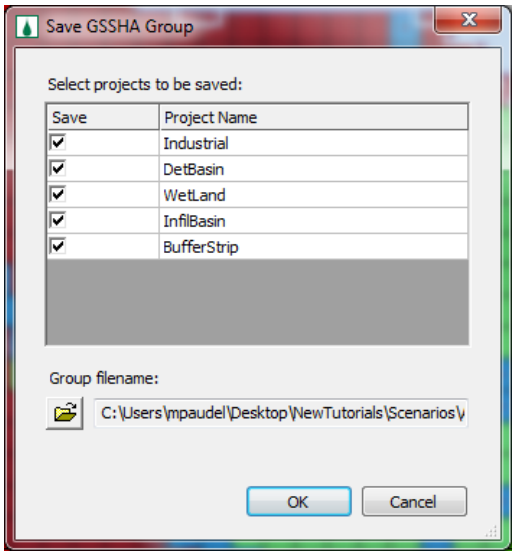
4. Notice an arc embedded in the background image that shows the location of the proposed buffer strip.
5. Since a buffer strip has high roughness value, modify the Land Use Index map. In the data tree, under *2d Grid Data,* select project ***BufferStrip.***
6. Click on *LUBufferStrip Index map* to select it.
7. In *2D grid Module*  , click on *Select Grid Cell* tool  .
8. Hold Shift Key in the keyboard and select the grid cells that overlay the buffer strip arc shown in the background image. After selecting all the cells release the shift key.
9. Change the *Index Map ID to* **200**. This is done by changing in the properties window on the right hand side of the screen.
10. Turn the 'contour color fill' option back in. Select ***Display|Display Options.*** In the *2D Grid Data*, check the option to display contours. Zoom in to the area and see if the cells that are defined as the buffer strip are colored differently. If not change the Index Map id for that cell to 200 again.
11. In the data tree, under *2D Grid Data*, right-click ***BufferStrip*** GSSHA project and select ***Map tables...***
12. In the *Roughness tab* and Click on *Generate ID* button. Select NO. This will add a new field at the end of the list with ID 200.
13. Enter a roughness value of 2.0.
14. Click Done.
15. Turn off the display of background image and turn the contour options back on.

16. On the data tree, right-click on project ***BufferStrip*** and select ***Save Project File…*** Save the project file as ***Personal\Scenarios\Abatement\ BufferStrip.prj.***

8 Saving a GSSHA Group

All the different scenarios to compare are done. Note that the scenarios have not been run yet. Instead of running them individually, save all these GSSHA projects as a GSSHA Group. WMS will then run each of the projects and plot the hydrograph from each simulation in the same window to compare the different alternative abetment measures.

1. In the ***Grid Module*** select **GSSHA | Save Group…**
2. In the Save GSSHA Group dialog, check on all the GSSHA models to be saved in the group.
3. Although the projects have been saved as groups, make sure they are saved properly by clicking on the *Browse* button and saving the group as ***Personal\Scenarios\Abatement\Abatement.ggp***
4. Select OK.



9 Running a GSSHA Group

Now run the scenarios to compare the detention basin and wetland alternatives to the modified land use.

1. Select **GSSHA | Run GSSHA group…**
2. Make sure that all the projects are selected and the path is correct.
3. Click *OK*
4. WMS will run all these scenarios and plot the outflow hydrographs on the same plot.
5. Export all the hydrographs to the spreadsheet named ***tables\ScenarioModeling.xls***. Export a hydrograph by right-clicking on

the *Outlet Hydrograph* under each scenario in the *Project Explorer* and then selecting View Graph. When viewing the hydrograph, there is a right-click option to *Export/Print* the hydrograph data.