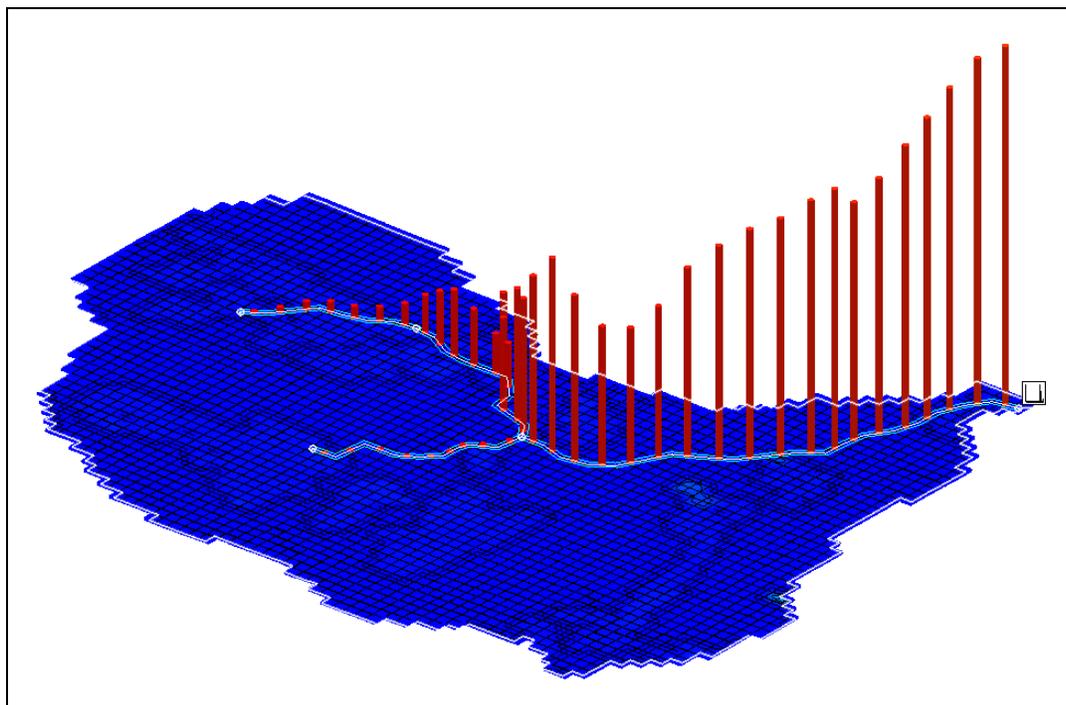


WMS 11.0 Tutorial

Simulating Constituent Transport in GSSHA

Model constituent transport in GSSHA



Objectives

Develop input parameters for and run a long-term model that simulates constituent transport both with and without sediment transport.

Prerequisite Tutorials

- GSSHA Long-Term Simulations
- GSSHA Long-Term Simulations Data Formatting

Required Components

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

Time

- 20-30 minutes



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1 Introduction

Two types of reactive constituent transport are available in GSSHA. Any constituent can be simulated as a simple first order reactant. The nutrient cycle can also be simulated with the Nutrient Simulation Model (NSM). In either case, the overall simulation methods within the GSSHA model are the same.

In this tutorial simulate total nitrogen and total phosphorous as simple first order reactants. First, create a constituent transport model without soil erosion and later add sediment transport to the model. This will allow looking at the differences between only dissolved as well as coupled dissolved and sorbed transport.

1.1 Getting Started

To begin the tutorial, do the following:

1. Open WMS, or click **New**  to reset WMS to its defaults.
2. Switch to the  **2D Grid** module.
3. Select *GSSHA* | **Open Project File...** to bring up the *Open* dialog.
4. Browse to the *data files* folder for this tutorial and select “Base.prj”.
5. Click **Open** to exit the *Open* dialog and import the GSSHA project.
6. Select *GSSHA* | **Save Project File...** to bring up the *Save GSSHA Project File* dialog.
7. Select “GSSHA Project File (*.prj)” from the Save as type drop-down.
8. Enter “contaminant.prj” as the File name.
9. Click **Save** to save the project under the new name and exit the *Save GSSHA Project File* dialog.

10. In the Project Explorer, turn off all coverages except for “ GSSHA”.

The project should appear similar to Figure 1.

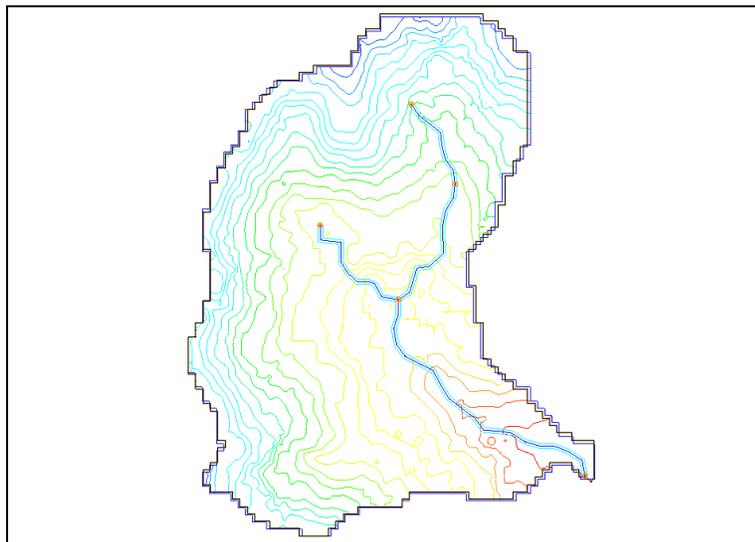


Figure 1 Initial GSSHA project

2 Adding and Defining Contaminants

In this tutorial, there is a dairy farm northwest of the outlet at the lower right (outlined in Figure 2). This dairy farm acts a contaminant source in the watershed. Constituent transport can be simulated on the overland flow plane, in the channel network including reservoirs, and in the soil column.

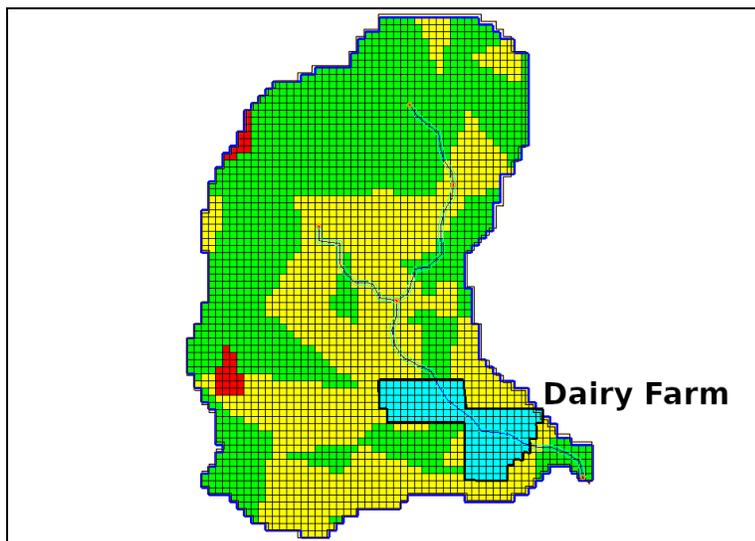


Figure 2 Dairy farm location

2.1 Adding Contaminants

To set up the parameters, do the following:

1. Switch to the  **2D Grid** module.
2. Select *GSSHA | Job Control...* to bring up the *GSSHA Job Control Parameters* dialog.
3. In the list at the bottom right, turn on *Contaminant transport* and click the **Edit parameter...** to the right of it to bring up the *GSSHA Contaminants* dialog.
4. Click **Add** twice to create two entries in the spreadsheet below the **Add** button.
5. Use the following table to fill in the entries for the first five columns on each row:

Row	Description	Index Map	Precipitation Concentration	Partition
1	Nitrogen	lu_dairy	0.0	2.7
2	Phosphorous	lu_dairy	0.0	18.0

6. In the *Base Output Filename* column, on row 1, click  to bring up the *Save File* dialog.

The *Base Output Filename* column specifies the location of the output files that will be generated for each contaminant. These output files will be saved in the *data files* folder for the project.

7. Enter “Nitrogen” as the *File name* and click **Save** to exit the *Save File* dialog.
8. Repeat steps 6-7 for row 2, using “Phosphorous” as the *File name*.
9. In the *Contaminant Transport Options* section, turn on *Run Soil Contaminant Transport*.
10. Enter “0.1” as the *Mixing layer depth*.
11. Turn off *Run Sediment Contaminant Transport*.
12. Click **Done** to close the *GSSHA Contaminants* dialog.

2.2 Setting Output Control Parameters

Now adjust the output control parameters. The **Output Control** button is located at the bottom of the *GSSHA Job Control Parameters* dialog.

1. Click **Output Control...** to bring up the *GSSHA Output Control* dialog.
2. In the *Other* section, verify that *Output contaminants* is turned on (it may be grayed out).
3. Turn on *Suppress screen printing*.
4. In the *Gridded datasets* section, turn off all entries.
5. Repeat step 4 for the *Link / Node datasets* section.
6. Click **OK** to close the *GSSHA Output Control* dialog.

2.3 Defining Contaminant Coefficients in the Channels

The contaminant coefficients in the channels need to be defined by doing the following:

1. In the *Channel routing computation scheme* section, click **Edit Parameters...** to bring up the *GSSHA Channel Routing Parameters* dialog.
2. In the *Contaminant transport* section, turn on *Compute contaminant transport*.
3. Enter “0.0” as the *Decay coefficient*, the *Dispersion coefficient*, and the *Initial concentration*.
4. Click **OK** to close the *GSSHA Channel Routing Parameters* dialog.
5. Click **OK** to close the *GSSHA Job Control Parameters* dialog.

3 Defining Contaminant Parameters

In the previous sections, two contaminants (nitrogen and phosphorous) were created and given basic definitions. The contaminant parameters for them now need to be defined in the *GSSHA Map Table Editor* dialog. The values for roughness, evapotranspiration, infiltration, and initial moisture have already been defined in the project.

This can be done by doing the following:

1. Select *GSSHA | Map Table...* to bring up the *GSSHA Map Table Editor* dialog.
2. On the *Contaminants* tab, select “lu_dairy” from the *Using index map* drop-down.
3. Select “Nitrogen” from the *Contaminant* drop-down.
4. Click **Generate IDs** to create four IDs in the spreadsheet.
5. Using the table below, fill in the spreadsheet:

ID	7	9	13	111
Description 1	forest	grass	row crop	dairy
Description 2				
Dispersion (m²/s)	0.00	0.00	0.00	0.00
Decay (per day)	0.00	0.00	0.00	0.00
Uptake (m/day)	0.10	0.10	0.10	0.10
Soil concentration (mg/kg)	4499.00	4847.00	2169.00	15854.00
Groundwater concentration (mg/l)	1.00	1.00	1.00	1.00
Initial Concentration (mg/l)	0.00	0.00	0.00	0.00
Soil water distribution (L/kg)	2.70	2.70	2.70	2.70
Max concentration/solubility (mg/l)	360000.00	360000.00	360000.00	360000.00

6. Select “Phosphorous” from the *Contaminant* drop-down.
7. Select “lu_dairy” from the *Using index map* drop-down.
8. Click **Generate IDs** to create four IDs in the spreadsheet.
9. Using the table below, fill in the spreadsheet:

ID	7	9	13	111
Description 1	forest	grass	row crop	dairy
Description 2				
Dispersion (m ² /s)	0.00	0.00	0.00	0.00
Decay (per day)	0.00	0.00	0.00	0.00
Uptake (m/day)	0.01	0.01	0.01	0.01
Soil concentration (mg/kg)	710.00	901.00	629.00	3115.00
Groundwater concentration (mg/l)	1.00	1.00	1.00	1.00
Initial Concentration (mg/l)	0.00	0.00	0.00	0.00
Soil water distribution (L/kg)	18.00	18.00	18.00	18.00
Max concentration/solubility (mg/l)	220000.00	220000.00	220000.00	220000.00

Note that phosphorous has a much greater affinity for soils, as indicated by the higher partition coefficient. It also has lower solubility and a lower uptake rate, so expect nitrogen to be exported more from the watershed. More information about contaminant parameters can be found on the GSSHA wiki.¹

10. Click **Done** to close the *GSSHA Map Table Editor* dialog.

4 Saving and Running

Before running GSSHA, the project should be saved by doing the following:

1. Select *GSSHA* | **Save Project File...** to bring up the *Save GSSHA Project File* dialog.
2. Select “GSSHA Project File (*.prj)” from the *Save as type* drop-down.
3. Enter “contaminant_run1.prj” as the *File name*.
4. Click **Save** to exit the *Save GSSHA Project File* dialog.

Now that the project has been saved, run GSSHA:

5. Select *GSSHA* | **Run GSSHA...** to bring up the *GSSHA Run Options* dialog.
6. Click **OK** to close the *GSSHA Run Options* dialog and bring up the *Model Wrapper* dialog.
7. When GSSHA finishes, turn on *Read solution on exit* and click **Close** to exit the *Model Wrapper* dialog.

The project should appear similar to Figure 3.

¹ See <https://www.gsshawiki.com/>

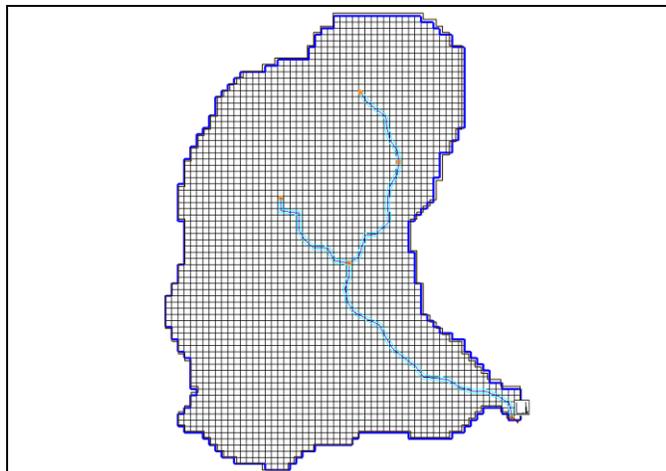


Figure 3 After first run

5 Viewing the First Run Results

GSSHA generates contaminant maps for both the channel and the overland flow for all the constituents being modeled.

5.1 Constituent Mass

First, view the constituent mass graph.

1. In the Project Explorer, right-click on “ Outlet Constituent Mass Graph” and select **View Graph...** to bring up the *Constituent Mass* dialog.
2. At the top of the dialog, alternately turn on and off *Nitrogen* and *Phosphorous*.
3. Turn on both *Nitrogen* and *Phosphorous*.

The plot should appear similar to Figure 4.

4. Click **OK** to close the *Constituent Mass* dialog.

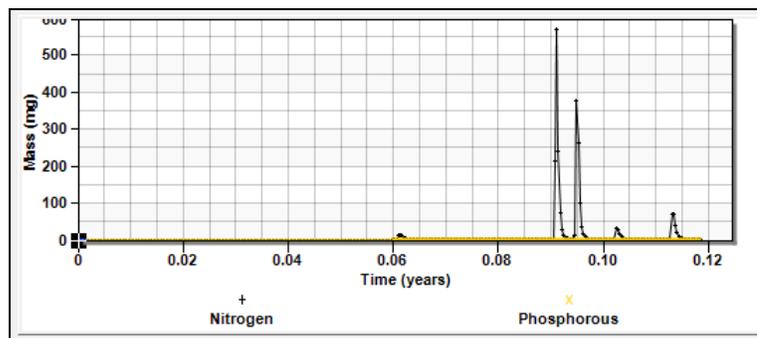


Figure 4 Constituent mass after the first run

5.2 Constituent Concentration

Next, view the constituent concentration in the same manner:

1. Right-click on “ Outlet Constituent Concentration Graph” and select **View Graph...** to bring up the *Constituent Concentration* dialog.
2. At the top of the dialog, alternately turn on and off *Nitrogen* and *Phosphorous* to see the difference between the two.
3. Click **OK** to close the *Constituent Concentration* dialog.

The plot should appear similar to Figure 5 when both are turned on.

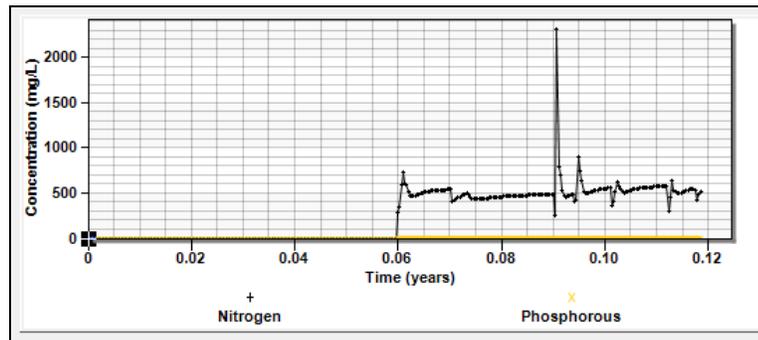


Figure 5 Constituent concentration after the first run

5.3 Adjusting Grid Contour Options

Now visualize the contaminant concentration and mass for both nitrogen and phosphorous by changing the grid contour options.

1. Select “ Nitrogen.chan (conc)” in the Project Explorer.
2. Click **Display Options** to bring up the *Display Options* dialog.
3. Select “2D Scatter Data” from the list on the left.
4. On the *Scatter Point* tab, turn on *Contours*.
5. Enter “8” as the *Radius* and “50.0” as the *Z magnification*.
6. Click **Options...** to bring up the *Nitrogen.chan (conc) Contour Options* dialog.
7. In the *Contour Method* section, select “Normal Linear” from the first drop-down.
8. Click **OK** to close the *Nitrogen.chan (conc) Contour Options* dialog.
9. Click **OK** to close the *Display Options* dialog.
10. Select various time steps from the Properties section on the right side of the Graphics Window.
11. Use the **Rotate**  and **Perspective View**  tools to view the project from various oblique angles.
12. Feel free to explore the time steps for “ Nitrogen.chan (mass)”, “ Phosphorous.chan (conc)”, and “ Phosphorous.chan (mass)”, as well.

Some of the time steps will show vertical bars showing the varying concentrations along the stream at that time, similar to Figure 6.

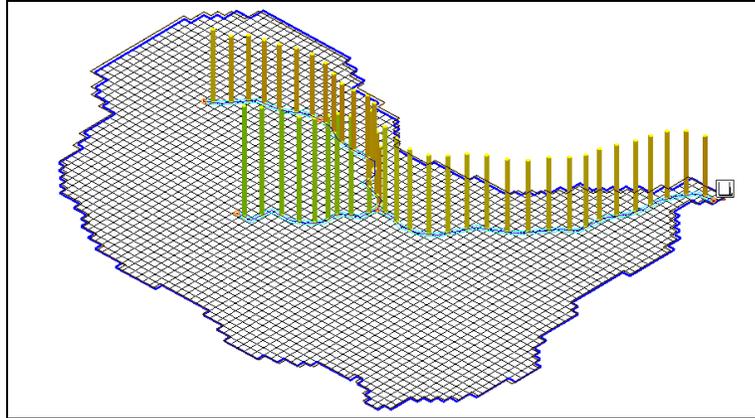


Figure 6 Rotated oblique view showing varying concentrations

6 Adding Sediment Transport

Now, turn on the soil erosion and sediment transport in the constituent transport model that was developed in the previous step and see how it affects the constituent transport.

To save some time, a GSSHA project is already created that has sediments turned on and the constituents defined. Modify this project and run it by doing the following:

1. Open WMS, or click **New**  to reset WMS to its defaults.
2. Switch to the  **2D Grid** module.
3. Select *GSSHA* | **Open Project File...** to bring up the *Open* dialog.
4. Select “ContaminantWSedBase.prj” and click **Open** to exit the *Open* dialog.
5. Turn off all coverages except “ GSSHA” in the Project Explorer.
6. Select *GSSHA* | **Save Project File...** to bring up the *Save GSSHA Project File* dialog.
7. Select “GSSHA Project File (*.prj)” from the *Save as type* drop-down.
8. Enter “ContamWSed.prj” as the *File name*.
9. Click **Save** to save the project under the new name and exit the *Save GSSHA Project File* dialog.

The project should appear similar to Figure 7.

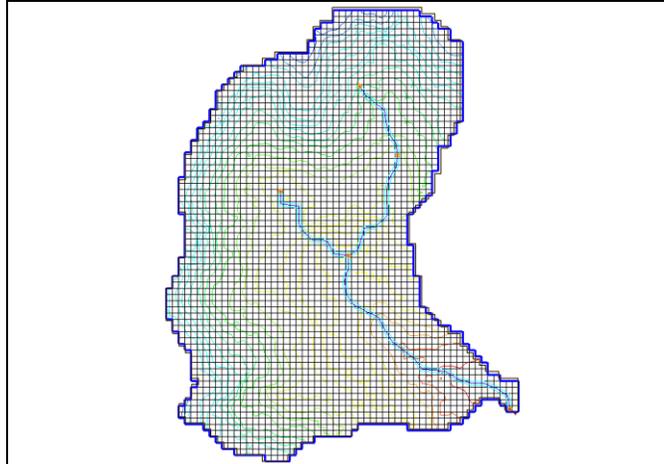


Figure 7 Initial appearance for the second project

6.1 Sediment Parameters

First, set up the sediment parameters.

1. Select *GSSHA | Job Control...* to bring up the *GSSHA Job Control Parameters* dialog.
2. In the list at the bottom right, turn on *Soil erosion* and click **Edit Parameter...** to bring up the *Overland soil erosion* dialog.
3. In the *Sediments* section, verify that the columns match the following table:

	Description	Sp. Grv.	Pt. Diam.	Sorb Affinity	Base Output Filename
1	Sand	2.650	0.25000		Sand
2	Silt	2.650	0.16000		Silt
3	Clay	2.650	0.00100		Clay

4. Click **OK** to close the *Overland soil erosion* dialog.

6.2 Contaminant Parameters

Next, edit the contaminant parameters.

1. Click **Edit parameter...** to the right of *Contaminant transport* to bring up the *GSSHA Contaminants* dialog.
2. Verify the contents of the spreadsheet match those in the table below:

	Description	Index Map	Precipitation Concentration	Partition	Base Output Filename
1	Nitrogen	lu_dairy	0.0	2.7	Nitrogen
2	Phosphorous	lu_dairy	0.0	18.0	Phosphorous

3. In the *Contaminant Transport Options* section, turn on *Run Soil Contaminant Transport* and *Run Sediment Contaminant Transport*.

4. Enter “0.1” as the *Mixing layer depth*.
5. Click **Done** to close the *GSSHA Contaminants* dialog.
6. Click **Output Control...** to bring up the *GSSHA Output Control* dialog.
7. In the *Other* section, turn on *Suppress screen printing* and *Output contaminants*.
8. Turn off the other two options in the *Other* section.
9. Click **OK** to close the *GSSHA Output Control* dialog.
10. Click **OK** to close *GSSHA Job Control Parameters* dialog.

6.3 Map Table Parameters

Now adjust the map table parameters.

1. Select *GSSHA | Map Tables...* to open the *GSSHA Map Table Editor* dialog.
2. On the *Contaminants* tab, and select “Nitrogen” from the *Contaminant* drop-down.
3. Make sure the parameters match those found in the first table in Section 3, above.
4. Select “Phosphorous” from the *Contaminant* drop-down.
5. Make sure the parameters match those found in the second table in Section 3, above.
6. On the *Soil Erosion* tab, review the parameters for each of the soil erosion IDs.
7. When done reviewing, click **Done** to close the *GSSHA Map Table Editor* dialog.

GSSHA can now be run with the sediment transport parameters.

7 Save and Run

Before running GSSHA, the project should be saved:

1. Select *GSSHA | Save Project File...* to bring up the *Save GSSHA Project File* dialog.
2. Select “GSSHA Project File (*.prj)” from the *Save as type* drop-down.
3. Enter “ContamWSed_run2.prj” as the *File name*.
4. Click **Save** to save the project under the new name and exit the *Save GSSHA Project File* dialog.
5. Select *GSSHA | Run GSSHA...* to bring up the *GSSHA Run Options* dialog.
6. Click **OK** to close the *GSSHA Run Options* dialog and bring up the *Model Wrapper* dialog.
7. When GSSHA finishes, turn on *Read solution on exit* and click **Close** to exit the *Model Wrapper* dialog.

8 View Results

Once done running, GSSHA generates contaminant concentration and mass maps for both the channel and the overland flow for all the constituents being modeled. They can be viewed by doing the following:

1. In the Project Explorer, right-click “ Outlet Constituent Mass Graph” and select **View Graph...** to bring up the *Constituent Mass* dialog.
2. In the *Display* column, turn on *Nitrogen*.

The plot should appear similar to Figure 8.

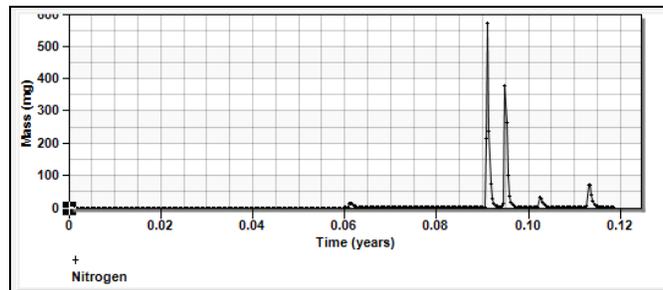


Figure 8 Constituent mass of nitrogen

3. Turn off *Nitrogen* and turn on *Phosphorous*.

The plot should appear similar to Figure 9.

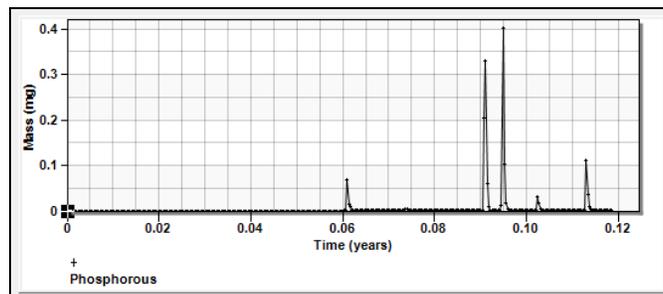


Figure 9 Constituent mass of phosphorous

4. Click **OK** to close the *Constituent Mass* dialog.
5. Right-click “ Outlet Constituent Concentration Graph” and select **View Graph...** to bring up the *Constituent Concentration* dialog.
6. In the *Display* column, turn on *Nitrogen*.

The plot should appear similar to Figure 10.

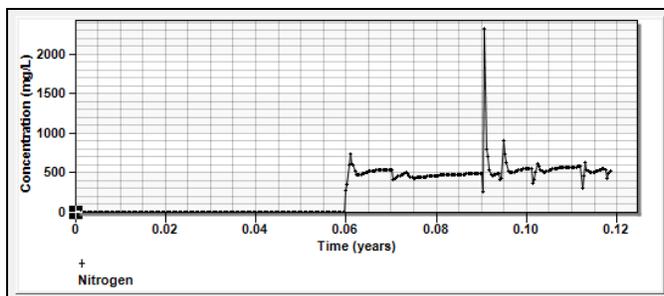


Figure 10 Constituent concentration of nitrogen

7. Turn off *Nitrogen* and turn on *Phosphorous*.

The plot should appear similar to Figure 11.

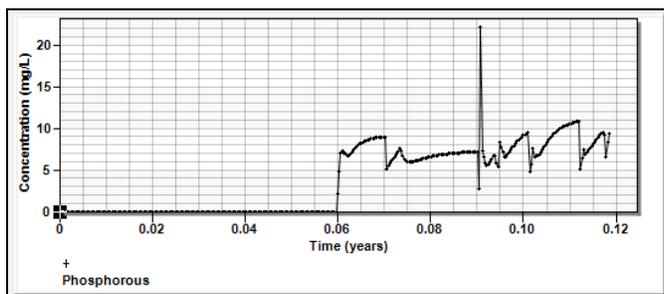


Figure 11 Constituent concentration of phosphorous

Notice that while still smaller than the nitrogen export, the phosphorous export is increased when coupled with sediment transport, while nitrogen is little affected. This is due to differences between the constituents' affinity for sediment particles.

8. Click **OK** to close the *Constituent Mass* dialog.
9. Right-click  "Outlet Sediment Graph" and select **View Graph...** to bring up the *Sedograph* dialog.

The dialog should appear similar to Figure 12.

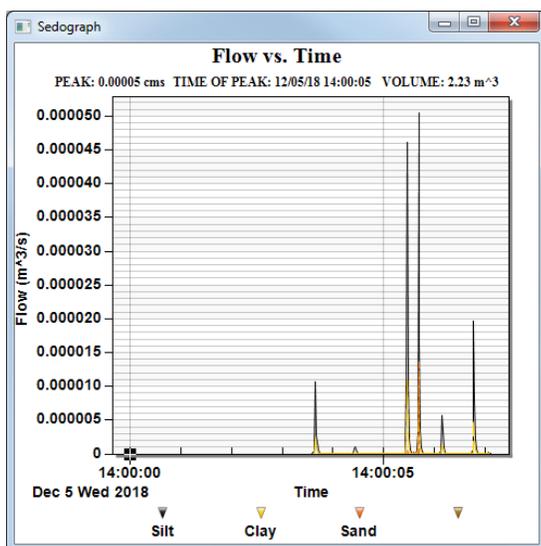


Figure 12 Sedograph dialog

10. Click  to close the *Sedograph* dialog.
11. Right-click  "Outlet Sediment TSS Graph" and select **View Graph...** to bring up the *Sediment TSS Graph* dialog.

The dialog should appear similar to Figure 13.

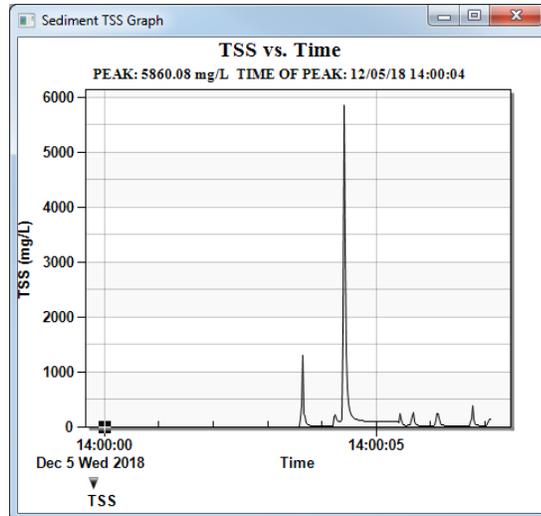


Figure 13 *Sediment TSS Graph* dialog

12. Click  to close the *Sediment TSS Graph* dialog.

9 Conclusion

This concludes the "Simulating Constituent Transport in GSSHA" tutorial. Feel free to continue to experiment, or close the program.