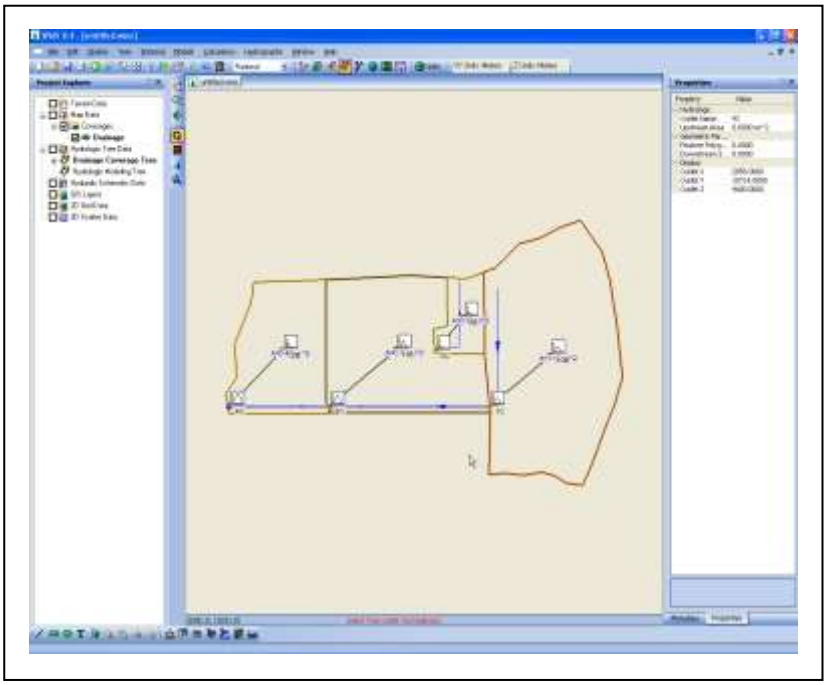
WMS

v. 10.0

WMS 10.0 Tutorial

Storm Drain Modeling – Storm Drain: Hydrographic Design

Learn how to run sub-basin hydrographs through a storm drain network



Objectives

Build a rational method model and compute sub-basin hydrographs. Digitize a small pipe network and define the pipe parameters. Run the rational method hydrographs through the storm drain model using the FHWA storm drain analysis engine.

Prerequisite Tutorials

- Watershed Modeling – Rational Method Interface
- Editing Elevations – Using TINs

Required Components

- Data
- Drainage
- Map
- Hydrology
- Hydrologic Models
- Storm Drain

Time

- 30-60 minutes

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1 Introduction

Storm Drain is a hydraulic analysis and design program for storm drain and sanitary sewer systems. It was developed by the Federal Highway Administration (FHWA) with the intent of providing hydraulic engineers a quick and accurate method of designing and analyzing storm drain, sanitary sewer, and combination systems. The Storm Drain interface in WMS uses the same HYDRA program to perform calculations that is currently part of the FHWA's HYDRAIN suite of hydraulic programs.

This exercise demonstrates how to use WMS to set up a Hydrographic Drainage simulation for use with Storm Drain. We will set up drainage areas and Runoff Coefficients for a subdivision, similar to the previous chapter, but users will also specify gutter locations in the Drainage coverage. As illustrated in this exercise, the pipe network does not need to flow parallel or in the same direction as the over-lying drainage. However, there are some limitations in the way the drainage coverage is constructed in order to run a hydrographic analysis with Storm Drain. The most important limitation is that each inflow hydrograph needs to be associated with one and only one gutter at the storm drain inlet. In other words "extra" stream arcs that are not part of the gutter leading into the inlet should be deleted.

In this analysis, users will generate input hydrographs using the Rational Method calculator, but it should be emphasized that any hydrologic method that produces a hydrograph can be used, or hydrographs may be entered manually.

2 Objectives

In this exercise, users will set up a hydrographic storm drain simulation for a hypothetical subdivision. The objective of this exercise is to teach users the basic steps for defining a Storm Drain input file for hydrographic analysis. These steps include the following:

1. Build the drainage basins and make adjustments for limitations in doing a hydrographic analysis
2. Perform a simple Rational Method analysis to generate input hydrographs
3. Digitize a small pipe network based on the surface drainage
4. Define the necessary parameters for the pipe network
5. Run Storm Drain (HYDRA)
6. View the solution

3 Developing the Surface Drainage Coverage

We will begin with a drainage coverage created with techniques typical to those described in earlier chapters. In order to prepare the drainage coverage for storm drain analysis users will eliminate all of the stream arcs, except those that lead into a given outlet (a storm drain inlet in this case). Having extra branching streams prevents WMS from building the storm drain input file correctly. users must decide which arc represents the primary stream (in this case a gutter) into an inlet and delete the others.

1. Open WMS. If WMS is already open, select *File* | **New** then click **No** when asked to save changes.
2. Switch to the **Map** module.
3. Select *File* | **Open** to access the *Open* dialog.
4. Locate the "stormhydro" folder in the files for this tutorial. If needed, download the tutorial files from www.aquaveo.com.
5. Open "sdstart.map".

3.1 Eliminating Unnecessary Stream Arcs and Nodes

Figure 1 shows the drainage coverage with the extra streams highlighted (arrows provide additional clarification). In order to prepare the drainage coverage correctly users will need to delete these stream arcs.

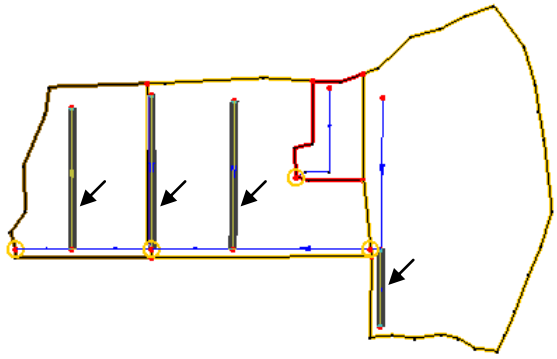


Figure 1 Initial drainage coverage with unnecessary stream arcs shown

1. Select the **Select Feature Arc** tool.

2. While holding down the *SHIFT* key (for multi-selection) select the four arcs highlighted in Figure 1.
3. Select the **Delete** macro (or *Edit* | **Delete** or the *DELETE* key) to remove the arcs.
4. Select **OK** if prompted.

Users must now delete the extra nodes that were at the intersection of the arcs just deleted and the remaining arcs so that there is just a single arc entering the storm drain inlet points.

5. Select the **Select Feature Point/Node** tool.
6. If it is difficult to see the nodes, select *Display* | **Display Options** to open the *Display Options* dialog.
7. On the *Map* tab, click on the red dot which is the symbol for *Points/Nodes*.
8. A *Point Properties* dialog will appear. Change the *Radius* to "4".
9. Click **OK** to close the *Point Properties* dialog.
10. Click **OK** to close the *Display Options* dialog.
11. While holding down the *SHIFT* key, select the three nodes identified by arrows in Figure 2 (be sure to select the point to the right of the outlet at the far right and not the point that is the outlet).

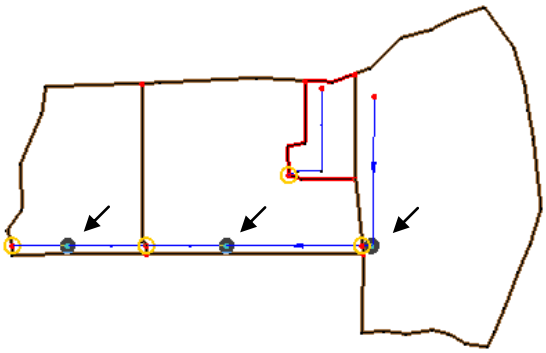


Figure 2 Nodes that need to be converted to vertices

12. Select *Feature Objects* | **Vertex ↔ Node**.
13. Select the **Frame** macro to center the image.

3.2 Initializing Storm Drain Simulation

In order to assign the remaining stream arcs to be gutters and the outlet points as storm drain inlets users must initialize a storm drain analysis.

1. Select "Storm Drain-FHWA" from the *Models* drop-down list at the top of the screen.
2. Select *Storm Drain-FHWA* | **New Simulation**.

3.3 Assigning Stream Arcs as Gutters

1. Select the **Select Feature Arc** tool.
2. While holding down the *SHIFT* key, select all four stream arcs as indicated in Figure 3.

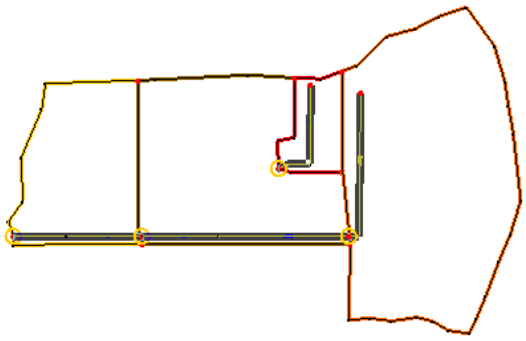


Figure 3 Arcs to be selected

3. Select *Feature Objects* | **Attributes**.
4. Select "Gutter" for the *Type* in the *Feature Arc Type* dialog.
5. Choose the **Atts** button to define the properties of the gutters.
6. The *Storm Drain Gutter* dialog will appear. Set the *Type* to "Uniform Gutter" (this should be the default) and set the *Manning's n* to "0.015", the Roadway *Cross-slope* to "0.02", and the *Width* to "2.0".
7. Select **OK** to close the *Storm Drain Gutter* dialog.
8. Select **OK** to close the *Feature Arc Type* dialog.

3.4 Assigning Outlets as Storm Drain Inlets

For this analysis, two of the outlets will be defined in areas of depression (sump conditions) while the other two will have bypass flow (on grade conditions).

1. Select the **Select Feature Point/Node** tool.
2. While holding down the *SHIFT* key select both of the outlet points of the entire basin system, and the outlet of the isolated interior basin as indicated in Figure 4

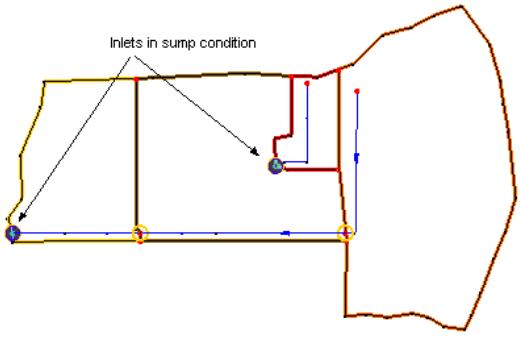


Figure 4 Outlet points to be selected

3. Select *Feature Objects* | **Attributes**.
4. In the *Drainage Feature Point Type* dialog, select "Storm drain inlet".
5. Choose the **Properties** button. The *Storm Drain Inlet Properties* dialog will open.
6. Set the *Type* to be "Grate in sump condition", the *Subtype* to be "Reticuline", the *Width* to be "2.0", the *Length* to be "6.0", the *Inlet Perimeter* to be "16.0", and the *Area* to be "8.5".
7. Select **OK**.
8. Select **OK**.
9. Select one of the other two remaining outlets (this will ensure that the two selected outlets become unselected).
10. Now while holding down the *SHIFT* key select the remaining outlet (the one that has not yet been selected).
11. Select *Feature Objects* | **Attributes**.
12. In the *Drainage Feature Point Type* dialog, select "Storm drain inlet".
13. Choose the **Properties** button. The *Storm Drain Inlet Properties* dialog will open.
14. Set the *Type* to be "Grate on grade", the *Subtype* to be "Reticuline", the *Width* to be "2.0", and the *Length* to be "6.0".
15. Select **OK** to close the *Storm Drain Inlet Properties* dialog.
16. Select **OK** to close the *Drainage Feature Point Type* dialog.
17. Select *Feature Objects* | **Compute Basin Data**.
18. In the *Units* dialog, select **OK**.

4 Running a Rational Analysis

Users will perform a simple Rational analysis of this subdivision and use the Rational method hydrographs as input for the hydrographic storm drain analysis. Users should remember, though, that any of the hydrologic analysis models in WMS can be used, or input hydrographs may be entered manually.

1. Select the **Hydrologic Modeling** module.
2. Change the *Model* drop-down box located at the top of the WMS interface to "Rational".

4.1 Defining Rational Method Basin Parameters

1. Double-click on one of the basin icons using the **Select Basin** tool and define the basin parameters in the *Rational Method* dialog according to Figure 4-1 and Table 1. Select another basin and define its parameters until all basin data is defined. For more details on defining a Rational Simulation see the chapter on Rational method analysis (Volume 2, Chapter 5).

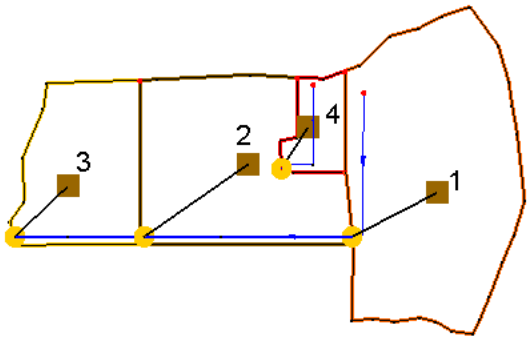


Figure 4-1: Basin locations.

Table 1 Rational Method basin parameters

Basin	C	I (in/hr)	Tc (min)
1	0.10	2.4	22
2	0.15	2.7	18
3	0.15	3.1	12
4	0.20	3.8	07

2. Select **OK** in the *Rational Method* dialog.

4.2 Defining Rational Method Routing Parameters

1. Define the intensity and routing time for the four confluence points connected to the basins according to Table 2. As with basins, reach data are entered by double-clicking on the yellow outlet icons using the **Select Outlet** tool.

Table 2 Rational Method routing parameters

Outlet	Routing Lag (min)	I (in/hr)
1	5	2.4
2	4	1.9
3	0	1.7
4	0	3.8

2. Select **OK** in the *Rational Method* dialog.

4.3 Computing Hydrographs

1. Double-click on the outlet for the isolated interior basin (the outlet of basin 4 in Figure 4-1
2. Choose the **Compute Hydrographs** button at the bottom of the *Outlet* column in the *Rational Method* dialog.
3. Select **Done** (use the default settings in the *Rational Method Hydrograph* dialog).
4. Select **OK**.
5. Double-click on the outlet for the entire watershed (the outlet of basin 3 in Figure 4-1)
6. Choose the **Compute Hydrographs** button at the bottom of the *Outlet* column in the *Rational Method* dialog.

7. Select **Done** (use the default settings in the *Rational Method Hydrograph* dialog).
8. Select **OK**.

At this point, users should have hydrographs defined for the drainage coverage. These hydrographs will be used as input to the storm drain problem.

5 Creating the Pipe Network

Users will now create a storm drain pipe network that connects the isolated interior basin to the others and exits west of the watershed outlet. Users will do this by creating a Storm Drain coverage and then digitizing the storm drain pipes using the **Create Feature Arc** tool.

5.1 Digitizing Storm Drain Pipes

1. Right-click on the "Coverages" folder in the Project Explorer.
2. Select **New Coverage**.
3. Change the *Coverage type* to "Storm Drain-FHWA" in the *Properties* dialog.
4. Select **OK**.
5. Select the **Create Feature Arc** tool.

6. Beginning at a point just to the left (west) of the outlet of the watershed (basin 3) begin a pipe network segment and end it by double-clicking on top of the outlet of basin 3.
7. Now complete the storm drain network by creating the pipe segments from downstream to upstream between basin 3 and basin 2, basin 2 and basin 1, and a connection from the pipe between basin 2 and basin 1 to the outlet of basin 4. Be sure that feature nodes (segment endings) are created by double-clicking to end the arc to correspond with the storm drain inlets of the drainage coverage. Your storm drain coverage should look similar to Figure 2.

Figure 2 View of the Storm Drain Coverage

5.2 Entering Storm Drain Parameters

1. Select *Storm Drain-FHWA* | **Job Control**. The *FHWA Storm Drain Job Control Information* dialog will appear.

2. Set the *Title* to "Hydrographic Storm Drain Analysis".
3. Set the *Criteria Switch* to "3 - Storm (Hydrographic) only".
4. Set the *Timestep* to "2".
5. Set the *Units* to "English".
6. Choose the **Pipe Data Properties** button.
7. Set the values in the *Pipe Data Properties* dialog according to Figure 3.

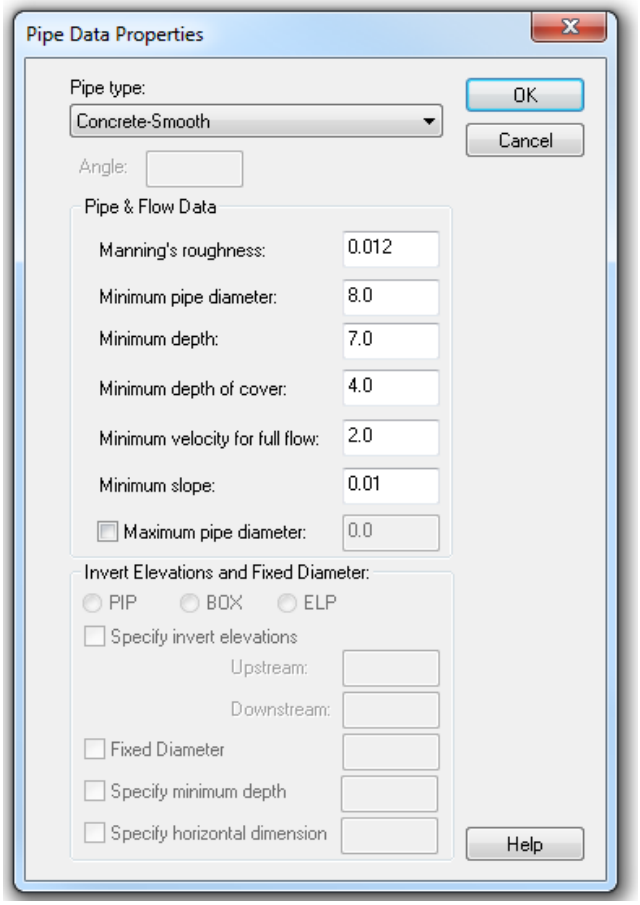
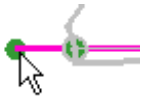


Figure 3 Pipe properties

8. Select **OK**.
9. Select **OK**.

5.3 Defining the Outfall and Manhole Locations



1. Choose the **Select Feature Point/Node** tool.
2. Double-click on the node to the left of the drainage basin to open the *Storm Drain Node Attributes* dialog.
3. Set the *Node Type* as "Outfall".
4. Select **OK**.

5. Use the *SHIFT* key to select the four nodes of the storm drain coverage that correspond to the four storm drain inlets (manholes) of the drainage coverage as shown in Figure 4.
6. Select *Feature Objects* | **Attributes** to open the *Storm Drain Node Attributes* dialog.
7. Set the *Node Type* as "Access Hole".
8. Set the *width* to be "4.0".
9. Select **OK** to close the *Storm Drain Node Attributes* dialog.

A user could define each manhole separately by double-clicking on the node and setting the node type and manhole width, but it is more efficient to define them all at once. At this point users should have one outfall node, four manhole nodes, and a single pipe junction in the storm drain coverage as identified in Figure 4. If this is not the way the storm drain coverage is set up, then correct it now by double-clicking the nodes and setting the correct values.

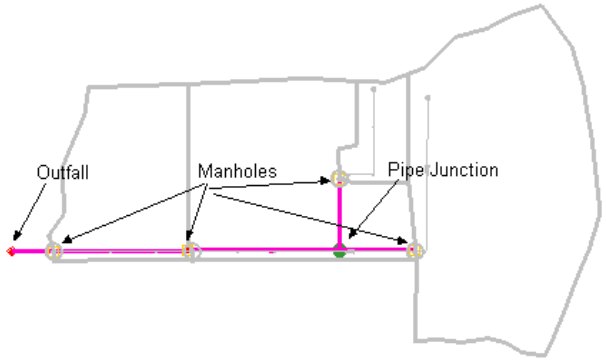


Figure 4 Correct setup of the Storm Drain Coverage

5.4 Linking Nodes

To properly portray the relationship between the drainage coverage and the storm drain coverage, users need to explicitly define links between corresponding nodes.

1. Select *Storm Drain-FHWA* | **Link Nodes**.
2. Change the Tolerance to "25" in the Link Storm Drain and Drainage Nodes dialog.
3. Click the **Auto Link** button. This should link the four storm drain inlet nodes of the drainage coverage to the four manholes of the storm drain coverage.
4. If not, increase the tolerance by an increment of 5 and select the **Auto Link** button until the four node pairs are linked.
5. When done, click **OK** to close the *Link Storm Drain and Drainage Nodes* dialog.

5.5 Assigning Elevations and Mapping Hydrographs

We also need to assign elevations to all the nodes in the "Storm Drain" and "Drainage" coverages. Elevations can either be defined manually, or with the use of a background TIN or DEM. In this exercise, users will manually define them.

1. Toggle the display of the "Drainage" coverage off in the Project Explorer.
2. Choose the **Select Feature Point/Node** tool.
3. Set the elevations of the nodes in the Storm Drain coverage according to the values given in Figure 5. To set an elevation, select the node and change the elevation in the *Feature Point Z* edit field in the *Properties* window on the right of the WMS interface and press **Enter**.

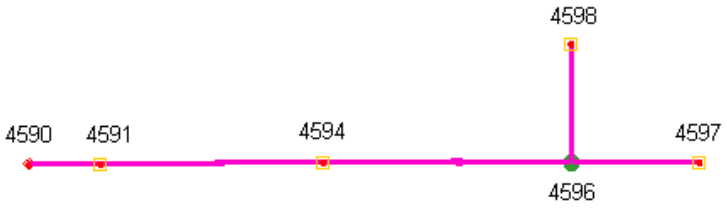


Figure 5 Node elevations for storm drain pipes

4. Toggle the "Drainage" coverage on and the "Storm Drain-FHWA" coverage off in the Project Explorer.
5. Select the "Drainage" coverage in the Project Explorer so that it is the active coverage.
6. Select and set the elevations of all the nodes connected to the gutter arcs according to Figure 6.

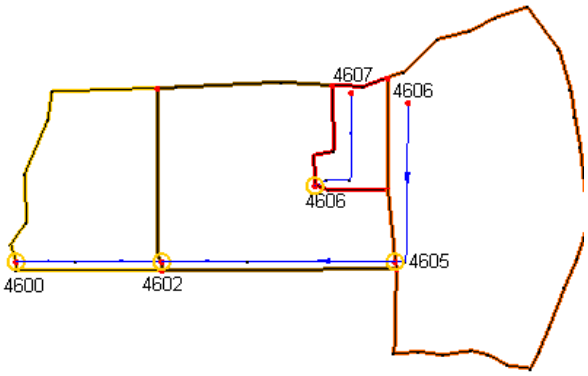


Figure 6 Node elevations for gutters

7. Set "Storm Drain-FHWA" as the active coverage in the Project Explorer.
8. Select *Storm Drain-FHWA* | **Map Hydrographs**.

With Drainage and Storm Drain nodes linked, and elevations assigned to the pipes and gutters, users are ready to save and run the Storm Drain model.

6 Saving the Simulation and Running Storm Drain

1. Select *File* | **Save As** to open the *Save As* dialog.
2. Make sure the *Save as type* filter is set to "WMS XMDF Project Files (*.wms)".
3. Enter "wms_storm_hyd" as the *File name*.
4. Select **Save**.
5. Select *Storm Drain-FHWA* | **Save Simulation**.
6. In the *Save File* dialog, save the file as "wms_st_h".
7. Select *Storm Drain-FHWA* | **Run Simulation**.
8. In the *Run Storm Drain* dialog, set the *input file name* to "wms_st_h.hda" and the *output file name* to "wms_st_h.lst".

The input and output file name prefixes can be up to 8 characters in length. If users enter a name longer than 8 characters, it is truncated to 8 characters when Storm Drain writes the file. Further, no directory in the path to the files can be longer than 8 characters.

9. Select **OK**. The *Model Wrapper* window will open and Storm Drain will run automatically.
10. Once Storm Drain (HYDRA) has finished running, select **Close**.
11. Select **OK**.
12. Select *File* | **Edit File**.
13. Open "wms_st_h.lst" from the *Open* dialog.
14. Select **OK** to open the file with Notepad.

By browsing through this file, users will see all of the parameters calculated by the Storm Drain model, such as recommended pipe diameters, pipe invert elevations, flows, velocities, and hydraulic grade line computations.

15. Close Notepad.

7 Conclusion

In this exercise, users have experimented with the Storm Drain function of WMS. In particular, users should have learned to set up a hydrographic storm drain simulation for a hypothetical subdivision. Users should now be comfortable with the basic steps for defining a Storm Drain input file for hydrographic analysis. These steps include the following:

1. Build the drainage basins and make adjustments for limitations in doing a hydrographic analysis
2. Perform a simple Rational Method analysis to generate input hydrographs
3. Digitize a small pipe network based on the surface drainage
4. Define the necessary parameters for the pipe network
5. Run Storm Drain (HYDRA)

6. View the solution

