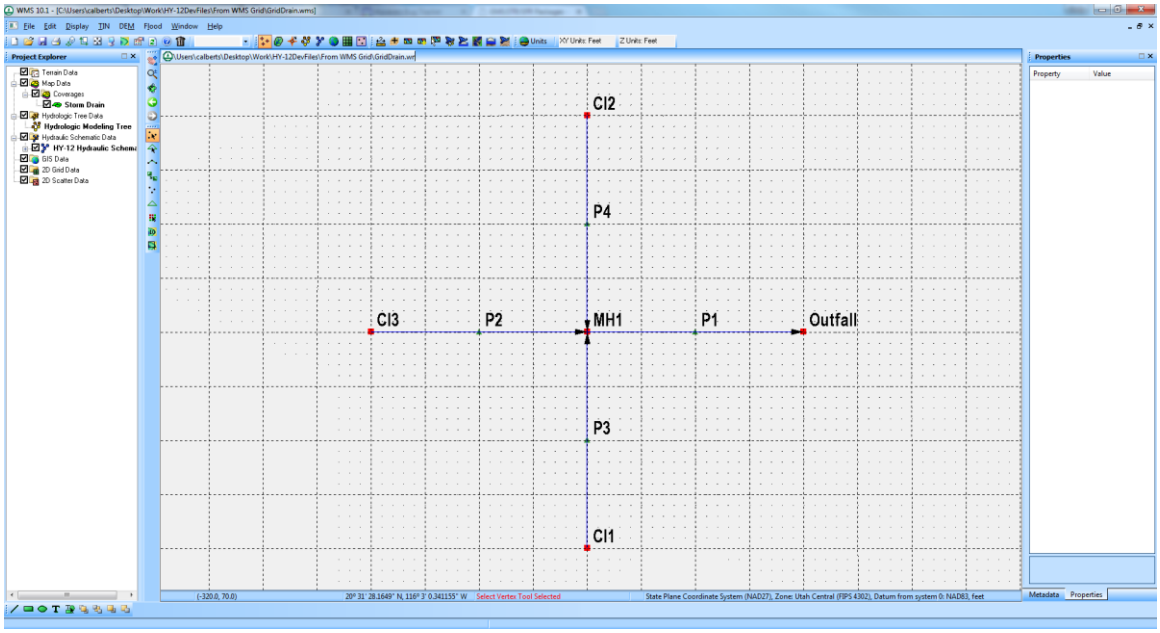
WMS

v. 10.1

WMS 10.1 Tutorial

Storm Drain Modeling – Simple HY-12 Analysis with the Drawing Grid

Setup a simple HY-12 storm drain model in the WMS interface using the WMS drawing grid and inlet and pipe information



Objectives

Learn to define a storm drain network and its associated data using the WMS drawing grid. Learn to assign known access hole and pipe elevations and other storm drain information to the HY-12 model in WMS. Then run the HY-12 model and view the results. Use WMS to convert the HY-12 model into an EPA-SWMM model. Then run EPA-SWMM and compare the results with HY-12.

Prerequisite Tutorials

- Introduction – Basic Feature Objects
- Editing Elevations – DEM Basics

Required Components

- Data
- Map
- Hydrology
- Storm Drain

Time

- 20–30 minutes

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1 Introduction

The US Federal Highway Administration's HY-12 is a DOS-based storm drain analysis program that can be used for designing inlets, pipes, and the general layout of a storm drain network. An HY-12 model can be generated by drawing the proposed pipe and inlet locations in a storm drain coverage. The map module locations are then converted to a 1D schematic where the HY-12 model parameters are defined.

Many of the HY-12 computations, such as channel calculations, curb and gutter calculations, and rational method computations, are based on computations in FHWA's Hydraulic Toolbox software.[1] Refer to the documentation in both the Hydraulic Toolbox and in HY-12 installations to learn about the specific computation methods used in HY-12. Many of the computations used in the HY-12 model are described in FHWA's *Urban Drainage Design Manual, Hydraulic Engineering Circular No. 22* (HEC-22).[2]

This tutorial shows how to create a model of a basic storm drain network using the WMS drawing grid. The storm drain network consists of four pipes, 3 inlets and an access hole. It flows from the 3 inlets toward a central access hole and then down to the outfall on the right side of the pipe network.

It demonstrates how to draw a basic schematic of a hypothetical storm drain network using the drawing grid as a guide and how to assign pipe invert, access hole, ground, and inlet elevations to the model. It demonstrates how to use the WMS HY-12 interface with the drawing grid to create and compute the results from a storm drain network model. It then converts the model into an EPA-SWMM model to compare the modeling results

Before attempting this tutorial, it is recommended to complete the "Introduction – Basic Feature Objects" and "Editing Elevations – DEM Basics" tutorials.

[1] See https://www.fhwa.dot.gov/engineering/hydraulics/software/toolbox404.cfm.

[2] See https://www.fhwa.dot.gov/engineering/hydraulics/pubs/10009/10009.pdf.

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2 Getting Started

Starting WMS new at the beginning of each tutorial is recommended. This resets the data, display options, and other WMS settings to their defaults. To do this:

1. If necessary, launch WMS.
2. If WMS is already running, press *Ctrl-N* or select *File* | **New…** to ensure that the program settings are restored to their default state.
3. A dialog may appear asking to save changes. Click **No** to clear all data.

The graphics window of WMS should refresh to show an empty space.

3 Draw Storm Drain Schematic

3.1 Set up the WMS Drawing Grid

First, turn on the grid:

1. Select *Display* | **Display Options…** to bring up the *Display Options* dialog.
2. Select "Drawing Grid" from the list on the left.
3. On the *Grid Options* tab, turn on *Snap to grid*, *Display grid lines*, and *Display grid points*.
4. Under *Display grid lines*, enter "5" as the *Line spacing grid increment*.
5. Under *Display grid points*, enter "1" as the *Point spacing grid increment*.
6. Click **OK** to close the *Display Options* dialog.

The WMS drawing grid should now be displayed (Figure 1) with points and lines that will be used for the layout of the storm drain network. The points may be difficult to see.

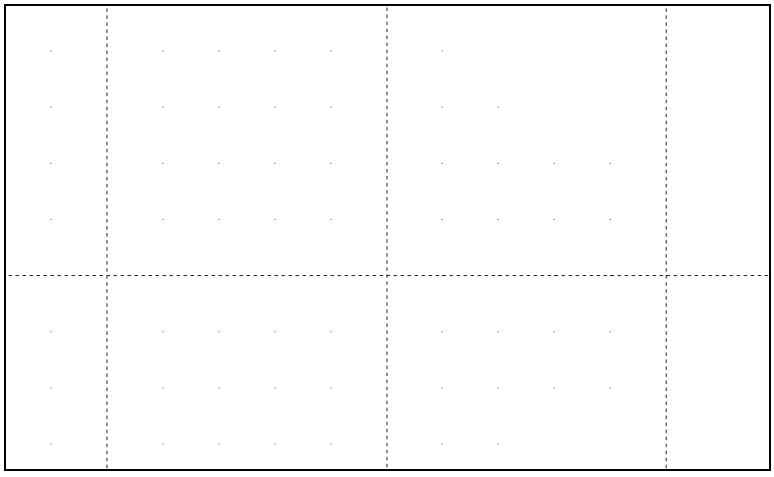

Figure 1 WMS drawing grid with lines and points

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3.2 Define Storm Drain Network

In this section, draw the storm drain network using the drawing grid and convert it to a hydraulic schematic that can be used to define HY-12 link and node data.

1. Right-click "Drainage" in the Project Explorer and select *Type* | **Storm Drain**.

For the next step, notice that the cursor coordinates field (-200.0, 0.0) —at the lower left corner of the WMS display window—shows the location of the mouse cursor on the grid.

2. Using the **Create Feature Point** tool, create a point at each of the following five coordinates on the grid:
   - -200.0,0.0
   - 0.0, 200.0
   - 200.0, 0.0
   - 0.0, -200.0
   - 0.0, 0.0

Once created, the five points should appear similar to Figure 2.

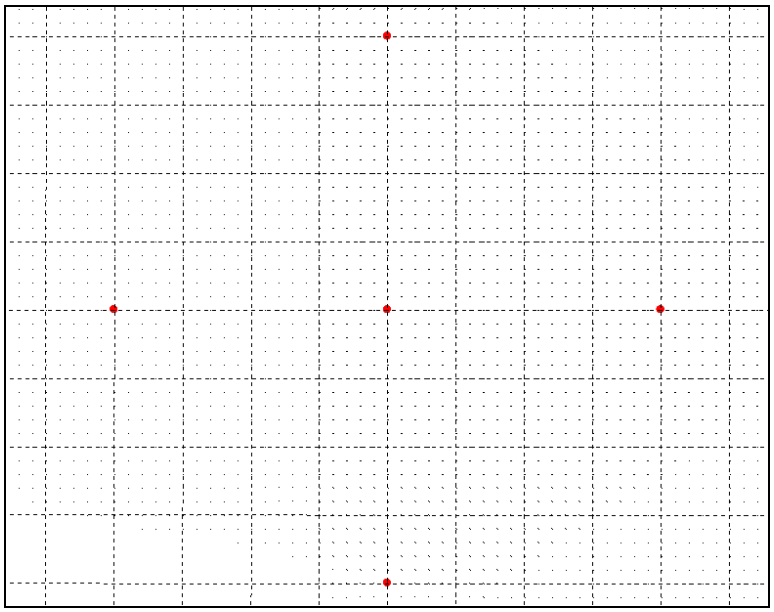

Figure 2 Five points

The point on the right will be the outfall, and the flow from the other points will go through the center point before moving on to the outfall.

3. Using the **Create Feature Arc** tool, create arcs from upstream to downstream, flowing from the left, top, and bottom points to the center point, then from the center point to the right point (Figure 3).
4. Click **Display Options** to bring up the *Display Options* dialog.
5. Select "Map Data" from the list on the left.

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6. On the *Map* tab, turn on *Link Arrows* and click **OK** to close the *Display Options* dialog.

The arrows should appear as in Figure 3, indicating flow direction. Remember the rules of creating feature objects: Do not cross any arcs and make sure to click close enough the points in the model so the arcs snap to them.

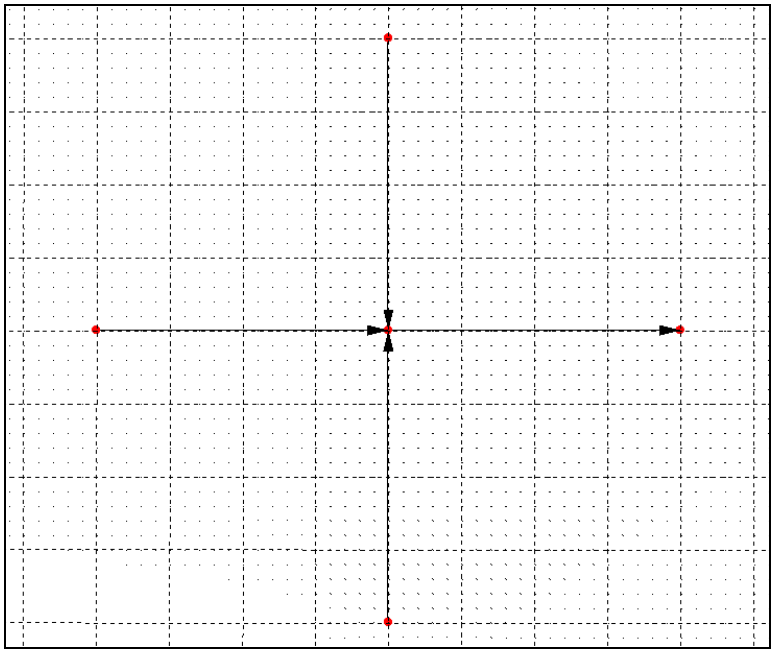

Figure 3 Pipe layout and flow direction

If the pipes were drawn correctly, the arrows will point in a direction flowing toward the outfall. If the flow direction needs to be corrected, do the following (otherwise, skip to step 8):

7. Using the **Select Feature Point/Node** tool, right-click on the outfall node and choose **Reorder Streams**.

This command changes all of the pipe directions so that they flow toward the outfall.

8. Select *Storm Drain* | **Map → 1D Schematic** to bring up the *Select Model* dialog.
9. Select "HY-12" from the wide drop-down and click **OK** to close the *Select Model* dialog.

The hydraulic schematic has now been created, and all the nodes and links have been labeled (Figure 4).

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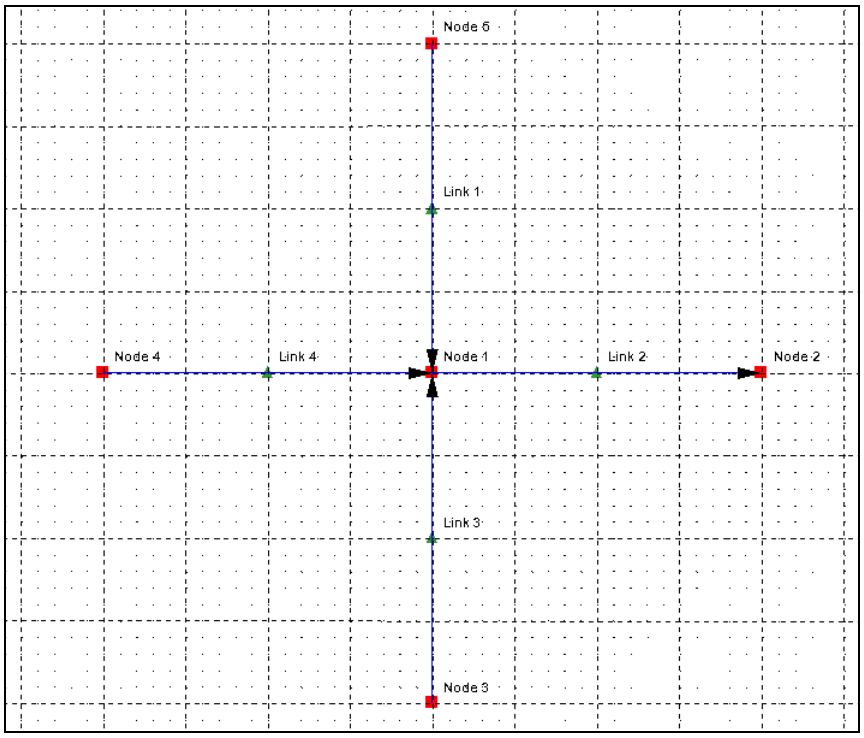

Figure 4 1D hydraulic schematic created

4 Define HY-12 Structure Information

After creating the schematic, it is important to define structure information for the HY-12 model. A structure represents a hydraulic or hydrologic computation object that requires input and provides output. Some of the output, such as a discharge flow or a hydrograph from a rational method computation, may be used in a structure located downstream in the model.

One or more structures are defined at each link or node. Structures that *cannot* be represented by a line, such as an access hole, an inlet, or a rational method sub-basin, are defined at nodes:

- Access Hole
- Gutter Inlet
- Junction
- Minor Loss
- Outfall
- Rational Method Basin
- Reservoir
- Transition

Structures that *can* be represented by a line, such as a pipe or a gutter, are defined at links:

- Channel
- Gutter
- Pipe
- Pipe Storage

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Some structures only have interfaces in the advanced HY-12 interface and must be defined there rather than in the simplified interface. For more information about each of these structures, their computations, and their file formats, refer to the FHWA HY-12[3] and Hydraulic Toolbox documentation.[4] In this section, enter inlet, access hole, pipe, and outfall names as well as the hydraulic input parameters for these structures.

4.1 Define Names

Custom names can be assigned to each link and node in the network giving them a reference to actual ID names in existing or proposed networks.

1. Select "HY-12 Hydraulic Schematic" in the Project Explorer to switch to the **Hydraulic Modeling** module.
2. Using the **Select Hydraulic Node** tool, double-click on any one of the nodes to open the *HY-12 Properties* dialog.
3. Select "All" from the *Show* drop-down.
4. Using the table below, rename the nodes. Notice that the CI names are not in numerical order.

Original Name	New Name
Node 1	MH1
Node 2	Outfall
Node 3	CI1
Node 4	CI3
Node 5	CI2

Feel free to resize and position the *HY-12 Properties* dialog to better see the original node names.

5. Select "Links" from the *Attribute Type* drop-down.
6. Using the table below, rename the links:

Original Name	New Name
Link 1	P4
Link 2	P1
Link 3	P3
Link 4	P2

[3] See http://wmsdocs.aquaveo.com/HY-12_User_Manual.pdf.

[4] See https://www.fhwa.dot.gov/engineering/hydraulics/software/toolbox404.cfm.

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7. When finished, click **OK** to close the *HY-12 Properties* dialog.

The node and link labels in the WMS display window should now be updated (Figure 5). All nodes labeled "CI" are inlets and the single node beginning with "MH" is an access hole. Compare the link and node labels with Figure 5 to make sure they have been assigned correctly.

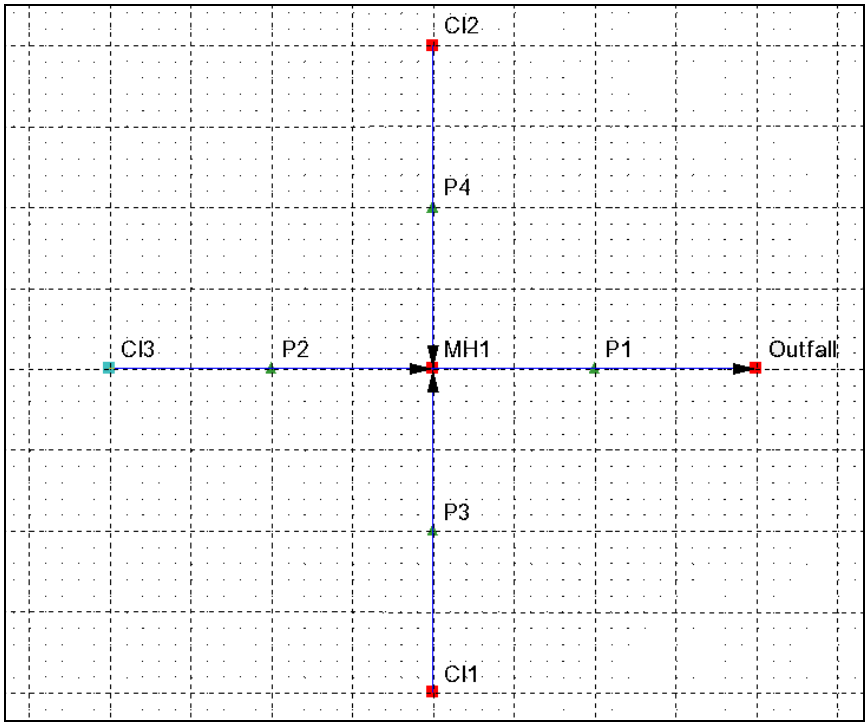

Figure 5 Nodes and links renamed

4.2 Define Pipes

Pipe properties are stored within the links and edited from within the *HY-12 Properties* dialog.

1. Using the **Select Hydraulic Link** tool, double-click on any of the pipes (links) to bring up the *HY-12 Properties* dialog.
2. Select "All" from the *Show* drop-down.
3. On the *ALL* row, select "<NONE>" from the drop-down in the *Shape* column.

The default pipe shape in HY-12 is a circular pipe, so all of the links will be assigned this default shape.

4. On the *ALL* row, select "Pipe" from the drop-down in the *Structure Type* column.
5. Enter "4.0" in the *Diameter/Span (ft/m)* column for all four links.
6. On the *ALL* row, enter "0.013" in the *Pipe Manning's n* column.
7. On the *ALL* row, enter "0.33333" in the *Wall Thickness (ft/m)* column.

Do not close the *HY-12 Properties* dialog as the next section will continue to use it.

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4.3 Define Inlets and Access Holes

Inlets, access holes, outfalls and other node types are also assigned in the *HY-12 Properties* window.

1. Select "Nodes" from the *Attribute type* drop-down at the top of the *HY-12 Properties* dialog.
2. Check the box on the *MH1* row in the *Define Access Hole* column.
3. Enter "4.0" on the *MH1* row in the *Diameter/Width (ft/m)* column.
4. On rows *CI1*, *CI2*, and *CI3*, check the boxes in the *Define Inlet* and *Assume Full Capture* columns.
5. On the *Outfall* row, check the box in the *Define Outfall* column.

For the purposes of this tutorial, the other parameters should be left at the default value.

6. Click **OK** to close the *HY-12 Properties* dialog.
7. Select *File* | **Save** to bring up the *Save As* dialog.
8. Select "WMS XMDF Project File (*.wms)" from the *Save as type* drop-down.
9. Enter "mapgrid.wms" as the *File name* and click **Save** to close the *Save As* dialog.
10. Select *HY-12* | **Assign Lengths and Orientations**.
11. Click **OK** when advised which links were assigned length.
12. Click **OK** when advised which links were assigned orientation.
13. Using the **Select Hydraulic Link** tool, double-click on any of the links to bring up the *HY-12 Properties* dialog.
14. Select "All" from the *Show* drop-down.
15. Notice that all of the links have a value in the *Length (ft/m)* column.
16. Click **OK** to close the *HY-12 Properties* dialog.

4.4 Assign Node Invert and Surface Elevations and Flows

Values defining the surface and invert elevations will need to be assigned to each node.

1. Using the **Select Hydraulic Node** tool, double-click on any one of the nodes to open the *HY-12 Properties* dialog.
2. Select "All" from the *Show* drop-down.
3. Use the following table to enter elevations in the indicated columns:

	Column name			
Name	Surface Elevation (ft/m)	Inlet Invert Elevation (ft/m)	Access Hole Invert Elevation (ft/m)	Outfall Elevation (ft/m)
MH1	4015.5		4008.8	
Outfall	4015.0			4007.0
CI1	4017.0	4010.0		
CI2	4017.0	4010.0		
CI3	4017.0	4010.0		

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4. Use the following table to enter inflows for each of the inlets. Access holes are assumed to not have any inflows.

Inlet Location	Inflow (cfs/cms)
CI1	7.0
CI2	12.0
CI3	14.0

4.5 Assign Pipe Invert Elevations

Pipe links are also assigned an upstream and downstream invert elevation.

1. Select "Links" from the *Attribute type* drop-down.
2. Use the following table to enter upstream and downstream pipe invert elevations:

Link Name	Upstream Invert Elevation (ft/m)	Downstream Invert Elevation (ft/m)
P1	4008.8	4007.0
P2	4010.0	4008.8
P3	4010.0	4008.8
P4	4010.0	4008.8

3. Click **OK** to close the *HY-12 Properties* dialog

5 Define HY-12 Project Parameters

Project parameters are global parameters that are used in the entire project.

1. Select "  HY-12 Hydraulic Schematic" in the Project Explorer.
2. Select *HY-12* | **Edit Project Parameters…** to bring up the *HY-12 Properties* dialog.
3. In the *Project* section, enter "Grid_Network" as the *Project Name*.
4. Enter "Inlet_Inflow" as the *Project Notes*.
5. Enter your name as the *Project Designer*.
6. In the *Project Run Parameters* section, select "English Units" from the *HY12 Unit System* drop-down.
7. In the *Units* column on the *Material Database* row, click **Select File…** to bring up the *Select an HY-12 Material Database File* dialog.
8. Select "txt file (*.txt)" from the *Files of type* drop-down.
9. Select "materialDB.txt" and click **Open** to exit the *Select an HY-12 Material Database File* dialog.
10. Select "Report Errors, Warnings, and Notices" from the *Error Reporting* drop-down.
11. Select "Specify length, angle, and elevations, compute Slope" from the *HY12 Calculate Geometry* drop-down.

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12. In the *Design or Analysis Parameters* section, select "Analyze" from the *Analyze or Design?* drop-down.
13. Enter "1.0" as the *Drop Allowed in an Access Hole*.
14. Select "Match Crown Elevations" from the *Method to match pipes across access holes* drop-down.
15. In the *Steady or Unsteady Parameters* section, select "Steady Flow" from the *Steady or Unsteady Flow* drop-down.
16. Turn off *Use one IDF for Entire Project* and *Ignore Gutter Inlets*.
17. Turn on *Assume Gutter Inlets Capture All Flow*.
18. In the *Interface Options* section, turn off *Use Advanced Interface*.
19. Click **OK** to close the *HY-12 Properties* dialog.
20. **Save** the project.

6 Run HY-12

The HY-12 model is now set up. Run the model by doing the following:

1. Select *HY-12* | **Run HY-12…** to bring up the *Run HY-12 Simulation* dialog.
2. If the *Filename and path* for the *HY-12 executable* is blank, click **Select File…** to bring up the *Select an HY-12 Executable* dialog.
3. Browse to the location of HY-12 (the default location is *C:\Program Files (x86)\HY-12*), select it, and click **Open** to exit the *Select an HY-12 Executable* dialog.
4. Verify that *Selected Material Database* states "File Exists and Read Correctly". If it does not, click **Select File…** and locate it in the *HY12CadFile\HY12CadFile* folder.
5. Make any other desired changes to the *Input Files* and *Result Files*, then click **Run Simulation** to bring up the *Model Wrapper* dialog.
6. When the HY-12 model finishes, turn on *Read solution on exit*.
7. Click **Close** to exit the *Model Wrapper* dialog and bring up the *View Data File* dialog. If *Never ask this again* was previously turned on, this dialog will not appear. If this is the case, skip to step 9.
8. Select the desired text editor from the *Open With* drop-down and click **OK** to exit the *View Data File* dialog and open the results in the selected external text editor.
9. When done reviewing the HY-12 results file in the external editor, click to close the text editor and return to WMS.

HY-12 uses and creates a number of text files when it runs. These are available for review in the *Run HY-12 Simulation* dialog.

10. Feel free to review any of the text files used or created by HY-12 by clicking on **View…** in the *View/Notes* column in the *Run HY-12 Simulation* dialog.

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11. Once done reviewing the HY-12 text files, click **Close** to exit the *Run HY-12 Simulation* dialog.
12. Select *HY-12* | **View HY-12 Structure IDs** to bring up the *HY-12 ID Lookup* dialog.

This dialog displays a table view of the Link and Node names next to the HY-12 IDs. Use this as a reference when reviewing the "Storm Drainage System Report". The report uses HY-12 IDs to reference the various structures in the simulation. The *Sort based on* drop-down can be used to sort the list of IDs by one of the columns.

13. Click **Done** to close the *HY-12 ID Lookup* dialog when done.

7 View HY-12 Output

Whether or not the model run was successful, HY-12 generates a report file. If the run was successful, WMS imports the results, which include the energy and hydraulic grade line (EGL, HGL) elevations at each node in the model. For hydrographic simulations, HY-12 computes a hydrograph at each node in the model.

If desired, view a plot of the EGL or the HGL for a node at each time step in the model. Both of these results are read into WMS after an HY-12 run is completed. This section will show how to view the results in the HY-12 output file and graphically in WMS.

7.1 View Detailed Output

1. **Frame** the project.
2. Using the **Select Hydraulic Node** tool, select any node.
3. Select *HY-12* | **View Detailed Link/Node Output…** to bring up the *View Data File* dialog. If the *Never ask this again* option has previously been checked, this dialog will not appear. If this is the case, skip to step 5.
4. Select the desired text editor from the *Open With* drop-down and click **OK** to close the *View Data File* dialog and open the report in the desired text editor.
5. A report giving detailed link and node computation results about the selected node will appear in the text editor. When done reviewing the HY-12 output file, click the in the top right corner of the text editor window to close the text editor and return to WMS.

Feel free to review any other node computation results as desired.

7.2 View HGL and EGL Plots

Hydraulic Grade Line (HGL) and Energy Grade Line (EGL) plots can be viewed by selecting one or more non-branching links in the model. The plot shows all pipes and access holes between the selected links and nodes.

1. Using the **Select Hydraulic Node** tool, select the "Outfall" node.
2. While holding down the *Shift* key, select node "CI3" (an upstream node).

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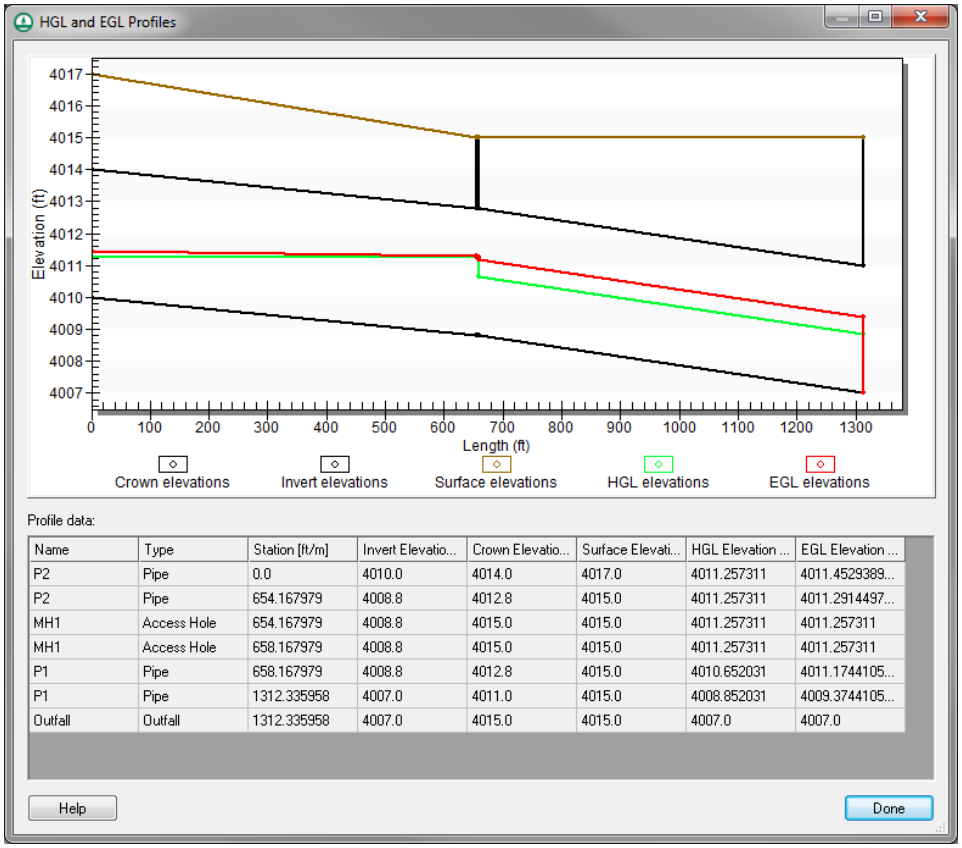
3. Select *HY-12* | **View EGL and HGL Plots…** to bring up the *HGL and EGL Profiles* dialog (Figure 6).
4. Review the HGL, EGL, and ground surface elevation plots and values. When done, click **Done** to close the *HGL and EGL Profiles* dialog.



Name	Type	Station [ft/m]	Invert Elevatio...	Crown Elevatio...	Surface Elevati...	HGL Elevation ...	EGL Elevation ...
P2	Pipe	0.0	4010.0	4014.0	4017.0	4011.257311	4011.4529389...
P2	Pipe	654.167979	4008.8	4012.8	4015.0	4011.257311	4011.2914497...
MH1	Access Hole	654.167979	4008.8	4015.0	4015.0	4011.257311	4011.257311
MH1	Access Hole	658.167979	4008.8	4015.0	4015.0	4011.257311	4011.257311
P1	Pipe	658.167979	4008.8	4012.8	4015.0	4010.652031	4011.1744105...
P1	Pipe	1312.335958	4007.0	4011.0	4015.0	4008.852031	4009.3744105...
Outfall	Outfall	1312.335958	4007.0	4015.0	4015.0	4007.0	4007.0

Figure 6 HGL and EGL Profiles dialog

8 Converting to an EPA-SWMM Model

Note: This section requires a paid version of WMS. These steps will not work in the Community Edition.

Now use WMS to convert the model to an EPA-SWMM model. After converting the model, the simulation will be saved and exported to the EPA-SWMM interface where it can be run and model results can be visualized.

1. Select "SWMM" from the model drop-down (Figure 7).

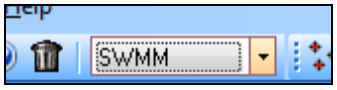


Figure 7 Model drop-down

This converts all of the link and node names, parameter definitions, and elevations into a SWMM model. It will use the same schematic, so the display window will not be changed.

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2. Using the **Select Hydraulic Node** tool, double-click on any one of the nodes to open the *Hydraulic Properties* dialog.
3. Select "All" from the *Show* drop-down.

Notice that the properties have been directly converted from the HY-12 model.

4. Select "Links" from the *Attribute type* drop-down.

Notice that the properties have been directly converted from the HY-12 model.

5. Click **OK** to close the *Hydraulic Properties* dialog.

8.1 Run EPA-SWMM

1. Select *SWMM* | **Run EPA-SWMM…** to bring up the *Select an EPA SWMM File* dialog.
2. Select "EPA SWMM file (*.inp)" from the *Save as type* drop-down.
3. Enter "SWMM_network.inp" as the *File name*.
4. Click **Save** to close the *Select an EPA SWMM File* dialog and open the external EPA-SWMM application.
5. Within the EPA-SWMM application, click **Run a simulation** to bring up the *Run Status* dialog.
6. Once the dialog indicates the run was successful, click **OK** to close the *Run Status* dialog.

Now create a profile plot within EPA-SWMM to visualize the results.

7. Select the outfall node at the right of the schematic.
8. Click **Create a Profile Plot** to bring up the *Profile Plot Selection* dialog (Figure 8).

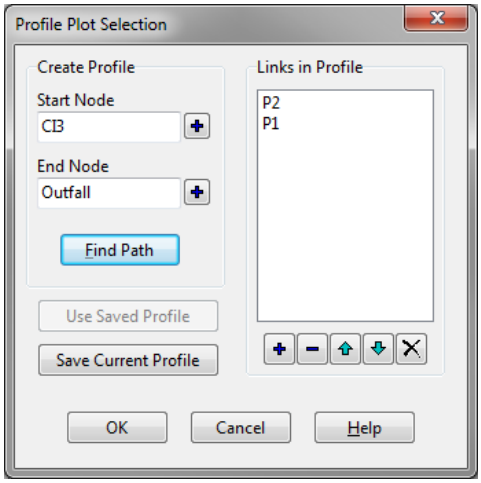

Figure 8 Profile Plot Selection dialog

9. Click the + button next to the *End Node* field to add the selected node name to the *End Node* field.

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10. Move the *Profile Plot Selection* dialog out of the way, if necessary, and select the CI3 node (the left node).
11. Click the + button next to the *Start Node* field to add the selected node name to the *Start Node* field.
12. Click **Find Path** to show the path in the *Links in Profile* section.
13. Click **OK** to close the *Profile Plot Selection* dialog and bring up a "Water Elevation Profile" plot (Figure 9).

There are several other ways of viewing the data within EPA-SWMM. Feel free to explore these options, consulting the EPA-SWMM documentation as necessary. These results can be used to compare with the results computed from HY-12.

14. When done reviewing the results, comparing the results, and exploring the EPA SWMM tools, click the  in the upper right corner to close EPA SWMM.
15. Save the current simulation if prompted, and then return to WMS.

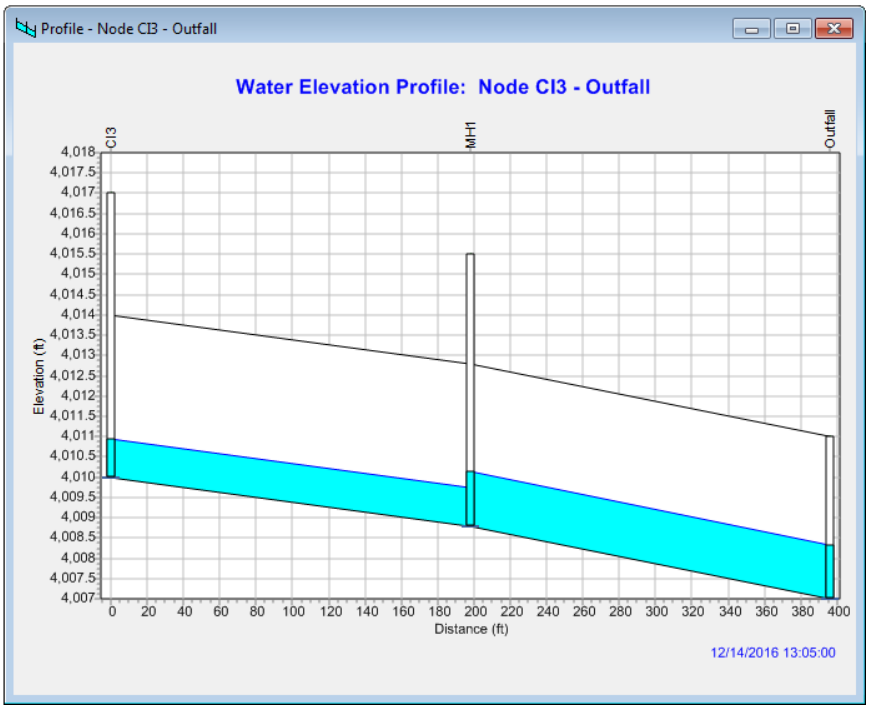

Figure 9 Water Elevation Profile from node CI3 to the outfall

9 Conclusion

This concludes the "Storm Drain Modeling – Simple HY-12 Analysis with the Drawing Grid" tutorial. The following key concepts were demonstrated and discussed:

- Setting up the drawing grid.
- Defining a storm drain network.
- Defining HY-12 structures in the storm drain network and assigning parameters to the structures.

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- Assigning pipe invert, access hole, ground, and inlet elevations to the HY-12 model.
- Running and viewing the HY-12 results.
- Converting the model to an EPA-SWMM model.
- Running EPA-SWMM and comparing the results with the HY-12 results.

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