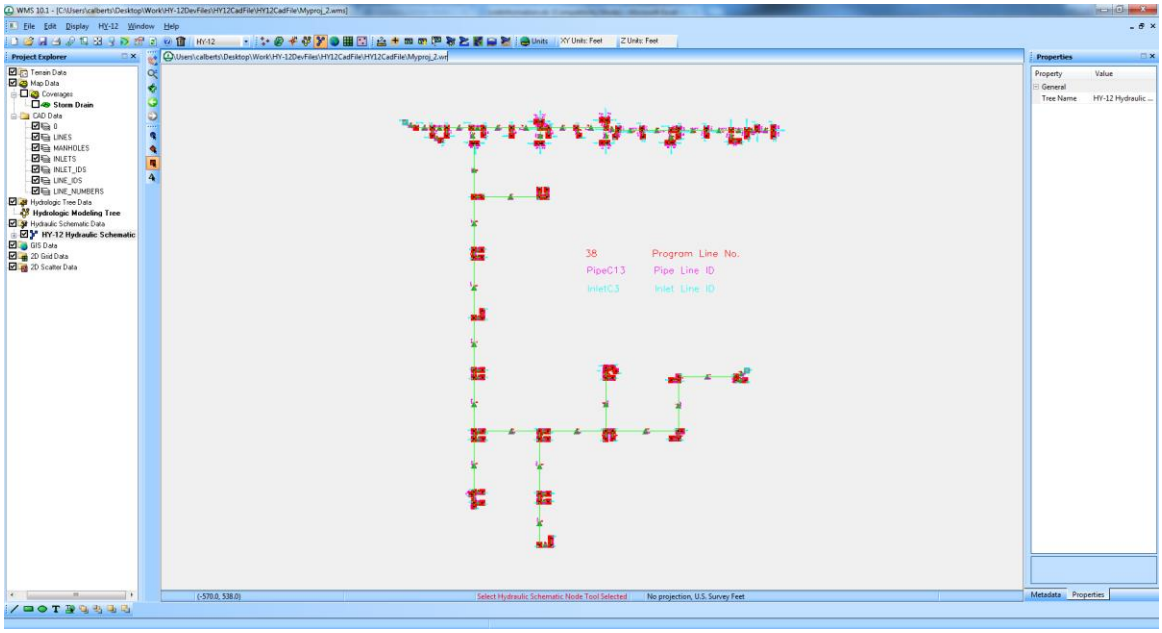
WMS

v. 10.1

WMS 10.1 Tutorial

Storm Drain Modeling – HY-12 Analysis with CAD Data

Setup an HY-12 storm drain model in the WMS interface using CAD data with inlet and pipe information



Objectives

Learn to define a storm drain network and its associated data using CAD centerlines. Learn to assign known manhole and pipe elevations and other storm drain information to the HY-12 model in WMS.

Prerequisite Tutorials

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

Required Components

- Data
- Map
- Hydrology
- Microsoft Excel

Time

- 40–50 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 discusses and demonstrates how to use the WMS HY-12 interface to design a storm drain network within a small suburban development in Ashland, Nebraska by using a CAD drawing, how to define HY-12 structures in the storm drain network and assign parameters to the structures, assigning pipe invert, access hole, ground, and inlet elevations to the HY-12 model, running HY-12, and then viewing the HY-12 results.

It is recommended that the "Introduction – Basic Feature Objects" and "Editing Elevations – DEM Basics" tutorials be completed prior to this one.

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.

[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.

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 Importing and Converting CAD Data

Start by opening WMS and loading in the CAD file. CAD files within WMS can be converted into map features such as feature arcs, feature points, and feature nodes and vertices along the arcs. These map features will be used to define the geometry of the HY-12 storm drain network.

1. Click **Open** to bring up the *Open* dialog.
2. Select "All Files (*.*)" from the *Files of type* drop-down.
3. Browse to the *HY12CadFile\HY12CadFile* folder and select "Hydraflow Plan Layout.dxf".
4. Click **Open** to import the CAD file and exit the *Open* dialog.

This CAD file contains all of the pipe network centerlines and points.

5. Under "Hydraflow Plan Layout.dxf" in the Project Explorer, turn off all CAD layers except "LINES".
6. Right-click on "Hydraflow Plan Layout.dxf" and choose *CAD To* | **Feature Objects…** to bring up the *CAD → Feature Objects* dialog.

Notice that only "LINES" is selected.

7. Click **OK** to close the *CAD → Feature Objects* dialog and bring up the *Clean Options* dialog.
8. Enter "1.0" for both the *Tolerance* and the *Minimum length*.

This tolerance will ensure that any nodes within a one foot tolerance of another node will be snapped together.

9. Click **OK** to close the *Clean Options* dialog and bring up the *Properties* dialog.
10. Select "Storm Drain" from the drop-down on the *Coverage* type row in the *Value* column.
11. Click **OK** to close the *Properties* dialog.
12. Turn off "CAD Data" in the Project Explorer.

This allows better visualization of the map features. The project should appear similar to Figure 1.

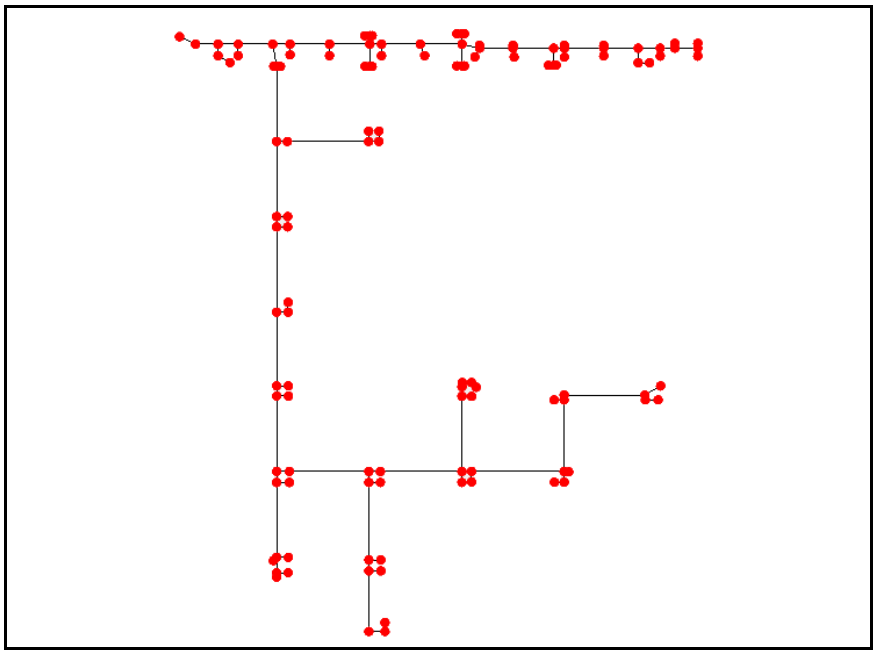


Figure 1 Initial storm drain schematic

3.1 Reordering the Stream Arcs

In a storm drain network, the flow direction must be properly assigned to each pipe/link. WMS assigns the direction from the start node flowing to the end node, depending on how the arc was drawn. These arcs are often drawn backward in CAD, so they will need to be reordered.

1. Click **Display Options** to open the *Display Options* dialog.
2. Select "Map Data" from the list on the left.
3. On the *Map* tab, turn on *Link Arrows* and click **OK** to exit the *Display Options* dialog.

The link arrows indicate the direction of flow in the HY-12 model. Notice that many of the arrows are pointing away from the outfall node. This needs to be fixed in order for the model to work properly and provide useful data.

4. Switch to the **Map** module.
5. Using the **Select Feature Point/Node** tool, right-click on the outfall node (the top left node in this case, see Figure 2) in the schematic and select **Reorder Streams**.

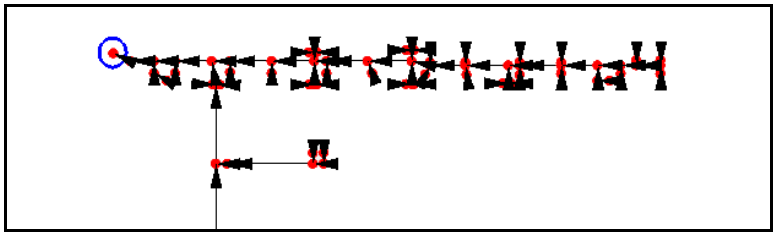


Figure 2 Outfall node location and flow direction arrows

The stream directions have now been reordered. All flow direction arrows should indicate downstream flow in the direction of the outfall node.

3.2 Mapping Features to 1D Hydraulic Schematic

The map features are now ready to be converted into a 1D Hydraulic schematic used by HY-12 to input link and node parameters. Set the model type within the Hydraulic modeling module.

1. Click **Display Options** to bring up the *Display Options* dialog.
2. Select "Map Data" from the list on the left.
3. On the *Map* tab, turn off *Link Arrows* and click **OK** to close the *Display Options* dialog.
4. Select *Storm Drain* | **Map → 1D Schematic** to bring up the *Select Model* dialog.
5. Select "HY-12" from the wide drop-down and click **OK** to close the *Select Model* dialog.

A 1D hydraulic schematic of nodes and links has now been created (Figure 3).

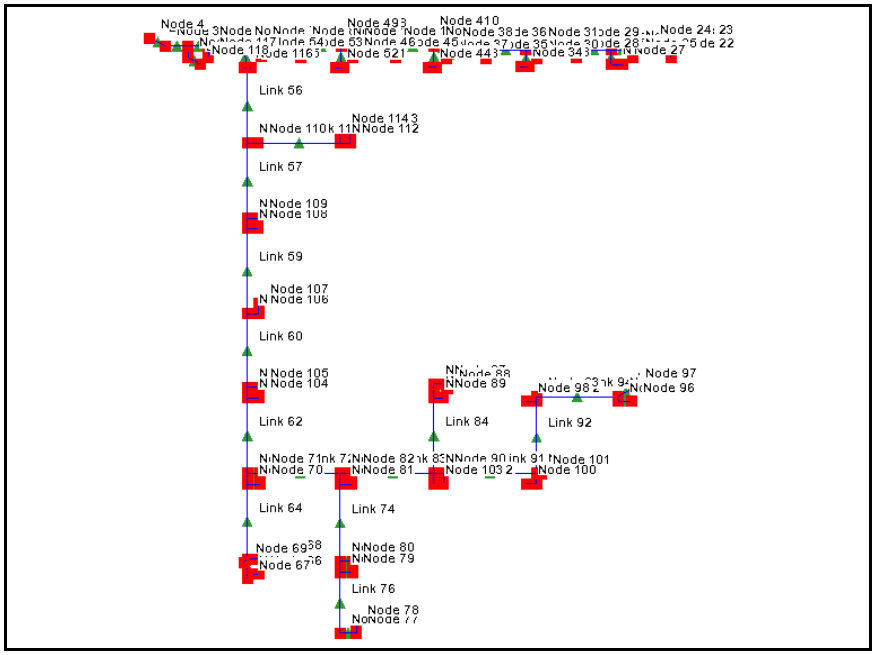


Figure 3 1D nodes and links all labeled

4 Defining Links and Nodes

4.1 Defining Link and Node Names

Now that the 1D hydraulic schematic has been created, the links and nodes will be assigned more specific names. For convenience, spreadsheets with names and other link/node properties have been created to allow copying and pasting of the data to the HY-12 link/node properties.

1. Select "HY-12 Hydraulic Schematic" in the Project Explorer.
2. Using the **Select Hydraulic Link** tool, double-click on any link in the schematic to bring up the *HY-12 Properties* dialog.
3. Select "All" from the *Show* drop-down.
4. Outside of WMS, open a spreadsheet program.
5. Open the "LinkNameMapping.xls" file located in the *HY12CadFile\HY12CadFile* folder.
6. Select cells B2 down through B118 and copy (*Ctrl-C*) them to the clipboard.
7. In WMS in the *HY-12 Properties* dialog, select the cell labeled "Link 1" in the *Name* column and press *Ctrl-V* to paste the new link names into the column.
8. Select "Nodes" from the *Attribute type* drop-down.
9. Switch to the spreadsheet program and open the "NodeNameMapping.xls" file located in the *HY12CadFile\HY12CadFile* folder.
10. Select cells B2 down through B119 and copy (*Ctrl-C*) then to the clipboard.
11. In WMS in the *HY-12 Properties* dialog, select the cell labeled "Node 1" in the *Name* column and press *Ctrl-V* to paste the new node names into the column.
12. Click **OK** to close the *HY-12 Properties* dialog.
13. Turn on "INLET IDS" and "LINE NUMBERS" in the Project Explorer.
14. **Zoom** in and verify the node (inlet) and line numbers from the CAD file match the new numbers entered from the spreadsheets.

Three of the node names will not match because the inlet IDs *C142* and CI1 were used for multiple inlets in the DXF file.

15. If there are any other inlet IDs or link IDs that do not match, enter the correct *Name* by using either the **Select Hydraulic Link** or **Select Hydraulic Node** tool to double-click and bring up the *HY-12 Properties* dialog.
16. Select *File* | **Save** to bring up the *Save As* dialog.
17. Select "WMS XMDF Project File (*.wms)" from the *Save as type* drop-down.
18. Enter "AshlandStormDrain.wms" as the *File name*.
19. Click **Save** to save the project under the new name and exit the *Save As* dialog.

It is recommended to **Save** the project periodically, especially after making a large number of edits.

4.2 Defining Link Data

In addition to the link names, other link attributes will need to be defined for the HY-12 network. In this section, the links will be assigned elevations, roughness, link type, and the lengths and angle of orientations will be computed.

1. Using the **Select Hydraulic Link** tool, double-click on any link to open the *HY-12 Properties* dialog.

2. Select "All" from the *Show* drop-down.
3. Select "Name" from the *Sort based on* drop-down.
4. On the *All* row, select "Pipe" from the drop-down in the *Structure Type* column.
5. Outside of WMS, open a spreadsheet program.
6. Open the "LinkInformation.xls" file located in the *HY12CadFile\HY12CadFile* folder.
7. Select cells C2 down through C118 (the *Up Invert Elev (ft)* column) and copy (*Ctrl-C*) them to the clipboard.
8. In WMS in the *HY-12 Properties* dialog, select the cell on the "1" row in the *Upstream Invert Elevation (ft/m)* column and press *Ctrl-V* to paste the link elevations into the column.
9. In the spreadsheet program, select cells D2 through D118 (the *Dn Invert Elev (ft)* column) and copy (*Ctrl-C*) them to the clipboard.
10. In WMS in the *HY-12 Properties* dialog, select the cell in the "1" row in the *Downstream Invert Elevation (ft/m)* column and press *Ctrl-V* to paste the elevations into the column.
11. Repeat steps 9–10, using cells F2 through F118 (the values in the *Pipe Size (ft)* column) and pasting them into the *Diameter/Span (ft/m)* column in the *HY-12 Properties* dialog.

Leave the drop-downs in the *Shape* column at the default of "<NONE>". This indicates the shape is circular.

12. In the *All* row in the *Pipe Manning's n* column, enter "0.013".

The wall thickness will be assigned default values based on the pipe size after closing this dialog, so it does not need to be set at this time.

13. Click **OK** to exit the *HY-12 Properties* dialog.
14. Select *HY-12* | **Assign Lengths and Orientations**.

WMS uses the upstream and downstream invert elevations, and the *X* and *Y* coordinates to compute a slope and angle of orientation for each link.

15. Click **OK** when advised which links were assigned lengths.
16. Click **OK** when advised which links were assigned orientations.
17. Using the **Select Hydraulic Link** tool, double-click on any link to bring up the *HY-12 Properties* dialog.
18. Select "All" from the *Show* drop-down.
19. Notice that WMS calculated and assigned values for the *Slope*, *Inlet Angle (Degrees)*, and *Wall Thickness (ft/m)* columns.
20. Click **OK** to close the *HY-12 Properties* dialog.

4.3 Defining Node Data

The nodes also need additional attributes defined, including surface elevation, node type, upstream invert elevation, and inflow rates.

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. Select "Downstream Link Name" from the *Sort based on* drop-down.
4. Outside of WMS in the spreadsheet program, "LinkInformation.xls" should still be open. Select cells I2 through I118 (the values in the *Upstream Surface Elevation (ft)* column) and copy (*Ctrl-C*) them to the clipboard.
5. In WMS in the *HY-12 Properties* dialog, select the cell on the "1" row in the *Surface Elevation (ft/m)* column and press *Ctrl-V* to paste the link elevations into the column.
6. On the *Outfall* row in the *Surface Elevation (ft/m)* column, enter "1068.0".
7. Check the box in the *Define Outfall* column on the *Outfall* row.
8. Enter "1059.27" as the *Outfall Invert Elevation (ft/m)* on the *Outfall* row.
9. Select "Name" from the *Sort based on* drop-down.
10. On the *All* row, check the box in the *Define Inlet* column.
11. Uncheck the box in the *Define Inlet* column for the *Outfall* node, the three "CM" nodes (*CM1*, *CM2*, and *CM3*), and all of the nodes with "Manhole" in the name.

Manholes, outfalls, and CMs are not considered inlets.

12. On the *All* row, check the box in the *Define Access Hole* column.
13. On the *Outfall* row, uncheck the box in the *Define Access Hole* column.
14. On the *All* row, enter "4.0" in the *Diameter/Width (ft/m)* column.
15. Select "Downstream Link Name" from the *Sort based on* drop-down.
16. In the spreadsheet program, select cells I2 through I118 (the values in the *Upstream Surface Elevation (ft)* column) and copy (*Ctrl-C*) them to the clipboard.
17. In WMS in the *HY-12 Properties* dialog, select the cell on the "1" row in the *Inlet Invert Elevation (ft/m)* column and press *Ctrl-V* to paste the link elevations into the column.

Note that some of the inlet elevation boxes are grayed out and inactive. WMS pastes the correct values into the active inlet elevation boxes, while skipping the inactive boxes.

18. In the spreadsheet program, select cells C2 through C118 (the values in the *Up Invert Elev (ft)* column) and copy (*Ctrl-C*) them to the clipboard.
19. In WMS in the *HY-12 Properties* dialog, select the cell on the "1" row in the *Access Hole Invert Elevation (ft/m)* column and press *Ctrl-V* to paste the link elevations into the column.
20. On the *All* row, check the box in the *Assume Full Capture* column.

Since not all nodes are defined as inlets, notice that many of the check boxes are grayed out. This option only applies to the nodes that are defined as inlets.

21. Outside of WMS in the spreadsheet program, open "NodeInformation.xls".
22. Select cells F2 through F118 (the values in the *Q Capture (cfs)* column) and copy (*Ctrl-C*) them to the clipboard.
23. In WMS in the *HY-12 Properties* dialog, select the cell on the "1" row in the *Inflow (cfs/cms)* column and press *Ctrl-V* to paste the link elevations into the column.
24. Click **OK** to close the *HY-12 Properties* dialog.
25. **Save** the project.

5 Defining HY-12 Project Parameters

Project parameters are global parameters that are used for the entire project. This section, set up the project parameters that will be needed to run the simulation.

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 "Ashland" as the *Project Name*.
4. Enter "10 Year Flows" 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. Click **Select File…** in the *Units* column on the *Material Database* row to bring up the *Select an HY-12 Material Database File* dialog.
8. Select "materialDB.txt" and click **Open** to close the *Select an HY-12 Material Database File* dialog.
9. Select "Report Errors, Warnings, and Notices" from the *Error Reporting* drop-down.
10. Select "Specify length, angle, and elevations, computer Slope" from the *HY12 Calculate Geometry* drop-down.
11. In the *Design or Analyze Parameters* section, select "Analyze" from the *Analyze or Design?* drop-down.
12. Enter "1.0" as the *Drop Allowed in an Access Hole*.
13. Select "Match Crown Elevations" from the *Method to match pipes across access holes* drop-down.
14. In the *Steady or Unsteady Parameters* section, select "Steady Flow" from the *Steady or Unsteady Flow* drop-down.
15. Turn off *Use on IDF for Entire Project* and *Ignore Gutter Inlets*.

16. Turn on *Assume Gutter Inlets Capture All Flow*.
17. In the *Interface Options* section, turn off *Use Advanced Interface*.
18. Click **OK** to close the *HY-12 Properties* dialog.
19. **Save** the project.

6 Running HY-12

The HY-12 model setup is now complete. 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.
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 Viewing 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 Viewing Detailed Output

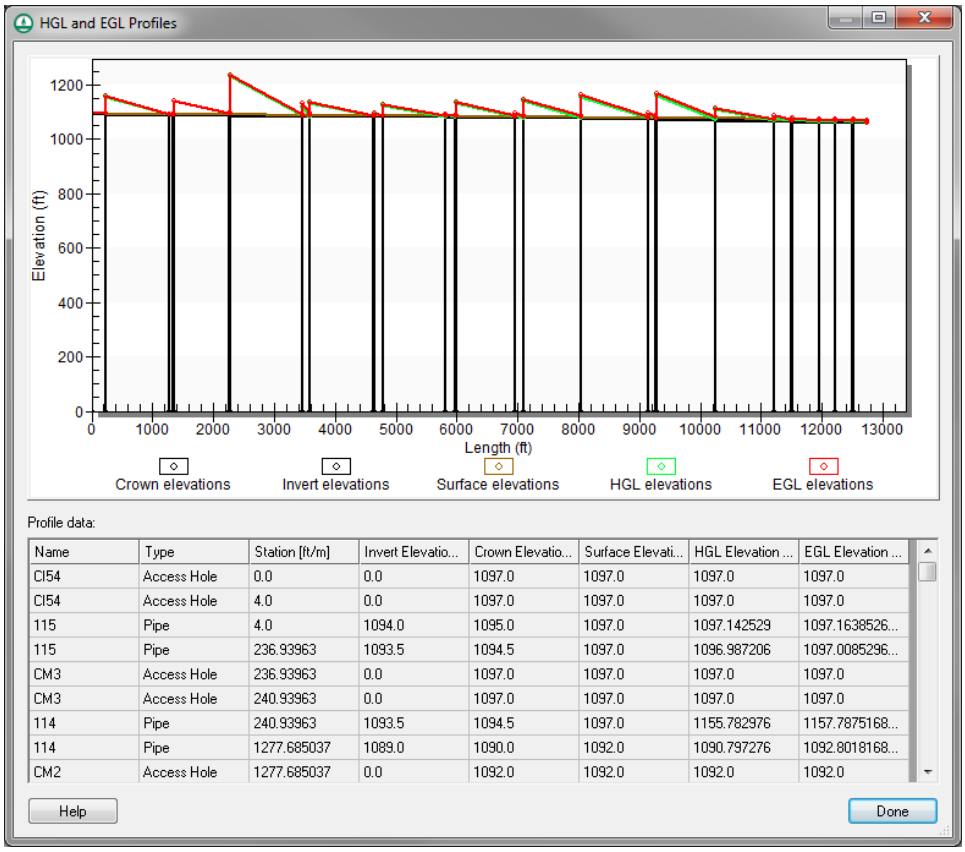
1. **Frame** the project.
2. Using the **Select Hydraulic Node** tool, select any node.
3. Select *HY-12* | **View Detailed Link/Node Output…** to bring up the *View Data File* dialog. If the *Never ask this again* option has previously been checked, this dialog will not appear. If this is the case, 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 Viewing 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 "CI54" (the most upstream node).
3. Select *HY-12* **| View EGL and HGL Plots…** to bring up the *HGL and EGL Profiles* dialog (Figure 4).
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 ...
CI54	Access Hole	0.0	0.0	1097.0	1097.0	1097.0	1097.0
CI54	Access Hole	4.0	0.0	1097.0	1097.0	1097.0	1097.0
115	Pipe	4.0	1094.0	1095.0	1097.0	1097.142529	1097.1638526...
115	Pipe	236.93963	1093.5	1094.5	1097.0	1096.987206	1097.0085296...
CM3	Access Hole	236.93963	0.0	1097.0	1097.0	1097.0	1097.0
CM3	Access Hole	240.93963	0.0	1097.0	1097.0	1097.0	1097.0
114	Pipe	240.93963	1093.5	1094.5	1097.0	1155.782976	1157.7875168...
114	Pipe	1277.685037	1089.0	1090.0	1092.0	1090.797276	1092.8018168...
CM2	Access Hole	1277.685037	0.0	1092.0	1092.0	1092.0	1092.0

Figure 4 HGL and EGL Profiles dialog

8 Conclusion

This concludes the "Storm Drain Modeling – HY-12 Analysis with CAD Data" tutorial. The following key topics were discussed and demonstrated:

- Defining a storm drain network by importing a CAD file.
- Defining HY-12 structures in the storm drain network.
- Assigning parameters to the structures in the network.
- Assigning pipe invert, access hole, ground, and inlet elevations to the HY-12 model.
- Running HY-12.
- Viewing the HY-12 results.

