AutoCAD Civil 3D Hydraflow Storm Sewers Extension

User's Guide

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Getting Started

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Hydraflow Storm Sewers Extension is a full-featured application you can use for hydrologic and hydraulic analysis of both simple and complex storm sewer networks. Use this tool to determine the hydraulic grade line in an existing system or to plan and design a new system.

Use Hydraflow Storm Sewers Extension to model and design storm sewer networks using traditional methods. Hydraflow Storm Sewers Extension can design and model a network of up to 250 storm sewer lines.

A storm sewer network is made up of lines. A line represents a length of pipe that has a junction at the upstream end. Junctions can be manholes, inlets, j-boxes, or other structures where losses or gains occur. You can have more than one line enter a junction, but only one line can exit the junction. You also have the option to specify multi-barrels for any line.

You create the storm sewer system in Hydraflow Storm Sewers Extension by specifying the required data, one line at a time, starting at the downstream end. Hydraflow Storm Sewers Extension is menu driven, so you can perform tasks and maintain a working model of your system by adding lines as necessary. You do not need to enter all the anticipated lines initially.

The general process for modeling a storm sewer system includes these tasks:

- Setting or verifying the Design Codes to determine the design constraints.
- Adding the lines.
- Computing the storm sewer system and creating and printing reports.

IMPORTANT If you plan to use the Rational Method, first set up your rainfall data file. For more information, see IDF Curve Setup on page 16. To get started, you can use the sample set of IDF (intensity-duration-frequency) curves that ships with the program. For sample file locations, see Hydraflow Storm Sewers Extension Files and File Locations on page 2.

Using Hydraflow Storm Sewers Extension, you can model more than one system at a time because you can specify any number of outfall lines.

Use this manual to learn the process of designing storm sewer systems with the Hydraflow Storm Sewers Extension. The Help has a summary of modeling guidelines, as well as a detailed explanation of the main application window and options for data input.

Help and Documentation

Use the *Hydraflow Storm Sewers Extension User's Guide* and the online help to learn how to use the application.

You can access both resources from the Help menu.

- For online help, click Help menu ➤ Contents.
- For the *Hydraflow Storm Sewers Extension User's Guide*, click Help menu ➤ User's Guide (PDF).

You can also open the online help from the application. Press *F1* or click the Help button in any dialog box.

Hydraflow Storm Sewers Extension Files and File Locations

Hydraflow Storm Sewers Extension has the following different file types:

File Type	Description
Project files	Store all project data including IDF curves, custom reports, and the background images that were being used when the project was last saved. Project files are saved in an ASCII format and can be viewed in any word processor. Project files have a *.stm* extension. Hydraflow Storm Sewers Extension only stores the name and location of *.dxf*-based background images.
IDF Curves	Store the curve data and have an *.idf* extension.
Custom Report Files	Store the layout of each custom report as a single file and have an *.rpt* extension.
Initialization files	Named *Storm2008.ini* and used to store information about the different settings in Hydraflow Storm Sewers Extension such as the Options settings, Design Codes, Cost codes, and the name of the IDF curve and custom report used when the program was last run. This file is automatically saved and retrieved from the file folder where Hydraflow Storm Sewers Extension is installed.

You get an error message during the install or uninstall of the software if this *.ini* file cannot be found by Hydraflow Storm Sewers Extension.

Hydraflow Storm Sewers Support and Sample Files

The following Storm Sewers support and sample files are installed with the product:

- storm.ini
- SampleProject.stm
- SampleBackground.dxf
- Sample2008.STM
- PipeSystem.dxf
- ManualSample2008.stm
- GSG_features_pipe_networks.xml
- DualLineSample.stm
- AllFields.rpt

These files are installed to the following locations:

Microsoft Vista

C:\Users\<username>\AppData\Local\Autodesk\C3D2011\enu\HHApps\StormSewers

C:\Program Files\Autodesk\AutoCAD Civil 3D 2011\UserDataCache\HHApps\StormSewers

Microsoft XP

C:\Program Files\Autodesk\AutoCAD Civil 3D\UserDataCache\HHApps

C:\Documents and Settings\<username>\Local Settings\Application Data\Autodesk\C3D2011\enu\HHApps

Sample .IDF curve files are installed to the following locations:

Microsoft Vista

C:\ProgramData\Autodesk\C3D2011\enu\HHApps\IDF

Microsoft XP

C:\Documents and Settings\All Users\Application Data\Autodesk\C3D2011\enu\HHApps\IDF

Upgrading From Previous Versions

You can migrate previous versions of project files with a *.stm* extension as far back as version 7.0. When you save a file with a Hydraflow Storm Sewers Extension format, the file cannot be reopened in a previous version. There is no backward compatibility.

To open your previous version **.IDF* file, on the toolbar, click the IDF button. In the Rainfall IDF dialog box, click Open and browse to the IDF file.

NOTE In Civil 3D 2010, you can import .stm files that were created or saved from older versions of the Storm Sewers Extension; for example, the Storm Sewers Extension for AutoCAD Civil 3D 2009 or earlier. You can also successfully open .stm files that were created or saved from 2009, or earlier, versions of the Storm Sewers Extension in the Storm Sewers Extension version 2010. However, in the Storm Sewers Extension for Civil 3D 2009, or earlier versions of the Storm Sewers Extension, you cannot open .stm files that were saved in the Storm Sewers Extension for Civil 3D 2010, or that were exported from Civil 3D 2010.

It is also important to note that when importing .stm files that were saved prior to version 2010, they may contain hydraulic grade line (HGL) values, however, they will not contain some of the other hydraulic properties, as listed below. The following values are calculated in the Storm Sewers Extension version 2010, but are not found in older versions of .stm files (prior to 2010):

Pipes

- Energy Grade Line Up
- Energy Grade Line Down
- Flowrate

Structures

- Energy Grade Line
- Known Capacity

NOTE Hydraflow Storm Sewers Extension cannot open version 7 IDF files.

NOTE To avoid compatibility errors, select the Pipes or Inlets tab before you open files from version 2003 and earlier.

Storm Sewer Projects

To open a project

- Click File menu ➤ Open Project.

NOTE Hydraflow Storm Sewers Extension is compatible with previous version project files from version 7.0 forward, however when you save a project in this version you cannot open it in a previous version. Project files are not backward compatible. To load an IDF curve from a previous version, open the old version *.*IDF* file (version 2000 forward) by clicking  (IDF) on the toolbar. Select and open the IDF file, and then save the IDF file. (no earlier than version 2000)

To save a project

- Click File menu ➤ Save.
  The first time you save a project click Save Project As and enter the project file name.

Working in SI Units

Hydraflow Storm Sewers Extension is designed to operate in either U.S. Customary or SI units. All input data is entered in the current units setting. At any time, you can switch the current units setting. Hydraflow Storm Sewers Extension automatically performs a data conversion.

To change units

1. On the main application window, click Options ➤ Units.
2. Select U.S. Customary or SI. Selecting SI allows you to enter metric values.
3. Click Yes to perform the data conversion.

Cost codes must be updated because the Cost module requires that the Initial Depth and Increment be set with a whole number and the conversion process creates fractions.

Verify that the values in the Design Codes have not changed.

TIP If you need to create a straight-line graph to represent rainfall data, see Entering Rainfall Data at a Constant Rate on page 17.

Data Conversion Considerations

Usually, existing data is converted using standard English - to - metric conversion factors. Pipe sizes are approximated. For example, converting a pipe size from 18 inches to SI renders 18 x 25.4 in/mm = 457.2 mm. The equivalent metric size for an 18-inch pipe is 460 mm.

IMPORTANT The rounded conversion of pipes affects the calculation results. Because the cross-sectional area of the pipes are not exactly identical, there is a slight change in velocity and hydraulic grade line (HGL).

Some Restrictions Apply

In the Design Codes, if you select Check For Inlet Control, only the Standard Orifice Equation option can be used when working in SI units.

When you save project files, the file is saved in the current units. To retrieve these files, you are prompted to change current unit settings to match the units in the incoming file. For best results, do not to switch back and forth between SI and U.S. Customary units.

Hydraflow Storm Sewers Extension Main Application Window

The Hydraflow Storm Sewers Extension main application window has pull-down menus, a toolbar at the top of the window, and a toolbox to the side. You enter data using both spreadsheets and dialog boxes. To fill in data fields, you enter the text or number and press the Tab key, not Enter. Pressing Enter is the same as clicking OK and pressing Esc is the same as clicking Cancel. Use the Tab key to move the focus to the next item. To go back to a previous item, press Shift-Tab.

As you enter lines, they are automatically numbered in the order of input. The first line you input is line number 1 and the second line input is number 2, and so on. This does not necessarily mean that line X flows into line X-1. Part of the input data for each line is the downstream line number. This indicates to Hydraflow Storm Sewers Extension the line that line X flows into. If you need to label your lines in a certain order, you have the option to assign Line IDs and Inlet IDs.

The main application window offers flexibility for data input and viewing with the four tabs Plan, Pipes, Inlets, and Results. The display tab you choose is determined by the task you are working on. For example, when you are adding lines to your system, you can use the Plan view to graphically draw your system, but if you prefer entering line data in a spreadsheet, you can use the Pipes or Inlets tab. Another option is to enter the Line data in the Add/Edit dialog box.

After you enter the storm sewer system data, you can use menu options to edit data and compute results. You can choose from four options to compute results, depending on the necessary level of accuracy and whether you are modeling an existing system or designing a new system. The results always shows the following details:

- hydraulic grade line
- full flow capacity of the storm sewer system
- comprehensive inlet analysis including carryover, captured, and bypassed flows
- total cost
- pertinent data, drawings, and graphs

The bottom panel of the main application window is a status bar that displays the progress bar, project file name, and the N, E coordinates.

Modeling Overview

You begin design on your storm sewer system by specifying the required data, one line at a time, starting at the downstream end. The program calculates the accumulated data, such as drainage areas and time of concentration (Tc). A small amount of required data for each line returns a high level of detail. You can perform the tasks using the menu options and save and reopen project files at any time.

Modeling Existing Storm Sewer Systems

Using Hydraflow Storm Sewers Extension, you can model existing systems by describing the invert elevations, length, and size for an individual line. Enter anticipated flows for each line using either the Rational Method, or the direct entry of known flow rates (Qs), or a combination of both. Using the automatic capacity calculation feature, you compare the actual conditions with the full flow capacity for the storm sewer system. This comparison determines weak links in the storm sewer system. You can then use the design options in the Hydraflow Storm Sewers Extension to correct deficiencies in the system.

Designing New Storm Sewer Systems

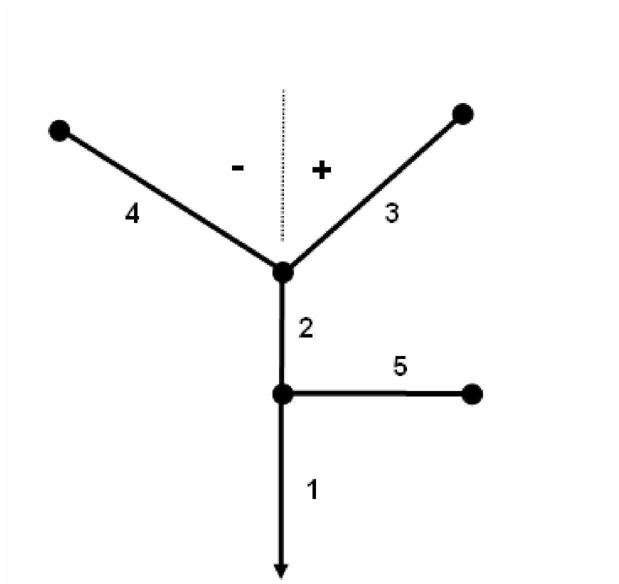
Designing a new system is similar to modeling an existing system. For each line, you omit the invert elevations and pipe size. When these blank values are encountered during the calculations, Hydraflow Storm Sewers Extension automatically designs the invert elevation and pipe size based on the Design Codes you have specified. Design Codes include, minimum/maximum pipe sizes and slopes, design velocity, pipe crown alignment, and minimum depth of cover. For the design flows, you can enter anticipated flows using either the Rational Method, or the direct entry of known Qs, or a combination of both.

You can enter known values for any lines in your system. For example, you can enter an existing invert elevation for a line and omit the pipe size, enter the pipe size and omit the invert elevation. Hydraflow Storm Sewers Extension calculates missing parameters based on the Design Codes.

Line Numbering

As you enter lines, they are automatically numbered in the order of input. For each line you create, you assign the Downstream Line Number to determine the downstream flow for each line.

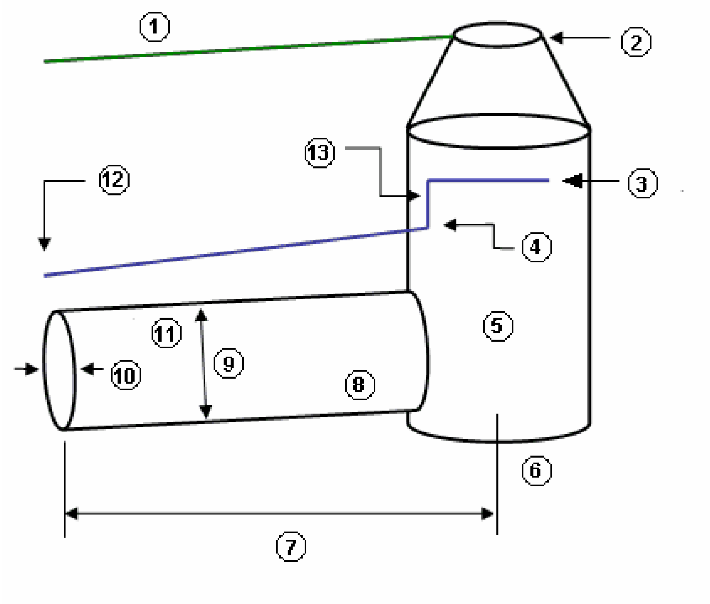
The following illustration shows a typical storm sewer system layout.



(1) Outfall begins at line 1	(3) The deflection angle for line 3 is 45 degrees
(2) Line 2 has a deflection angle of 0	(4) Line 2 is the downstream line for line 4 with a deflection angle of -55 degrees

The Basic Storm Sewer Line

A Line is a length of pipe with a junction at the upstream end. The length of the pipe can be any distance upstream and the junction can be one of nine types. The pipe section can be circular, elliptical, or box. The pipe cross-sectional dimensions are described by rise and span. You can specify invert elevations up and down as well as finish ground or inlet/rim elevations. In this release of Hydraflow Storm Sewers Extension there are user-defined structure shapes, lengths, widths, and diameters. Each line can have unique roughness coefficients, junction loss coefficients, as well as drainage areas, runoff coefficients, inlet times, and inlets.

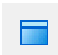


(1) Grade	(6) Centerline	(11) Crown
(2) Rim Elevation	(7) Length	(12) HGDN
(3) HG Junction	(8) Invert	(13) Junction Loss
(4) HG UP	(9) Rise	
(5) Junction	(10) Span	

Toolbox - Inlet and Junction Types

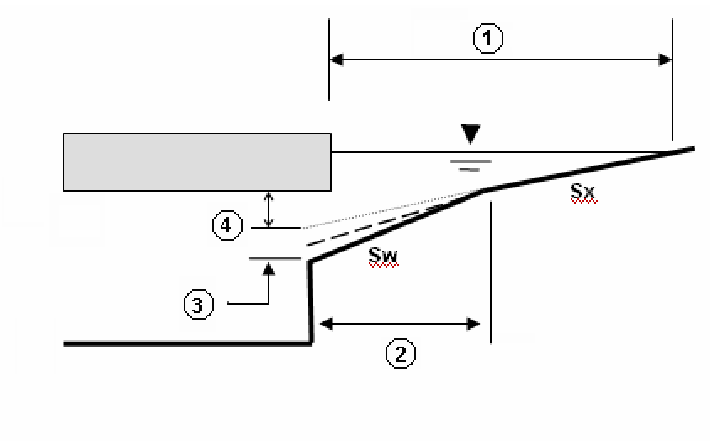
A line in your storm sewer system can have an inlet at its upstream end. Select inlet and junction types from the toolbox icons on the side of the main application window.

Icon	Junction Type
	Manhole
	Curb
	Grate
	Combination Curb and Grate

Icon	Junction Type
	Generic
	Drop Curb
	Drop Grate
	Open Headwall
	None

Gutters can have compound cross-slopes, including gutter depressions at the inlet face. Hydraflow Storm Sewers Extension follows the FHWA HEC No. 22 methodology and inlet types.

In the following illustration, the local depression and the throat height are measured from a line projecting from the slope, Sx. The Sw is the heavy dashed line and refers to the gutter cross slope, upstream of the inlet face.



(1) Spread

(2) Gutter Width

(3) Local Depression

(4) Throat Height

Running Hydraflow Storm Sewers Extension

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Basic Workflow

What follows is a brief description of the workflow for setting up your storm sewer model, computing the results, and printing reports and drawings.

Check the Design Codes

Each time you launch Hydraflow Storm Sewers Extension, it loads the Design Codes and Cost data from the *Storm2008.ini* file. When you exit the program, these values are automatically saved and then reloaded the next time you launch the program.

Load IDF curves

Hydraflow Storm Sewers Extension comes with sample IDF (intensity-duration-frequency) files that you can use to get started. For information on file locations, see Hydraflow Storm Sewers Extension Files and File Locations on page 2.Each time you start Hydraflow Storm Sewers Extension, the most recently used IDF curve is automatically loaded. For more information, see IDF Curve Setup on page 16.

Draw the lines

Using the Plan tab, you can graphically enter lines by clicking the desired inlet type (the upstream end of the line) from the side toolbox and then dragging your cursor to draw the desired length and angle. You must click OK after drawing each line. If you prefer a spreadsheet- like interface, you can enter lines using the Pipes tab or Inlet tab. As you enter each line, Hydraflow Storm Sewers Extension assigns default data.

Add line data

Click the Pipes tab and enter flow and physical data, such as invert elevations and pipe sizes.

Add inlet data

This step is optional if you assign default inlet values. On the Inlet tab, enter any necessary data. For example, with inlets on grade you must specify a longitudinal gutter slope.

Click  (Edit Data In Dialog Box) to open the Add/Edit dialog box where you can also add line and inlet data.

Compute

On the toolbar, click  (Run). Click the Results tab to view the results and print reports.

Quick Start Tutorial

This tutorial provides an overview of the general process for modeling a storm sewer system, which includes the following tasks:

- Verifying or setting the Design Codes to determine the design constraints.
- Adding lines from the Plan tab in the main application window, working in a downstream - to - upstream direction.
- Computing the storm sewer system and reviewing the options for creating reports.

IMPORTANT If you plan to use the Rational Method, first set up your rainfall data file. For more information, see IDF Curve Setup on page 16. To get started, you can use the sample set of IDF curves that ships with the program. For information on sample file locations, see Hydraflow Storm Sewers Extension Files and File Locations on page 2.

In this tutorial you compute the flows and design the Drop Curb inlet. You also design the storm sewer pipes that convey the design flows including the sizes, invert elevations, and slopes for a 5-year return period. The default settings in the Design Codes are used for the design parameters.

You will use the following process:

- Draw the system
- Add line data
- Compute
- View results and print reports

Draw Your System

1. On the main application window, click the Plan tab and click  (Add Line w/Manhole) on the side toolbox to create Line 1.
2. Move your cursor to the outfall location and drag in the upstream direction. The length and angle for the line are displayed in the text boxes at the top of the window. Enter 60 feet for the length and 0 degrees for the angle. During the design process, you can use the text boxes to directly enter lengths and angles and also to make edits.

   NOTE If you want to connect to a downstream line, begin drawing at or near the connecting junction. Hydraflow Storm Sewers Extension automatically snaps the lines together.

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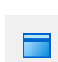
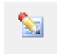
3. Right-click Line 1 ➤ OK. The line changes to blue.
4. For Line 2, click  (Add Line w/ Curb Inlet Drop) from the side toolbox.
5. Move your cursor to the upstream end of Line 1. The text box displays the angle and the length as you move the cursor. Drag your cursor to a length of 50 feet at -45 degrees deflection.
6. Right-click Line 2 ➤ OK or click  on the side toolbox.

Add Line Data

1 Click  (Edit Data In Dialog Box) at the top of the side toolbox, or double-click the Manhole junction icon (MH) for Line 1 to display the Add/Edit dialog box.

2 Use the Tab key to navigate the input boxes. Enter the following data for Line 1:
   - Line ID = Outfall to Line 1
   - Line Length = 60.00 ft
   - Deflection Angle = 0 deg
   - Invert Elevation Down = 100.00 ft
   - Inlet/Rim Elevation Down = 106.60 ft
   - Inlet/Rim Elevation Up = 107.75 ft

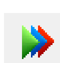
3 Click Next and enter the following data for Line 2:
   - Line ID = Line 1 to Line 2
   - Line Length = 50.00 ft
   - Deflection angle = -45 deg
   - Drainage Area = 3 acres
   - Runoff Coefficient = 0.65
   - Inlet Time = 15 min.

4 Click the Inlet/Junction tab to add data for this inlet.

5 Enter the following inlet data:
   - Inlet ID = Inlet 2DC
   - Inlet Length = 0 (This sets it up to be automatically designed)
   - Throat Height = 4 in
   - Road Cross-Slope = .05 ft/ft

6 Click OK and then click Exit.

Compute

1 Click  (Run) on the top toolbar to compute the results.

2 In the Compute System dialog box, specify the following:
   - Return Period = select 5 Yr from the drop-down list
   - Calculation Options = Analysis w/ Design
   - Starting HGLs = Click the cell and select Crown from the drop-down list
   - Use Interactive Feature = Selected

3 Click OK. The Interactive Design window is displayed.

   A profile of Line 1 is displayed that has the pipe size and slope at 18-inches at 0.25% to accommodate the computed 5-yr flow rate of 9.0 cfs (cubic feet per second).

The hydraulic information for Line 1 is displayed at the top of the dialog box. You can modify the data in the bottom section of the table using the spin button control on the right. The spin control increases or decreases the data items. When you click a data item, the background displays in yellow to indicate that the item is available to edit.

4 Click the Up button to proceed upstream to Line 2.

The blue line represents the pipe, the red line indicates the HGL, and the green line shows the Inlet/Rim elevations.

Line 2 has been automatically designed for full-flow. Because the drop curb Inlet Length was set to zero, the inlet was also automatically designed. Click the Inlet Section tab on the upper left of the Plot window.

The Drop Curb inlet is designed by first setting the Inlet Depth equal to the Throat Height and then solving for the required length of opening. In this example, the Throat Height was set to 4 inches (0.33 ft). The resulting required length is 15.72 feet. This value divided by four sides equals 3.93 feet per side, and a total spread width of 17.27 ft.

Occasionally you will need to make changes to your designs for practical reasons. For example, an inlet with even 4-foot sides may be more practical in the field than 3.93 feet. To make this change, click the Curb Length column. The background of the column is yellow indicating that the column is available to edit. Next, click the top part of the blue-colored spin control until the Curb Length value is 16.00. Because these are real-time edits, the inlet hydraulics change immediately and the spread width is decreased to 17.10 feet.

5 Click Finish to return to the main application window.

View Results on the Results Tab

After completing the computations, you have options to create profiles and reports to export or print.

1 On the main application window, click the Results tab.

2 To plot profiles, on the Results tab, highlight the rows that correspond to the beginning and ending lines you wish to plot.

3 Click  (Profile) on the top toolbar.

4 Click Exit to return to the main application window.

Design Code Settings

Hydraflow Storm Sewers Extension calculates and designs the storm sewer system based on the Design Code settings.

In the Design Codes dialog box, you specify design constraints, initial conditions, and the default input values.

Design Code settings are embedded in each project file and are automatically saved when you exit Hydraflow Storm Sewers Extension. They are reloaded the next time you start the program.

There are three tabs on the Design Codes dialog box: Pipes, Inlets, and Calculations.

- To access the Design Codes dialog box, click Edit menu ➤ Design Codes or click  (Codes) on the toolbar.

Pipes Tab - Design Codes Dialog Box

Design

NOTE In Storm Sewers the list of pipe sizes is hard coded and cannot be customized. This list does not distinguish between inner and outer pipe diameter, pipe material, or pipe class. When you perform calculations that resize pipes, the results include only the sizes in the list. However, you can always manually edit the pipe size.

Minimum Pipe Size

Specifies the smallest pipe size that Hydraflow Storm Sewers Extension uses when designing pipe sizes. Click the down-arrow and select a size.

Maximum Pipe Size

Specifies the largest pipe size that Hydraflow Storm Sewers Extension uses when designing pipe sizes.

Design Velocity

Specifies the design velocity in ft/sec (m/sec). If you specify zero for both invert and pipe rise, Hydraflow Storm Sewers Extension selects a pipe size based on this velocity. If a specific pipe size is not available, Hydraflow Storm Sewers Extension selects the next smaller size to keep the Design Velocity at a minimum. For example, if the theoretical size is 19.5 inches, Hydraflow Storm Sewers Extension rounds down and uses an 18-inch pipe. Hydraflow Storm Sewers Extension uses this velocity along with Manning's n Equation to determine the pipe slope.

Minimum Slope

Specifies the minimum slope in percent. Hydraflow Storm Sewers Extension uses this value for design only, and does not set any invert slopes less than this value. If the theoretical slope is less than the Minimum Slope, Hydraflow Storm Sewers Extension resets the designed slope to this value.

Maximum Slope

Specifies the maximum slope in percent. Hydraflow Storm Sewers Extension uses this for design only and does not set any invert slopes greater than this value.

Minimum Cover

Specifies the minimum cover in feet (meters). This value should be from the natural ground to the crown of the pipe. The pipe thickness is neglected. The minimum cover constraint is used only when you specify Full Design as the calculation option. Select Zero At Outfalls to prevent Hydraflow Storm Sewers Extension from setting the outfall ends too deep.

Default N Value

Specifies the pipe roughness coefficient for new lines.

Size Options

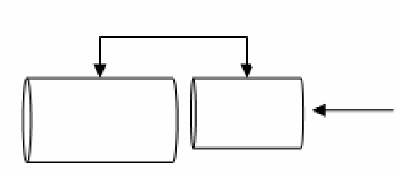
Specify the pipes sizes that are available for design. Use this option in locales where certain pipe sizes are not commercially available, such as 21-inch, 27-inch, and 33-inch.

Alignment

During design, Hydraflow Storm Sewers Extension matches either the crowns of the pipes or their inverts.

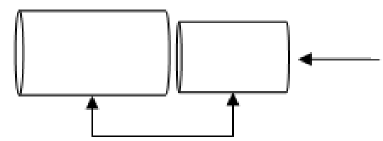
Match Crowns

Select to match the crowns of pipes regardless of their size. Matching crowns prevents a line from flowing into another line against a head. The following illustration shows Match Crowns:



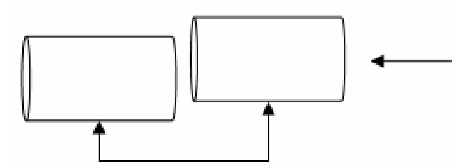
Match Inverts

Select to match inverts. The following illustration shows Match Inverts:



Matchline Drop

Specify a value for the drop in invert elevation across junctions of equal pipe sizes. For example, if a 24-inch line enters and exits a junction, Hydraflow Storm Sewers Extension automatically lowers the outgoing line by the amount you specify. The following illustration shows a Matchline Drop.



Allow Smaller Downstream Pipes

Select this option in situations where the required pipe size is smaller than the pipe size connecting upstream. Typically, it is not a good design practice for pipes to decrease in the downstream direction, however this option is available for unique design situations.

Inlets Tab - Design Codes Dialog Box

Defaults

Eliminate redundant data by entering preset values for inlets and gutters on the Inlets tab. Each time you add a line, values are taken from this data. If necessary you can edit the line data later.

NOTE The Curb Opening is a global setting and it affects all curb inlets, but this setting does not apply to combination or drop curb inlet types.

Design

Grate Design Depth

When you design grate inlets in sags, Hydraflow Storm Sewers Extension sizes the grate using the orifice equation. If it knows the depth and Flow Rate (Q), it can solve for the grate size. For more information, see Inlets on page 71.

Composite Runoff Coefficients

Hydraflow Storm Sewers Extension gives you the option to have three preset runoff coefficients to use when you add line data and for composite areas. This is useful in situations where you always use these fixed Runoff Coefficient (C) values. These values are based on the corresponding land uses. You can also enter a C value for each line.

Calculations Tab - Design Codes Dialog Box

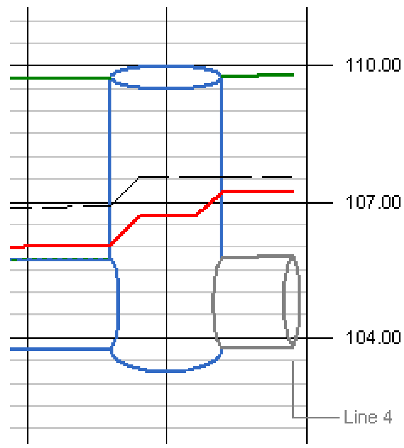
HGL Options

Min. Starting Depth

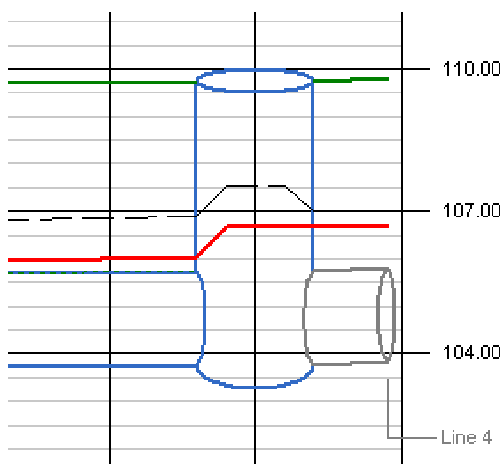
Specifies how to choose the starting water surface elevation at the downstream end of any line, except outfalls. The choices are: Normal, Crown, (dc + D)/2, and Critical depth. If the starting hydraulic grade line (HGL) at any line, other than an outfall line, is below the Minimum Starting Depth, Hydraflow Storm Sewers Extension automatically sets the starting HGL to this specified depth. This value refers to all lines upstream, not the beginning HGL.

Correct EGL Discrepancies

Specify this option to maintain the energy grade line at junctions in order to prevent a rise in energy in the downstream direction. This can occur if additional flows are added. This option holds the energy grade line (EGL) for the next upstream line and adjusts the starting HGL (EGL – Velocity head). The following illustration shows an example of an increase in the EGL in the downstream direction (flow runs right to left) with the option to correct the EGL discrepancy turned off.



The following illustration shows the result when the option to correct the EGL discrepancy is selected. There is a double jump in the HGL, indicating the starting HGL for the upstream line was adjusted.



Check For Inlet Control

A pipe flows under inlet control when it is more difficult for the flow to enter the pipe than it is for the flow to get through the pipe. Specify this option to check each HGL calculation for inlet control. Choose either HDS-5 method or standard orifice equation.

Flow Options

Accumulate Known Qs

You can enter known flow into any line of your system. Specifying this option accumulates known Qs as Hydraflow Storm Sewers Extension works downstream. If this option is cleared, the known Qs are not added.

Use Inlet Captured Flows In System

Typically, inlet flow quantity calculations are done separately from system flows. Most designers assume that all the flows computed by the Rational Method enter the pipes. If selected, this option limits the system flows to those captured by the inlets. In most situations this option should not be selected.

WARNING If the junction is not an inlet, then it cannot capture inlet flows, resulting in a zero Q. If a line has a drainage area, C, and inlet time, the junction type must be an inlet when this option has been selected. This option has been selected if the total Qs shown on the reports do not match the corresponding Q = Cia.

Suppress Pipe Travel Time

Select this option to ignore travel times in pipes when computing Tc for the system.

Min. Tc Used To Calc Intensity (min)

Select this option to prevent Hydraflow Storm Sewers Extension from using intensities based on Tc values below a certain minimum. Specify the minimum.

Junction Loss Coefficients

Hydraflow Storm Sewers Extension automatically computes and assigns junction loss coefficients based on the junction configuration when you select Automatic. Coefficients are selected based on the data adapted from FHWA HEC No. 22. For more information, see Junction Loss Coefficients on page 65. The selected coefficients are based on the angle of the lines entering the junction at its upstream end.

NOTE If you select the Automatic option, you cannot edit the loss coefficients when you add or edit line data.

For angles less than 90 degrees, Hydraflow Storm Sewers Extension uses the following equation to compute junction loss coefficients:

$$K = \left[1 - \left(\frac{90 - Deflection\,Angle}{90}\right)^2\right]$$

If the junction is an inlet, K is multiplied by 1.5. In no case is K less than 0.15 for Manholes or 0.50 for Inlets.

For bends greater than or equal to 90:

Inlets K = 1.5

Manholes K = 1.00

For Lines at ends of a branch, K = 1.00

Select Manual Entry to enter user-defined coefficients.

IDF Curve Setup

Hydraflow Storm Sewers Extension can develop any number of IDF (intensity-duration-frequency) curves, for any number of geographic locations, with up to eight return periods. The IDF curves are equation-based and can generate intensities in the range of 5-minutes to 24 hours. After the initial setup, Hydraflow Storm Sewers Extension, manages the IDF curves and automatically loads them when you start the program.

During calculations, Hydraflow Storm Sewers Extension automatically computes the rainfall intensity from the currently loaded IDF curves for use in the Rational Method. You must provide data so that these curves match those that you are presently using. You can modify the sample files that ship with the program (*sampleFHA.IDF* and *FLZone1.IDF*). For information on sample file locations, see Hydraflow Storm Sewers Extension Files and File Locations on page 2.

The rainfall data file is set up from the main application window. After you enter the IDF data, Hydraflow Storm Sewers Extension stores the IDF curves in a user-defined file name. This file is loaded each time Hydraflow Storm Sewers Extension is started. During design, Hydraflow Storm Sewers Extension uses the IDF curve and the computed Tc to compute the intensity.

Hydraflow Storm Sewers Extension can store an unlimited number of different rainfall files for different jobs or locations. These IDF curves can be loaded for use at any time.

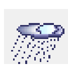
You can enter points from an existing IDF curve or create a new IDF curve from map data.

Using Existing Data

To set up your curves to match existing IDF data

On the IDF Table tab, enter data for the intensity values in inches per hour for the 5, 15, 30, and 60 minute durations corresponding to the 1, 2, 3, 5, 10, 25, 50, and 100-year storms. You can leave the values for a return period data blank. For example, if you do not use or have 1-year data, leave those values blank. This method is recommended for use with the western United States currently included in the latest NOAA Atlas 14. Use the intensity values provided in Atlas 14.

To enter rainfall intensity data

1 Click  (IDF) on the top tool bar. The Rainfall IDF Curve dialog box displays and the IDF Graph tab displays the current IDF curve.

2 Click the IDF Table tab. Click Clear or click a cell and enter data.

3 Enter the intensity amounts in inches/hour or centimeters/hour from your Intensity - Duration - Frequency curves. You must enter all data for each return period used.

4 Click Ok. Hydraflow Storm Sewers Extension calculates the corresponding rainfall intensity equation coefficients.

For more information, see Viewing and Editing I-D-F Curves on page 19.

Entering Rainfall Data at a Constant Rate

In situations where you need to create a straight-line graph to represent constant rainfall, you can use the FHA equation and manipulate the values.

To create a constant rate graph

1 Click  on the toolbar.

2 In the Rainfall IDF Curve dialog box, click the Coefficients tab and then click FHA.

There are three coefficients in this equation, B, D, and E.

Enter a value of 0 for coefficients D and E. The B value represents the intensity in inches/hour. The resulting graph is a straight-line graph that you would expect from a constant rate.

Creating From Map Data

Using Hydraflow Storm Sewers Extension, you can generate new IDF curves from NWS precipitation data. The computational procedure is that as described in FHA Circular No. 12, Drainage of Highway Pavements.

Technically, when using Hydro-35 data or existing curves, Hydraflow Storm Sewers Extension manipulates the input data to generate coefficients B, D, and E, for use in an intensity vs. Tc equation.

$$I = \frac{B}{(Tc + D)^{E}}$$

Where:

I = rainfall intensity in in/hr (cm/hr).

Tc = time duration.

B, D, and E = coefficients.

The required data can be precipitation values from NWS Hydro-35 (Eastern United States) or NOAA Atlas (Western United States) Hydro-35 and the NOAA Atlases is available at National Technical Information Service (NTIS) 1-800-553-6847. Ask for publication number PB272112. (Hydro-35)

You must be working in U.S. Customary units to generate IDF Curves from map data. After you create the curves, you can change the U.S. Customary Units to SI units. To change the units, on the main application window click Options menu ➤ Units.

Building IDF Curves

If you are located in the eastern and central United States, get the precipitation data for NWS Hydro-35 from the National Weather Service (NWS) web site. The values are in total inches, not inches per hour (in/hr) and consist of the 5-, 15-, and 60- minute durations corresponding to the 2- and 100-year frequencies.

If you are located in the western United States, get the precipitation data from NOAA Atlas for your state. The values are in total inches, not inches per hour (in/hr) and consist of the 6- and 24- hour durations corresponding to the 2- and 100-year frequencies. The average elevation in feet is also needed.

To build IDF curves from Hydro-35 data

1. Click the I-D-F Curves menu ➤ Create New From Map Data and then click either Eastern States or Western States.
2. Do one of the following:
   - For Eastern states, enter precipitation amounts in the Build IDF Curves From Hydro-35 Data dialog box.
   - For Western states, enter precipitation amounts in the Build IDF Curves From NOAA Atlas dialog box.

   Click OK.

Hydraflow Storm Sewers Extension calculates the corresponding rainfall intensity equation coefficients.

Third Degree Polynomial

Hydraflow Storm Sewers Extension has the option of creating IDF curves using a third degree polynomial equation as follows:

$$I = A + Bx + Cx^2 + Dx^3$$

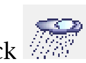
Where:

I = rainfall intensity in in/hr (cm/hr).

X = Ln (time duration in minutes).

A, B, C, D = coefficients.

To create polynomial-based curves

1 Click I-D-F Curves menu ➤ View/Load Curves or click  on the toolbar. The current IDF curve is displayed.

2 Click the Coefficients tab.

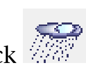
3 Click the Poly tab.

4 Click Clear and then enter new coefficients.

5 Click OK.

6 Click the IDF Graph tab to view the curves.

Viewing and Editing I-D-F Curves

Regardless of the method used to create your new curves, Hydraflow Storm Sewers Extension always generates equation coefficients and a graphical display of the curves. To view this data, on the main application window, click I-D-F Curves menu ➤ View/ Load Curves or click  (IDF) on the toolbar.

In the Rainfall IDF Curve dialog box you can do the following:

- edit the equation coefficients
- save the current IDF file
- print a copy of the plotted graph
- create a numerical report of the IDF data

To edit coefficients

1 In the Rainfall IDF Curve dialog box, click the Coefficients tab.

2 Click in the cell that you want to change, and enter a new value.

3 Click OK.

4 Click the IDF Graph tab to view the change on the plot.

To save the file

1 In the Rainfall IDF Curve dialog box, click  .

2 In the Save As dialog box, enter a name for the file. All IDF files have a *.idf* extension.

> **NOTE** Save all IDF files to the folder where Hydraflow Storm Sewers Extension is installed to ensure that this IDF file loads when you launch Hydraflow Storm Sewers Extension.

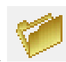
To print IDF curves

1 In the Rainfall IDF Curve dialog box, click  .

2 In the Graphs Print Menu dialog box, specify the print options and click Print.

3 Select the Numerical Report check box to print a report of the numeric data.

To open an existing IDF curve

1 In the Rainfall IDF Curve dialog box, click  .

2 Browse to the file that you want to load and click OK.

3 When you are finished viewing, click Exit to return to the main application window.

Hydraflow Storm Sewers Extension uses the currently loaded IDF curve in all subsequent calculations. The name of the current IDF curve is displayed on all printed reports. Hydraflow Storm Sewers Extension remembers this file when you exit the program, and reloads it the next time you start the program.

Cost Code Setup

Using Hydraflow Storm Sewers Extension, you have the option to calculate the total cost of the storm sewer design, including pipe and cut depth quantities. During the design phase, Hydraflow Storm Sewers Extension automatically computes the system cost, based on the cost code data you enter.

Hydraflow Storm Sewers Extension computes the pipe quantities and cut depths based on the values you specify in the Cost Estimate Module dialog box. For example, if a 15-inch pipe is buried from 6 to 8 feet, invert to grade will cost $40.00 / lf. During the calculations, Hydraflow Storm Sewers Extension computes the total quantity of 15-inch pipe that falls into this cut depth category and multiplies it by $40.00 to arrive at a cost. Each pipe size in each cut category is investigated during the calculations. The subtotals are added to get the total system cost, which you can print as a report.

You can set up three different scenarios, each with unique cost values and cut depth increments. You can assign each scenario a name or description.

> **NOTE** Setting up cost codes is optional.

To set up cost tables

1 Click Edit menu ➤ Cost Codes.

2 In the Cost Estimate Module dialog box, specify one of the following scenarios.

- RCP
- CMP
- PVC

3 Enter a description for the scenario in the description box. The selected scenario button changes to match the description you enter.

4 In the Depth Ranges section, enter the Initial Depth, press Tab and enter the increment. The remaining columns are set based on the increment value.

   The table columns are set up using the Initial Depth and Increment. These values must be whole feet or meters.

5 Enter the corresponding unit costs in the rows and columns. Use the Tab key to move to the next cell.

6 Click Apply when you have completed entering cost values, and then click Exit.

   Hydraflow Storm Sewers Extension automatically saves this cost table in its *Storm2008.ini* file and reloads it when you next start the program.

Adding Lines

In Hydraflow Storm Sewers Extension you can choose from several options to add lines. The Plan tab offers a graphical display, the Pipes and Inlets tabs are designed like a spreadsheet, and the Add/ Edit Dialog box gives you options to choose from drop-down lists. Systems are built by adding lines from the downstream end working upstream. You can add up to 250 lines for each project. Each line is automatically numbered in sequence beginning with line number 1.

Line Data

As you add lines to your storm sewer system, Hydraflow Storm Sewers Extension assumes that you are adding them in the upstream direction. Line numbers are automatically assigned and increase in the upstream direction. Line 100 can have a downstream line number of 30. But line 30 cannot have a downstream line number of 100. When you assign a downstream line or inlet number, the line must already exist in the system. More than one line can enter a junction, but only one can exit.

Flows for each line can consist of known Qs or Rational Method flows. If a particular line does not have any incoming overland flows, such as a manhole, then enter 0 and Hydraflow Storm Sewers Extension carries upstream flows through the line.

You can specify invert elevations and line sizes or leave these values blank, and Hydraflow Storm Sewers Extension determines the values. Hydraflow Storm Sewers Extension uses an energy-based method for HGL calculations, and negative line slopes are allowed; however, Hydraflow Storm Sewers Extension does not provide design options or compute full-flow capacities for lines that are on negative slopes.

Adding Lines From the Plan Tab

To add lines from the Plan tab

1 Click a junction type from the side toolbox.

2 In the drawing area, move your cursor in an upstream direction to the desired length.

3 Optionally, enter the Angle and Length values in the text boxes at the top of the dialog box.

NOTE If you need to lock a line while manually entering the deflection angle and length, click next to the Ang box or the Length box to lock the existing values. Locking the values prevents them from being changed by any cursor movement. Click to unlock. You can lock and unlock at any time during the process.

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4 Repeat the previous steps for each line, or right-click ➤ Add Another Line. Hydraflow Storm Sewers Extension automatically snaps to the last line drawn and uses the same junction type.

5 When you have finished adding lines, do one of the following:

- Right-click ➤ OK or press Enter.
- To cancel a line, right-click ➤ Cancel.
- To cancel a line after you click OK, click Edit menu ➤ Undo.

For each line that you add, a certain amount of line data is entered automatically based on the values you set in the Design Codes.

Changing the Downstream Line

You can switch the downstream line or manually select a downstream line using the Dnstrm Line = text box on the status bar. Enter the desired line number and click to accept the new downstream line. For more information, see Moving Lines on page 33.

Adding Lines From the Pipes Tab or the Inlets Tab

One advantage to using the Pipes tab or the Inlets tab is that spreadsheet display allows you to view and edit all the data for the storm sewer system in one window. The procedure for adding lines from either tab is the same.

To add lines from the Pipes tab or the Inlets tab

1 Select the downstream line by clicking the arrow in the first column.

2 Select a junction from the side toolbox.

NOTE You do not have to specify a downstream line because Hydraflow Storm Sewers Extension assigns the last line added as the downstream connecting point.

3 For each line that you add, a certain amount of line data is entered automatically based on the values you set in the Design Codes. A line length of 50 feet or 16 meters is also added.

4 Use the Tab key to navigate through the options, or click a cell and enter the value.

5 When you have finished adding data for a line, do one of the following:

- Click OK to accept the data.
- Click Cancel to remove the line.
- After you click OK, if you need to cancel the action, click Edit menu ➤ Undo.

Adding Lines From the Add/Edit Data Dialog Box

If you prefer a traditional dialog box, you can use the Add/Edit Data dialog box to create lines.

To add lines in the Add/Edit dialog box

1. Click  (Edit Data In Dialog Box) at the top of the side tool box.
2. Click the Add button to add a new line. Hydraflow Storm Sewers Extension assigns the last line added as the downstream line. For each line that you add, a certain amount of line data is entered automatically based on the values you set in the Design Codes. A line length of 50 feet or 16 meters is also added.
3. Navigate through this dialog box using the Tab key.
4. Click the Inlet/Junction tab to add inlet data.
5. Click OK to accept the data.
6. Click Exit to return to the main application window.

For more information, see Editing Lines on page 28.

For more information about the options on the Pipes tab, see Add/Edit Data Dialog Box - Pipes Tab on page 23.

Add/Edit Data Dialog Box - Pipes Tab

The following section describes the options on the Pipes tab.

Line ID

Specify a name or label to identify the line; for example MHx - MHy. Do not use commas or quotation marks. This interferes with the Hydraflow Storm Sewers Extension file format.

Downstream Line No.

Enter the line number that the current line flows into. If you have drawn your system on the Plan tab, this data item is set. The downstream line number of Line 1 is always 0, the outfall. Hydraflow Storm Sewers Extension supports multiple systems (outfalls). Any line with a zero downstream line number becomes an outfall.

Line Length (ft, m)

Enter the length of this line in feet (meters). It is the distance between junction centers. If you have drawn your system on the Plan tab, this data item is set. When you add lines from the other tabs, Hydraflow Storm Sewers Extension sets the length at 50 feet. You can edit the line length if necessary.

Deflection Angle (Deg)

Enter the angle between this line and the projection of its downstream line in degrees. Angles to the right are positive and angles to the left are negative. The deflection angle for Line 1 is usually 0. To change the orientation of your system, you can specify an angle for line 1 or other outfall line. If you have drawn your system on the Plan tab, this data item is set.

Northing, Easting (ft, m)

Optional. These are the plan x, y coordinates. If you have drawn your system in from the Plan tab, these data items are already set. However, this feature allows you to override and set manually.

Junction Type...

Select the junction type from the list box. A line can have a manhole or inlet at its upstream end and it can be in a Sag or On Grade. You can also specify this on the Inlets tab as the Inlet Type.

Known Q (cfs, cms)

Enter known or additional flow data for this line. This value is added to any other incoming flows and is also carried downstream to be added to other downstream lines when Accumulate Known Qs is selected in the Design Codes. If you selected Use Inlet Captured Flows in the Design Codes, Known Qs are ignored on manholes or non-inlet type junctions.

Drainage Area (ac, ha)

Enter the drainage area that contributes to this line only. Hydraflow Storm Sewers Extension accumulates the areas during the calculations.

Runoff Coefficient (C)

Enter the runoff coefficient corresponding to this drainage area. Hydraflow Storm Sewers Extension computes a weighted or composite coefficient by clicking the  on the side toolbar. Hydraflow Storm Sewers Extension computes a weighted C using the three C values specified in the Design Codes. For more information, see Runoff Coefficients (C) on page 81.

Tc Options

Specify the option of using a known Tc or calculating it using either the FAA or TR55 methods. Choose by clicking the corresponding option button or from the drop-down list on the Pipes tab.
Inlet time is the time it takes for runoff to travel from the most remote upstream point in the drainage area to the inlet in question.

- Known Tc. This is the default method. Simply enter the Tc in minutes.
- FAA method. Collected data from airfield drainage by the Army Corps of Engineers was used to develop this method and is now widely used in urban drainage design.
- TR-55 method. This option allows you to compute Tc by using the 3-component Tc as used by TR-55. Hydraflow Storm Sewers Extension has a built-in TR-55 worksheet that computes Tc.

Inlet Time (min)

Enter the inlet time (overland flow time) for this catchment. It is usually 10 to 20 minutes. This is not the computed Tc for the system but the Tc for this inlet only. Hydraflow Storm Sewers Extension computes the overall Tc during the calculations.
If FAA or TR55 was chosen for the Tc Method, click the corresponding FAA or TR55 button to open the built-in Tc calculator. If using the Pipes tab, click the special function button % to open the Tc calculator. Your cursor must be on the Inlet Time column to activate. The computed values are automatically entered as the Inlet Time.

NOTE You can model a system with Rational method flow information and without inlets. Draw your system using manholes at junctions while specifying drainage areas, C values, and inlet times. In the reports there is no inlet analysis if you use this design method.

Tc Method

FAA or TR55 for more information, see Calculate Tc Using the FAA Method on page 25 and Calculate Tc Using the TR55 Worksheet on page 26.

Invert Elevation Down (ft, m)

Enter the invert elevation for the downstream end of the line. Enter 0 to have Hydraflow Storm Sewers Extension determine the value. When you are adding upstream lines, Hydraflow Storm Sewers Extension automatically places a default value equal to the upstream invert of the downstream line.

Slope of Invert (opt.) (%)

Optionally, enter the slope of the line in percent. If you enter a value, Hydraflow Storm Sewers Extension computes the upstream invert and uses it as the default value for the upstream invert elevation. If you do not enter a slope, Hydraflow Storm Sewers Extension computes it based on the invert elevations you enter.

Invert Elevation Up (ft, m)

Enter the elevation of the invert at the upstream end of the line. Enter 0 to have Hydraflow Storm Sewers Extension set it for you. This item is automatically set to 0 if the downstream invert is set to 0. Hydraflow Storm Sewers Extension does not design downstream inverts when the upstream invert is fixed.

Line Rise (in, mm)

Enter the diameter of the pipe or the height of the box or elliptical pipe in inches (mm). Enter 0 to have Hydraflow Storm Sewers Extension set the pipe size. If you entered 0 for any of the invert elevations, Hydraflow Storm Sewers Extension sizes a circular pipe based on the design velocity. Otherwise the design is based on Manning's Equation setting, where the slope of the energy grade line is equal to the slope of the invert.

Line Type

Displays the current line type in the list box between the Line Rise and Line Span input boxes. Hydraflow Storm Sewers Extension can model circular, box and elliptical pipes. To change the line type, click the arrow in the list box and specify elliptical, box, or circular. Hydraflow Storm Sewers Extension does not design pipe sizes for elliptical or box sections.

NOTE Hydraflow Storm Sewers Extension does not directly model arch pipes because of inconsistent depth-to-area relationships. If you need to model a pipe section such as an arch, it is recommended you use an equivalent section of a box or elliptical section. Set the invert and crown to match conditions. Then compute the span that gives an equivalent cross-sectional area of the desired section.

Line Span (in, mm)

Enter the width of the box or elliptical section in inches. If this line is a circular pipe, press Tab to accept the default.

No. Barrels

Select the number of barrels from the drop-down list. You do not need to adjust the Line Length. The Line Length is the distance between junction centerlines.

Manning's n-Value

Enter the roughness coefficient for this line. Hydraflow Storm Sewers Extension assumes a default value that you set in the Design Codes. To choose other n-values, click the arrow on the list box and select a new value.

Junction Loss Coeff.

Enter the junction loss coefficient for this line. This number usually ranges from 0.15 to 1.5 and is multiplied by the velocity head of the flow exiting the junction of this line. The computed loss is then added to the hydraulic grade line (HGL) at the upstream end of this line (HGUP) to produce the HGJ, and is typically the starting HG for any incoming lines. Hydraflow Storm Sewers Extension automatically computes and assigns junction loss coefficients, based on the junction configuration, if you specify Automatic on the Design Codes - Calculations tab. For more information, see Design Code Settings on page 12 and Computational Methods on page 63.

Inlet / Rim Elev. (ft, m)

Enter the finish or natural ground elevation at the upstream end of the line. This item is used for design when the Calculation Option Design is chosen. Otherwise this entry is only cosmetic.
You must enter the downstream Inlet/Rim elevation when entering Line 1 or other outfall line data. At other lines, the downstream Inlet/Rim elevation is shown but disabled.

Calculate Tc Using the FAA Method

The FAA method bases calculations on data that was collected from airfield drainage by the Army Corps of Engineers. This method is now commonly used in urban drainage design.

To calculate Tc using the FAA method

1 On the Add/Edit - Pipe tab dialog box, under Flows select FAA as the Tc method.

2 Click FAA next to the Inlet Time.

3 In the Tc By FAA Method, specify the following:
   - Flow Length: Enter the hydraulic flow length in feet.
   - Watercourse Slope: Enter the slope of Flow Length as a percentage.
   - Enter the Runoff Coefficient

4 Click Compute to calculate Tc.

5 Click Exit.

Calculate Tc Using the TR55 Worksheet

Hydraflow Storm Sewers Extension allows you to specify up to 3 components for each flow type: areas A, B, and C. These values are saved with the project *.stm* file.

1 On the Add/Edit - Pipe tab dialog box, under Flows select TR55 as the Tc method.

2 Click TR55 next to the Inlet Time.

3 Under Sheet Flow, specify values for A, B, and C. Sheet flow is the flow over plane surfaces usually in the upper reaches of the drainage area. A typical n-value is .011 for smooth surfaces such as concrete, asphalt, or bare soil. Dense grasses yield .24, Bermuda grass is .41, and woods range from .40 to .80, depending on the underbrush.

NOTE This method for computing sheet flow is limited to a flow length of not more than 300 feet. After 300 feet, sheet flow turns to shallow concentrated flow.

4 Under Shallow Concentrated Flow, specify values for A, B, and C. This is the surface between sheet flow and open channel flow. Hydraflow Storm Sewers Extension automatically computes the average velocity based on the watercourse slope and surface type (Paved or Unpaved).

5 Under Channel Flow, specify values for A, B, and C. The program assumes that for these data items the channel is bank-full. Hydraflow Storm Sewers Extension automatically computes the average velocity.

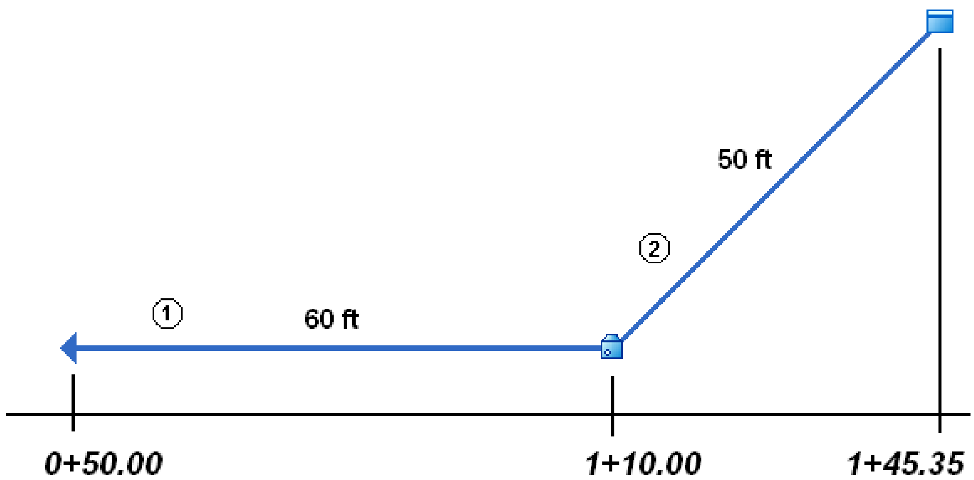
6 Click Compute. Hydraflow Storm Sewers Extension computes Tc and travel times for each segment.

7 Click Exit.

User-Defined Station Up / Down (Add/Edit Data Dialog box only)

This optional item is only available in the Add/Edit Data dialog box. Enter user-defined values that correspond to a Line. Typically these are stations developed from a baseline or centerline from a base map.

User-Defined Stations are shown in the following illustration.



(1) Line 1
User Defined Sta Down = 50.00
User Defined Sta Up = 110.00

(2) Line 2
User Defined Sta Down = 110.00
User Defined Sta Up = 145.35

Hydraflow Storm Sewers Extension optionally plots profile drawing(s) using the stations. For more information, see Plotting Graphs on page 56.

Add/Edit Data Dialog Box - Inlets/Junction Tab

Inlet ID

Enter a name or label for the Inlet; for example, Inlet 1. Do not use commas or quotation marks.

General

Inlet Type

Specify the inlet type from the list. A line can have a manhole or inlet at its upstream end and can be in a sag or on grade. Inlet types can also be entered on the Pipe tab as a Junction Type.

- On Grade: Specify this option if the inlet is on a continuous grade. Enter a positive slope value.
- On Sag: Specify this option if the inlet is in a sump or sag location. Drop curbs are assumed to be in a sag condition.

NOTE This option is not required for Manholes, Headwalls, and None.

Bypass Target

Enter the number of the line that will receive all bypass flows. Enter 0 to have the flows sent offsite. Unlike Downstream Line Numbers, inlet bypass flows can be sent to any inlet in your system. This is useful in situations when gutters flow opposite their line flow. This target is indicated on the Plan tab when you select Gutter Lines on the main application window Options menu.

Curb / Drop Curb Inlet

Specify the following

- Inlet Length: Enter the total length of the opening in feet or meters (Curb, Combination, and Drop Curb inlets).
- Throat Height: Enter the height of the opening in inches or meters, measured from the projection of cross slope, Sx. Do not include any local depression amount.(Curb - Horiz, Combination, and Drop Curb inlets).

Grate/ Drop Grate Inlet

Enter the Opening Area, Width, and Length.

Generic Inlet

Enter a known or assumed capacity for the inlet in cfs, cms. If the generic inlet has a known capacity of 5 cfs, for example, Hydraflow Storm Sewers Extension bypasses 2 cfs if the Q catchment plus Q carryover equals 7 cfs. Generic inlets are not meant to be used in sags. When the user-specified capacity is less than the total Q, Hydraflow Storm Sewers Extension bypasses the excess to the bypass target line. If you set this value to zero, Hydraflow Storm Sewers Extension automatically designs based on 100% capture.

Gutter Details

NOTE Gutter Details are not required for Manholes, Headwalls, None, and Drop inlet types.

- Cross Slope, Sx: Enter the transverse slope of the pavement section only, Sx in ft/ft or m/m.
- Cross Slope, Sw: Enter the transverse slope of the gutter section only, Sw in ft/ft or m/m.
- Local Depression: Enter any local depression amount in inches (mm). This value is measured from the projection of Sx.
- Gutter Width: Enter the width of the gutter section in ft (m). This is the width as it corresponds to the Sw value, if specified, and should not be less than any grate widths specified for this line. For a Drop Grate inlet, select a width wide enough to contain the entire grate width.
- Longitudinal Slope: Required for inlets on grade. Enter the gutter slope, or longitudinal slope of this inlet in ft/ft (m/m). If the inlet is located in a sag, Hydraflow Storm Sewers Extension automatically sets this to 0 and disables the input box. This item is not required for inlets in sags.
- Manning's n-Value: Select an n value for the gutter section. This is not required on inlets in a sags.

Structure

Shape

Optional. This defines the shape of the junction. Choose Circular or Rectangular from the drop-down list.

Length

Optional. If the shape is circular, enter the diameter in ft(m). Otherwise enter the length and width. The length is the direction of the pipe length.

Width

Optional. If the shape is circular, enter the diameter in ft(m). Otherwise enter the width.

Editing Lines

You can edit and recalculate storm sewer lines at any time.

When you change line data the COMPUTE button is displayed on the Results tab, indicating that the data is not current. The data must be current if you want to print reports.

There are three ways to edit lines:

- Double-click the line or data item you want to edit.
- Click  Edit on the toolbar.
- Select Edit Line(s). Click the Edit menu at the main application window. On the Plan tab, click a line to select it. The line color changes to red.

When you are in edit mode, make the necessary changes and then click  Ok or press Enter. Click  or Esc if you do not want to save the changes. To cancel a line edit after you click OK, click Edit menu ➤ Undo. You can use the Undo command after adding a line, editing a line, inserting or deleting a line, renumbering lines, and computing.

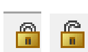
Plan Tab Editing Options

Once you have entered at least one line into your system, Hydraflow Storm Sewers Extension draws and displays your system at the Plan tab. Use the Plan tab to graphically manipulate the layout. Use the zoom icons to enlarge the drawing, move the drawing up, down, left or right, and print the drawing. To move or change the length of line, double-click the line and drag it to make the change. To accept the change, click OK.

When the display option Show Junction Icons is selected, double-clicking a junction icon displays the Add/Edit Data dialog box for editing.

Nodes

Specify that Nodes are locked or unlocked. If locked, all junctions hold their coordinates, except for the junction you are editing. When unlocked, upstream junctions maintain the deflection angles but are relocated according to the new position of the edited line.



Specify a deflection angle and line length. Optionally, lock these parameters to maintain current values by clicking the lock icon.

Ang

Displays the deflection angle for the current line. In the edit mode, you can directly enter the deflection angle. If locked, the deflection angle is held when you adjust the line length.

Length (ft)

Displays the length of the current line. In the edit mode, you can directly enter the line length. If locked, the length is held constant.

Dnstrm Line

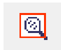
While in the edit mode, specify or edit the downstream line number for the current line.

 Zoom In

Enlarges the drawing. Click and your cursor changes to a crosshairs centered inside a red rectangle. The rectangle represents the scale limits of the enlarged drawing. Move the rectangle to the area you want to enlarge and click. Hydraflow Storm Sewers Extension redraws the system to an enlarged scale. Repeat this process to enlarge further.

 Zoom Out

Enlarges the drawing extents.

 Zoom Drawing Extents

Resets the default scale for the storm sewer system.

 Zoom Background Extents

Resets the default scale for the background image.

Changing Background and Foreground Display Colors

In Hydraflow Storm Sewers Extension you can change the background and foreground colors of the Plan View tab. The default colors are a white background and blue foreground.

To change colors

1. Click Options menu ➤ Plan View ➤ Color. You have options to change Foreground - Lines, Foreground - Gutter Lines, Background, or Use Defaults.
2. Select the item you want to change and in the Color dialog box, select a new color.
3. Click Use Defaults to restore original settings.

NOTE The Foreground - Lines refers to the direction of the bypass and carryover flows of the inlets, not the actual inlets.

Green lines in plan view indicate the direction of the bypass and carryover flows. To toggle the bypass inlet lines on and off, click Options menu ➤ Plan View and select or clear Show Gutter Lines.

Pipes and Inlets Tab Editing Options

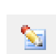
The Pipes and Inlet tabs are similar to a traditional spreadsheet. To edit, double-click an item, make the change and click OK. Use the Tab key to navigate through cells and use the scroll bars to view hidden rows and columns.

When you click a cell to edit, you have the right-click menu options for the Undo, Cut, Copy, Paste, and Delete commands.

Add/Edit Data Dialog Box

Use this dialog box to add and edit data. This box is opened by clicking the Data button on the top of the side tool box or by double-clicking the junction icon.

To access the Add/Edit dialog box

1. On the side toolbox, click  (Edit Data In Dialog Box) or double-click a junction icon in the drawing.
2. Enter or edit data. Use the Tab key to navigate through the fields.
3. Click the Inlet/Junction tab to edit inlet data.
4. Click Exit to return to the main application window.

Global Editing

In the Add/Edit Data dialog box you have an option to apply data edits to any range of lines in your system. For example, you can reset the pipe sizes for a range of lines, or raise or lower the inverts for the entire system.

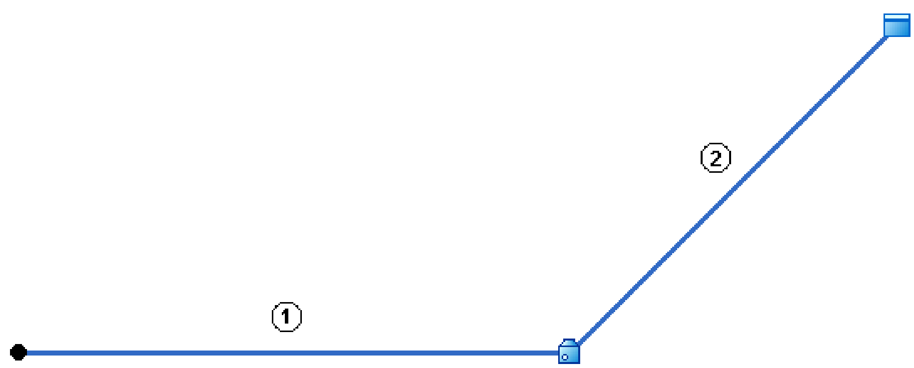
To make global edits to a range of lines

1. In the Add/Edit Data dialog box, select the value you want to change and enter new data. For invert elevations, you can either specify absolute values or add a + or - prefix to the value. For example, to lower each invert elevation by 1 foot, enter -1. To raise the inverts by 0.5 enter +0.5.
2. Click Global.
3. In the Global Edit Line Type dialog box, specify the range or select All.
4. Click OK.

Inserting and Deleting Lines

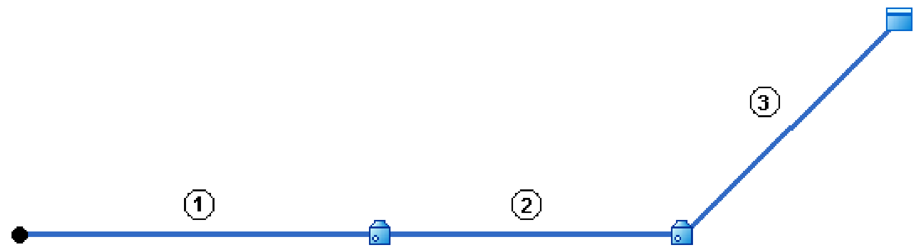
Hydraflow Storm Sewers Extension allows you insert and delete lines from your system at any time. When you insert or delete a line, Hydraflow Storm Sewers Extension renumbers the lines from the point of deletion or insertion to the last line by decreasing or increasing the line numbers by 1. The Line IDs and all line and inlet data are preserved.

The following illustrations show inserting a new line between lines 1 and 2.



(1) Line 1 Outfall

(2) Line 2



(1) Line 1 Outfall

(2) Line inserted is the new line 2

(3)The line that was previously Line 2 now becomes Line 3

To delete a line

1 Click to select the line you want to delete.

2 Do one of the following:

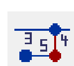
- On the toolbar, click  .
- Click Edit menu ➤ Line ➤ Delete.

The line is deleted. To restore the line click Edit menu ➤ Undo.

To insert a line into an existing system or junction

1 Click to select the line you want to the new line to flow into. The line you select is the downstream line for your new line. If no line is selected, a new line is inserted downstream of Line 1.

2 Do one of the following:

- On the toolbar, click  .
- Click Edit menu ➤ Line ➤ Insert ➤ A New Line.

Hydraflow Storm Sewers Extension automatically inserts a new line that is 50 feet or 15.2 meters long and the last used inlet type.

3 Click OK.

4 Repeat the process as necessary to add more lines.

If you need to remove a line, click Edit menu ➤ Undo.

Inserting Junctions

You can insert junctions into existing lines.

To insert a junction in an existing line

1 Select the line.

2 Click Insert ➤ Junction In A Line. A manhole junction is automatically inserted midway between the upstream and downstream ends.

3 Drag the junction to the desired location.

4 Right-click ➤ OK or click .

5 Double-click the junction. Make any necessary data changes in the Add/Edit Data dialog box.

NOTE Hydraflow Storm Sewers Extension sets the invert in and out elevations and the ground elevations of the new junction by straight line interpolation between the upstream and downstream junctions. Each line number upstream of the new junction is increased by 1.

Moving Lines

In situations when you need to relocate an entire branch of lines in your system, you can change a downstream Line Number and move the line. All the connecting lines are updated. This method of moving the system is not possible if the new downstream line has a higher line number. To move an entire branch, you can click and drag it.

To relocate lines

1 Click Options menu ➤ Plan View ➤ Labels and clear the check mark next to Show Junction Icons.

2 Select the most downstream line of the branch you wish to move.

3 Move your cursor over the downstream end of the selected line until the cursor changes to a crosshair.

4 Drag your cursor to the upstream end of the new location.

5 Click the Options menu ➤ Plan View ➤ Labels and select the check mark next to Show Junction Icons.

Moving a Storm Sewer System

If necessary you can move the entire storm sewer system of lines with one procedure. As you move the system, you can see the X and Y coordinates on the lower status bar.

For more information on moving branches of line see, Moving Lines on page 33.

To move a storm sewer system to specific coordinates

1 Select an outfall line.

2 Click Edit menu ➤ Line ➤ Set Outfall Coord.

3 In the Set Outfall Coordinate dialog box, enter new Northing and Easting values.

To move only the outfall point

1 On the Plan tab, click next to Nodes.

2 Select a line.

3 Move your cursor over the downstream end of the selected line until the cursor changes to a crosshair.

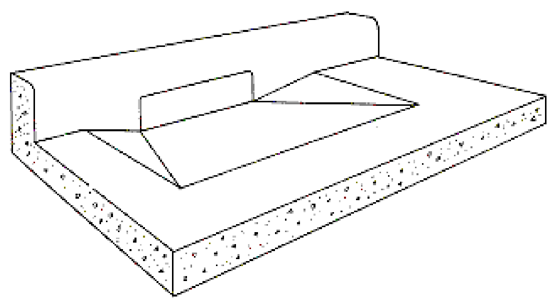
4 Move the cursor to the new location.

Inlet Types

The following section describes Inlet types.

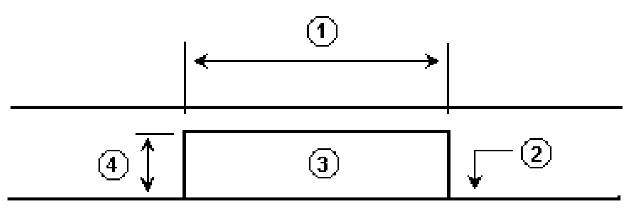
Curb Inlet

A typical curb opening inlet has a rectangular opening along the face of the curb to which it is attached. They can have throat openings that are horizontal or inclined. (This is set in the Design Codes). Hydraflow Storm Sewers Extension assumes inclined throat openings to be 45 degrees.

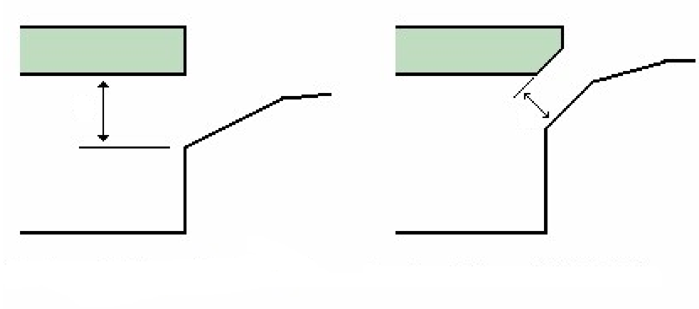


The following illustration shows the front view of a curb inlet where

- 1= Length
- 2= Gutter
- 3= Opening
- 4= Throat Height

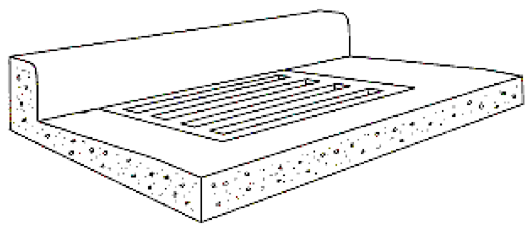


All curb inlets must be either horizontal as shown in the following illustration on the left, or inclined as shown in the following illustration on the right.



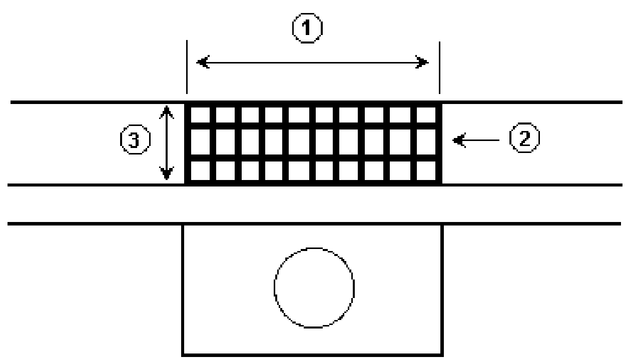
Grate Inlet

With grate inlets on grade, the Gutter Width should equal the Grate Width.



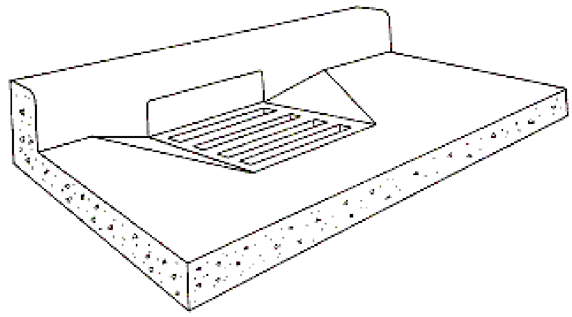
The following illustration shows

- 1= Length
- 2= Grate
- 3= Width



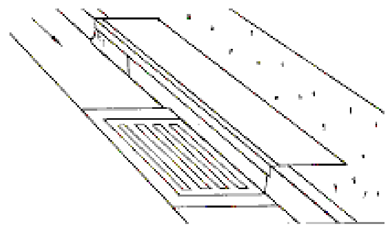
Combination

Combination inlets require the same input data as Curb and Grate Inlets. Enter unique lengths for the grate and curb opening. When the curb opening is larger than the grate length, Hydraflow Storm Sewers Extension assumes the open curb portion is located upstream of the grate, often called a sweeper inlet. Combination inlets are assumed to have horizontal throat openings.



Sweeper Inlets

As determined by HEC-22, the capacity of combination inlets on grade is equal to the grate alone. Capacity is computed by neglecting the curb opening. The sweeper inlet has an interception capacity equal to the sum of the curb opening upstream of the grate plus the grate capacity. The grate capacity of sweeper inlets is reduced from the interception by the upstream curb opening.



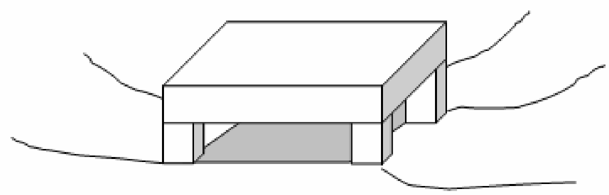
Generic Inlets

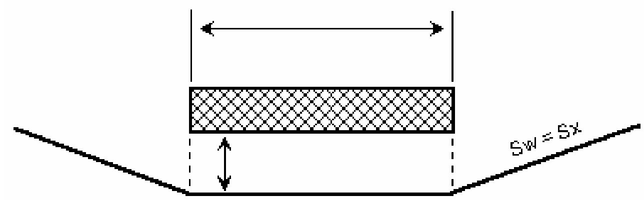
Use this inlet type if none of the other inlet types here work for the design situation, or if you want Hydraflow Storm Sewers Extension to design a capacity for you. For example, if this generic type has a known capacity of 10 cfs, Hydraflow Storm Sewers Extension bypasses 2 cfs if the Q catchment plus Q carryover equals 12 cfs.

NOTE Generic inlets are not intended to be used in sags (zero gutter slope) when the user-specified capacity is less than the total Q. In this situation Hydraflow Storm Sewers Extension bypasses the excess to the bypass line number.

Drop Curb Inlets

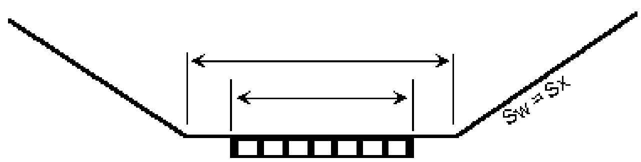
These inlets are a type of curb inlet used in sags in open yard areas. They typically have four sides with rectangular openings. The length you enter should be equal to the sum of the four sides. Compound cross-slopes are not allowed.





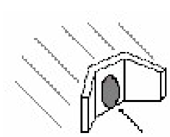
Drop Grate Inlets

Drop grate inlets are similar to the drop curb inlets except that they can be in either sag or grade locations. Their Sx, Sw values must be equal.



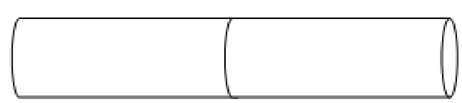
Open Headwalls

Open headwalls do not require gutter or inlet input data. Selecting this junction type is mainly for cosmetic reasons. Headwalls capture 100% of the flow. Enter the Ground/Rim elevation as it corresponds to the top of the headwall. Do not use this junction as an outfall.



No Junction

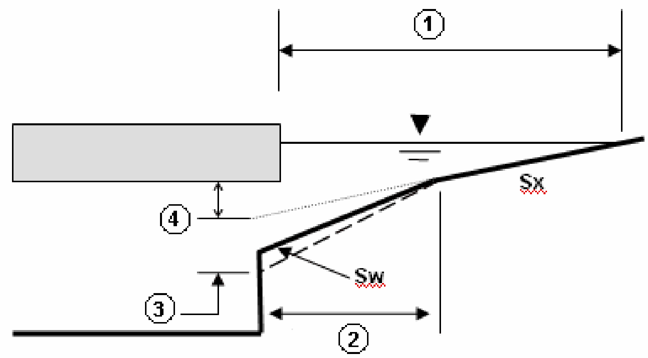
Select No Inlet when you need to connect two pipes without the use of a traditional junction. This is useful for modeling pipes on curves. Make a series of straight lines with No Junction as the junction type. The loss coefficient, when in the Auto mode, is treated the same as a manhole.



Gutters

Inlets have a gutter cross section that consists of a gutter width and slope, and compound gutter cross slopes, (Sw and Sx), and an optional local depression. If Sx and Sw have unique values, HEC-22 calculations treat gutters as if they were depressed. In the following illustration,

- 1= Spread
- 2= Gutter Width
- 3= Local Depression
- 4= Throat Height



Inlet ID

Enter a name or label to identify the inlet; for example, Inlet 1. Do not use commas or quotation marks because they interfere with the Hydraflow Storm Sewers Extension file format.

Inlet Type

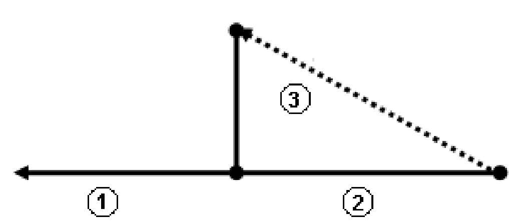
Any line can have a manhole or inlet at its upstream end and can be in a sag or on grade. Select the appropriate inlet type from the list. You can enter this value as a Junction Type on the Pipes tab.

On Grade or Sag

Select On Grade from the drop-down list if the inlet is on a continuous grade. If the inlet is in a sag or sump location, select Sag. This value is not required for Manholes, Headwalls, and None. Drop Curb inlets are assumed to be in a sag condition.

Bypass Target

Enter the line number for the line that the bypass flows into. Enter 0 to have the flows sent offsite. Unlike Downstream Line Numbers, inlet bypass flows can be sent to any inlet in your system. This is useful in situations when gutters flow opposite their line flow. This target is indicated on the Plan tab when Gutter Lines has been selected from the Options menu in the main application window.
In the following illustration, the downstream line number for Line 2 is Line 1, however the bypass target is Line 3.



Inlet Length (Curb, Combination, and Drop Curb inlets)

Enter the total length of the opening in feet or meters.

TIP By setting this value to zero, Hydraflow Storm Sewers Extension automatically designs it for you based on 100% capture.

Throat Height (Curb - Horiz, Combination, and Drop Curb inlets)

Specifies the height of the opening in inches or millimeters and is measured from the projection of cross slope, Sx. Do not include any local depression amount.

Throat Height (Curb-Inclined throat)

This is the height of the opening in inches or millimeters and is measured perpendicular to the throat opening angle (assumed to be 45 degrees). Do not include any local depression amount.

Opening Area (Grate, Combination, and Drop Grate inlets)

Enter the clear opening area of the grate. Required only in sags.

Grate Width and Length (Grate, Combination, and Drop Grate inlets)

Enter the width and length of the grate.

TIP Set the Length to zero for automatic design. Hydraflow Storm Sewers Extension sizes the inlet length for 100% capture. When Hydraflow Storm Sewers Extension designs for grates in sags, including combination inlets, it sizes the grate opening area based on the Grate Design Depth in the Design Codes.

Known Capacity (Generic inlets)

Enter a known or assumed capacity for this inlet in cfs, cms. If the generic inlet has a known capacity of 5 cfs, for example, Hydraflow Storm Sewers Extension bypasses 2 cfs if the Q catchment plus Q carryover equals 7 cfs.

WARNING Generic inlets are not meant to be used in sags. When the user-specified capacity is less than the total Q, Hydraflow Storm Sewers Extension bypasses the excess to the bypass target line.

TIP By setting this value to zero, Hydraflow Storm Sewers Extension automatically designs it for you based on 100% capture.

Cross Slope, Sx

Enter the transverse slope of the pavement section only, Sx in ft/ft or m/m. The value equals Sw when modeling Drop inlets. This item is not required for Manholes, Headwalls or None inlet types.

Cross Slope, Sw

Enter the transverse slope of the gutter section only, Sw in ft/ft or m/m. The value equals Sx when modeling Drop inlets. This item is not required for Manholes, Headwalls, None and Drop inlet types.

Local Depression

Enter any local depression amount in inches (mm). This value is measured from the projection of Sx.

Gutter Width

Enter the width of the gutter section in feet (meters). This is the width as it corresponds to the Sw value, if specified, and should not be less than any grate widths specified for this line. If this is a Drop Grate inlet, you should select a width wide enough to contain the entire grate width. This item is not required on Manholes, Headwalls, None, and Drop Curb inlet types.

Longitudinal Slope

Enter the gutter slope, or longitudinal slope of the inlet in ft/ft (m/m). If the inlet is located in a sag, Hydraflow Storm Sewers Extension automatically sets this value to 0 and disables the input box. This item is not required on Manholes, Headwalls, None, Drop Curb inlet types or inlets in sags, but is required for inlets on grade.

Manning's n-Value

Select an n value for the gutter section. This is not required on any inlet in a sag, Manholes, Headwalls, None and Drop Curb inlet types.

Structure Shape

Optional. Defines the shape of the junction. Choose Circular or Rectangular from the drop-down list.

Structure Diameter / Length, Width

Optional. If the shape is circular, enter the diameter in feet (meters); otherwise, enter the length and width. The length is in the direction of the pipe length while the width is perpendicular.

Labels

On the Plan tab you have options to annotate your drawing with user-defined labels. There are options for various available fonts and colors.

WARNING Do not use quotation marks in the label text.

To add labels

1 On the Plan tab, click  (Add Text To Drawing).

2 Drag your cursor to move the label box to the area you want to annotate, click and enter text.

3 Click  .

To edit label fonts

1 On the Plan tab, click  .

2 In the Font dialog box, make the necessary changes and click OK.

3 Click  .

To move labels

1 Hold your cursor over the upper left corner of the text. The cursor changes to a crosshairs.

2 Drag the label to a new location.

To edit or delete labels

- Double-click a label and make changes.
- Click the label you want to delete and click  .

To change the label display options

1 On the Plan view tab, click Options menu ➤ Plan View ➤ Labels.

2 Select from the following label display options. Labels with check marks are displayed.
   - Show Line Numbers

- Show Line Ids
- Show Inlet Ids
- Show User Defined Labels
- Show Junction Icons

3 Text Scale gives you options to adjust the size of the labels from small to medium to large. The Auto selection adjusts the font size based on the drawing scale.

Computing the System

When you have completed entering line data, the next step is to compute the storm sewer system. Select one of the following options from the Compute menu:

- Analysis and Design
- Enhanced Modeling System (EMS)
- Full Design
- Capacity Only

For more information, see Calculation Options on page 43.

You can also click  on the main application window to compute the system.

NOTE After you complete the storm sewer system design, Hydraflow Storm Sewers Extension considers it to be an existing system.

After you compute the system, the results are displayed on the Results tab in several report styles. You can print the reports from the results tab or select formal reports from the Print Reports option. For more information, see Reports on page 49.

The following section describes the options on the Compute System dialog box.

Hydrology

Return Period

Select a return period from the drop-down list. The Rational Method flow calculations performed are based on the return period. If you are using Known Qs or the Capacity Only calculation option, this value is cosmetic and does not affect calculations; you should specify Known Qs only.

Calculation Options

For more information on each option, see Calculation Options on page 43.

Analysis w/Design

Select in situations where downstream constraints are important, and when you need to correct deficiencies in an existing systems. This method starts downstream and works upstream and does not recognize the minimum cover constraint.

Enhanced Modeling System (EMS)

Select for existing systems where hydraulic analysis is critical and maximum accuracy important. EMS has all the design features of the Analysis and Design option. Pipes and slopes are designed only on the first iteration.

Full Design

Select to force pipe slopes to follow the ground surface instead of the theoretical slope calculated with Manning's Equation. This option reduces the occurrence of drop structures and excavation costs. The pipe slope does not exceed the Maximum Slope set in the Design Codes.
Use the Full Design option when upstream constraints are important and when designing new systems. This method works from the upstream down and adheres to the minimum cover constraint.

Capacity Only

Select in situations when you want to use the Qs equal to the full-flow capacity of the pipes. When you specify this option, Rational Method flow data and known Qs are ignored. Hydraflow Storm Sewers Extension computes flows using Manning's Equation where A = full area of the pipe, and S = slope of the invert.

Design Options

Reset Pipe Sizes

Specifies all pipe sizes are reset to zero.

Reset Invert Elevations

Specifies all invert sizes are reset to zero.

Hold Outfall Invert(s)

Specifies the outfall invert values do not change.

Starting HGLs

Outfall Line ID

Displays the line ID.

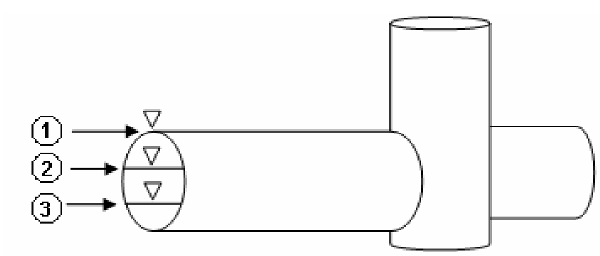
Invert Elev Dn (ft)

Specifies the invert elevation.

Starting HGL

Specify the known elevation in the drop-down box. This is the elevation of an existing tailwater from where the hydraulic grade line (HGL) calculations begin at the downstream end of the outfall line. This elevation cannot begin below critical depth. If you set the elevation below critical depth, it is automatically reset to critical depth. If you do not know the elevation, specify one of the following as shown in the illustration:

- (1) Crown: Sets the tailwater at the crown of the downstream end of the line.
- (2) Normal: Sets the initial tailwater at normal depth (as determined by Manning's Equation) of the line. In situations where the normal depth is less than the critical depth, Hydraflow Storm Sewers Extension changes the starting HG to critical depth.
- (3) Critical: Sets the initial tailwater at critical depth (min. specific energy) of the line.



- (dc + D)/2: Follows the starting HGLs used in HDS-5 and is (Critical depth + Diameter) / 2.

User Options

Use Interactive Feature

Select to display an interactive design screen where you can modify the design during the design process and see how the modifications affect the computed HGL.

NOTE This option is only available when you specify Analysis w/Design or Full Design in the Calculation Options.

For more information, see Use Interactive Feature on page 44.

Calculation Options

In the Compute System dialog box, you can choose from one of the following options to compute results.

Analysis w/ Design

After the flows have been computed, this option analyzes and designs starting downstream and working upstream, and uses the existing data for the calculations, such as pipe sizes and invert elevations. Data options that are set to 0, are designed by Hydraflow Storm Sewers Extension. First Hydraflow Storm Sewers Extension calculates the pipe size based on the specified design velocity, (Q/V = A). Next it computes the corresponding invert slope based on Manning's Equation, and with the new pipe area. Based on the settings in the Design Codes, it sets the downstream crown (or invert) equal to the next downstream line's crown (or invert). If the inverts have been set to 0, then Hydraflow Storm Sewers Extension begins at the downstream end of Line 1, sets the crown elevation equal to the starting HG, and proceeds upstream. Hydraflow Storm Sewers Extension does not assign pipe sizes outside the range you specify in the Design Codes.

Enhanced Modeling System

Traditionally, storm sewers are designed to flow full because the pipes are sized to accommodate the design flows and velocities, and there are no conflicting numbers, so the time of concentration (Tc) matches the flow rate (Q).

When analyzing existing systems, the actual velocity is not known until the hydraulic grade line (HGL) is computed. The computed Qs and HGL are based on assumed pipe velocities. When the actual velocity is different from the assumed velocity, the computed Tc is incorrect and the computed Q and HGL are incorrect. Enhanced Modeling System solves the problem by directing Hydraflow Storm Sewers Extension to recompute the hydraulic grade line, based on actual flow rates and actual Tc. Hydraflow Storm Sewers Extension computes three system iterations so that the computed Tc matches what was assumed with reasonable accuracy.

Hydraflow Storm Sewers Extension first computes the HGL using the Tc based on the design velocity. Next it computes the storm sewer system a second time using Tc based on actual velocities. These new velocities are still incorrect because they are based on the original HGL calculation, however they are more accurate than those used on the first trial. Several system iterations cause the Qs, Tcs and resulting HGL to converge to correct values. Three iterations are the most practical balance between accuracy and the time required to produce the results.

Full Design

With this option, Hydraflow Storm Sewers Extension resets all pipe sizes and invert elevations to zero and redesigns the entire system. Pipes are sized first based on the specified minimum/maximum pipe sizes and design velocity. It then computes the invert slopes using Manning's Equation and the computed pipe size. Next it sets the invert elevations as high as possible but always below the minimum cover specified. At junctions, the outlet invert elevation is fixed by the lowest Inlet/Rim elevation. This option requires all lines to have Inlet/Rim elevations.

When selecting pipe sizes, Hydraflow Storm Sewers Extension computes the required area based on the design velocity. All pipe sizes are within the range specified in the Design Codes.

Capacity Only

This option has some design limits. For example, if a pipe size has been set to 0 for design, Hydraflow Storm Sewers Extension cannot size it because it does not know the flow rate, Q. It sets the pipe size equal to the minimum size specified in the Design Codes. Pipe inverts and slopes are set by the same methods as in the other calculation options, using Manning's Equation and the design velocity.

Use Interactive Feature

Select the Use Interactive Feature to display the Storm Sewer interactive dialog box, where you can graphically modify the design during the design process. Even when using Full Design, you can immediately see how the modifications affect the computed HGL.

NOTE This option is not available if you specify Enhanced Modeling System or Capacity in the Calculation Options on the Compute System dialog box.

During the calculation process, Hydraflow Storm Sewers Extension plots the current line or inlet. Hydraulic information displayed in the top section of the dialog box is read only. In the bottom section of the dialog box, you can make modifications using the arrow buttons. The arrow buttons increase or decrease the values for the selected data item. To change the data item, click the item in the Pipes or Inlets tab.

Hydraflow Storm Sewers Extension sets the invert and pipe size and then plots it. You can redesign the system in many ways such as, resize the line, raise or lower the inverts individually or together, and realign the pipe with its downstream or upstream lines. You can also realign the up or downstream ends with the Minimum Cover line (green dotted line). Each time you make a change, Hydraflow Storm Sewers Extension updates the calculation so you can immediately see the results.

When you are ready to accept the current design, you can move to the next line, oversee the design as it progresses, and make any necessary changes. Proceed through the lines or click Finish at any time to skip interacting with the remaining lines. You can move back and forth between lines.

HGL data is appended with an “i” when flowing under inlet control and a “j” when the line contains a hydraulic jump.

You can use the interactive feature with both pipe data and inlets, and you can work in the line Profile, Inlet Section and Plan view.

The following section describes the options in the Interactive display.

Slider Control

Use this control to increase or decrease the sensitivity or increments of the blue arrow controls. The minimum is .01 and the maximum is 1.0. Each time you click the blue arrow, the value changes by the amount set in this control. For example, you might want to set the value to 1.0 to adjust inlet throat heights and to 0.01 to adjust invert elevations.

NOTE The Slider control is not used when changing pipe sizes. Also, the control value is divided by 10 when adjusting gutter slopes and inlet cross slopes, Sx and Sw.

Navigation Controls

Each of the display views (Profile, Inlet Section, and Plan), have common navigation controls that you can use to move through the storm sewer system design.

Undo

Returns the line to its previous state.

Design

Totally redesigns the line size and invert elevations using the Analysis w/ Design Calculation Option. The pipe size and invert elevations are reset to zero and designed with the values you specify in the Design Codes. The inlet is redesigned from the Inlet Section view.

Up

Moves to the next upstream line. Click > to go to the last upstream line.

Down

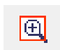
Returns to the previous line. Click the < to go to Line 1.

Finish

Stops the interactive design process at any time. Hydraflow Storm Sewers Extension completes the design with no user interaction.

Cancel

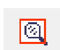
Cancels the current operation. To restore previous values, on the main application window click Edit menu ➤ Undo Compute.

 Zoom In

Enlarges the drawing. Click the Zoom In icon. The cursor changes to a crosshairs centered inside of a red rectangle. The rectangle represents the scale limits of the enlarged drawing. Move the rectangle with your cursor to the area you want to enlarge, and then click. Hydraflow Storm Sewers Extension then redraws the system to an enlarged scale. Repeat this process to enlarge further.

 Zoom Out

Enlarges the drawing extents. Repeat as desired.

 Zoom Drawing Extents

Resets the Scale: When Hydraflow Storm Sewers Extension draws the system, it selects a scale so the entire system is displayed. To redraw the system to this default scale, click the Reset button.

 Design Codes

Displays the Design Codes dialog box. If you make changes in the Design Codes, the changes affect only the current line and upstream lines. To make the changes global, move downstream to Line 1 and proceed back upstream.

 Toggle On/Off EGL Line

Toggles the Energy Grade Line off and on. When selected On, the EGL plots as a black dotted line.

 Print

Sends a hard copy of the display to the printer.

Profile View - Storm Sewer Design Dialog Box

Pipe

Size

The pipe size is increased or decreased (commercially available sizes only) using the arrow control. If the line is a box or elliptical section, only the Rise changes.

Barrels

Increase or decrease the number of pipe barrels with a maximum of four barrels.

Invert Locked

Dn, Dn and Up, Up

Click up or down, to increment or decrement the selected invert variable by the amount set by the slider control. When Down and Up has the focus, both inverts are changed.

Inlet/Rim Elevation

Dn or Up

Click up or down to increment or decrement the selected inlet/rim elevation variable by an amount set by the slider control.

Known Q

(cfs)

Add or subtract flow from the system. This is useful for extracting Q in order to lower the HGL to a specific level. The Known Q also affects inlets and it is possible to zero-out the overland flow to the inlet. You can globally edit the junction types temporarily to Manholes.

 Match Crowns

Adjusts the invert elevations for the line to conform to the Alignment setting in the Design Codes. For example, modifying the pipe size can cause the pipe crowns to go out of alignment. This option resets the new pipe to match the crown of the line.

NOTE This control affects only the Invert Elevation value that is selected. For example, when the Invert Dn is selected, this button realigns only the downstream invert.

 Adjust to Min. Cover

Moves the pipe up or down to match the minimum cover line. The minimum cover displays as the dotted green line.

NOTE This control affects only the selected Invert Elevation value. For example, when the Invert Up is selected, this button realigns the upstream invert only.

Lock to hold the invert elevations while you make adjustments, for example to the pipe size. If unlocked, adjusting a pipe size causes the crown to stay in place and the inverts to lower. When locked, the crown moves up or down.

Carry Edit Downstream

Carries the invert edits in the downstream direction to connecting lines.

NOTE When carrying edits downstream, only lines in the direction of flow are affected. In other words the change goes only with the flow, not the numbers.

Carry Edit Upstream

Invert edits in the upstream direction to other connecting lines. For example, if you raised the upstream invert elevation of a particular line by 1 foot, this would render other upstream lines a foot below. By clicking the Carry Edits Up, all lines in the upstream direction are raised by 1 foot.

Inlet Section View - Storm Sewer Design Dialog Box

Hydraflow Storm Sewers Extension has the ability to interactively modify inlet parameters. The inlet analysis feature provides a better understanding of the methodology, the variables involved, and how they affect the interception capacity of inlets. For example, this feature could analyze the minor effect Throat Height has on Curb Inlets on grade, or the more dramatic effect of changes in cross slope and local depressions on the same type of inlet.

Similar to the Profile view, click the data cell you want to edit, and then use the arrow controls to increase or decrease the value. The increments are equal to the Slider control value with the exception of the Gutter properties (Sl, Sw, and Sx). Those increments are equal to the Slider value / 10.

Image Controls

These controls allow you to manipulate the views of the drawing. They function differently, however, depending on whether you are in 2D or 3D mode.

Toggle 2D or 3D display

Displays the view of the inlet in either 2D or 3D.


Adjust Y-Scale

While in 2D view, these independently increase or decrease the Y scales. In 3D view, they move the location of the center of projection.


Adjust X Scale

While in 2D view, these independently increase or decrease the X scales. In 3D view, they move the location of the center of projection.


Reset

Resets the drawing scale to the default.

Plan View - Storm Sewer Design Dialog Box

Use the Plan view button to display information for each line and to navigate through the lines in the system.

When you use the navigation controls, Hydraflow Storm Sewers Extension follows the flow path and not the line numbering sequence.

To view or edit a particular line, click the junction icon for the line, and then switch to the Profile or Inlet Section window to make changes.

Results Tab

When you have finished computing the system, Hydraflow Storm Sewers Extension displays the final results on the Results tab. On this tab you can choose various report tabs to view your data. You also have the option to create a custom report.

To print the Results tab data, click  . Using this option does not print a formal report.

You can save a report to a comma-delimited or tab-delimited text file and then export it to another program.

To export a report file

1 Click File menu ➤ Import/Export ➤ Export ➤ Export Results ➤ and choose either Tab-delimited Text File or Comma-delimited Text File

2 In the Save As dialog box, specify the location and enter the file name.

3 Click Save.

IMPORTANT On the Results tab, the Compute button indicates the results are current. If you make edits to the data, you must recompute that data to make the Results tab current.

The following section describes the information contained in the various report types displayed on the Results tab.

Summary

Displays the results in a summary form. Use the vertical and horizontal scroll bars to view any hidden data. The minor loss is the junction loss at the upstream end of the line. HGJ is the HG in the junction, HGL UP, and Minor Loss.

DOT Style

Similar to a traditional Department of Transportation tabulated report. Use the vertical and horizontal scroll bars to view any hidden data.
In this report, the Total Flow can be more or less than the Capacity. The capacity is Q based on Manning's Equation with full flow. This equation assumes the slope of the energy grade line, EGL, is equal to the slope of the invert, which is rarely the case. If the slope of the EGL is greater than the slope of the invert, it is most likely that the total flow is greater than the full flow capacity. If the slope of the EGL is less than the slope of the invert, the total flow can be less than the full flow capacity, and the pipe could be flowing full.

NOTE The Total Flow may not equal the flows computed by Total Runoff and Additional Q. If you select the Use Inlet Captured Flows In System option in the Design Codes - Calculations tab, the Total Flow in this report equals what is captured by the inlet(s).

Inlet

Reports the inlet analysis. The intended data does not apply to cells that do not contain information. The column, Q = CIA also includes any additional or Known Q's. The Inlet Spread refers to the spread width at the inlet, and the Gutter Spread refers to the gutter just upstream of the inlet.
Inlets in a sag or those that have equal Sx and Sw have equal inlet and gutter spread widths.

FL DOT

Modeled after the state of Florida Department of Transportation, this report uses the built-in runoff coefficients specified in the Design Codes, C1, C2, and C3. The columns headings are as follows:

- Actual Velocity: The average of the upstream and downstream velocities.
- Design Velocity: The velocity of the pipe at Design Capacity.
- Actual Capacity: The actual flow in the pipe.
- Design Capacity: The full-flow capacity of the pipe as determined by Manning's Equation.

If you compute the system using the Calculation Option for Capacity Only, these values report as equal.

My Report

Create a report with customized columns of data.

HGL Calcs

Provides a line-by-line tabulation of the hydraulics of the system. A complete description of the procedure is available as a hard-copy print-out.
Depths and HGL/EGL values are appended with the following footnotes when the indicated conditions exist

- ** Critical Depth: Indicates the depth is at critical.

- i – Inlet Control: Indicates the line under inlet control.
- j – Line: Contains hydraulic jump.

Changing the View of the Results Tab

Choose from the following options to change the view and display order of the data on the results tab.

If you want to...	Then
Freeze columns	Starting with the left-most column, move the cursor over the first, non-frozen column, usually the Line No. column to start, but not over the column heading. As you move the cursor to the left, the cursor changes to a lock icon. Drag the cursor to the right for the number of columns you want to freeze. To unfreeze, repeat the process in reverse.
Move columns	Hover over the desired column heading. The cursor changes to an arrow with a box at the bottom. Drag the column either right or left to the new position.
Resize columns	Hover over a column line in the heading. The cursor changes to a sizing cursor. Drag the column line to a new position.
Delete columns	Hover over a column line in the heading and drag the column to a zero width.
Select a range of columns	Click the rows in the range that you want to select.
Refresh columns	Click the Refresh button on this tab. This does not affect frozen columns.
Reorder columns	Click to reverse the display order.

Reports

The Results tab presents the data for the storm sewer system in spreadsheets for the various report methods. Using the Print Reports command you can create formal report sheets for the storm sewer data.

Print Reports

In the Print Reports dialog box, you can choose from the following report format options:

- Plan View
- Inventory
- Structures
- Tc Tabulation
- Summary
- DOT Style

- Inlet
- FL-DOT
- MyReport
- HGL Calcs
- w/Procedure

Cost Estimate

- RCP
- CMP
- PVC

Options

Specify the lines you want in the report and the option to Print Upstream To Downstream.

To display the Print Reports dialog box

1 Click File menu ➤ Print, or click  .
Hydraflow Storm Sewers Extension adds the project name to your reports. The Project name is specified in the Edit pull-down menu on the main application window.

2 Select a report style. Only report styles with current input data are available.

3 Specify the range of lines to include in the report.

NOTE This option does not apply to the Plan View.

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4 Specify the Cost Estimate. You can specify the three options if you want to report the cost for each type of pipe material.

5 By default, reports print starting from Line 1 working upstream. Optionally specify Print Upstream to Downstream to reverse the direction.

6 Click Preview to view the report. If you have specified multiple report styles, use the navigation arrows to view each page.

7 Click Print.

NOTE Hydraflow Storm Sewers Extension automatically sets the orientation of your printer on Landscape.

Creating A Custom Report

The first time you create a custom report, click My Report on the Results tab. In the Custom Report dialog box, enter a name for the report (9 character limit). This name does not reflect the name of the *.rpt* file, but it is the name on the custom report button on the Results tab. Hydraflow Storm Sewers Extension automatically loads the most recently used custom report at startup, similar to the IDF curves. The button on the Reports tab defaults to the name of the last used custom report.

NOTE The first column, Line No. is fixed and must be a part of all reports. It cannot be deleted.

With Custom Reports you can

- have up to 100 columns
- repeat variables
- add and delete columns
- save multiple custom report layouts

For more information and a description of each variable, see Custom Report Variables List on page 51.

Custom Report Toolbar

Icon	Action
Clear Table	Clears existing report table.
Open Report	Browse to a previously saved report.
Save Report	Saves the current report with a *.rpt* extension.
Help	Displays the online Help.

To create a custom report

1 On the Results tab, click the MyReport button.

NOTE The custom report button on the Reports tab defaults to the name of the last used custom report.

2 Specify a Report Name.

3 Click to clear the existing report.

4 Click to add a new column.

5 Click the drop-down arrow in a column heading and specify the variable.

6 Click Apply.

7 Repeat steps 4 and 5 to add columns and variables.

8 Click to save the report and return to the main application window.

Custom Report Variables List

This section describes the variable options that are available in the custom report columns.

Area Dn

The cross-sectional area of flow at the downstream end of the line.

Area Up

The cross-sectional area of flow at the upstream end of the line.

Bypass Line No.

The line which receives bypass flows.

C1, C2, C3

User-defined runoff coefficients specified in the Design Codes.

Capacity

Full-flow capacity of the line as determined by Manning’s Equation with the slope, S, set to the slope of the invert.

Cover Dn

The distance from the Ground/Rim Elev Dn to the top of the downstream end of the line. N/A if Ground/Rim Elev = 0.

Cover Up

The distance from the Ground/Rim Elev Up to the top of the upstream end of the line. N/A if Ground/Rim Elev = 0.

Critical Depth

The depth at minimum specific energy.

Cross Slope, Sw

The cross slope of the gutter section.

Cross Slope, Sx

The cross slope of the pavement section.

Curb Length

The length of opening for curb and drop curb inlets.

Deflection Angle

Angle between the line in question and a line projecting upstream of the downstream line. Angles to the right are positive, left are negative.

Depth Dn

Depth of flow at the downstream end of the line.

Depth Up

Depth of flow at the upstream end of the line.

Downstream Line No.

The number of the line, to which the current line connects at the downstream end.

Drainage Area

Area of land contributing to runoff for the current line or inlet. Not a total.

Easting, X

The X or Easting coordinate of the upstream end of the line.

EGL Dn

Energy grade line at the downstream end of the line. HGL Down plus velocity head.

EGL Up

Energy grade line at the upstream end of the line. HGL Up plus velocity head.

EGL Junct

Energy grade line in the junction at the upstream end. HGL Jnct plus Velocity Head Up. Equals HGL Jnct when under Inlet Control.

Energy Loss

Energy loss due to pipe friction. Equals the average friction slope times the line length.

Flow Rate

The flow (Q) used to calculate the hydraulic grade line (HGL) in the system.

Friction Slope Ave

Average slope of the energy grade line, or (S), determined by Manning's Equation.

Friction Slope, Sf Dn

The slope (S) determined by Manning's Equation using the parameters at the downstream end of the line, depth, area, wetted perimeter.

Friction Slope, Sf Up

The slope (S) determined by Manning's Equation using the parameters at the upstream end of the line, depth, area, wetted perimeter.

Grate Area

The clear opening area of the inlet grate.

Grate Length

The longitudinal length of the inlet grate.

Grate Width

The transverse width of the inlet grate.

Ground/Rim Elev Dn

The elevation of the ground/rim as entered for the downstream line of the line in question.

Ground/Rim Elev Up

The elevation of the ground/rim as entered at the upstream end of the line in question.

Gutter Depth

Depth of flow in the gutter, upstream of the inlet.

Gutter Slope

Longitudinal slope of the gutter.

Gutter Spread

Width of flow in the gutter, upstream of the inlet.

Gutter Width

The transverse width of the gutter.

HGL Dn

Hydraulic grade line at the downstream end of the line.

HGL Up

Hydraulic grade line at the upstream end of the line. Does not include the minor loss.

HGL Jnct

Hydraulic grade line in the junction at the upstream end of the line. This value is equal to HGL Up plus the minor loss.

HGL Jump Up

The elevation of the water surface at the initial depth (upstream end) of a hydraulic jump.

HGL Jump Dn

The elevation of the water surface at the sequent depth of a hydraulic jump.

Hw

Headwater. The elevation of the HGJ minus the invert elevation upstream.

Incr CxA

Runoff coefficient (C) times the Drainage Area for the individual catchment.

Incr Q

Incr CxA times Intensity. Also known as Q catchment or runoff to the individual inlet.

Inlet Depth

Depth of flow at the inlet face.

Inlet Efficiency

Q Captured/Q Catchment expressed as a percentage.

Inlet ID

User-defined text to describe the inlet.

Inlet Location

Sag (Gutter Slope = 0) or on grade (Gutter Slope > 0).

Inlet Spread

Width of flow at the inlet.

Inlet Time

User-defined travel time of the Drainage Area.

Intensity System

The computed intensity at a given point or node in the pipe system based on Tc.

Intensity Inlet

The computed intensity at a given inlet based on Inlet Time.

Invert Dn

Invert elevation at the downstream end of the line.

Invert Up

Invert elevation at the upstream end of the line.

Jump Loc

Location of the hydraulic jump. Equals the distance from the downstream end of the line to the sequent depth.

Jump Len

Length of the hydraulic jump. Distance upstream from the sequent to initial depth.

Junction Loss Coeff.

User-defined value multiplied by velocity head to compute minor loss. Refers to the upstream end of the line.

Junction Type

Manhole, Curb Inlet, Headwall.

Known Q

User defined. Any additional known flows to be injected into the system at the upstream end of the line. This value is also is added to inlet flows.

Line Cost
The total cost of the line as determined by the cost codes.

Line ID
User-defined description for the line.

Line Length
Length of the line from center-to-center of junctions.

Line Size
The line Rise and Span reported in one column, including multi-barrels.

Line Slope
Slope of the line. Invert (Up – Invert Dn) / Line Length. Expressed as a percentage.

Line Type
Circular, Elliptical or Box section.

Local Depression
User defined. Amount of depression for the inlet. Measured from the projection of Cross Slope (Sx).

Mannings n Gutter
N-value of the gutter section.

Mannings n Pipe
N-value of the line.

Minor Loss
Junction Loss Coeff. x Velocity Head.

Northing, Y
The Y or Northing coordinate of the upstream end of the line.

Pipe Travel Time
Equals Line Length / Velocity Ave. Can be suppressed to zero in Design Codes.

Q Bypass
Flow that is not captured by an inlet and bypassed to the bypass target line.

Q Captured
Flow that was captured by the inlet.

Q Carryover
Q Bypass from an upstream inlet.

Rise
Vertical distance traversed by the pipe.

Runoff Coeff.(C)
Rational Method runoff coefficient.

Span
Horizontal distance traversed by the pipe.

Storage
The volume of the flow in the line based on actual depths.

Subarea, A1, A2, A3
The drainage area corresponding to C1, C2, and C3 for the catchment in question.

Tc

Time of concentration.

Throat Ht

Vertical distance of the inlet throat opening measured from the projection of cross slope (Sx).

Total Area

Total drainage area contributing to flow at a given point in the system.

Total CxA

Sum of incremental CxA up to a given point in the system.

Total Runoff

Total CxA x Intensity System.

User Sta Dn/Up

User-defined stations.

Velocity Ave

Average velocity in the line.

Velocity Dn/Up

Velocity at the downstream / upstream end of the line.

Velocity Head Dn/Up

Velocity head at the downstream / upstream end of the line (V2/2g).

Velocity Head Jump Dn/Up

Velocity head at the sequent and initial depths of the jump respectively.

Plotting Graphs

Hydraflow Storm Sewers Extension offers two types of plots:

- A multipurpose Line Plot with a single-line drawing, inlet, and plan
- Profile plot

Line Plot

A line plot is a drawing of an individual line that shows a profile view, inlet section view, and a plan view.

To draw a line plot

1. On the main application window, select a line.
2. Click  .

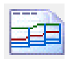
   The line properties are displayed at the bottom of the screen. HGL data is appended with an “i” if its flowing under inlet control and appended with a “j” if the line contains a hydraulic jump.
3. Use the directional arrow buttons to move from one line to the next. Hydraflow Storm Sewers Extension moves in the direction of the flow, and not necessarily by line number.

NOTE Preview is not available on individual line plots.

Profile Plot

Hydraflow Storm Sewers Extension draws a horizontal profile of lines from the Start line to the End line. The profile is automatically drawn from left to right, working upstream. The profile is drawn only as the water flows, and any branches in the range of lines selected are ignored.

To draw a profile

1. Click  on the upper toolbar.
2. To change the range of lines, select the line numbers from the drop-down list, and then click Redraw button.

   NOTE To draw a profile of a range of lines, on the Results tab, click and drag to highlight the lines and then click  .

3. Optionally use the scale options to change the scale of the profile drawing.
   - Y Min: The elevation where the Y-scale begins. Enter the new elevation and then click the Lock button. To revert to the default scale, unlock.
   - Y Max: The maximum elevation of the Y-scale. Enter the new elevation and then click the Lock button. To revert to the default scale, unlock.
   - Y-Axis Ticks (Spin button): Increase or decrease the number of Y-scale tick marks on the plot by using this spin button located to the right of the Y-Max Lock.
   - XIncr: This is the horizontal scale selector. Choose a desired scale from the drop-down list. Next, click the adjacent Lock button to set and redraw at the new scale. To revert to the default scale, unlock.
   - X-Axis ticks (Arrows): Increase or decrease the number of X-scale tick marks on the plot by using the arrows located to the right of the XIncr Lock.
4. Optionally, use the following label options:
   - Junction Label On/Off
   - Pipe Label On/Off
   - Text size
   - HGL On/Off
   - EGL On/Off
   - Nat Grnd On/Off
   - Horiz Grid On/Off
   - Vert Grid
   - Toggles Reach to User Stationing

NOTE You can zoom in on a plot by simply dragging your cursor from the upper left to the lower right of the desired extents.

Exporting a Profile to DXF

Use this command to export the current plot as a *.dxf* file for use in CAD programs.

To export a profile to DXF

1 On the toolbar, click  .

2 In the Storm Sewer Profile dialog box, click  .

3 In the Export Profile as DXF dialog box, enter the following values:

- Horizontal Scale: Select a horizontal scale from the drop-down list.
- Vertical Scale: Enter the vertical scale.
- Text Scale Factors: Enter a text scale value for the Station Elevations and the Lines.
- Border: Select this option to draw a border around the profile.

4 Click OK.

5 Enter a file name and click Save. Labels and lines are assigned individual layers so you can use or delete them as needed.

Import and Export DXF Files and XML Files

Hydraflow Storm Sewers Extension allows you to import and export from *.dxf* and LandXML data files plan layouts and background images. CAD programs, such as AutoCAD, produce both *.dxf* and LandXML files which provides a seamless connection between Hydraflow Storm Sewers Extension and many other CAD programs.

Background Maps

Rather than drawing your system in your CAD program, Hydraflow Storm Sewers Extension allows you to import a background DXF file that helps with the accuracy of the pipe alignments as you draw your system layout. Background images can come from any standard *.dxf* file but are limited to Line, Polyline, LWPolyline, Arcs, and Circles. Line weights, certain entity types, and Blocks and Text are not supported in order to maintain a high speed of redraws.

NOTE Hydraflow Storm Sewers Extension does not save DXF background images with project files. The background images are saved to *C:\Program files\Hydraflow Storm Sewers Extension\mydxfbackground.dxf*. When you open a project file (*.stm*) that had a background image, Hydraflow Storm Sewers Extension reloads the *.dxf* file and positions the pipe network layout as it was when last saved. If transporting your *.stm* file, be sure to also include any background images. Hydraflow Storm Sewers Extension does save LandXML background images with the *.stm* project file.

To import a background image

1 Click  ➤ Background Image From DXF.

2 Navigate to the *.dxf* file that you want to import and click Open. Hydraflow Storm Sewers Extension reads the file and displays the results on the Plan tab.

3 Use the Zoom and Crop options to modify the background map.

4 Optionally, move the storm sewer system to match the background image by dragging the outfall (downstream end of line 1) to the desired coordinates.

5 To clear the background map, click Options menu ➤ Plan View ➤ Background Image ➤ Clear.

NOTE Hydraflow Storm Sewers Extension must redraw the background image with each edit. With complex background images, performance is slow because of this process. To turn off the Auto Redraw feature, click Options menu ➤ Plan View ➤ Background Image and then clear the Use Auto Redraw option.

Importing DXF Plan Layouts

Hydraflow Storm Sewers Extension can import a plan layout of up to 250 lines. Hydraflow Storm Sewers Extension can merge the imported file with an existing plan or start a new plan. If you merge files, the total number of lines must not exceed 250. You can also import invert elevations. With imported files, Hydraflow Storm Sewers Extension computes the lengths, downstream line numbers, and deflection angles, then assigns them to the corresponding alignment data. Next you edit the lines to provide missing data such as the flow data and junction type.

IMPORTANT Before you import a DXF plan, the following conditions must be met:

- Line segments must be drawn in your CAD program as Single Line segments or Polylines.
- Lines must be drawn in the upstream direction.
- The first line drawn must either be Line No. 1 or the last line in your system.
- Use the CAD program Snap feature to ensure that the line segment coordinates are connected. Hydraflow Storm Sewers Extension connects them if they are within 2 feet of each other, but it is best to use the Snap mode.
- Specify a layer name that begins with a letter. AutoCAD uses 0 as its default layer name, and this can cause issues with Hydraflow Storm Sewers Extension.
- You can only import one system (one outfall) at a time. If you want to import multiple systems, they must be imported individually.

To import a DXF plan layout

1 Click File menu ➤ Import/Export ➤ Import ➤ Pipe Layout from DXF.

2 Navigate to the file that you wish to import and click Open.

3 In the DXF Import dialog box, specify the layer that you used in your CAD program.

4 Specify of the following options:
   - New Layout: Use this option for a new project.
   - Merge To Existing: Use this option button if you want Hydraflow Storm Sewers Extension to add the imported file to the current project file. Select a line number to connect to or choose, New Outfall.
   - Include Elevations: Use this option if you have assigned invert elevations (Z- coordinates) to each of the line segments and you want Hydraflow Storm Sewers Extension to include them in the import.

5 Click Import.

Troubleshooting

Hydraflow Storm Sewers Extension reads the DXF file and tries to put together the network by connecting line segments with similar (plus or minus 2 feet) coordinates. Line 1 should be the only line that it cannot connect. If the import fails, check the import file to verify that the lines are drawn in the upstream direction, or that two or more lines did not match coordinates, then reimport the file. Hydraflow Storm Sewers Extension attempts to import all the lines until an error is found.

When importing, Hydraflow Storm Sewers Extension assumes the import file to be in the current units setting, U.S. Customary or SI.

Exporting a Plan to a DXF Files

Using Hydraflow Storm Sewers Extension you can export Plan plots DXF files.

To export a plan layout

1. Click File menu ➤ Import/Export ➤ Export ➤ Export Plan to DXF.
2. Navigate to the file that you wish to export, and then click Save.

Importing LandXML Files

Hydraflow Storm Sewers Extension can import and export LandXML data files. As a result, design teams and clients can share data across platforms quickly and easily. LandXML data files are independent of operating systems, computers, and the vendors who create them. For example, you can create your storm sewer project in AutoCAD Civil 3D. Then you can export the LandXML file (it includes the background map and pipe system) to Hydraflow Storm Sewers Extensionto run the calculations, and then export the results back to any other LandXML supporting software for final drafting. You could also create your project in Hydraflow Storm Sewers Extension and export it as a new LandXML file for import into other LandXML-supporting programs.

LandXML files contain drawing elements, such as line or pipe entities, and other attribute data such as invert elevations, pipe diameters, flow rates, and HGLs. You might, for example, import a LandXML file containing a background map along with a proposed pipe layout developed in AutoCAD Civil 3D. The XML file is imported with the associated hydraulic data, such as HGL, flows, pipe slopes, and sizes left blank. Hydraflow Storm Sewers Extension runs the calculations, updating the XML file with the unknowns, and then exports back to the CAD program. LandXML, unlike DXF files, can be used by Hydraflow Storm Sewers Extension to import both background images and pipe layouts in a single step.

LandXML Background Maps

Rather than drawing your system in your CAD program, Hydraflow Storm Sewers Extension allows you to import a background image from a LandXML file that to assist in maintaining the accuracy of the pipe alignments as you draw your system layout. Background images can come from any LandXML file containing Parcel and Alignment elements.

LandXML background images are saved with the Storm Sewers Extension *.stm* project files.

You can import pipe networks from any LandXML file containing PipeNetworks. LandXML files that contain PipeNetworks elements, have one or more PipeNetwork systems. The individual networks are listed in the Available Pipe Networks list box where you select the network(s) you wish to import.

Importing LandXML Files

To import a LandXML file

1 Click File menu ➤ Import/Export ➤ LandXML and select the Import tab.

2 In the Import/ Export LandXML dialog box, browse to the file you want to import.

3 Click Open. Hydraflow Storm Sewers Extension parses the XML file for the following information:

- Project Name: The name of the project as provided by the LandXML author.
- Project Description: A description of the project as provided by the LandXML author.

4 Specify the following Import Options:

- Selected Pipe Networks: Imports the selected networks shown in the Available Pipe Networks list. The box to the right shows the total number of pipes (lines) contained in the selected pipe networks.
- Parcels as background: Imports available Parcels for a background image. The box to the right shows the number of Parcel elements contained in the file.
- Alignments as background: Imports available Alignment elements. The box to the right shows the number of Alignment elements contained in the file.

5 Click Import.

Matching Your Background with Your Existing System

If you import a background after drawing the pipe layout, you can move the pipe system to match or correlate with the background image. On the Plan tab, drag the outfall (downstream end of line 1) to the desired coordinates or position at the Plan tab.

Clearing the Background Image

Clearing the background image is done from the Options menu. To clear the background image, click Options menu ➤ Plan View ➤ Background Image ➤ Clear.

Auto Redraw

During the process of drawing and editing lines or moving labels, Hydraflow Storm Sewers Extension redraws the loaded background image with every edit. Complex background images require more time to redraw. To avoid slow performance, you can turn off the Auto Redraw feature. To turn this option off and on, click Options menu ➤ Plan View ➤ Background Image ➤ Use Auto Redraw.

Exporting LandXML Files

To export a LandXML file

1 Click File menu ➤ Import/Export ➤ LandXML and click the Export tab.

2 Specify one of the following:

- As New: Select to create a new LandXML file. The only data required for this option is a project name, description and file name. This file contains only PipeNetwork data, not background images.
- Update An Existing XML File: For example, this could be the same file used to import the system. Updating simply changes existing data in the file, such as flow rates, HGLs, and invert elevations.

IMPORTANT When you update an existing LandXML file, the LineIDs are used to match the Pipe names in the LandXML file, and the Inlet IDs are used to match the LandXML Struct names. If Hydraflow Storm Sewers Extension does not find a match, you receive an error message.

3 Under Existing Pipe Networks, select the Pipe Networks corresponding to the ones you want to update. LandXML files that contain PipeNetworks elements, have one or more PipeNetwork systems. The individual networks are listed in the Existing Pipe Networks list.

4 Under Export Options do the following:

- enter a project name and description
- select the check box if you want to use USSurveyFoot as the linear unit

5 Click Export. In the Save XML File dialog box, specify a new name for the file or overwrite an existing file.

Computational Methods

3

Standard Step Method

Hydraflow Storm Sewers Extension uses the energy-based Standard Step method to compute the hydraulic profile. This method is an iterative procedure that applies Bernoulli's Energy Equation between the downstream and upstream ends of each line in the system. It uses Manning's Equation to determine head losses due to pipe friction. Using this method, a solution can always be found regardless of the flow regime. This method makes no assumptions as to the depth of flow, and is only accepted when the energy equation has balanced.

Hydraflow Storm Sewers Extension uses the following equation for all flow conditions:

$$\frac{V_1^2}{2g} + Z_1 + Y_1 = \frac{V^2}{2g} + Z_2 + Y_2 + HL$$

Where:

V = velocity in ft/s (m/s, metric)

Z = invert elevation in ft (m)

Y = HGL minus the invert elevation in ft (m)

Friction losses are computed by:

$$HL = \frac{(hf_1 + hf_2)}{2}$$

Where:

$$hf = \left(\frac{Qn}{K_m A R^{.667}} \right)^2 \times LineLength$$

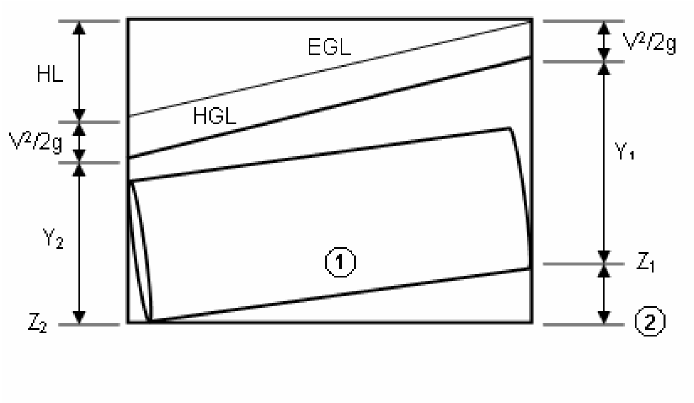
and where:

Km = 1.486 (1.0)

n = Manning's n

A = Cross-sectional area of flow in sqft (sqm)

R = Hydraulic radius



Pipe and Open Channel Flow

Hydraflow Storm Sewers Extension computes the hydraulic grade line using a method that is similar to the method used for computing open channels. The application begins computing at the most downstream line and works in a standard step procedure in an upstream direction. This method assumes the starting hydraulic grade line elevation, HGL, is known. For more information, see Computing the System. Hydraflow Storm Sewers Extension assumes an upstream HGL for a given line and then checks the energy equation. If the energy equation does not balance, another HGL is assumed and the iterative process continues until the assumed HGL equals the computed HGL. The starting downstream HGL for the next upstream line is based on the computed HGL plus any junction (minor) loss.

If the starting HGL at the downstream end of any line (except outfalls) is below the Minimum Starting Depth that was set in the Design Codes, Hydraflow Storm Sewers Extension automatically change the HGL to the Minimum Starting Depth.

Hydraflow Storm Sewers Extension computes the HGL for any given line at three places:

HGL Down	Represents the downstream end of the line. At the beginning of an outfall there is a user-defined elevation which can be a known elevation, Crown, Normal Depth (dc + D)/2, or Critical Depth. At all other lines it is equal to the HGL Junct of its downstream line. However, if the energy grade line (EGL Dn) is less than the energy grade line (EGL) in the downstream junction (EGL Junct), the HGL Down is reset to the EGL Junct minus the velocity head. This prevents an increase of energy in the downstream direction if you have selected Correct EGL Discrepancies in the Design Codes dialog box on page 12. If the starting HGL is below the Minimum Starting Depth that you specified in the Design Codes, Hydraflow Storm Sewers Extension automatically changes the HGL to the Minimum Starting Depth.
HGL Up	Represents the upstream end of the pipe and is computed using the Standard Step Method. If you select the option Check For Inlet Control on the Calculations tab in the Design Codes dialog box, and the line is flowing under inlet control, the HGL Up is equal to the HGL Junct minus the upstream velocity head.

HGL Junct	Represents the junction at the upstream end of each Line, and is equal to the HGL Up plus any minor or junction loss. If you select the option Check For Inlet Control on the Calculations tab in the Design Codes dialog box, and the line is flowing under inlet control, the HGL Junct is equal to the depth determined by the Inlet Control procedure. The energy grade line (EGL) is computed as the HGL plus velocity head. If the line is flowing under inlet control, velocity at this point is zero and the EGL equals HGL.

Critical Depth

Critical depth is computed using the following equation:

$$Dc = \left(\frac{1.01}{D^{.26}}\right) \times \left(\frac{Q^2}{g}\right)^{.25}$$

Where:

Dc = Critical depth

D = Pipe diameter

Q = Flow rate

NOTE If Dc is greater than 85% of D, then a trial-and-error method is used to find the minimum specific energy, for example the critical depth. For more information please refer to *Open Channel Hydraulics*, McGraw - Hill, 1985, by Richard H. French.

Junction Losses

Junction losses are computed using the following equation:

$$JunctionLoss = k\left(\frac{V^2}{2g}\right)$$

Where:

k = Coefficient

V = Velocity of flow exiting the junction

Junction losses are not computed for lines at critical depth or lines that flow under inlet control.

Junction Loss Coefficients

Hydraflow Storm Sewers Extension automatically computes and assigns junction loss coefficients based on the junction configuration when you specify Automatic in the Design Codes - Calculations tab. Coefficients are selected based on data adapted from FHWA HEC No. 22. These selected coefficients are based on the angle of the lines entering the junction at its upstream end.

For angles less than 90 degrees, Hydraflow Storm Sewers Extension uses the following equation to compute junction loss coefficients K:

$$K = \left[1 - \left(\frac{90 - Deflection\,Angle}{90} \right)^2 \right]$$

If the junction is an inlet, K is multiplied by 1.5. K is never less than 0.15 for Manholes, or 0.50 for Inlets. For angles greater than or equal to 90, Inlets K = 1.5, and Manholes K = 1.00. For Lines at ends of a branch, K = 1.00

A conservative value for this coefficient is 1.0, which assumes all of the velocity head is lost at the manhole, and the junction is simply a reservoir being fed by any incoming lines. The incoming velocity is lost and converted to static head.

Supercritical Flow

Hydraflow Storm Sewers Extension can automatically compute supercritical flow profiles with hydraulic jumps. If the energy equation does not balance, Hydraflow Storm Sewers Extension initially assumes critical depth and proceeds to the next upstream line. When the subcritical profile is finished, the calculation procedure is reversed for any lines with critical depth assumed at their upstream ends, (from upstream to downstream), and computes the supercritical profile.

Hydraulic Jump

The Momentum Principle is used to determine the depths and locations of hydraulic jumps. At each step (one tenth of the line length) during supercritical flow calculations, the momentum is computed and compared to the momentum developed during the subcritical profile calculations. If the two momentums are equal, then a hydraulic jump must occur.

NOTE There are some situations when a hydraulic jump does not exist or when it is submerged.

The following condition must be satisfied to determine a hydraulic jump:

$$M_1 = M_2$$

Momentum (M) of the subcritical profile equals the momentum of the supercritical profile.

$$M = \frac{Q^2}{gA} + \bar{y}A$$

Where:

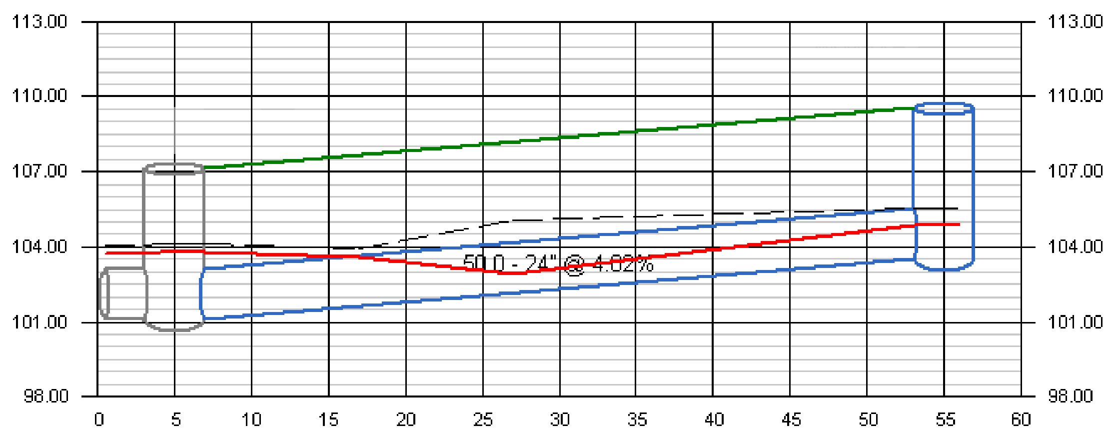
Q = Flow rate

A = Cross-sectional area of flow

Y = Distance from the water surface to the centroid of A

The location of the jump is the point along the line when M1 = M2, and is reported as the distance from the downstream end of the line. The length of the jump is difficult to determine, especially in circular sections. A generally acceptable jump length is between 4 and 6 times the sequent depth. Hydraflow Storm Sewers Extension assumes 5 for the jump length.

The following illustration shows the computation of supercritical flow profiles with hydraulic jumps. The dotted line represents the energy grade line (EGL).



Inlet Control

Inlet and outlet control is often a misunderstood concept in storm sewer hydraulics. Inlet control occurs when it is more difficult for the flow to enter the pipe than to move through the pipe. The critical factors during inlet control are the cross-sectional area of the pipe and the inlet geometry. The roughness coefficient, pipe length, and slope are not necessary.

Outlet control occurs when it is more difficult for the flow to move through the pipe than to enter the pipe. The solution is to compute the HGL assuming both exist, and then selecting the larger of the two.

You can check HGL calculations for inlet control on all junctions except for No Junction types. One calculation method is derived from HDS-5 Hydraulic design of Highway Culverts, and the other is the standard orifice equation. If the computed HGL for inlet control is greater than the computed HGL (outlet control), then the HGL Junct is set equal to the inlet control value. When inlet control is used, the minor loss (junction loss) is not computed.

The standard orifice equation used is:

$$Q = CoA\sqrt{2gh}$$

Where:

Co = Orifice coefficient = 0.62

A = Cross-sectional area of flow in sqft (sqm)

h = Headwater depth to the center of A in ft (m)

NOTE This is the default equation used when working in SI units.

Flow Under Inlet Control

The HDS-5 method uses the following inlet control equation:

$$Hdi = D \times \left[c \left(\frac{Q}{A\sqrt{D}} \right)^2 + Y - .5S \right]$$

Where:

Hdi = Headwater depth above invert

D = Line Rise, ft

c = 0.0398 (Coeff. for square edged circular section)

Q = Flow rate, cfs

A = Full cross-sectional area of pipe, sqft

Y = Coeff. 0.67

S = Line slope, ft/ft

This equation only applies when Q/AD0.5 is greater than or equal to 4.0.

NOTE Inlet control is only considered when you select the Check For Inlet Control option on the Calculations tab in the Design Codes dialog box. If this option is not selected then inlet control is not evaluated.

The Rational Method

Hydraflow Storm Sewers Extension computes peak flows using the Rational Method. The Rational Method uses the following formula:

$$Q = KrCiA$$

Where:

Q = discharge in cfs (cms)

Kr = 1 (.0277)

C = runoff coefficient. Runoff Coefficients (C) on page 81.

i = rainfall intensity in in/hr (cm/hr)

A = drainage area in ac (ha)

The rainfall intensity is computed by the formula:

FHA Equation

$$I = \frac{B}{(Tc + D)^E}$$

Where:

B, D, and E are constants

Tc = time of concentration in minutes, subject to the Min. Tc set in the Design Codes.

The constants are pre-computed by Hydraflow Storm Sewers Extension and are based on geographic location. Tc is the time required for water to flow from the most remote point of the drainage area to the point of the system in question. Hydraflow Storm Sewers Extension computes Tc by choosing the longest of the following times:

- Tc of the upstream line plus the time of flow through the line from the upstream run.
- Tc as above for any other connecting line(s).
- The inlet time of the line under consideration.

For the most upstream run, the Tc is the inlet time. For all succeeding lines, the Tc is computed as the largest value of the three items above.

When computing flows for downstream lines, Hydraflow Storm Sewers Extension uses a total CxA, that is, CA for the line in question plus CA for the next upstream line plus CA for the next upstream line and so on.

Third-Degree Polynomial Equation

Hydraflow Storm Sewers Extension has the option of creating IDF curves using a third-degree polynomial equation as follows:

$$I = A + Bx + Cx^2 + Dx^3$$

Where:

I = rainfall intensity in in/hr (cm/hr)

X = Ln (time duration in minutes)

A = coefficient

B = coefficient

C = coefficient

D = coefficient

Appropriate values for X are 8 to 180 minutes, subject to the Min. Tc set in the Design Codes.

Rainfall IDF Curves

Hydraflow Storm Sewers Extension builds its rainfall IDF (intensity-duration-frequency) curves from user-supplied data. In the case of using map data (FHA Method), Hydraflow Storm Sewers Extension computes rainfall intensity values based on the methods presented in FHWA Hydraulic Engineering Circular No. 12, Drainage of Highway Pavements, more commonly known as HEC-12. The calculation methods for the Eastern and Central United States are different from the Western region.

IMPORTANT This method does not produce 1- or 3-year return periods.

Eastern and Central United States

Precipitation values for the 2-year and 100-year frequencies of 5, 15, and 60 minute durations are required for input. Hydraflow Storm Sewers Extension uses these values and the following equations to estimate values for 10 and 30-minute durations:

10 min value = 0.59 x (15 min) + 0.41 x (5 min)

30 min value = 0.49 x (60 min) + 0.51 x (15 min)

The following equations are used to compute values for return periods intermediate to the 2 and 100 year frequencies.

5-yr = 0.278 x (100-yr) + 0.674 x (2-yr)

10-yr = 0.449 x (100-yr) + 0.496 x (2-yr)

25-yr = 0.669 x (100-yr) + 0.293 x (2-yr)

50-yr = 0.835 x (100-yr) + 0.146 x (2-yr)

Once the rainfall volumes have been computed for the 2-yr through 100-yr frequencies of 5, 10, 15, 30, and 60-minute durations, Hydraflow Storm Sewers Extension converts them to intensity values in in/hr.

Western States

Precipitation values required for input are the 24-hour and 6-hour durations for the 2-year and 100-year frequencies. Hydraflow Storm Sewers Extension uses these values and the following equations to compute 60-min duration values.

Y2 = 0.218 + 0.709 x [X1 (X1/X2)]

Y100 = 1.897 + 0.439 x [X3 (X3/X4)] - 0.008 x Z

Where:

Y2 = 2-yr, 60-min value

Y100 = 100-yr, 60-min value

X1 = 2-yr, 6-hr value

X2 = 2-yr, 24-hr value

X3 = 100-yr, 6-hr value

X4 = 100-yr, 24-hr value

Z = point elevation in hundreds of feet

Next, Hydraflow Storm Sewers Extension uses a built-in nomograph to compute precipitation amounts for return periods intermediate to the 2-year and 100-year frequencies. Built-in ratios are then applied to convert the 60-minute volumes to 5, 10, 15 and 30-minute volumes.

The rainfall volumes are then converted to intensities in in/hr.

Equation Coefficients

Hydraflow Storm Sewers Extension computes rainfall intensity I for any time duration or Tc, using the FHA equation described above.

$$I = \frac{B}{(Tc + D)^E}$$

The coefficients B, D, and E are computed by Hydraflow Storm Sewers Extension using a log-log interpolation of the rainfall intensity values. As a result, intensity plots to an almost straight line. Hydraflow Storm Sewers Extension then uses a trial and error process of determining a constant D which when added to corresponding Tc, allows the line to plot straight. The coefficient B is the ordinate at t = 1. The coefficient E is the slope of the plotted line. This procedure is repeated for each frequency.

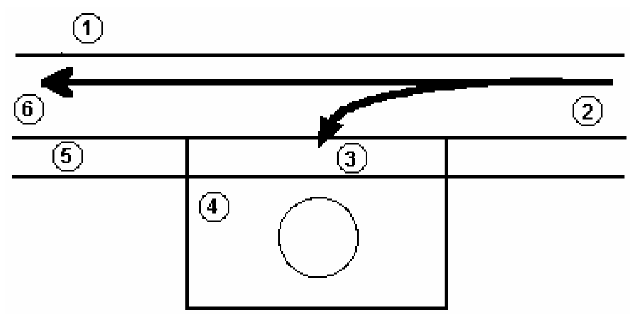
Using Existing IDF Curves to Develop Coefficients

You can derive your own equation coefficients in case the computed ones do not match what you are accustomed to. Simply reverse the procedure described above. Plot your existing rainfall intensity - duration curve(s) on log-log paper. The values B, D, and E can then be found and directly entered into Hydraflow Storm Sewers Extension. Normally, the initial plotted line is not straight. If it does plot straight, D = 0. Otherwise, select a constant D, such as 5. Add this to each of the Tc ordinates. Re-plot the line. If it is straight, D = 5. If it is not straight, try different constants until the line is straight. B is then the intensity at Tc = 1, while E is the slope of the plotted IDF line. Simply edit the IDF curve coefficients to match the ones derived and save.

Inlets

One of the best features of Hydraflow Storm Sewers Extension is its ability to design and analyze a system of multiple types of inlets. Inlets are located at the upstream end of a line and can be in a sag or on a longitudinal slope and can be of any size. The purpose of this analysis is to determine the amount of flow a particular inlet can capture, the ponding depth, inlet and gutter spread widths, the amount of flow that is bypassed, and what effect it has on downstream inlets. Hydraflow Storm Sewers Extension has design features that size inlets to capture 100% of the flow. To simplify this process, Hydraflow Storm Sewers Extension assumes that all inlets have common n-values. These values are specified in the Design Codes Inlets tab. Gutters, however, contain unique n-values for each line.

Hydraflow Storm Sewers Extension follows the basic methodology of FHWA HEC-22 for inlet interception capacity calculations. Clogging factors are not used in this program. Adjust your inlet lengths to account for clogging factors.



(1) Gutter	(3) Q Captured
(2) Q Carryover	(4) Inlet
(5) Top of Curb	(6) Q Bypassed

Plan View

Flow Rate (Q) catchment

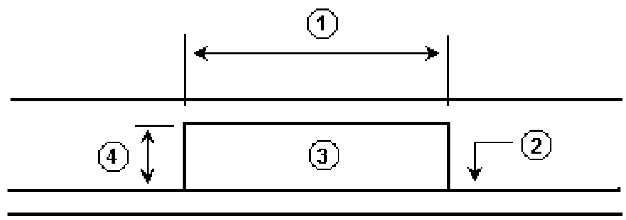
Hydraflow Storm Sewers Extension uses a separate and slightly different analysis for determining Qs for inlets than for the overall line network. The Qs for inlets are computed using the Rational formula, Q = CIA. But I is the intensity based on the individual catchment's inlet time, not the cumulative Tc, and the C x A term is the individual catchment's drainage area and corresponding runoff coefficient. This Rational Method Q is labeled as Incr Q and Q=CiA in the reports. Known Qs are added to overland flows.

Carryover and Bypassed Flow Rates (Qs)

Qs for individual inlets are developed from two components. The first is that from the drainage area or runoff for the catchment. The second is from excess or noncaptured flows. Noncaptured flow is called *carryover* when it is coming from upstream inlets. It is called *bypassed* when an inlet cannot capture 100% and sends a portion of the total flow offsite or to another specified target inlet. Carryover and bypass flows are both noncaptured flows. To an inlet, carryover is an incoming flow and bypassed is an outgoing flow. These flows are labeled as Q carryover and Q bypassed on the reports. Lines with a manhole or no inlet bypass all carryover flows to the downstream line.

Inlets in Sags

An inlet in a sag, or sump, has no longitudinal slope and the gutter slope equals zero. In addition, inlets in sags capture 100% of the flow and have no bypass flow. The Drop Curb inlet must be in a sag.



(1) Length (3) Opening

(2) Gutter (4) Throat Height

Curb Inlets in Sags

Curb inlets operate as weirs to depths equal to the curb opening height and as orifices at depths greater than 1.4 times the throat height. At depths in between, flow is in a transition stage.

Depressed Curb Opening

The equation used for the interception capacity of the inlet operating as a weir is:

$$Q = Cw(L + 1.8W)d^{1.5}$$

Where:

Cw = 2.3 (1.25)

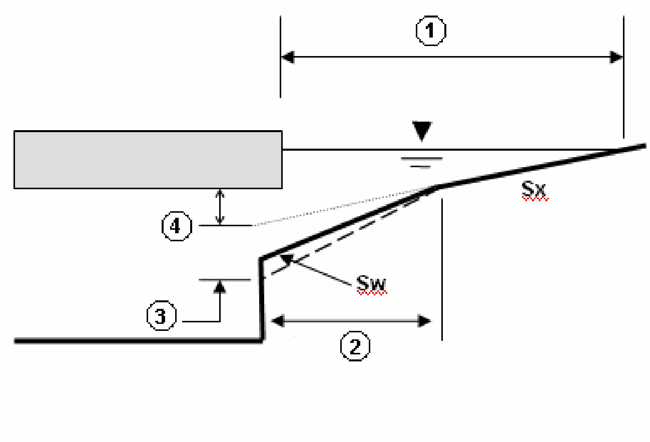
L = Length of curb opening in ft (m)

W = Gutter width in ft (m)

d = Depth at the face of curb measured from the cross

slope, Sx, in ft (m)

Note: If L > 12 feet then the equation for non-depressed inlets is used, as specified in HEC-22.



(1) Spread

(2) Gutter WIdth

(3) Local Depression

(4) Throat Height

Without Depression

The following equation is used for the interception capacity of the inlet operating as a weir:

$$Q = CwLd^{1.5}$$

Where:

Cw = 3.0 (1.60)

L = Length of curb opening in ft (m)

d = Depth at the face of curb measured from the cross

slope, Sx, in ft (m)

The equation used for the interception capacity of the curb inlet (depressed and non-depressed) operating as an orifice is

$$Q = CohL\left(\sqrt{2gd_o}\right)$$

Where:

Co = 0.67

h = Total height of curb opening in ft (m)

L = Length of curb opening in ft (m)

g = 32.2 (9.8) gravity

do = Depth measured to the center of the inlet opening in ft (m)

It should be noted that the inlet depths reported are measured from the lip of the curb opening, Depth = Do + (h / 2) where h is the total opening. Inclined Depths = Do + (h / 2)Sin(45o).

In transition flow, Hydraflow Storm Sewers Extension uses both equations and selects the smallest Q.

If the inlet length has been set to 0 by you, Hydraflow Storm Sewers Extension automatically computes it by using the above weir equations, assuming the depth to be equal to the total curb opening and solving for L.

Grate Inlets in Sags

Grate inlets in sags operate as weirs to a certain depth, dependent on their bar configuration, and operate as orifices at greater depths. Hydraflow Storm Sewers Extension uses the procedure as described in HEC No. 22. Hydraflow Storm Sewers Extension uses both orifice and weir equations at a given depth. The equation that produces the lowest discharge is used. The standard orifice equation used is

$$Q = CoAg\sqrt{2gd}$$

Where:

Co = 0.67

Ag = Clear opening area in sqft (sqm)

g = 32.16 (9.8) gravity

d = Depth of water over the grate in ft (m)

The following weir equation is used:

$$Q = Cw(L + 1.8W)d^{1.5}$$

Where:

Cw = 3.0 (1.66)

P = Perimeter of the grate in ft (m) disregarding side against curb

d = Depth of water over the grate in ft (m)

If the grate area, A, has been set to 0 by you, Hydraflow Storm Sewers Extension automatically computes it using the orifice equation, and by assuming d = Grate Design Depth as entered in the Design Codes - Inlets tab. If the perimeter, P, has been set to 0 by you, Hydraflow Storm Sewers Extension sets it by assuming d = Grate Design Depth as specified in the Design Codes, and solving for P in the weir equation. It is believed that when the depth of water over the grate = 0.3 ft (.09 m), the inlet begins to act as an orifice.

Combination Inlets in Sags

The interception capacity of combination inlets in sags is equal to that of the grate alone in weir flow. In orifice flow, the capacity is equal to the capacity of the grate plus the capacity of the curb opening (Ref. HEC-22). Hydraflow Storm Sewers Extension essentially uses the procedure described above for grate inlets in sag. However, when the depth at the curb creates orifice conditions for the grate, Hydraflow Storm Sewers Extension uses both procedures, grate and curb inlets in sags, and adds their capacities to arrive at the total capacity. Note that both weir and orifice equations are used for the curb inlet analysis. In other words, the grate could be in orifice flow while the curb opening is in weir flow.

As with the single grate inlet, if the grate area, A, on the combination inlet is set to 0, Hydraflow Storm Sewers Extension automatically computes it using the orifice equation, assuming d = Grate Design Depth as entered in the Design Codes, and solving for Ag. If the perimeter, P, is set to 0, Hydraflow Storm Sewers Extension sets it by assuming d = Grate Design Depth as entered in the Design Codes, and solving for P in the weir equation. There is not a design option for the curb opening length on combination inlets. Hydraflow Storm Sewers Extension by default sets it equal to the grate length if found to be 0.

Inlets on Grade

An inlet on grade has a positive longitudinal gutter slope. Hydraflow Storm Sewers Extension uses methods presented by HEC-22. Note that for depressed inlets, the quantity of flow reaching the inlet depends on the upstream gutter section geometry, and not the depressed section.

Curb Inlets on Grade

The interception capacity for curb inlets is computed using the following equation, which also applies to slotted inlets:

$$L_T = K_T Q^{0.42} S_L^{0.3} \left(\frac{1}{nSe}\right)^{0.6}$$

Where:

LT = Curb opening length for 100% capture in ft (m)

KT = 0.6 (0.817)

Q = Gutter flow in cfs (cms)

SL = Gutter slope, longitudinal in ft/ft (m/m)

n = Manning's n-value

Se = Equivalent cross slope

$$Se = S_X + S'_W E_o$$

Where:

Sx = Cross slope of pavement in ft/ft (m/m)

S'w = Depression in ft (m) / gutter width in ft (m) or, for non-depressed inlets, cross slope Sw - cross slope Sx

E0 = Ratio of flow in the gutter section to total gutter flow

When the inlet length is set to 0 (design), Hydraflow Storm Sewers Extension automatically sets the inlet length equal to LT. If the specified inlet length is larger than LT, it captures 100% of the flow and Q captured equals Q. If the specified inlet length is less than the computed LT, then Q captured is computed as follows:

$$Qcaptured = Q_T \times E_F$$

Where:

QT = Q catchment + Q carryover

EF = 1 - (1 - L/LT)1.8 = Efficiency

Q bypassed equals QT - Q captured

Grate Inlets on Grade

The interception capacity of grate inlets on grade is computed using the following equations, as specified in HEC-22:

$$E = R_f E_o + R_s(1 - E_o)$$

Where:

E = Efficiency of the grate

Rf = Ratio of intercepted frontal flow to total gutter flow

E0 = Ratio of frontal flow to total gutter flow

Rs = Side flow interception efficiency

The Rf term in the above equation is dependent on the specific grate properties illustrated in HEC-22 and does not match every situation. In that light, Hydraflow Storm Sewers Extension assumes Rf = 1. This assumes all frontal flow is intercepted without any loss of flow due to splash-over effects. All of the grate on grade examples given in HEC-22 compute an Rf = 1.

$$Rs = \frac{1}{\left[1 + \left(\frac{Kc V^{1.8}}{Sx L^{2.3}}\right)\right]}$$

Where:

Kc = 0.15 (0.0828)

V = Velocity of flow in the gutter in ft/s (m/s)

L = Grate length in ft (m)

The amount of intercepted flow for grates on grade = E x Q. Of course, any non-intercepted flow is bypassed.

If the grate length has been set to 0 for design, Hydraflow Storm Sewers Extension uses the following weir equation:

$$Q = CwP\, d^{1.5}$$

Where:

Cw = 3.0 (1.66)

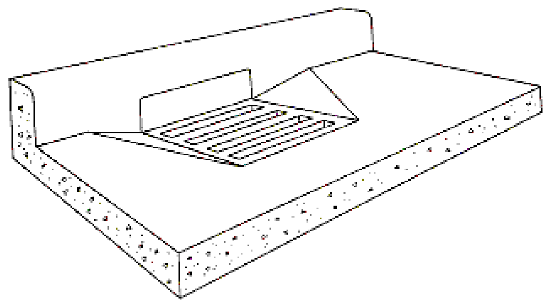
P = Perimeter of the grate in ft (m) disregarding side against curb

d = Depth of water over the grate in ft (m)

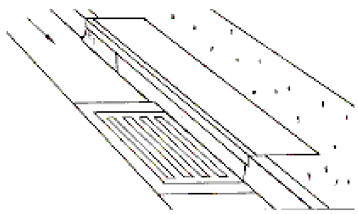
It solves for P and then sets the grate length, L, equal to P – 2 x (grate width). Note that this design does not guarantee 100% capture.

Combination Inlets on Grade

The interception capacity of combination inlets on grade is essentially equal to that of the grate alone. Hydraflow Storm Sewers Extension computes this capacity by neglecting the curb opening and using the methods described above.



Sweeper Inlets



When the curb opening length is longer than the grate length, Hydraflow Storm Sewers Extension assumes the open curb portion is located upstream of the grate, often called a *sweeper* inlet. The sweeper inlet has an interception capacity equal to the sum of the curb opening upstream of the grate plus the grate capacity. The grate capacity in this case is reduced by the interception by the upstream curb opening.

Gutter Spread

Hydraflow Storm Sewers Extension uses the following modified Manning Equation to compute the depth of flow in the gutter:

$$D = \left(\frac{Qn}{KcZ\sqrt{S}}\right)^{0.375}$$

Where:

D = Depth of flow in gutter in ft (m)

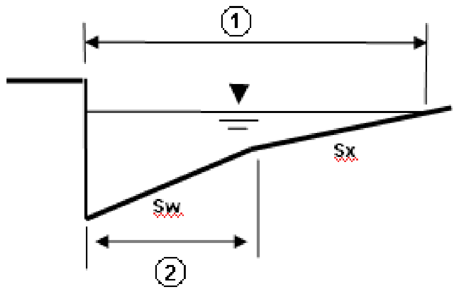
Q = Flow in gutter in cfs (cms)

Z = Reciprocal of the cross slope

S = Longitudinal gutter slope

Kc = 0.56 (0.376)

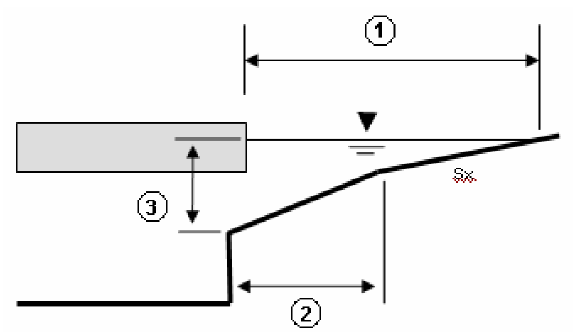
For compound cross slopes, Hydraflow Storm Sewers Extension uses a trial and error procedure and computes D in the gutter, (Sw) and (Sx) sections separately. From this depth, and cross-section geometry, Hydraflow Storm Sewers Extension computes the gutter spread. This depth and spread is labeled Gutter Depth and Gutter Spread respectively in the reports.



(1) Gutter Spread (2) Gutter Width

Inlet Spread

Using the above equations for the variety of inlet types and conditions Hydraflow Storm Sewers Extension computes the final inlet depth as the total depth at the inlet, not just d, for example. The inlet spread is then computed using basic geometry. This depth and spread is labeled as Inlet Depth and Inlet Spread respectively in the reports.



(1) Inlet Spread (2) Gutter Width

(3) Inlet Depth

Design Options

Hydraflow Storm Sewers Extension offers various design options regardless of which calculation option you use Analysis w/Design, EMS, Full Design, or Capacity Only. They are: 1) designing pipe sizes; 2) setting invert elevations, and 3) designing both simultaneously.

NOTE In Storm Sewers the list of pipe sizes is hard coded and cannot be customized. This list does not distinguish between inner and outer pipe diameter, pipe material, or pipe class. When you perform calculations that resize pipes, the results include only the sizes in the list. However, you can always manually edit the pipe size.

When designing, Hydraflow Storm Sewers Extension uses the following form of Manning's Equation.

$$D = \left(\frac{KdnQ}{\sqrt{S}} \right)^{0.375}$$

Where: D = Pipe diameter in ft (m)

n = Manning's n-value

Q = Line discharge in cfs (cms) or velocity x pipe area

S = Slope of the invert in ft/ft (m/m)

Kd = 2.16 (3.20)

This procedure assumes that the pipe is flowing full, and that the slope of the invert is equal to the slope of the energy grade line.

IMPORTANT The S, or slope term in Manning's Equation, in its traditional use, is the slope of the energy grade line, not the slope of the invert. This confuses many engineers. In real conditions, the slope of the invert seldom equals that of the energy grade line.

Case 1: Inverts given, pipe size set to 0 (Design).

Hydraflow Storm Sewers Extension automatically computes a pipe size by:

$$Area = \frac{Q}{DesignVelocity}$$

It then selects an available pipe size with a matching area. It only chooses certain sizes that have been predetermined. That is, 12 to 36 inches in 3-inch increments, and 42 to 102 inches in 6-inch increments, or their metric equivalents.

When a specific pipe size is not available, Hydraflow Storm Sewers Extension selects the next smaller size. For example, if the theoretical size is 31.5 inches, Hydraflow Storm Sewers Extension rounds down and selects the 30-inch.

Case 2: Pipe size given, invert set to 0.

When designing for invert elevations, Hydraflow Storm Sewers Extension simply uses the above equation, setting the velocity equal to the Design Velocity as set in the Design Codes - Pipes tab, and solves for S. It then sets the invert elevations accordingly. If the resulting slope S is less than the Minimum Slope, then S is reset to the minimum slope and a new pipe size is selected at the new slope, using Manning's Equation.

If Follow Ground Surface has been selected as a calculation option, then the slope is set first to match grade. If the slope exceeds the Maximum Slope as set in the Codes, then it is reset to the Maximum Slope.

Case 3: Inverts set to 0, Pipe size set to 0.

Hydraflow Storm Sewers Extension, computes the required full pipe area by:

$$Area = \frac{Q}{DesignVelocity}$$

It then selects an available pipe size with a matching area. With the chosen pipe size, it sets the inverts using the procedure in Case 2.

NOTE The final velocity does not always equal the Design Velocity because of the effects of the downstream HGL after the design is complete.

Enhanced Modeling System (EMS)

The Enhanced Modeling System is designed to eliminate conflicts between the time of concentration (Tc) and the final hydraulic grade line (HGL). Traditionally, storm sewers are designed to flow full. This is acceptable because the pipes are sized, after the fact, to accommodate the design flows and velocities and Tc matches Q.

When analyzing existing systems, however, the actual velocity is not known until the HGL is computed. The computed Qs and HGL are based on assumed pipe velocities.

When the real velocity is different from the assumed velocity, the computed Tc is incorrect and thus the computed Q and resulting HGL are incorrect. The EMS solves this problem by re-computing the HGL based on actual flow rates and actual Tc. To do this Hydraflow Storm Sewers Extension must compute three system iterations so that the computed Tc match those that were assumed with reasonable accuracy.

Hydraflow Storm Sewers Extension first computes the HGL using Tc based on the design velocity. It then computes the system a second time using Tc based on actual velocities. These new velocities are still incorrect because they are based on the original HGL calculation, however they are more accurate than those used on the first trial. As one would expect, several system iterations would cause the Q, Tc, and resulting HGL to converge to correct values. After extensive testing, it has been concluded that three iterations is the most practical balance between accuracy and time required to produce the results. The EMS should always be used on existing systems when the hydraulic analysis is critical and maximum accuracy is of importance.

Reference Tables

A

Runoff Coefficients (C)

Description of Area	Coefficient
Business:	
Central business	0.70 - 0.95
District and local	0.50 - 0.70
Residential:	
Single family	0.35 - 0.45
Multi-units	0.40 - 0.75
1/2 acre lots or larger	0.25 - 0.40
Industrial:	
Light	0.50 - 0.80
Heavy	0.60 - 0.90
Parks, cemeteries	0.10 - 0.25
Playgrounds	0.20 - 0.35
Railroad yards	0.20 - 0.40
Unimproved	0.10 - 0.30
Asphaltic	0.70 - 0.95
Concrete	0.80 - 0.95

Roofs	0.75 - 0.95

Manning’s n-Values

Surface	Manning's n
Reinforced concrete pipe	0.013
Reinforced concrete box	0.013
Vitrified clay pipe	0.013
Coated cast iron	0.011
Uncoated cast iron	0.012
Wrought-iron, black	0.013
Wrought-iron, galvanized	0.014
Smooth welded pipe	0.011
Riveted and spiral steel	0.015
Corrugated metal pipe	0.023
Corrugated aluminum pipe	0.023
Corrugated metal multi-plate	0.035
Polyvinyl chloride (PVC)	0.010

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