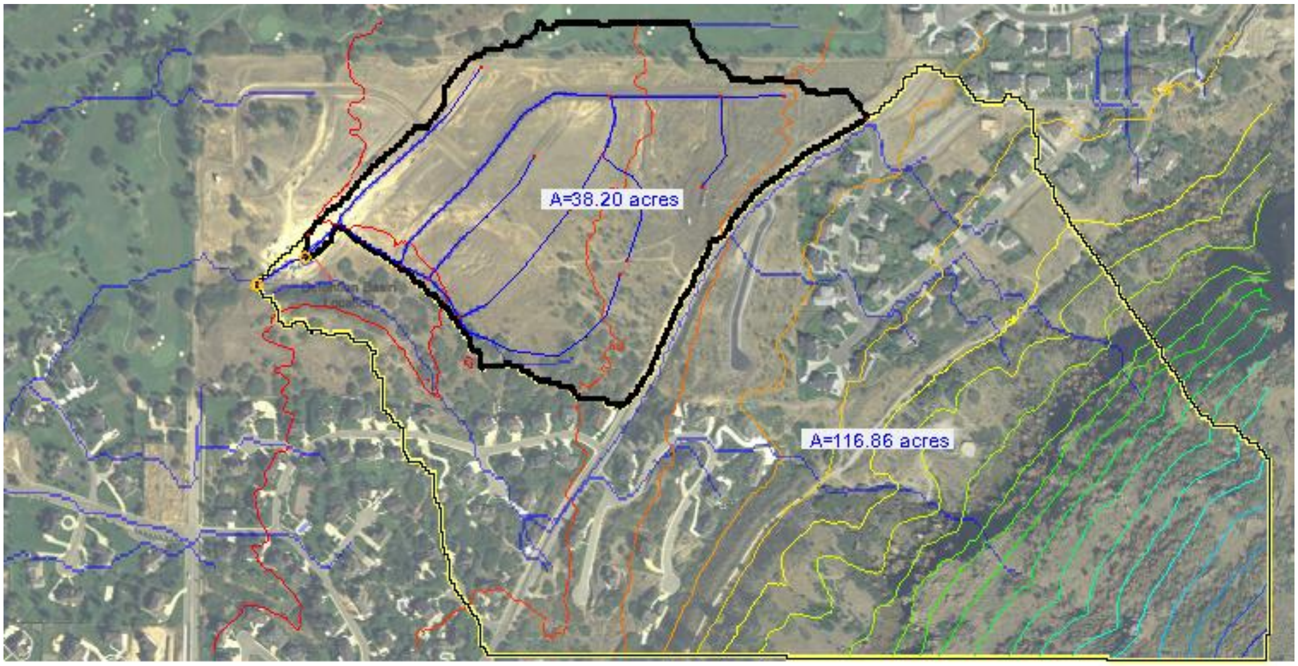
WMS 11.4 Tutorial

Using the Hydraulic Toolbox

Learn how to design inlet grates, detention basins, channels, and riprap using the FHWA Hydraulic Toolbox and WMS



Objectives

Learn how to use several Hydraulic Toolbox calculators and how they are integrated with WMS. Delineate a suburban watershed and estimate the watershed runoff using the rational calculator. Design a grate inlet, a detention basin, a channel, and the channel's riprap.

Prerequisite Tutorials

- DEM Delineation – T_c, Basin IDs, and Smoothing

Required Components

- WMS Core

Time

- 30–45 minutes

AQUAVEO™

1 Introduction

The US Federal Highway Administration's Hydraulic Toolbox is a MS Windows-based program with a set of calculator tools that can be used for such things as computing channel properties using Manning's equation and computing a sub-basin's discharge using the Rational method. The hydrologic and hydraulic calculations in the hydraulic toolbox have been integrated with feature objects in the WMS map module. When points, arcs, or polygons are defined in the WMS map module, hydraulic toolbox calculations can be assigned to these objects and WMS-computed data is passed to the hydraulic toolbox.

This tutorial shows how to delineate a small suburban sub-basin and then how to compute the sub-basin discharge and design hydraulic structures based on this discharge using the hydraulic toolbox calculators. It is recommended to be familiar with some of the more advanced watershed modeling techniques in WMS by following the advanced watershed modeling tutorial before attempting this one.

2 Objectives

The task in this tutorial is to design the drainage associated with Tuscany Creek, a small suburban development. This exercise demonstrates how to use the WMS link to the Hydraulic Toolbox to simulate a drainage design in a suburban area. The following tasks will be demonstrated in this tutorial:

- Delineating a suburban watershed.
- Estimating the runoff from the watershed using the Rational Method.
- Designing a grate inlet for conveying street discharges into a storm drain.
- Designing a detention basin to handle the flow from the Rational Method hydrograph.
- Designing a channel and its riprap to convey flow from a detention basin to a natural stream.

 © Aquaveo 2026

3 Define Drainage Data

3.1 Read Data

1. If necessary, launch WMS.
2. If WMS is already running, press *Ctrl-N* or select *File* | **New…** to ensure that the program settings are restored to their default state.
3. A dialog may appear asking to save changes. Click **Don't Save** to clear all data.

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

4. Select *File* | **Open…** to bring up the *Open* dialog.
5. Locate the *HydraulicToolbox* folder in the files for this tutorial. If needed, download the tutorial files from https://www.aquaveo.com/software/wms-learning-tutorials.
6. Select "TuscanyCreek.wms" and click **Open** to open the project and exit the *Open* dialog.

The Graphics Window should look similar to Figure 1.

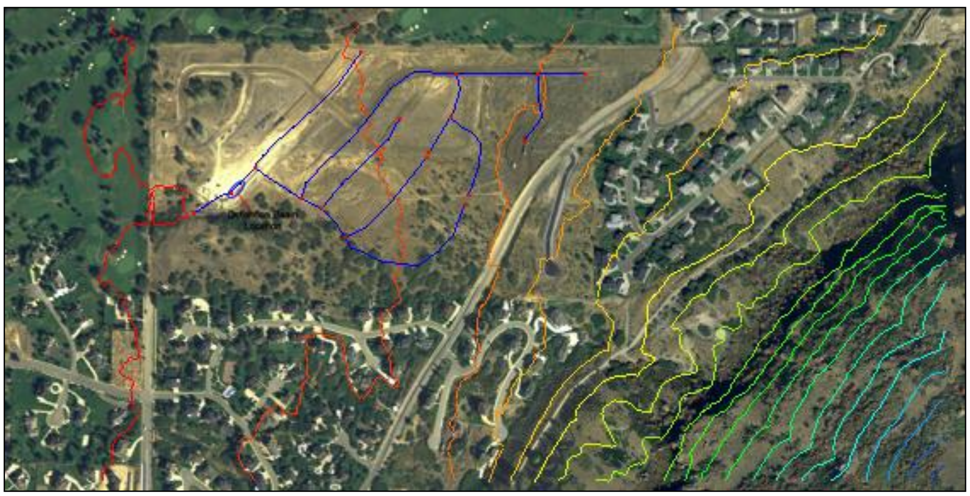


Figure 1 How the graphics window should look like at the start

3.2 Convert Roadway Drainage Paths to Streams

Since the drainage in the sub-basin of interest will be modified by the addition of roads, curbs, and other drainage conveyance structures, these drainage paths have been defined using a shapefile. Convert these drainage paths to stream arcs in the map module to use them to delineate the sub-basin.

1. Select " RoadDrainage.shp" in the Project Explorer.
2. Select *Mapping* | **Shapes** → **Feature Objects** to open the *GIS to Feature Objects Wizard* dialog – *Step 1 of 3*.
3. Select **Next >** to continue to *Step 2 of 3* of the wizard.
4. Select **Next >** to continue to *Step 3 of 3* of the wizard.
5. Select **Finish** to map the arcs to the " Drainage" coverage and to exit the *GIS to Feature Objects Wizard* dialog.

 © Aquaveo 2026

6. Turn off " RoadDrainage.shp" by deselecting its check box in the Project Explorer.
7. Select the " Drainage" coverage in the Project Explorer.

3.3 Define the Drainage Basin

With the streams defined, the flow directions and accumulations can be computed, and the streams can be used to define the drainage basins.

1. To ensure the units are correct for later, go to *Display* | **Display Projection…** to open the *Display Projection* window.
2. Ensure that in the *Vertical* section, that the *Units* drop-down is set to "Meters".
3. Click **OK** to close the *Display Projection* window and preserve the selection.
4. Using the **Select Feature Point/Node** tool, double-click on the node at the downstream end of the detention basin location shown in Figure 2 to bring up the *Drainage Feature Point Type* dialog.

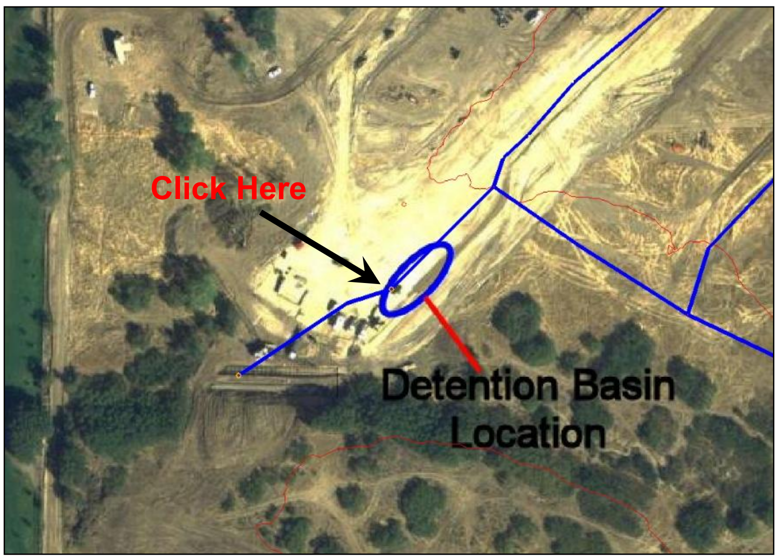


Figure 2 Select the node at the bottom of the Detention Basin Location

5. Select *Drainage outlet*.

This outlet point defines the terminus of the upper sub-basin. The boundaries for this upper sub-basin are the same as the boundaries for the subdivision being modeled.

6. Select **OK** to close the *Drainage Feature Point Type* dialog.
7. Switch to the **Drainage Module** .
8. Select *DEM* | **Compute Flow Direction/Accumulation…** to open the *Flow Direction/Accumulation Run Options* dialog.
9. Select **OK** to exit the *Flow Direction/Accumulation Run Options* dialog and open the *Units* dialog.
10. After ensuring that horizontal units and vertical units are the same, select **OK** to exit the *Units* dialog and bring up the *Model Wrapper* dialog.
11. Select **Close** once TOPAZ finishes running to exit the *Model Wrapper* dialog.

© Aquaveo 2026

This process may take a few minutes, depending on the computer. Notice the flow accumulation cells are displayed after TOPAZ is finished.

12. Right-click on " 42093886.flt" in the Project Explorer and select **Display Options…** to open the *Display Options* dialog.
13. Next to *Min Accumulation For Display,* click on **Change Units…** to bring up the *Units* dialog.
14. Under the *Basin Areas* drop-down, select "Acres".
15. Select **OK** to exit the *Units* dialog.
16. For *Min Accumulation For Display,* enter "3.0" *[acres]*.
17. Select **OK** to exit the *Display Options* dialog.
18. Switch to the **Drainage Module** .
19. Select *DEM* **| Define Basins.**
20. Select *DEM* **| Basins → Polygons.**
21. Select *DEM* **| Compute Basin Data** to bring up the *Units* dialog.
22. Select **OK** to accept the defaults and exit the *Units* dialog.
23. Right-click on the " Drainage" coverage in the Project Explorer and select **Zoom to Layer.**

Notice that two drainage basins are defined. The smaller sub-basin is the one to be modeled here because it covers the subdivision area. Ignore the other sub-basin for now.

4 Link Drainage Data with the Hydraulic Toolbox

Now that a sub-basin is defined, it is possible to associate hydraulic toolbox computations with points, arcs, and polygons in the map module.

© Aquaveo 2026

4.1 Define the Rational Method Computation

1. Select the " Drainage" coverage in the Project Explorer.

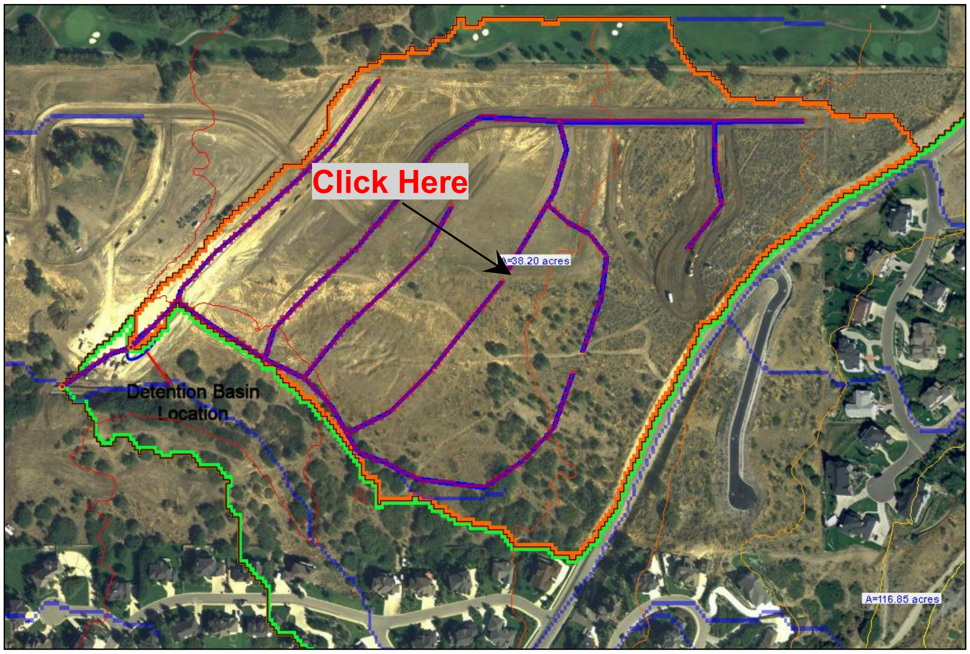


Figure 3 The sub-basin that should be selected

2. Using the **Select Feature Polygon** tool, double-click on the sub-basin upstream from the detention basin to bring up the *Drainage Feature Polygon Type* dialog.
3. Select **Edit Attributes…** next to *Drainage boundary* to open the *Edit Basin Polygon Attributes* dialog.
4. Turn on *Rational Method Analysis*.

This will create a new Rational Method Analysis and assign a default name to the analysis.

5. Change the name of the analysis to "Tuscany Creek Basin".
6. Click **OK** to exit the *Edit Basin Polygon Attributes* dialog.
7. Click **OK** to close the *Drainage Feature Polygon Type* dialog.

4.2 Define the Inlet and Detention Basin Computations

1. Using the **Select Feature Point/Node** tool, double-click on the node at the downstream end of the detention basin location shown in the background image to open the *Drainage Feature Point Type* dialog. (See Figure 4)

 © Aquaveo 2026

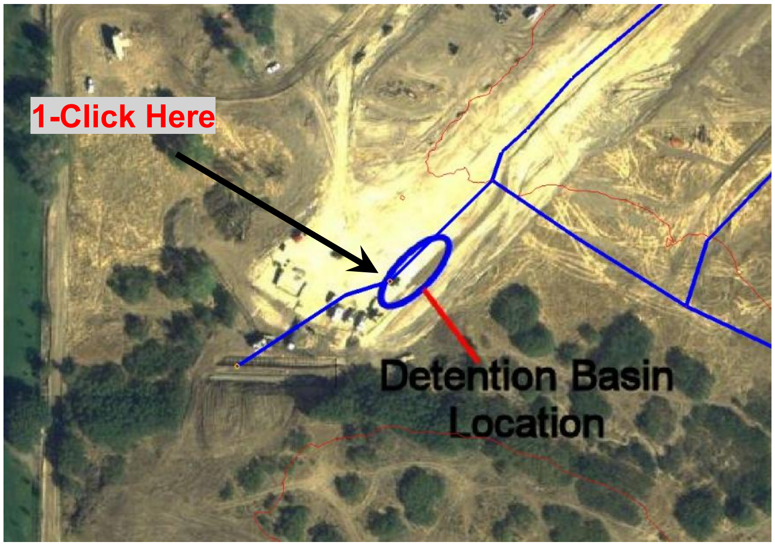


Figure 4 Node at downstream end of detention basin location

2. Click on **Edit Attributes…** to open the *Edit Drainage Point Attributes* dialog.
3. Turn on *Detention Basin Analysis*.
4. Change the name to “Tuscany Creek Detention Basin”.
5. Select **OK** to exit the *Edit Drainage Point Attributes* dialog.
6. Select **OK** to close the *Drainage Feature Point Type* dialog.

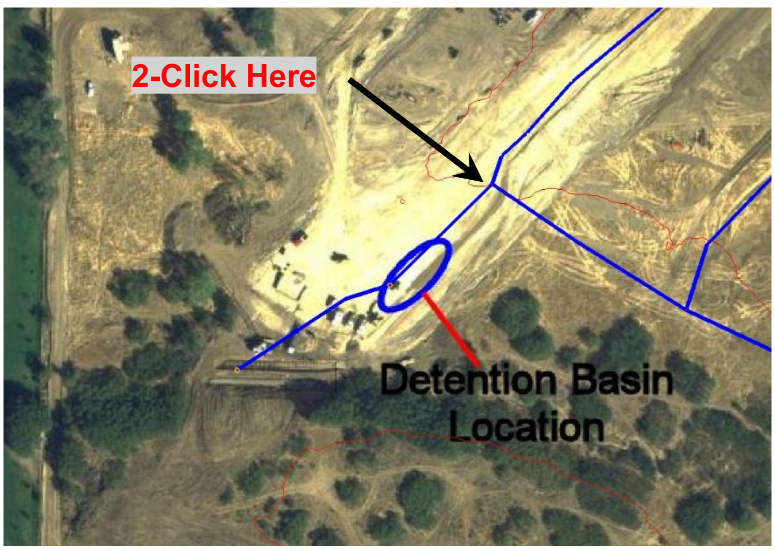


Figure 5 Node above detention basin location

7. Double-click on the node just above the detention basin location to open the *Drainage Feature Point Type* dialog. (See Figure 5)
8. Click **Edit Attributes…** to open the *Edit Drainage Point Attributes* dialog.
9. Turn on *Curb Inlet Analysis.*
10. Change the name to “Inlet Analysis”.
11. Click **OK** to exit the *Edit Drainage Point Attributes* dialog.
12. Click **OK** to close the *Drainage Feature Point Type* dialog.

 © Aquaveo 2026

4.3 Define the Channel and Channel Lining Computations

1. Using the **Select feature Arc** tool, double-click on the stream arc downstream from the detention basin location to open the *Feature Arc Type* dialog.
2. Select **Edit Attributes…** to open the *Edit Stream Arc Attributes* dialog.
3. Turn on *Channel Analysis* and *Channel Lining Design Analysis*.
4. Change *Channel Analysis* name to “Detention Basin Channel” in the edit box
5. Change *Channel Lining Design Analysis* to “Detention Basin Lining” in the edit box.
6. Select **OK** to close the *Edit Stream Arc Attributes* dialog.
7. Select **OK** to close the *Feature Arc Type* dialog.

5 Define Hydraulic Toolbox Parameters

With the locations of the hydraulic toolbox structures defined in WMS, the structures and the associated geometric data is copied to the Hydraulic Toolbox.

5.1 Compute the Rational Method Hydrograph

1. Select the **Hydraulic Toolbox** macro to open the Hydraulic Toolbox.

Note that the structures defined in WMS have been imported into the toolbox.

2. Within the toolbox, double-click on “Tuscany Creek Basin” to bring up the *Tuscany Creek Basin* dialog.

Notice that the basin area has been copied from the WMS interface. A runoff coefficient (C) and a rainfall intensity (I) need to be defined.

3. For the *Runoff Coefficient (C),* enter a value of 0.3 since this is a low-density suburban area.
4. In the *Compute I-IDF Curves* row, select the **Compute…** button of the spreadsheet to bring up the *Rational Method—IDF Computation* dialog.
5. In the *IDF curve computation* section, click **Define Storm Data…** to bring up the *Input variables for IDF curves* dialog.
6. Change the *Recurrence (yr)* to “100” using the drop-down.
7. Enter the following data for the 100-year storm (from NOAA Atlas 14):

Duration (min)	Intensity (in/hr)
5	7.03
10	5.35
15	4.40
30	2.98
60	1.84

8. Click **OK** to exit the *Input variables for IDF curves* dialog.
9. Select the *100-yr.* line in the IDF curve table in the top right of the dialog.

© Aquaveo 2026

10. In the *Time of Concentration* section (middle, left), activate *Specified tc* and enter a value of “12” minutes.
11. In the *Intensity Computation* section, select the **Compute Intensity** button.
12. Select **Done** to exit the *Rational Method—IDF Computation* dialog.

Notice the peak flowrate of 56.1 cfs from the basin.

13. In the *Compute Hydrograph* row, select the **Compute…** button to open the *Rational Method Hydrographs* dialog.
14. For the *Hydrograph computation method,* select “Rational method hydrograph” from the drop-down.
15. Click **OK** to exit the Rational Method Hydrographs dialog and bring up the *Tuscany Creek Basin - Rational Hydrograph Method* dialog
16. Open a spreadsheet or text file editor outside of WMS.
17. Copy the data from the *Tuscany Creek Basin –Rational Hydrograph Method* into the selected program for use in section 5.2.
18. Select **OK** to close the *Tuscany Creek Basin - Rational Hydrograph Method* dialog.
19. Click **OK** to close the *Tuscany Creek Basin* dialog.

5.2 Route the Rational Method Hydrograph through the Detention Basin

1. Double-click on “Tuscany Creek Detention Basin” to open the *Tuscany Creek Detention Basin* dialog.
2. Select the **Define Storage…** button to open the *Storage Capacity Input* dialog.
3. Select the *Known geometry* option to define a detention basin with the following data:
   - *Length:* “60” ft
   - *Width:* “30” ft
   - *Depth:* “10” ft
   - *Side slope:* “0.5” ft/ft
   - *Base elevation:* “0” ft
4. Select **OK** to exit the *Storage Capacity Input* dialog.
5. Select **Define Outflow Discharges…** to open the *Elevation Discharge Input* dialog.
6. Select the **Add Weir** button and define the following parameters (use the default values for all other parameters):
   - *Weir Length:* “3.0” ft
   - *Height above Base Elevation:* “8.0” ft
7. Select the **Add Riser** button and define the following parameters (use the default values for all other parameters):
   - *Opening Shape Type:* **“**Circular”
   - *Opening Diameter:* “0.5” ft

© Aquaveo 2026

8. Select the **Add Standpipe** button and define the following parameters (use the default values for all other parameters):
   - *Pipe diameter:* “1.0” ft
   - *Height above Base Elevation:* “2.0” ft
9. Select **OK** to exit the *Elevation Discharge Input* dialog.
10. Select the **Define Inflow Hydrograph…** button to open the *Inflow Hydrograph* dialog.
11. Change the *Number of x,y points* to “25”.
12. Navigate to the spreadsheet or text file outside of WMS where data was previously copied to in Section 5.1.
13. Copy the information from the file.
14. In the *Inflow Hydrograph,* in the top left cell under *Time (min),* paste the hydrograph data from the rational method calculation saved earlier in this tutorial.
15. Select **OK** to exit the *Inflow Hydrograph* dialog.
16. Select the **Route Hydrograph…** option to bring up the *Routed Hydrograph* dialog.

Note the peak discharge. Before this detention basin was added, the rational method computed a peak discharge of 56.1 cfs.

17. Select **OK** to exit the *Routed Hydrograph* dialog.
18. Select **OK** to exit the *Tuscany Creek Detention Basin* dialog.

5.3 Size a Storm Drain Inlet Grate at the Bottom of the Sub-Basin

1. Double-click on the “Inlet Analysis” computation to open the *Inlet Analysis* dialog.
2. Enter the following data for the inlet analysis:
   - *Longitudinal Slope of Road:* “0.04” ft/ft
   - *Cross-slope of Pavement:* “0.01” ft/ft
   - *Manning's roughness:* “0.015”
   - *Gutter Width:* “2.0” ft
   - *Design Flow:* “56.1” cfs (from the Rational Method computation)
   - *Inlet Location:* “Inlet in sag”
   - *Percent clogging: “*0.0”
   - *Inlet Types:* “Grate”
   - *Grate Types:* “P - 1-7/8”
   - *Grate Width:* “4.0” ft
   - *Grate Length:* “4.0” ft
3. Select the **Compute Inlet Data** button.

Notice the large width of spread at the sag and the large depth at the center of the grate. To avoid flooding, consider subdividing this watershed and adding additional inlets and storm drains to better convey water through each sub-basin. Continue with this analysis,

© Aquaveo 2026

assuming the computed width of spread and depth do not cause flooding problems around the inlet.

4. Select the **OK** button to close the *Inlet Analysis* dialog.

5.4 Size the Channel and Riprap Downstream of the Detention Basin

The 100-year peak flow in this subdivision has been computed using the rational method and the peak flow has been modified by routing it through a detention basin. In this design, the inlet near the bottom of the subdivision will also provide a degree of routing because of the storage provided by the width of spread and the depth above the inlet. This tutorial will ignore the storage above the inlet in this analysis. Now to design the channel and the channel lining to convey flow to the natural channel downstream of the detention basin:

1. Double-click on the “Detention Basin Channel” computation to open the *Detention Basin Channel* dialog.
2. Enter the following data for the channel analysis:
   - *Size slope 1 (Z1):* “2.0” (H:1V)
   - *Size slope 2 (Z2):* “2.0” (H:1V)
   - *Channel width (B): “*5.0” ft
   - *Longitudinal slope:* use the default value computed by WMS (should be 0.072).
   - *Manning's roughness:* 0.06 (a large-diameter riprap encased in a gabion mattress-a rock-filled wire container will be installed)
   - *Enter flow:* “34.762” cfs (from the peak detention basin discharge)
3. Select the **Calculate** button.

Notice that the flow is supercritical (the depth is less than critical depth) because of the steep slope.

4. Select **OK** to close the *Detention Basin Channel* calculation dialog.

Riprap can now be designed to be used to control channel erosion. This tutorial uses the Channel Lining Design Analysis Tool to design the riprap, but there is also a Riprap Analysis Tool that can be used in the Hydraulic Toolbox. In addition to riprap, a riprap filter material should be designed to be placed between the riprap and the original soil. The hydraulic toolbox provides a filter calculation and design tool as a part of the Riprap Analysis Tool. Design of a filter is not covered in this tutorial, but the installation of a filter reduces the failure potential of a riprap installation.

5. Double-click on the “Detention Basin Lining” computation to open the *Detention Basin Lining* dialog.
6. Change the *Lining* to “Gabion”.
7. In the *Select Channel* row, select “Detention Basin Channel” as the channel from the drop-down menu.

Notice that all the parameters entered and computed for the channel are copied to this calculator.

8. Enter a *D50* of “0.75” *mm.*
9. Enter a *Gabion Mattress Thickness* of “1.5” ft.
10. Enter a *Safety Factor* of “1.3”.

© Aquaveo 2026

Notice the analysis results at the bottom of the window. The Manning's n value has been changed to 0.057 based on the Bathurst equation for computing Manning's n. Both the channel bottom and the channel are stable. Since there will not be any curvature in this channel, a curvature radius does not need to be entered. Riprap or some sort of erosion control should be installed where this channel meets the main channel.

11. Click **OK** to exit the *Detention Basin Lining* dialog.

6 Create a Report from the Hydraulic Toolbox

Finally, create a report containing all the information entered in the hydraulic toolbox calculators. The formats available will depend on the software available on the computer being used. Some formats can be edited in word processing programs.

1. From the Hydraulic Toolbox, select *Calculators* **| Create Report…** to open the *Hydraulic Report Filename and Directory* dialog.
2. Browse to a folder where the report should be saved and enter “Tuscany Creek” as the filename.
3. Click **Save** to exit the *Hydraulic Report Filename and Directory* dialog and to open the *Report Generator* dialog.
4. While holding down the *CTRL* button, select all the calculations to be included in the report.
5. Select the desired file format from options given.
6. Select **OK** to exit the *Report Generator* dialog.

The report is created, and the default viewer brings up the report. If the report is in RTF format, it can be edited.

7. Close the Hydraulic Toolbox.

The results are saved and read into WMS. When the WMS project file is saved, the hydraulic toolbox input data and results are saved and read back into WMS when the WMS project is read.

7 Conclusion

This concludes the “Using the Hydraulic Toolbox” tutorial. This tutorial covered how to:

- Define drainage data
- Link drainage data with the Hydraulic Toolbox
- Define Hydraulic Toolbox parameters
- Create a report from the Hydraulic Toolbox

 © Aquaveo 2026