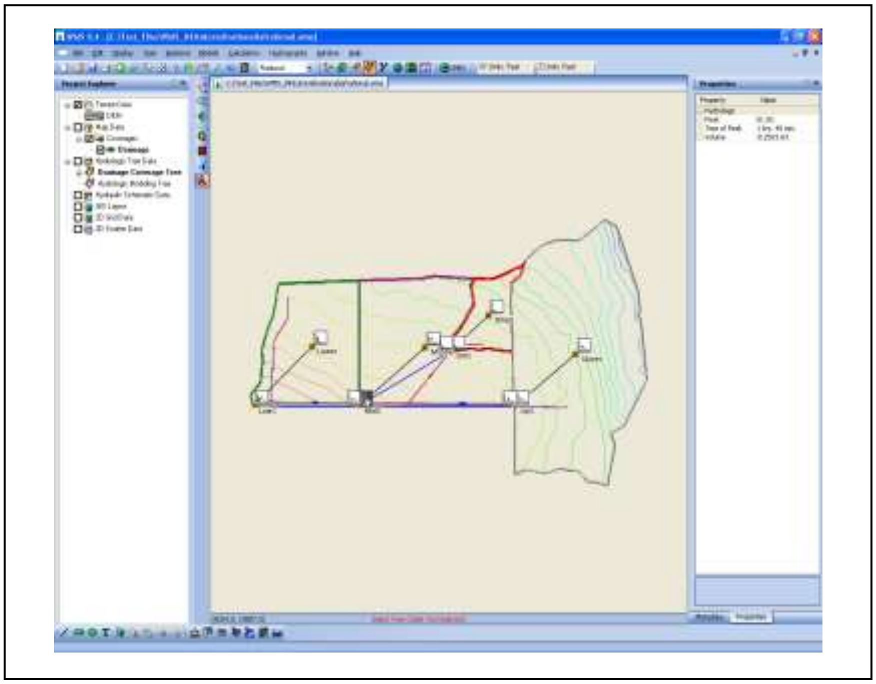
WMS

v. 10.0

WMS 10.0 Tutorial

Watershed Modeling – Rational Method Interface

Learn how to model urban areas using WMS' rational method interface



Objectives

This tutorial demonstrates how to model urban areas using the Rational method, one of the simplest and best known methods used in urban hydrology. Users learn how to compute rainfall intensity, compute hydrographs, and how to combine and route hydrographs using the traditional method and by summing hydrographs.

Prerequisite Tutorials

- Watershed Modeling – DEM Delineation
- Watershed Modeling – Advanced DEM Delineation Techniques (Optional)

Required Components

- Data
- Drainage
- Map
- Hydrology
- Hydrologic Models

Time

- 15-45 minutes

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1 Introduction

The Rational Method is one of the simplest and best known methods routinely applied in urban hydrology. Peak flows are computed from the simple equation:

$$Q = kCiA$$

where:

Q - Peak flow

k - Conversion factor

C - Runoff coefficient

i - Rainfall intensity

A - Area

In this exercise users will learn how to solve problems using a digital terrain model and the Rational Method.

2 Reading in Terrain Data

1. Open WMS. If WMS is already open select *File* | **New**.
2. If asked to save changes, click **No**.
3. Select *File* | **Open** .
4. Locate the “rational” folder in the files for this tutorial. If needed, download the tutorial files from www.aquaveo.com.
5. Locate and open “afrational.wms”. An image will appear in the Main Graphics Window.
6. Switch to the **Drainage** module.
7. Select *DEM* | **Compute Basin Data**.
8. The *Units* dialog will appear. The *Model units* should be feet. If they are not, click **Current Projection**.

9. In the *Display Projection* dialog, make sure both *Horizontal units* and *Vertical units* are set to "U.S. Survey Feet" by selecting that option from the drop down menus. Click **OK**.
10. For *Parameter units* set the *Basin Areas* to "Acres" and *Distances* to "Feet".
11. Select **OK**.
12. Select *Display* | **Display Options** to open the *Display Options* dialog.
13. Make sure "Drainage Data" is selected from the menu on the left. Click the **All off** button.
14. Select **OK** to close the dialog.

3 Running a Rational Method Simulation

The areas computed with the DEM can now be used in setting up a Rational Method simulation of the urban development. Each of the outlet points represents an inlet to a storm drain.

1. Switch to the **Hydrologic Modeling** module.
2. Next to the model macros at the top of the screen there is a combo box with a drop down menu. Select "Rational".
3. Double-click the basin icon for the basin labeled *"*Upper*"* in Figure 1.

The *Rational Method* dialog should appear. The parameters shown in the dialog correspond to the basin that was selected.

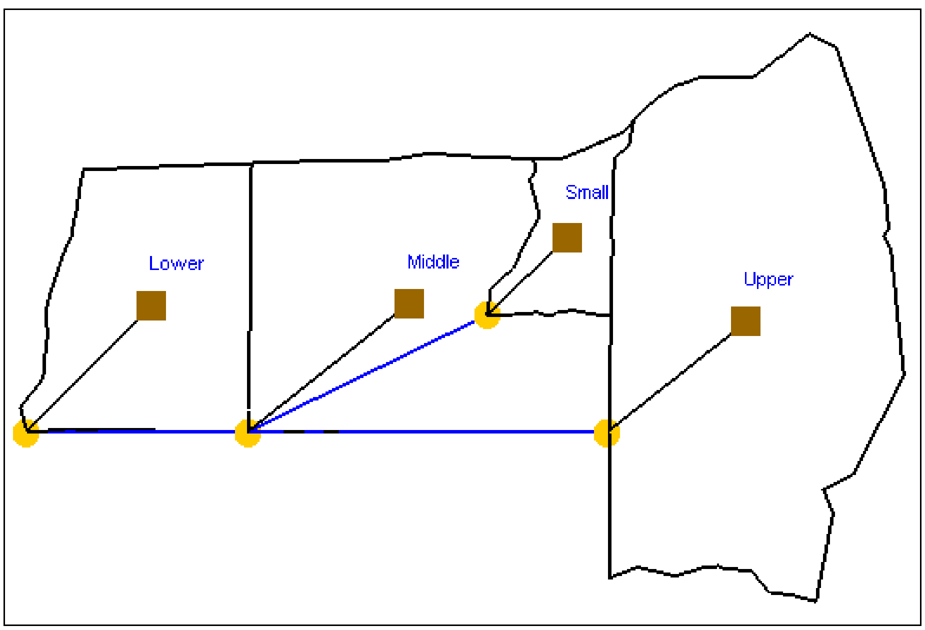

Figure 1 Basins

3.1 Runoff Coefficients and Time of Concentration

The runoff coefficient, C, is used to account for losses between rainfall and runoff. The more developed a catchment is, the higher the C value it will have.

1. For *Runoff Coefficient (C)* enter a value of “0.20”.
2. For *Time of concentration (Tc)* enter a value of “22”.
3. Select **OK**.
4. Double click on the basin labeled “Small” in Figure 1. The *Rational Method* dialog will reappear.
5. Enter a value of “0.35” for *Runoff Coefficient (C)*.
6. Enter a value of “6” for *Time of Concentration*.
7. Select **OK**.
8. Repeat this process for the other two basins, using the table below to fill in values for C and Tc.

Basin Name	Runoff Coefficient C	Time of Concentration t_c
Upper	0.20	22
Small	0.35	06
Middle	0.40	18
Lower	0.40	11

9. When users are finished entering the parameters select **OK** to close the *Rational Method* dialog.

A runoff coefficient coverage could be used to automatically map C values and basin data, or a time computation coverage could be employed to determine Tc values, but they can also be computed/estimated separately and entered as demonstrated here.

3.2 Rainfall Intensity (i) and Basin Peak Flows

As part of the WMS interface to the Rational Method, users can compute IDF curves using either HYDRO-35, NOAA, or user defined data. For this exercise users will use HYDRO-35 data and a recurrence interval of 10 years.

1. Double-click the icon for the “Upper” catchment. The *Rational Method* dialog will reappear.
2. In the *Compute I – IDF Curves* row click on the **Compute…** button.
3. A new dialog box called *Rational Method - - IDF Computation* will have appeared. Make sure the *HYDRO-35 Data (Eastern US)* option is selected.
4. Click on the **Define Storm Data…** button.
5. In the *Input variables for IDF curves* dialog, enter the following values to define IDF curves using HYDRO-35.

Time (min)	Depth (in)
2 yr. 5 min.	0.47
2 yr. 15 min.	0.97
2 yr. 60 min	1.72

100 yr. 5 min.	0.81
100 yr. 15 min.	1.75
100 yr. 60 min.	3.60

6. Select the **OK** button after correctly entering the rainfall values.

The IDF curves for the 2, 5, 10, 25, 50, and 100 year recurrence intervals will be drawn, and values listed for selected times given in the windows on the right of the *IDF Computation* dialog.

7. From the text window in the upper right hand part of the dialog, click on the line of data for the 10-yr recurrence interval as shown in Figure 2.

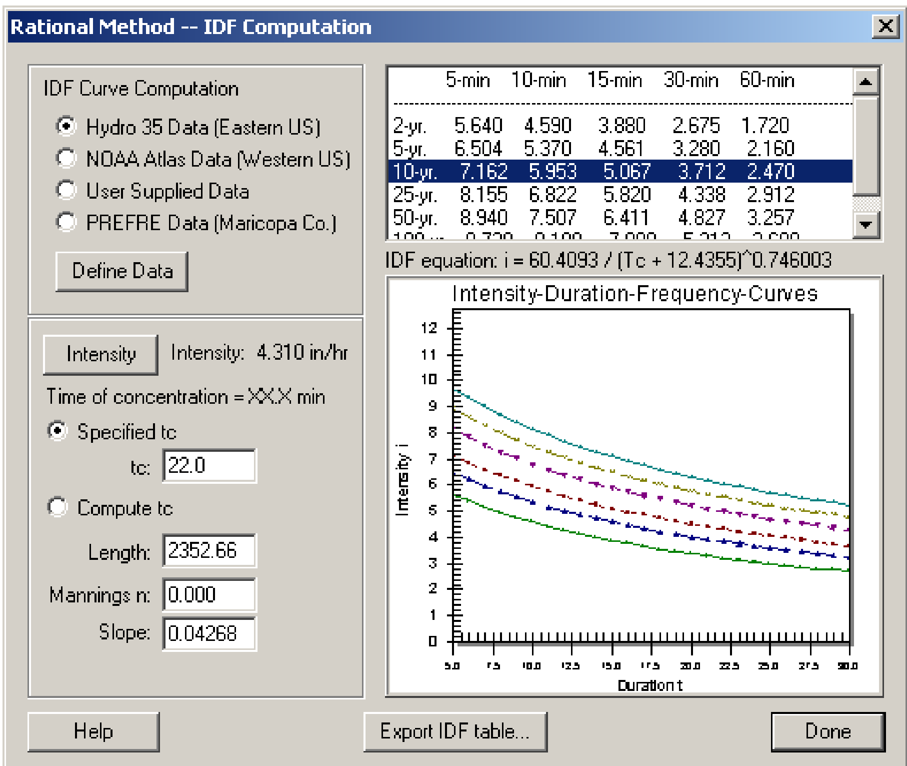

Figure 2 IDF Computation dialog with 10-yr Recurrence Interval Selected

The rainfall intensity is determined using the selected interval according to the value for time of concentration, which was previously entered.

8. Compute i by clicking on the **Compute Intensity** button.
9. Select the **Done** button. The value of i computed using the *Rational Method – IDF Computation* dialog is automatically entered for the Rainfall Intensity (I).

Note that the input for this basin is complete and a value for runoff Q is computed and displayed in the Flowrate (Q) row.

1. Select **OK**.

The HYDRO-35 data only needs to be entered once (unless different data is to be used for different basins), so the rainfall intensity for the remaining basins can be defined using the following steps:

2. Double click on the basin icon for "Small". The *Rational Method* dialog will reappear.
3. In the *Compute I – IDF Curves* row select the **Compute…** button.
4. Verify that the line of text for the 10-yr recurrence interval is highlighted in the *Rational Method - - IDF Computation* dialog.
5. Click on the **Compute Intensity** button.
6. Select **Done**.
7. Select **OK**.
8. Repeat these steps for the "Middle" and "Lower" basins.

3.3 Basin Hydrographs

As the data entry for each basin is completed, a peak flow (Q) is computed and listed in the Flowrate (Q) row. The Rational Method equation does not produce a hydrograph. However, one of several unit-dimensionless hydrographs can be used to distribute the peak flow through time to create a runoff hydrograph.

1. Double-click the basin labeled "Upper" in Figure 1.
2. In the *Compute Hydrographs* row click on the **Compute…** button. The *Rational Method Hydrograph* dialog will open.
3. For the *Hydrograph computation method* choose "Rational method hydrograph".
4. Select **Done** to compute the hydrograph.
5. Select **OK** in the *Rational Method* dialog.
6. Double-click on the small hydrograph box that appears to the upper right of the basin icon to open up a plot window of the hydrograph.

Users should see the hydrograph displayed in a plot window as shown in Figure 3.

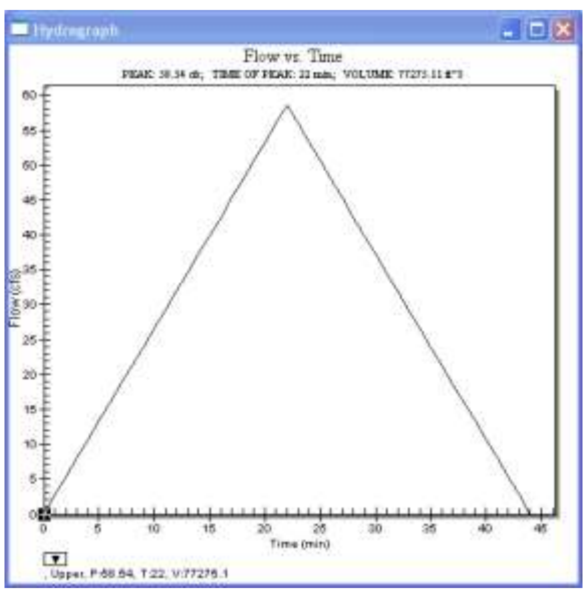

Figure 3 Rational method hydrograph for the Upper basin

7. When users are finished viewing the hydrograph close the plot window by selecting the X in the upper right corner of the window.

3.4 Outlet Peak Flows and Hydrographs (Traditional Method)

At outlet points WMS uses data from all upstream basins to calculate composite rational method parameters, which can be used to compute peak flows and generate hydrographs. The area is the cumulative upstream area, and the runoff coefficient is determined as an area weighted value from the upstream basins. The time of concentration at an outlet point is defined as the longest flow time from contributing upstream basins (times of concentration) combined with any lag (travel) times from channels. With the time of concentration at the outlet defined users will need to determine the appropriate rainfall intensity. In order for WMS to compute peak flows and hydrographs at outlets users will need to define the travel time between outlet points and the rainfall intensity for the total time of concentration at each outlet.

1. Select the **Select Outlet** tool.
2. Double-click on "UpC", which is the outlet icon of the "Upper" basin as shown in Figure 1**Error! Reference source not found.** (be sure to select the yellow circular outlet icon and not the square basin icon). The *Rational Method* dialog will reappear.

Users will note in the *Outlet* portion of the *Rational Method* dialog that information upstream from this outlet has been aggregated (in this case though there is just one basin upstream). The longest flow time is listed for the time of concentration, a cumulative area, and a weighted C value.

3. In the *Outlet* column and *Compute I – IDF Curves* row click on the **Compute…** button.
4. The *Rational Method* - - *IDF Computation* dialog will reappear. Make sure that the 10-yr line of text is highlighted.
5. Click on the **Compute Intensity** button.
6. Select **Done**.

Notice that a composite peak flow is computed and displayed in the *Flowrate (Q)* row for the outlet.

7. For *Routing Lag Time (Tl)* enter a value of "5" minutes.

This is the time that is takes for water to travel in the channel from outlet "UpC" down to oulet "MidC" and will be used for total time of concentration calculations at downstream outlet points.

8. Select **OK.**
9. Double-click the outlet icon names "SmC", which is the outlet of the "Small" basin. The *Rational Method* dialog will reappear.
10. In the *Outlet* column and *Compute I – IDF Curves* row click on the **Compute…** button.
11. The *Rational Method* - - *IDF Computation* dialog will reappear. Verify that the 10-yr line of text is highlighted.

12. Click on the **Compute Intensity** button.
13. Select **Done**.
14. For *Routing Lag Time (Tl)* enter a value of “3” minutes.
15. Select **OK**.
16. Double-click on the next downstream outlet named “MidC”. The *Rational Method* dialog will reappear.

Note that for this outlet the upstream areas are summed, the C values weighted, and the longest travel path is determined based on the upstream basin Tc’s and travel times between outlets.

17. In the *Outlet* column and *Compute I – IDF Curves* row click on the **Compute…** button.
18. The *Rational Method* **- -** *IDF Computation* dialog will reappear. Make sure that the 10-yr line of text is highlighted.
19. Click on the **Compute Intensity** button.
20. Select **Done.**
21. For *Routing Lag Time (Tl)* enter a value of “4” minutes.
22. Select **OK.**

The last or bottom-most outlet does not need to have a Routing lag time defined since the hydrograph accumulations will occur at this point, but users will still need to define the rainfall intensity.

23. Double-click on the bottom-most outlet point, “LowC”. The *Rational Method* dialog will reappear.
24. In the *Outlet* column and *Compute I – IDF Curves* row click on the **Compute…** button.
25. The *Rational Method* **- -** *IDF Computation* dialog will reappear. Verify that the 10-yr line of text is highlighted.
26. Click on the **Compute Intensity** button.
27. Select **Done**.
28. In the *Outlet* column and *Compute Hydrographs* row click on the **Compute…** button.
29. The *Rational Method Hydrograph* dialog will appear. Select the *Traditional method* option.
30. For *Hydrograph computation method* choose “Rational Method hydrograph”.
31. Select **Done**.
32. Select **OK** in the *Rational Method* dialog.
33. Double-click on the hydrograph icon for the most downstream outlet.
34. Close the hydrograph plot window when done viewing by selecting the X in the upper right corner of the window.

3.5 Combine Hydrographs by Summing

Besides the traditional method of computing peak flows and hydrographs for multiple sub-basins within a watershed, WMS will also allow users to lag hydrographs computed for basins and add them using the principle of superposition at outlets in order to produce downstream peak flows and hydrographs.

1. Double-click on the downstream-most outlet point named “LowC”. The *Rational Method* dialog will reappear.
2. In the *Outlet* column and *Compute Hydrographs* row click on the **Compute…** button.
3. The *Rational Method Hydrograph* dialog will reappear. Select the *Route by summing* option.
4. For the *Hydrograph computation method* choose the “Rational method hydrograph” option.
5. Select **Done**.
6. Select **OK**.
7. Double-click the hydrograph icon for the bottom-most outlet.

Users can now see the difference between these two methods as both hydrographs are plotted in the window.

8. Close the hydrograph plot window when done viewing by selecting the X in the upper right corner of the window.

4 Adding a Detention Basin

If users compute runoff using the route by summing method then they can route hydrographs through detention basin structures defined at any of the outlet locations.

1. Double-click the outlet named “MidC”, which is the outlet for the “Middle” catchment in Figure 1. The *Rational Method* dialog will reappear.
2. In the *Outlet* column and *Define Reservoir* row click on the **Define…** button.
3. In the *Detention Basin Hydrograph Routing* dialog, click the **Define…** button. A new dialog, the *Storage Capacity Input* dialog, will appear.

Users will now define a hypothetical detention basin for the “Small” catchment from approximate geometric parameters. WMS can compute a storage capacity curve for any rectangular basin. Users could also enter a pre-computed storage capacity curve or use the elevation data to calculate the storage capacity data.

4. Choose the *Known Geometry* option.
5. For *Length* enter “150” feet.
6. For *Width* enter “200” feet.
7. Enter a *Depth* of “30” feet.
8. Enter a *Side slope* of “2”.

9. Leave the *Base Elevation* at the existing value (it will be assumed on-grade at the outlet location).
10. Select **OK**. The *Detention Basin Analysis* dialog will appear.

Users will now define a standpipe and spillway (weir) for outlet structures and WMS will compute the elevation-discharge relationship automatically. In addition to standpipes and weirs users can define low-level outlets, or they can enter a pre-computed elevation-discharge relationship.

11. Click on the **Define Outflow Discharges…** button.
12. In the *Elevation Discharge Input* dialog, click on the **Add Standpipe** button.
13. Set the *Pipe diameter* to “4” feet.
14. Set the Standpipe *height above base elevation* to “7” feet.
15. Click on the **Add Weir** button.
16. Set the *Weir length* to “20” feet.
17. Set the Weir *height above base elevation* to “25” feet.
18. Select **OK** four times to return to the main WMS Main Graphics Window.

Users have now defined a detention facility that has a standpipe and a spillway for control structures. The incoming hydrograph to this outlet point will be routed through the detention facility before being routed downstream and combined with the hydrographs of other basins.

19. Select *Hydrographs* **| Delete All**.
20. Double-click on the downstream-most outlet point named “LowC”. The *Rational Method* dialog will reappear.
21. In the *Outlet* column and *Compute Hydrographs* row click on the **Compute…** button. The *Rational Method Hydrographs* dialog will reappear.
22. Select the *Route by summing* option.
23. For *Hydrograph computation method* choose “Universal hydrograph method”.
24. Select **Done**.
25. Select **OK**.
26. Double-click on the hydrograph icon for the outlet named “MidC” to view the incoming and routed hydrographs. Click the X at the top right of the *Hydrograph* window when finished viewing.

5 Conclusion

In this exercise users have learned some of the options available for using the Rational method in WMS. Users will want to continue experimenting with the different options so that they can become familiar with all the capabilities in WMS for doing Rational method simulations.

