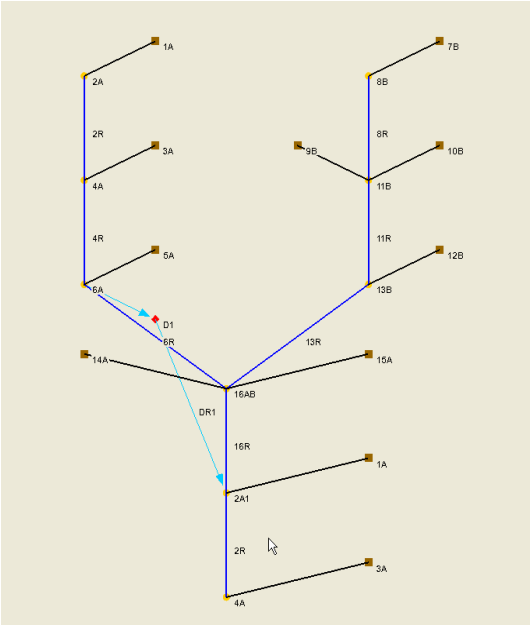
WMS

v. 9.1

WMS 9.1 Tutorial

Watershed Modeling – MODRAT Interface – Schematic

Build a MODRAT model by defining a hydrologic schematic



Objectives

This tutorial shows you how to define a basic MODRAT model using the hydrologic schematic tree in WMS. In this tutorial, you build a tree and define MODRAT hydrologic data for sub-basins and hydraulic structures.

Prerequisite Tutorials

- None

Required Components

- Hydrologic Models

Time

- 20-40 minutes

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1 Contents

1 Contents 2
2 Introduction 2
3 Creating a Topologic Tree (Schematic) 2
4 MODRAT Job Control 5
5 Schematic Tree Numbering 6
6 Edit MODRAT Input Parameters 7
6.1 Editing Basin Data 7
6.2 Editing Reach Parameters 8
7 Running a MODRAT 2.0 Simulation 9
8 Adding a Diversion (Flow Split) 10
9 Adding a Detention Basin 11
10 Running MODRAT 1.0 - Optional 14
11 Conclusion 15

2 Introduction

The Los Angeles County Department of Public Works' Modified Rational (MODRAT) model can be set up and run using the Hydrologic Modeling Module in WMS. This module allows MODRAT simulation of a watershed without requiring GIS or digital terrain data. The tools demonstrated in this exercise are public-domain – there is no charge for using these WMS features.

The following steps will guide you through setting up a topologic tree (schematic) representation of a watershed, entering necessary parameters, and executing a MODRAT simulation.

3 Creating a Topologic Tree (Schematic)

A topologic tree is a simple schematic that shows the connectivity of drainage areas (basins) with outlets (confluence points) and reaches. The schematic can be built in the Hydrologic Modeling module. The following steps will guide you in building a schematic for Palmer Canyon watershed (shown in Figure 3-1).

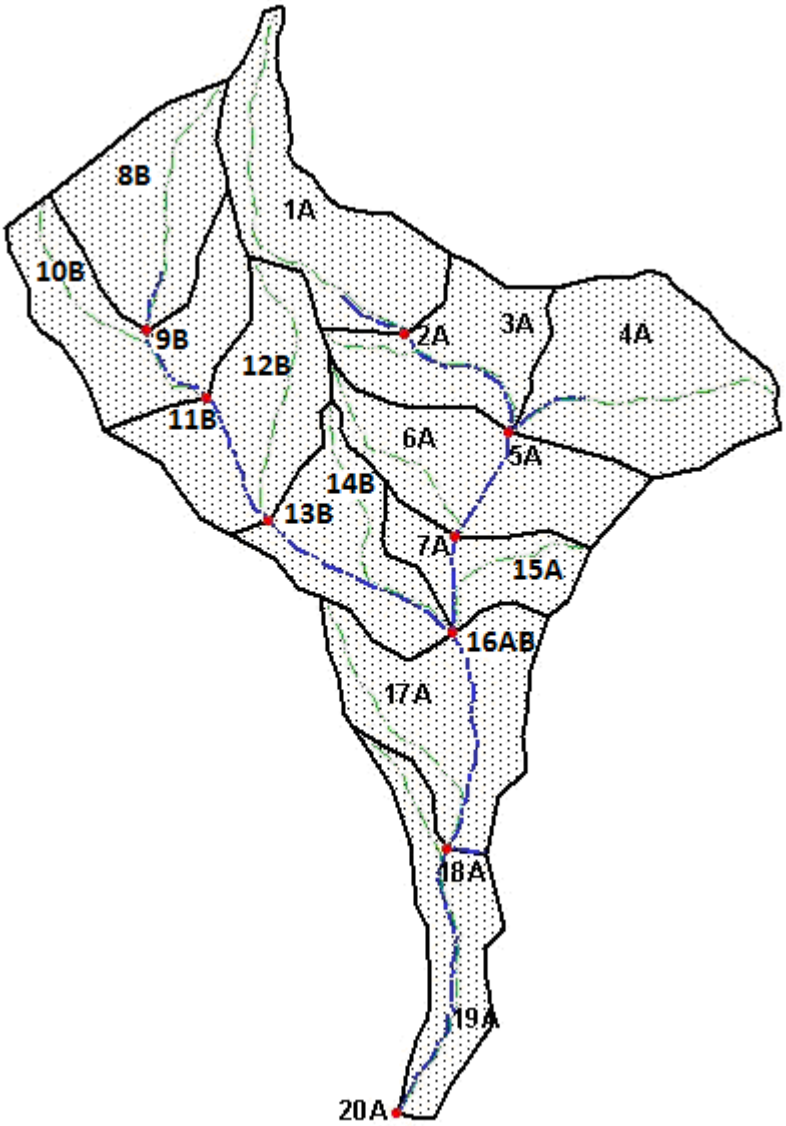


Figure 3-1: Palmer Canyon Watershed

1. Close all instances of WMS.
2. Open WMS.
3. Select the *Hydrologic Modeling* module .
4. Select *MODRAT* in the Model drop down list to make MODRAT the active model in WMS.

For the following steps, you can either follow the menu command instructions or press "O" or "B" on your keyboard to create an outlet or basin, respectively (after clicking somewhere in the graphics window to make it active).

5. Select ***Tree | Add | Outlet -OR- Press the O key*** – this creates the main watershed outlet.

6. Select ***Tree*** **|** ***Add*** **|** ***Basin -OR- Press the B key*** – this attaches a drainage area to the active outlet point.
7. Select ***Tree*** **|** ***Add*** **|** ***Outlet -OR- Press the O key*** – this adds a reach and outlet upstream from the active outlet point.
8. Select ***Tree*** **|** ***Add*** **|** ***Basin -OR- Press the B key.***
9. Select ***Tree*** **|** ***Add*** **|** ***Outlet -OR- Press the O key.***
10. Select ***Tree*** **|** ***Add*** **|** ***Basin -OR- Press the B key.***
11. Select ***Tree*** **|** ***Add*** **|** ***Basin -OR- Press the B key*** – this attaches a 2nd drainage area to the active outlet point.
12. Select ***Tree*** **|** ***Add*** **|** ***Outlet -OR- Press the O key.***
13. Select ***Tree*** **|** ***Add*** **|** ***Basin -OR- Press the B key.***
14. Select ***Tree*** **|** ***Add*** **|** ***Outlet -OR- Press the O key.***
15. Select ***Tree*** **|** ***Add*** **|** ***Basin -OR- Press the B key.***
16. Select ***Tree*** **|** ***Add*** **|** ***Basin -OR- Press the B key.***
17. Select ***Tree*** **|** ***Add*** **|** ***Outlet -OR- Press the O key.***
18. Select ***Tree*** **|** ***Add*** **|** ***Basin -OR- Press the B key.***

You have completed creating the main line in the Palmer Canyon watershed. Now you will create a tributary line.

19. Click on the yellow circle outlet icon labeled 4C.
20. Select ***Tree*** **|** ***Add*** **|** ***Outlet -OR- Press the O key*** – this creates a 2nd outlet and reach attached to the 4C outlet point.
21. Select ***Tree*** **|** ***Add*** **|** ***Basin -OR- Press the B key.***
22. Select ***Tree*** **|** ***Add*** **|** ***Outlet -OR- Press the O key.***
23. Select ***Tree*** **|** ***Add*** **|** ***Basin -OR- Press the B key.***
24. Select ***Tree*** **|** ***Add*** **|** ***Outlet -OR- Press the O key.***
25. Select ***Tree*** **|** ***Add*** **|** ***Basin -OR- Press the B key.***

The schematic is now complete. The display should appear as shown in Figure 3-2. The connectivity of basins, reaches, and outlets is established and you are ready to begin assigning MODRAT input parameters to the watershed.

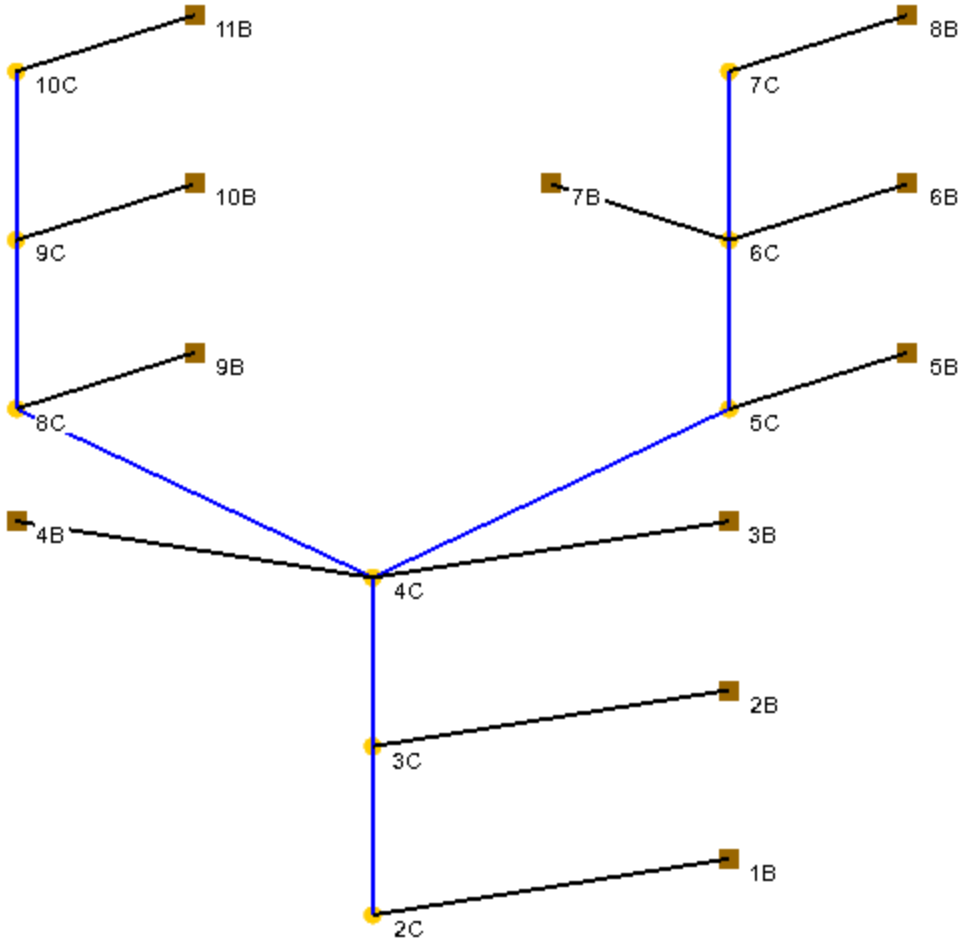


Figure 3-2: Schematic for Palmer Canyon Watershed

4 MODRAT Job Control

The Job Control window for MODRAT allows you to specify input and output filenames, simulation duration, and storm frequency.

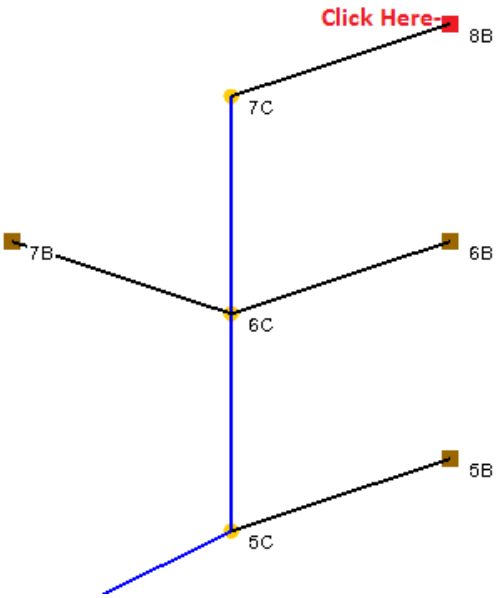
1. Select ***MODRAT | Job Control.***
2. Choose *MODRAT 2.0* at the top of the dialog.
3. Select *2* in the Run time drop down list.
4. Select *25 year* in the Frequency drop down list.
5. Enter "palmer1" in the Prefix box, and then select *Update*. Note that the default prefix for output files is now updated.
6. Enter "palmer_rain.dat" in the Rain file box. WMS will write the rainfall input data to this filename.

7. Enter *"C:\Program Files\WMS90\modrat\sgr_soilx_71.dat"* in the Soil file box. WMS will read the soil data from this file – this is the soil file appropriate for the San Gabriel River watershed where Palmer Canyon is located.
8. Select *OK*.

5 Schematic Tree Numbering

The MODRAT model requires that a watershed model be numbered sequentially in operational order from upstream to downstream. The order in which hydrologic units are processed depends on model numbering. WMS will help you automatically number the tree.

1. Click on the sub-basin (brown square) labeled 8B (most upstream on the right branch) to select it. This indicates to WMS the upstream end of the main line of the watershed.



2. Select ***MODRAT | Number Tree.***
3. Select *OK* to start numbering with location/lateral of 1A.
4. As the numbering process proceeds you will be prompted to "Select a lateral" for each of the basins at a confluence. Notice that WMS zooms into the outlet point labeled 14AB and its surrounding outlet points – Assign basin 4B to the "B" lateral of the watershed and select *OK*.
5. Assign basin 3B to the "A" lateral of the watershed and select *OK*.
6. Click on the *Frame* macro .

The numbering is now complete. Note that the basin selected when the numbering was initiated is now 1A. The main line is met by Line B at the 16AB confluence (outlet) point. The numbers now indicate the order in which the units will be processed by MODRAT.

Save your WMS project at this point.

7. Select ***File | Save As…*** .
8. Enter "PalmerCyn25.wms" and click *Save*.

WMS will save your project to a set of WMS Project files. The *.wms file is an index file and contains other information that instructs WMS to load all the files associated with the project when you open your project at a later time.

6 Edit MODRAT Input Parameters

Input parameters for each basin and reach must be defined for the watershed. The following sections will guide you through entering required data for basins and reaches. You will also set output preferences for each hydrologic unit.

6.1 Editing Basin Data

Each basin (drainage area) must have data associated with it to be successfully simulated by MODRAT.

1. Select ***MODRAT | Edit Parameters***. The MODRAT Parameters window will appear.
2. Select *All* in the "Show" drop down list.
3. Find the basin labeled 1A on the spreadsheet.
4. Enter a value of 67.74 for Area.
5. Enter a value of 8.56 for Time of Concentration (Tc).
6. Enter a value of 81 for Soil type.
7. Enter a value of 1.00 for % Impervious.
8. Enter a value of 10.25 for Rainfall depth.
9. In the Temporal distribution column click on the *Define…* button in the All row (colored yellow) of the spreadsheet. This will bring up a window where you will specify the rainfall temporal distribution (time vs. cumulative rainfall percentage).

Rather than type in values, you will load the default LACDPW 4th Day Design Storm distribution from a file.

9. Select the *Import* button.
10. Find and open the file named "*LACDPWStorm-4thday.xys*".

The LACDPW curve will appear in the spreadsheet/plot window.

11. Select *OK* to assign this curve to all basins.
12. In the All row (colored yellow) of the spreadsheet Choose *Hydrograph (*.HYF) and WMS plot file (*.SOL)* in the Hydrograph Output column.

You have now completed the input for one of the basins in the Palmer Canyon watershed. You will need to define data for all basins in a similar fashion:

13. Use the table below to input values for the basins shown:

Basin Name	Area	Tc	Soil	% Imp.	Rainfall	Output
3A	47.71	6.61	88	1.0	9.91	HYF/SOL
4A	82.87	7.15	88	1.0	9.96	HYF/SOL
6A	62.50	6.48	88	1.0	9.64	HYF/SOL
8A	57.69	6.12	81	1.0	10.05	HYF/SOL
9B	60.77	7.12	88	1.0	9.80	HYF/SOL
11B	65.61	7.12	88	1.0	9.76	HYF/SOL

13B	48.91	8.17	88	1.0	9.41	HYF/SOL
15B	31.47	5.74	88	1.0	9.42	HYF/SOL
17A	69.26	10.52	88	1.0	8.95	HYF/SOL
19A	46.02	13.22	11	8.35	8.32	HYF/SOL

14. When you are finished entering the parameters choose *OK* on the MODRAT Parameters dialog.

The basin parameters for all drainage areas should now be entered for the simulation. Now is a good time to save the work you have done so far.

15. Select ***File*** **|** ***Save***  .

You will now continue to work on editing parameters for the simulation.

6.2 Editing Reach Parameters

Each reach must have data associated with it to be successfully simulated by MODRAT. Reaches are selected in WMS by clicking on an outlet (confluence) point. The parameters for that point and the channel downstream from that point to the next can be edited.

1. Click on the outlet labeled 2A on the schematic.
2. Select ***MODRAT*** **|** ***Edit Parameters***. The MODRAT Parameters window will appear.
3. Find the outlet labeled 2A and enter a value of 1606.96 for Length.
4. Enter a value of 0.2553 for Slope.
5. Verify that *Variable* is selected as the Routing Type.
6. Verify that 0.014 is entered for Manning's n (default value).
7. Choose *Hydrograph (*.HYF) and WMS plot file (*.SOL)* in the Hydrograph Output column.

You have now completed the input for one of the reaches in the Palmer Canyon watershed. You will need to define data for all reaches in a similar fashion:

8. Select *All* in the "Show" drop down list.
9. Use the table below to input values:

Reach Name	Length	Slope	Routing Type	n	Output
5A	1172.57	0.0851	Valley	-	HYF/SOL
7A	955.29	0.1026	Valley	-	HYF/SOL
10B	967.88	0.2877	Variable	0.014	HYF/SOL
12B	1395.38	0.2710	Variable	0.014	HYF/SOL
14B	2151.68	0.0798	Valley	-	HYF/SOL
16AB	2247.75	0.091	Valley	-	HYF/SOL
18A	2835.86	0.0737	Valley	-	HYF/SOL
20A	0.00	0.00	Variable	0.014	HYF/SOL

10. When you are finished entering the parameters choose *OK* on the MODRAT Parameters dialog

The input parameters for all reaches should now be entered for the simulation. Save this data to your working project file.

11. Select ***File | Save***  .

7 Running a MODRAT 2.0 Simulation

All the data required to run a simulation is now ready. To make sure there are no omissions in the data, WMS will perform a model check. Follow the steps below:

1. Select ***MODRAT | Check Simulation***.
2. Review the model check report noting that there are 2 possible errors in the MODRAT model.
3. Note that the possible errors are reports for outlet 20A - this is the watershed outlet; therefore, there is no reach downstream that you need to define.
4. Click *Done* to exit the MODRAT Model Check.

The model checker is a simple way to verify that you have not left out any needed data. It does not verify that the model is correct, but that all the data needed to run the simulation is in place. To execute the MODRAT simulation, do the following:

5. Select ***MODRAT | Run Simulation***.
6. Review the input file; it should be named *"Palmer1.lac"*.
7. Ensure that the *Save file before run* toggle is checked.
8. Ensure that the Prefix for output files box contains "Palmer1".
9. Click *OK* to start the simulation.

A window will appear and report the progress of the MODRAT simulation.

10. Select *Close* once MODRAT finishes running (you may have to wait a few seconds to a minute or so).

The resulting hydrographs will be read in and a small hydrograph plot will appear next to each basin and outlet.

11. Double-click on the hydrograph icon next to outlet 20A.
12. Review the hydrograph plot that appears in a new plot window. Note that peak flow, time to peak, and volume are reported in the title and legend of the plot.
13. Hold the SHIFT key and double-click on the hydrograph icon next to outlet 16AB.
14. Review the new plot that appears with both hydrographs plotted on the same axes.
15. Close all plot windows by clicking on the X in the upper right corner of each window.
16. Select ***File | Edit File***.
17. Find and open the file named *"Palmer1.out"*.

18. Confirm that you want to open the file with Notepad, if prompted.
19. Review the text summary output of the simulation.
20. Close the file by clicking on the X in the upper right corner of the Notepad window.

You have successfully completed a simulation with MODRAT. There are many other options in the MODRAT that were not included in this simple model. The following sections will present 2 of those options: detention basins and diversions.

21. Clear the results by selecting ***Hydrographs | Delete All.***

8 Adding a Diversion (Flow Split)

The flow in a line of a MODRAT model can be split using a diversion in WMS. The diverted flow can be routed and returned to a downstream location in the model, if desired. To split flow at one location in your model, do the following:

1. Select the outlet named 14B by clicking on the yellow circle.
2. Select ***Tree | Add Diversion.***

WMS will insert the diversion.

3. Click on the outlet named 20A.
4. Select ***Tree | Retrieve Diversion***.

Note that the diversion arrow returns to the outlet named 20A. Since you have added a diversion in your model, you should now renumber your model to include this new diversion in the numbering scheme. Follow these steps to renumber your model:

5. Click on the sub-basin labeled 1A (most upstream on the right branch) to select it. This indicates to WMS the upstream end of the main line of the watershed.
6. Select ***MODRAT | Number Tree.***
7. Select *OK* to start numbering with location/lateral of 1A.
8. Assign basin 15B to the "B" lateral of the watershed and select *OK*.
9. Assign basin 8A to the "A" lateral of the watershed and select *OK*.
10. Click on the *Frame* macro  .

Now that the location and return have been defined, you will need to instruct MODRAT how to split the flow and route it in the diversion channel.

11. Double-click the outlet named 14BC – the MODRAT Parameters window will appear.
12. Turn on the *Relief Drains* display option if it is not already on.
13. Set the Relief drain type box to *Drain Capacity.*
14. Enter 250.0 in the Flow rate box – this is the maximum flow allowed in the main channel above which flow will be diverted.
15. Click *OK* to exit the window.

16. Double-click the diversion icon named 15C – the MODRAT Parameters window will appear.
17. Enter 5000.0 in the Length box.
18. Enter 0.05 in the Slope box.
19. Choose *Circular pipe* in the Routing type box.
20. Enter 0.014 in the Manning's n box.
21. Enter 3.0 (ft) in Size column (diameter).
22. Choose *Hydrograph (*.HYF) and WMS plot file (*.SOL)* in the Input/Output Options.
23. Click *OK* to exit the window.

The diversion is now complete. To re-run the simulation and see the effects of the split, do the following:

24. Select ***MODRAT | Run Simulation***.
25. Click the browse button next to the Input File. Name it "Palmer2.lac".
26. Ensure that the *Save file before run* toggle is checked.
27. Enter "Palmer2" in the Prefix for output files box.
28. Click *OK* to start the simulation.

A window will appear and report the progress of the MODRAT simulation. At the end of the simulation, do the following to return to WMS and view the results of the simulation:

29. Select *Close* once MODRAT finishes running (you may have to wait a few seconds to a minute or so).

The resulting hydrographs will be read in and a small hydrograph plot will appear next to each basin and outlet.

30. Double-click on the hydrograph icon next to outlet 14BC.
31. Note that the hydrograph peak is cut off at 250.0 cfs.
32. Double-click on the hydrograph icon next to diversion 15C.
33. Review the hydrograph in the relief drain channel.
34. Close all plot windows by clicking on the X in the upper right corner of each window.
35. Clear the results by selecting ***Hydrographs | Delete All.***

9 Adding a Detention Basin

You can place a detention basin at any outlet point and route incoming flow through that structure with MODRAT. In this model, you will define a detention basin at the watershed outlet (mouth of Palmer Canyon).

1. Double-click the outlet named 21AC – the MODRAT Parameters window will appear.

2. Turn on the *Reservoir Routing* display option.
3. Click the *Reservoir routing* toggle.
4. Click the *Define Reservoir* button.
5. A blank Elevation-Storage Capacity-Discharge window will appear. Click the *Define* button in the upper left.
6. Click the *Define Storage* button.

You will now define a hypothetical detention basin from approximate geometric parameters. WMS can compute a storage capacity curve for a rectangular basin. You could also enter a pre-computed storage capacity curve.

7. In the Storage Capacity Input window, select the *Known Geometry* option.
8. Enter 500 feet for Length.
9. Enter 500 feet for Width.
10. Enter a Depth of 20 feet.
11. Enter a Side slope of 1.
12. Leave the Base elevation at 0.0 (It will be assumed on-grade at the outlet location).
13. Select *OK*.

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

14. Select the *Define Discharges* button.
15. Select the *Add Outlet* button.
16. Set the Diameter to 4.90 feet.
17. Set the Invert elevation to 1.0 foot.
18. Set the Manning's n to 0.014.
19. Set the Slope to 0.001.
20. Select the *Add Weir* button.
21. Set the Weir length to 50.0 feet.
22. Set the Weir elevation to 17.0 feet.
23. Select *OK*.
24. Select *OK* in the Elevation – Storage Capacity – Discharge window.
25. Note the curves are now plotted in the Detention Basin Hydrograph Routing window, shown in Figure 9-1.

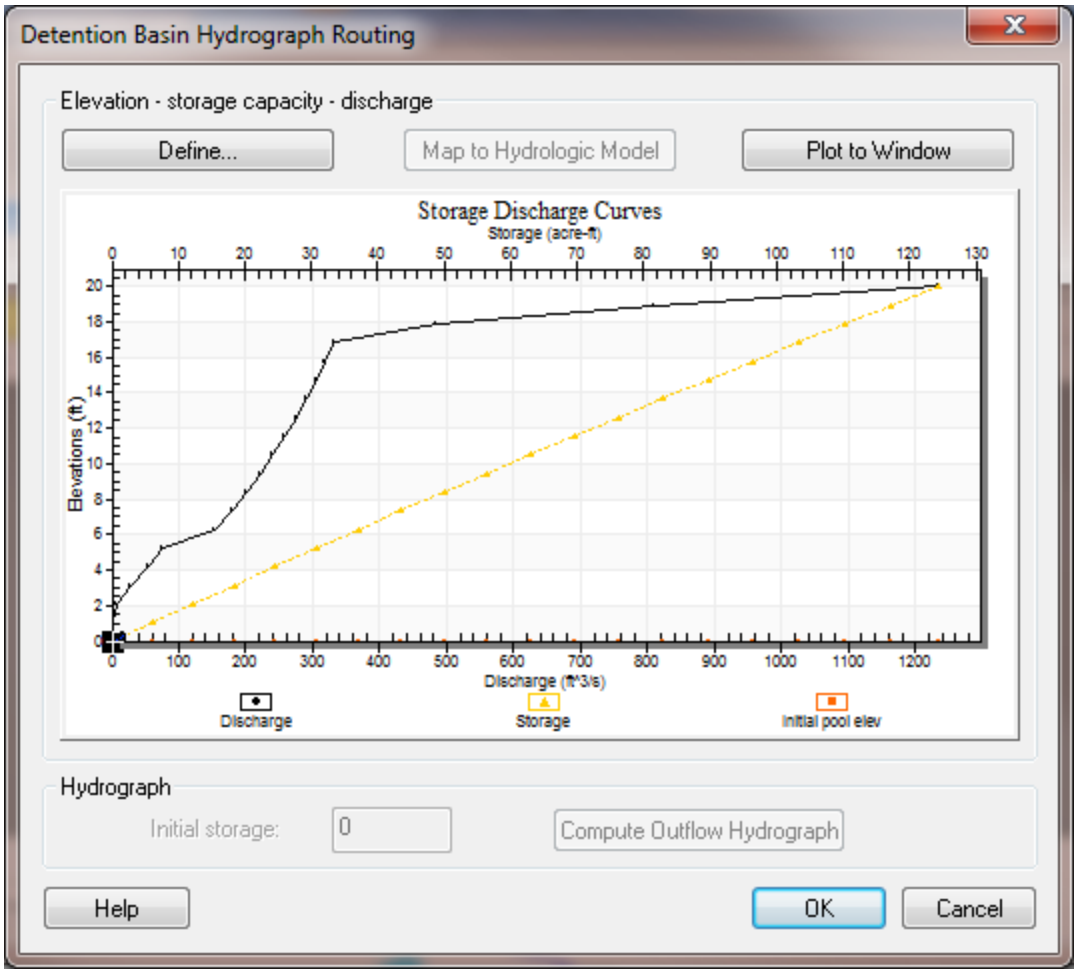


Figure 9-1: Reservoir Storage-Elevation-Discharge

26. Click *OK*.
27. Click *OK* to exit the MODRAT Parameters window.

You have now defined a detention facility that has an outlet pipe 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. To re-run the simulation and see the effects, do the following:

28. Select ***MODRAT | Run Simulation***.
29. Click the button next to the Input File and name it "Palmer3.lac".
30. Ensure that the *Save file before run* toggle is checked.
31. Enter "Palmer3" in the Prefix for output files box.
32. Click *OK* to start the simulation.

A window will appear and report the progress of the MODRAT simulation.

33. Select *Close* once MODRAT finishes running (you may have to wait a few seconds to a minute or so).

The resulting hydrographs will be read in and a small hydrograph plot will appear next to each basin and outlet.

34. Note that there are two hydrograph icons near 21A. Click on one, then hold the SHIFT key and double-click on the other. When selecting multiple hydrographs, you can also view all the selected hydrographs in a single plot by selecting the ***Display | Open Hydrograph Plot*** command.
35. Both hydrographs will be plotted in a new window. Note the effects of the detention basin on the incoming hydrograph.
36. Close all plot windows by clicking on the X in the upper right corner of each plot window.
37. Clear the results by selecting ***Hydrographs | Delete All.***

10 Running MODRAT 1.0 - Optional

To run the older version of MODRAT (MODRAT 1.0 which uses the 4 day storm approach instead of a continuous simulation approach) you simply need to change the rainfall input for your model. You must change some Job Control items and edit the precipitation input for the basins in your model.

1. Select ***MODRAT | Job Control.***
2. Choose *MODRAT* at the top of the dialog and ensure that the Time Period is set to *Days:4*.
3. Select *OK*
4. Select ***MODRAT | Edit Parameters***
5. Set the Type (upper left of the dialog) to *Basins*
6. Set the Show option (upper right of the dialog) to *All*
7. In the Temporal distribution column click on the *Define…* button in the All row (colored yellow) of the spreadsheet
8. Click on the *Import* button
9. Find and open the file named "*LACDPWStorm1500min.xys*"

The LACDPW1500min curve will appear in the spreadsheet/plot window.

10. Select *OK* to assign this curve to all basins

Note that the rainfall depths entered do not need to be changed since you ran a 4^{th} day simulation with MODRAT 2.0. These depths correspond to a 24 hour design storm and are appropriate with the 1500 min. curve used with MODRAT 1.0.

11. Select *OK* to close the *MODRAT Parameters* dialog.
12. Select ***MODRAT | Run Simulation***
13. Click the button next to the Input File and name it "Palmer4.lac"
14. Ensure that the *Save file before run* toggle is checked
15. Enter "Palmer4" in the Prefix for output files box

16. Click *OK* to start the simulation

A window will appear and report the progress of the MODRAT simulation.

17. Select *Close* once MODRAT finishes running (you may have to wait a few seconds to a minute or so)

The resulting hydrographs will be read in and a small hydrograph plot will appear next to each basin and outlet. Review hydrographs as needed.

11 Conclusion

In this exercise you have learned some of the options available for using the MODRAT model in *WMS*. You will want to continue experimenting with the different options so that you can become familiar with all the capabilities in *WMS* for doing MODRAT simulations.