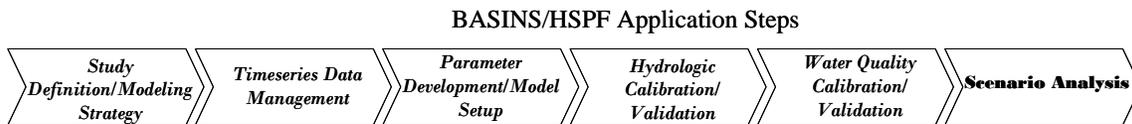




## Exercise 14 – Modeling Alternative Scenarios, BMPs, and TMDLs



In this exercise, we will simulate alternative conditions in the watershed, including best management practice (BMP) implementation, by making changes to the \*.uci file using both WinHSPF and GenScn. We will also perform various post-processing operations in order to analyze the differences between/among the scenarios. In the final part of the exercise, we will demonstrate a method for calculating a simplified TMDL. Actual TMDLs will likely require many other site-specific considerations.

### Questions addressed in this exercise:

- 1.) How do I create a base case scenario?
- 2.) How do I generate a scenario that represents historical conditions?
- 3.) How do I generate a scenario that represents possible future conditions?
- 4.) How do I generate a scenario that represents BMP implementation?
- 5.) How do I use results of an HSPF model to calculate a TMDL?

### A. Base Case Scenario

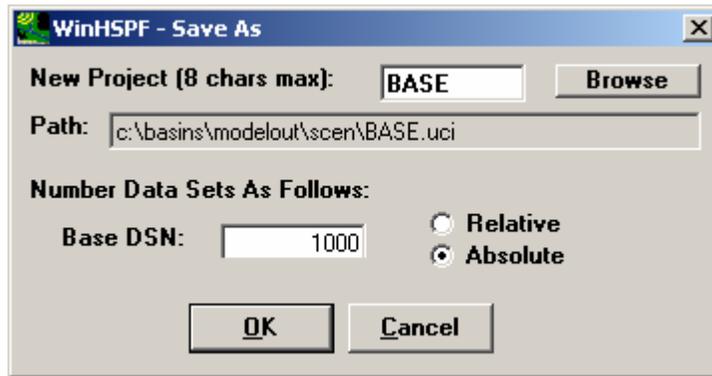
In this section, we will run the model using an input file that is similar (same initial input values) to those we used for Exercises 12 and 13. We will define a ‘base’ scenario, which can be thought of as the ‘current’ state of the watershed with regard to point sources, land use area and distribution, topography, etc. We will make changes to our simulation watershed and compare the results to our ‘base’ scenario in order to ascertain how various management options will affect the model output. Because of time constraints, we will focus on total nitrogen and sediment in this exercise.

#### **QUESTION ANSWERED:**

##### **1.) How do I create a base case scenario?**

1. If WinHSPF isn’t already open, from the **Start** menu under **Programs**, select **BASINS** and then **WinHSPF**.
2. From the **File** menu, select **Open**.
3. Navigate to *c:\basins\modelout\scen* and select “*scen.uci.*” Click **OPEN**.

4. From the **File** menu, select **Save As**.
5. Type “BASE” in the “New Project” box.
6. Leave the “Path” and “Base DSN” as they are. The “Save As” window should look like the following:



7. Click OK.
8. Click  (Run HSPF).
9. Click  (View Output through GENSCN).
10. Click the “HSPF Output” tab.
11. Check the box beside “*c:\basins\modelout\scen.wdm.*”
12. Click OK.
13. In the “Scenarios” frame, select “BASE.”
14. Click the “Add to time series list” button, .
15. Plot TOTAL-N for Reach 5 and SSED for Reach 6.
16. From the **Analysis** menu, select **Run Script**.
17. Navigate to *c:/basins/models/hspf/bin* and select “*GenScnWatershedSummary.spt.*”
18. Click OPEN.
19. In the “Script Arguments” window enter “base” in the “CurScenario” box, “TotalN” in the “gCurConstituent” box, and “*c:\BASINS\Modelout\scen\*” in the “InputDir” box.

- Note:** Be sure to use the same capitalization for the constituent name and include the backslash at the end of the input directory path.
20. Click OK.
  21. Repeat steps 16-20 and produce a report for sediment by entering “base” in the “CurScenario” box, “Sed” in the “gCurConstituent” box, and “c:\BASINS\Modelout\scen\” in the “InputDir” box.
  22. Click OK. Look at the annual loads for total nitrogen and sediment for various landuse categories.
  23. Close any open reports and return to WinHSPF.

## B. Scenario 1: Possible Historical Conditions

### *QUESTION ANSWERED:*

#### *2.) How do I generate a scenario that represents historical conditions?*

In this section, we will create a hypothetical historical scenario. We will assume that at some point in the past, the land use distribution was different than it is currently. We will adjust the land use segment areas, and then run the model and examine the effects of the change.

1. From the **File** menu, select **Save As**.
2. Type “HIST” in the “New Project” box.
3. Leave the “Path” and “Base DSN” as the default.
4. Click “OK.”
5. Click  (Landuse Editor).

Sources		Targets		
Available:	Selected:	Available:	Selected:	
	Add -> <- Remove Add All ->> <<- Remove All	PERLND 101 PERLND 102 PERLND 103 PERLND 104 IMPLND 101 PERLND 105	Add -> <- Remove Add All ->> <<- Remove All	RCHRES 1 RCHRES 6 RCHRES 3 RCHRES 2 RCHRES 5 RCHRES 4
Source ID	Source Description	Target ID	Target Description	Area (Acres)
PERLND 101	Forest Land	RCHRES 1	Western Branch Patux	5785
PERLND 102	Urban or Built-up La	RCHRES 1	Western Branch Patux	2830
IMPLND 101	Urban or Built-up La	RCHRES 1	Western Branch Patux	2830
PERLND 103	Agricultural Land	RCHRES 1	Western Branch Patux	6255
PERLND 104	Barren Land	RCHRES 1	Western Branch Patux	382
PERLND 101	Forest Land	RCHRES 6	North Collington Bra	2774
PERLND 102	Urban or Built-up La	RCHRES 6	North Collington Bra	641
IMPLND 101	Urban or Built-up La	RCHRES 6	North Collington Bra	641
PERLND 103	Agricultural Land	RCHRES 6	North Collington Bra	4569
PERLND 104	Barren Land	RCHRES 6	North Collington Bra	164
				<b>Total: 53560</b>

- Click in the “Area (acres)” column. Reassign the area (acres) associated with “Urban or Built-up Land” (both pervious and impervious) to “Forest Land,” “Barren Land,” and “Wetlands” for each reach **except Reach 5**.

**Note:** There is only urban land contributing to Reach 5. For simplification purposes, we will not redistribute this urban area to other landuse segments.

**Note:** It does not matter how you distribute the area associated with “Urban or Built-up Land” among “Forest Land,” “Barren Land,” and “Wetland.” We are creating a hypothetical historical scenario. After you have distributed the “Urban or Built-Up Land” area to the other landuse categories, make sure that the total area contributing to each reach has not changed. The following shows an example of how you might distribute the urban area:

Source ID	Source Description	Target ID	Target Description	Area (Acres)
PERLND 101	Forest Land	RCHRES 1	Western Branch Patux	7785
PERLND 102	Urban or Built-up La	RCHRES 1	Western Branch Patux	0
IMPLND 101	Urban or Built-up La	RCHRES 1	Western Branch Patux	0
PERLND 103	Agricultural Land	RCHRES 1	Western Branch Patux	9255
PERLND 104	Barren Land	RCHRES 1	Western Branch Patux	1042
PERLND 101	Forest Land	RCHRES 6	North Collington Bra	3774
PERLND 102	Urban or Built-up La	RCHRES 6	North Collington Bra	0
IMPLND 101	Urban or Built-up La	RCHRES 6	North Collington Bra	0
PERLND 103	Agricultural Land	RCHRES 6	North Collington Bra	4800
PERLND 104	Barren Land	RCHRES 6	North Collington Bra	215
PERLND 103	Agricultural Land	RCHRES 3	South Collington Bra	2000
PERLND 101	Forest Land	RCHRES 3	South Collington Bra	2328
PERLND 102	Urban or Built-up La	RCHRES 3	South Collington Bra	0
				<b>Total: 53560</b>

- Click OK.

We will assume for this hypothetical historical scenario that no point sources contributed to the watershed. In the following steps, we will turn “off” the point source in our model.

8. Click  (Point Sources).
  9. Click on the “Western Branch WWTP” in the “In Use:” frame.
  10. Click REMOVE.
  11. Click OK.
  12. Click  (Run HSPF).
  13. Click SAVE/RUN.
  14. Click  (View Output through GENSCN).
  15. Click the “HSPF Output” tab.
  16. Check the box beside “*c:\basins\modelout\scen.wdm.*”
  17. In the “Scenarios” frame, select “BASE” and “HIST.”
  18. Click the “Add to time series list” button, .
  19. Plot TOTAL-N for Reach 5 and SSED for Reach 6 for both scenarios to see how the changes in landuse affect the instream daily average concentrations.
  20. From the **Analysis** menu, select **Run Script**.
  21. Navigate to *c:/basins/models/hspf/bin* and select “*GenScnWatershedSummary.spt.*”
  22. Click OPEN.
  23. In the “Script Arguments” window enter “hist” in the “CurScenario” box, “TotalN” in the “gCurConstituent” box, and “*c:\BASINS\Modelout\scen\*” in the “InputDir” box.
- Note:** Be sure to use the same capitalization for the constituent name and include the backslash at the end of the input directory path.
24. Click OK.

25. Repeat previous steps and produce a report for sediment by entering “hist” in the “CurScenario” box, “Sed” in the “gCurConstituent” box, and “c:\BASINS\Modelout\scen\” in the “InputDir” box.
26. Click OK. Look at the annual loads for total nitrogen and sediment for various landuses. Compare these loads to those generated in the BASE scenario.  
  
**Note:** When the reporting scripts are run, the file is saved in the “Output” folder located in the same folder as your “.uci” file (i.e., \BASINS\modelout\scen\output).
27. Close all open reports and return to WinHSPF.

## C. Scenario 2: Future Conditions

### **QUESTION ANSWERED:**

#### **3.) How do I generate a scenario that represents possible future conditions?**

1. From the **File** menu, select **Open**.
2. Navigate to *c:\basins\modelout\scen* and select “*BASE.uci.*” Click OPEN.

**Note:** We are reopening the base case input file in order to create a new scenario with the original landuse area distribution.

3. From the **File** menu, select **Save As**.
4. Type “FUT” in the “New Project” box.
5. Leave the “Path” and “Base DSN” as the default.
6. Click OK.
7. Click  (Land Use Editor).
8. Click in the “Area (acres)” column and add 20-30% of the acres associated with “Forest Land” to “Urban or Built-up Land.”

**Note:** Make sure that when you distribute “Forest Land” to “Urban or Built-up Land,” the pervious/impervious fractions are similar to those in the base case scenario (50% pervious and 50% impervious) unless you think that future development will be either highly concentrated (resulting in a higher percentage of impervious urban land than pervious urban land) or sparsely concentrated (resulting in a lower percentage of impervious land than

pervious land).

9. Click  (Run HSPF).
10. Click SAVE/RUN.
11. Click  (View Output through GENSCN).
12. Click the “HSPF Output” tab.
13. Check the box beside “*c:\basins\modelout\scen.wdm.*”
14. In the “Scenarios” frame, select “BASE,” “HIST,” and “FUT.”
15. Click the “Add to time series list” button, .
16. Plot TOTAL-N for Reach 5 and SSED for Reach 6 for all scenarios to see how the changes in the landuse distribution affect the instream daily average concentrations.
17. From the **Analysis** menu, select **Run Script**.
18. Navigate to *c:/basins/models/hspf/bin* and select “*GenScnWatershedSummary.spt.*”
19. Click OPEN.
20. In the “Script Arguments” window enter “fut” in the “CurScenario” box, “TotalN” in the “gCurConstituent” box, and “*c:\BASINS\Modelout\scen\*” in the “InputDir” box.  
**Note:** Be sure to use the same capitalization for the constituent name and include the backslash at the end of the input directory path.
21. Click OK.
22. Repeat previous steps and produce a report for sediment by entering “fut” in the “CurScenario” box, “Sed” in the “gCurConstituent” box, and “*c:\BASINS\Modelout\scen\*” in the “InputDir” box.
23. Click OK. Look at the annual loads for total nitrogen and sediment for various landuses. Compare these loads to those generated in the BASE and HIST scenarios.
24. Close all reports and return to WinHSPF.

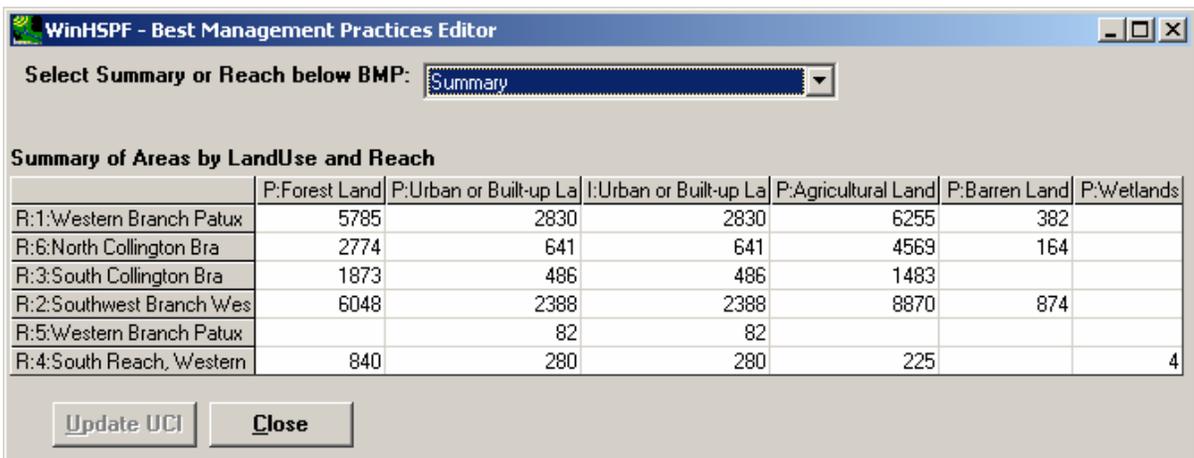
### D. Scenario 3: BMP Implementation

**QUESTION ANSWERED:**

4.) *How do I generate a scenario that represents BMP implementation?*

In this section, we will discuss modeling the impacts of best management practice (BMP) implementation within WinHSPF. To represent a BMP within WinHSPF, you need to do the following:

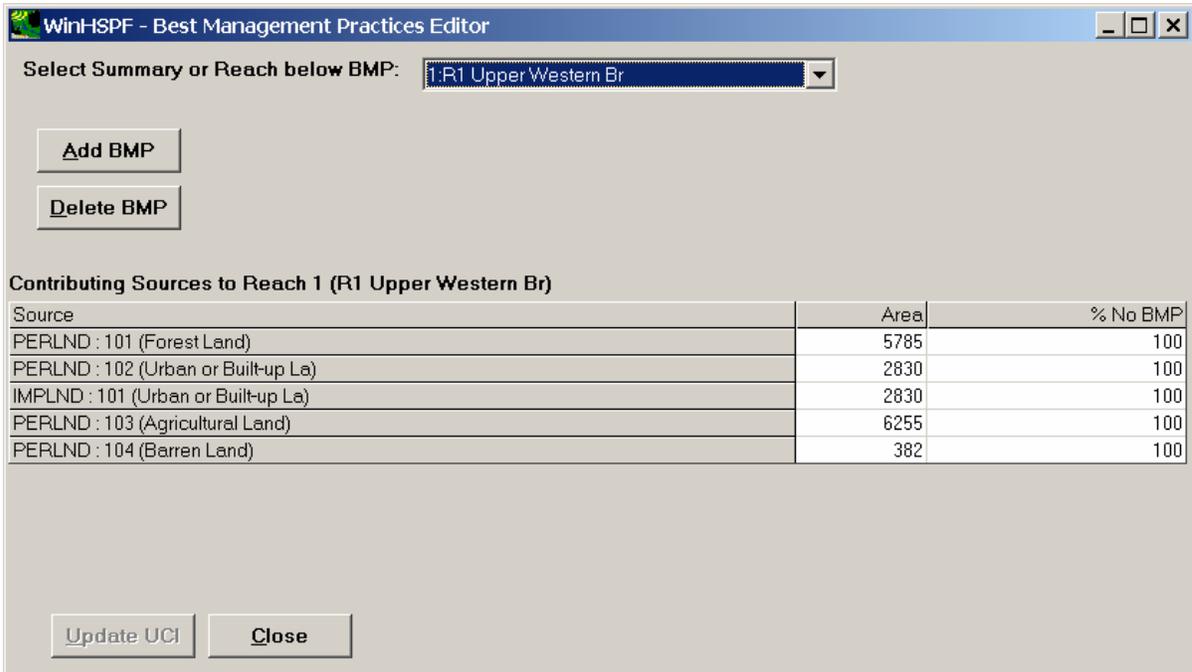
- Identify the landuse segments and model segments (i.e., PERLND segments and IMPLND segments) that will be affected by the BMP
  - Define the level of BMP implementation (i.e., the percentage of the model PERLND/IMPLND segment that will be affected by the BMP)
  - Define the specific BMP in terms of the removal efficiency for each constituent the BMP impacts
1. From the **File** menu, select **Open**.
  2. Navigate to *c:\basins\modelout\scen* and select “*BASE.uci.*” Click OPEN.
  3. From the **File** menu, select **Save As**.
  4. Type “BMP” in the “New Project” box.
  5. Leave the “Path” and “Base DSN” as the defaults and click OK.
  6. From the **Functions** menu, select **BMP**. The “Best Management Practices Editor” window will appear:



**Note:** The Best Management Practices Editor allows you to apply typical BMPs to various landuse segments within your model.

7. From the “Select Summary or Reach Below BMP:” menu, select “1:R1 Upper

Western Br” A window will appear that contains information about the contributing sources to Reach 1:



8. Click ADD BMP. A screen will appear in which you can edit landuse segment areas and the percentage of each landuse segment to which the BMP will be applied, and edit removal efficiencies.
9. Click in the cell that corresponds to “PERLND:103 (Agricultural Land)” and “% BMP 1” and type “75.”

Contributing Sources to Reach 1 (Western Branch Patux)			
Source	Area	% No BMP	% BMP 1
PERLND : 101 (Forest Land)	5785	100	0
PERLND : 102 (Urban or Built-up La)	2830	100	0
IMPLND : 101 (Urban or Built-up La)	2830	100	0
PERLND : 103 (Agricultural Land)	6255	100	75
PERLND : 104 (Barren Land)	382	100	0

10. Click in another cell: the cell corresponding to PERLND: 103 and “% No BMP” will automatically be changed to “25.”

Contributing Sources to Reach 1 (Western Branch Patux)			
Source	Area	% No BMP	% BMP 1
PERLND : 101 (Forest Land)	5785	100	0
PERLND : 102 (Urban or Built-up La)	2830	100	0
IMPLND : 101 (Urban or Built-up La)	2830	100	0
PERLND : 103 (Agricultural Land)	6255	25	75
PERLND : 104 (Barren Land)	382	100	0

**Note:** This means that we are applying a BMP to 75% of the agricultural land that drains into Reach 1.

11. Click UPDATE UCI.
12. Make sure the cell corresponding to PERLND:103(Agricultural Land) is still selected and click the “Edit Removal Efficiency” button.

**Note:** The Best Management Efficiency Editor is an interface to a BMP database that contains removal rates from literature for commonly used BMPs.

13. From the “BMP Name:” menu, select “Filter Strip.” The following table will become available:

BMP Name:	Filter Strip	BMP Operation # 1
Reference: References collected by Mike Thomas		
<b>Removal Fractions</b>		
Constituent	Fraction	DB Range
Sediment:Sand	0	70%-70%
Sediment:Silt	0	70%-70%
Sediment:Clay	0	70%-70%
Fecal Coliforms:Solution	0	76%-76%
Fecal Coliforms:Sand Assoc.	0	76%-76%
Fecal Coliforms:Silt Assoc.	0	76%-76%
Fecal Coliforms:Clay Assoc.	0	76%-76%
BOD	0	70%-70%
NO3:Solution	0	21%-21%
TAM:Solution	0	46%-46%

14. Change the values in the “Fraction” column to match the following:

Constituent	Fraction
Sediment:Sand	70%
Sediment:Silt	70%
Sediment:Clay	70%
NO3:Solution	21%
TAM:Solution	46%
NO2:Solution	21%
NH4:Sand Adsorbed	46%
NH4:Silt Adsorbed	46%
NH4:Clay Adsorbed	46%
Organic Nitrogen	46%

**Note:** Note that you will need to enter a fraction and not a percentage (e.g., 0.7 for 70%). This BMP database is limited, so you may want to adjust the sand fraction (and associated constituents) to have higher removal efficiencies than

silt, clay, and dissolved fractions. For example, you may want to reduce the Sediment:Silt and Sediment:Clay to 50% and the NH4:Silt and NH4:Clay to 30%.

15. Click UPDATE UCI.
16. Click CLOSE.
17. Repeat Steps (7-15) for Reaches 2-4.
18. Click UPDATE UCI within the “Best Management Practices Editor.”
19. Change the “Description” in the “Current BMP Details” to “Filter Strip.”
20. Click CLOSE.

**Note:** Notice that “BMPRAC” nodes have been added to each reach within the watershed schematic.

21. Click  (Run HSPF).
22. Click SAVE/RUN.
23. Click  (View Output through GENSCN).
24. Click the “HSPF Output” tab.
25. Check the box beside “*c:\basins\modelout\scen.wdm.*”
26. In the “Scenarios” frame, select “BASE,” and “BMP.”
27. Click the “Add to time series list” button, .
28. Plot TOTAL-N for Reach 5 and SSED for Reach 6 for all scenarios to see how the BMPs in landuse affect the instream daily average concentrations.
29. From the **Analysis** menu, select **Run Script**.
30. Navigate to *c:/basins/models/hspf/bin* and select “*GenScnWatershedSummary.spt.*”
31. Click OPEN.
32. In the “Script Arguments” window enter “bmp” in the “CurScenario” box, “TotalN” in the “gCurConstituent” box, and “*c:\BASINS\Modelout\scen\*” in the “InputDir” box.

**Note:** Be sure to use the same capitalization for the constituent name and include the backslash at the end of the input directory path.

33. Click OK.
34. Repeat previous steps and produce a report for sediment by entering “bmp” in the “CurScenario” box, “Sed” in the “gCurConstituent” box, and “c:\BASINS\Modelout\scen\” in the “InputDir” box.
35. Click OK. Look at the annual loads for total nitrogen and sediment for various landuses. Compare these loads to those generated in the BASE scenario.

**Note:** Notice that the new loads are not different than those from the base scenario. This is due to the way that the HSPF BMP Module handles BMP reductions, as simple removal efficiencies. Thus, the BMP module does not change the load from the land operations (PERLND and IMPLND), but instead reduces the percent of the load from the land that enters each reach. It represents each BMP as a separate intermediate operation between the PERLNDs and the RCHRES segment.

36. Look again at the reach portion of the same reports. Notice that the load of total nitrogen and sediment reaching the stream reaches has been reduced.

**Note:** You will see the reduction in the loads in the reaches due to the BMP.

37. Close any reports you may have opened and return to WinHSPF.

### *Other Optional Scenarios*

If you have time, you may want to run some of the following scenarios.

- BMP scenario with alternative removal efficiencies and implementation levels
- A combination of a future and BMP scenario to see what level of BMP implementation would be required to offset the impacts of the expected urbanization.

## **E. TMDL Calculations**

In this section, we will use WinHSPF and GenScn to calculate a simple total maximum daily load (TMDL) for total nitrogen. We will begin by plotting the existing state of the total nitrogen calibration with a hypothetical water quality standard for total nitrogen of 5 mg/L. The required margin of safety is 10%.

### ***QUESTIONS ANSWERED:***

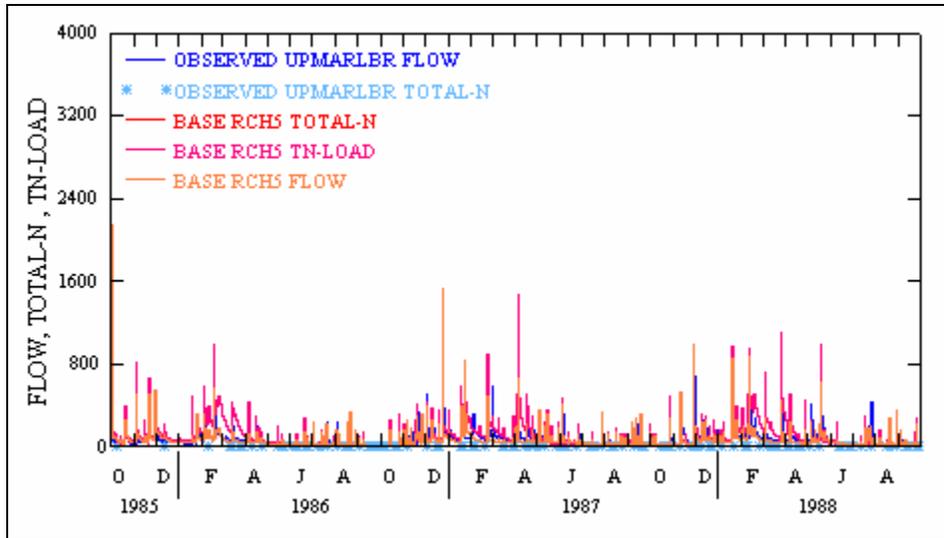
5.) *How do I use results of an HSPF model to calculate a TMDL?*

1. From the **File** menu, select **Open**.
2. Click OK when told you can only have one \*.uci file open.
3. Navigate to *c:\basins\modelout\scen* and select “BASE.uci.” Click OPEN.
4. Click  (View Output through GENSCN).
5. In the Locations frame, select “UPMARLBR” and “RCH 5.”
6. In the “Scenarios” frame, select “BASE” and “OBSERVED.”
7. In the “Constituents” frame, select “FLOW”, “TOTAL-N”, and “TN-LOAD.”
8. Click  (Add to Time-Series List). Your “Time Series” frame should look like the following:

Type	File	DSN	Scenario	Location	Constituent
WDM	scen	261	OBSERVED	UPMARLBR	FLOW
WDM	scen	265	OBSERVED	UPMARLBR	TOTAL-N
WDM	scen	1001	SCEN	RCH5	TOTAL-N
WDM	scen	1003	SCEN	RCH5	TN-LOAD
WDM	scen	1004	SCEN	RCH5	FLOW

We will now plot the total nitrogen load on the right axis and the observed and simulated flows on the auxiliary axis.

9. Click  (Generate Graphs).
10. Click “Yes” when asked if you want to use all timeseries in the list.
11. Select the **Standard** graph.
12. Click **Generate**. Your graph should look like the following:



13. **Double click** in the center of the plot. A “Graph Edit” window will appear.

Axes		Titles		Curves		Lines	General
Axis	Line Type	Marker	Color	Value Type	Legend Entry		
Left	Thin	None	blue	Mean	OBSERVED UPMARLBR FLOW		
Left	None	*	steelblue1	Mean	OBSERVED UPMARLBR TOTAL-N		
Left	Thin	None	red	Mean	BASE RCH5 TOTAL-N		
Left	Thin	None	hotpink	Mean	BASE RCH5 TN-LOAD		
Left	Thin	None	darkorange	Mean	BASE RCH5 FLOW		

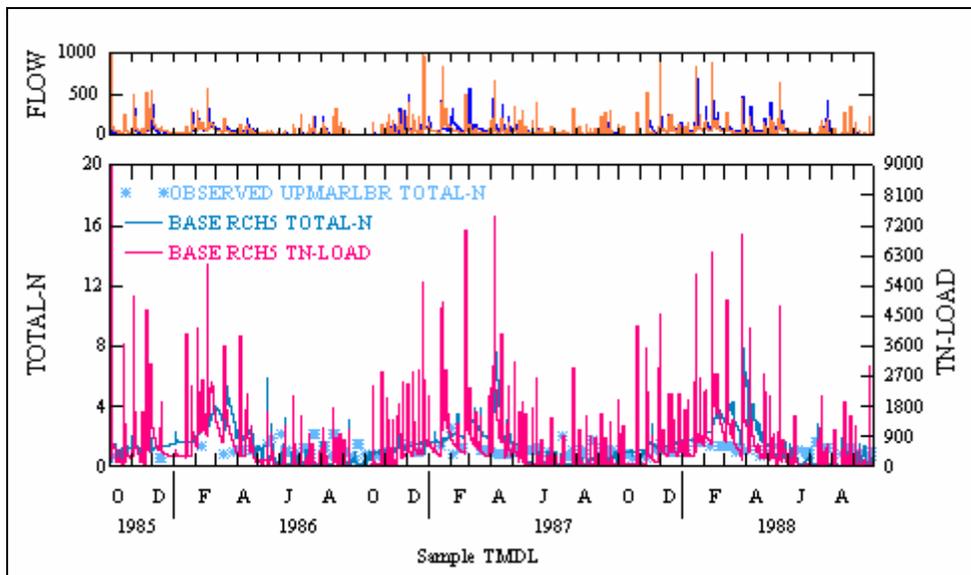
14. **Double click** in the center of each cell in the “Color” column to change the color of each timeseries if you would like.
15. **Double click** in the cells corresponding to both your observed and simulated flow in the “Axis” column and select “Auxiliary.”
16. **Double click** in the cell corresponding to TN-LOAD in the “Axis” column and select “Right.”

Axes		Titles		Curves		Lines	General
Axis	Line Type	Marker	Color	Value Type	Legend Entry		
Auxillary	Thin	None	blue	Mean	OBSERVED UPMARLBR FLOW		
Left	None	*	steelblue1	Mean	OBSERVED UPMARLBR TOTAL-N		
Left	Thin	None	red	Mean	BASE RCH5 TOTAL-N		
Right	Thin	None	hotpink	Mean	BASE RCH5 TN-LOAD		
Auxillary	Thin	None	darkorange	Mean	BASE RCH5 FLOW		

17. Click on the “Axes” tab and set the Left axis “Max” to “20” and the Right axes “Max” to “9000.” You may also want to change the axis titles within the “Titles” tab. Click APPLY and then OK.

Axes	Titles	Curves	Lines	General
X-axis:				
Left Y-axis:	TOTAL-N, TOTN			
Right Y-axis:	TN-LOAD			
Aux axis:	FLOW			
Main:	1 Sample TMDL			

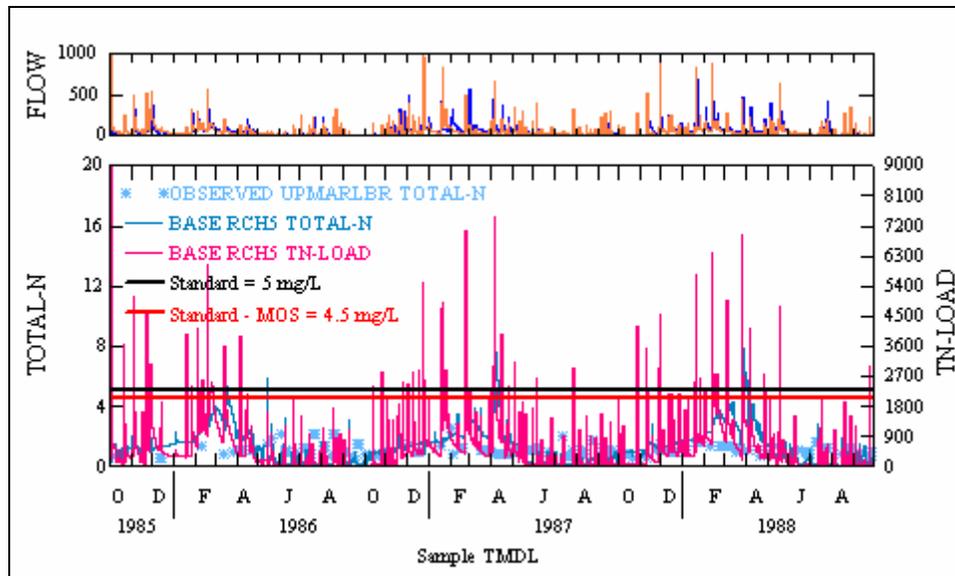
Your plot should look like the following:



18. **Double click** in the center of the plot. A “Graph Edit” window will appear.
19. Click on the “Lines” tab. Add two lines to the plot to show the hypothetical standard (with legend “Standard = 5 mg/L”) and the standard minus a 10% margin of safety (with legend “Standard – MOS = 4.5 mg/L”). You may want to change the colors and the thickness of the lines. Click APPLY and then OK.

Axis	Line Type	Color	Value	Le
Left	Medium	black	5	Sta
Left	Medium	red	4.5	Sta

Your plot should look similar to the following:



## F. Reduce NPS Loads to Achieve Standard and Derive TMDL

The above plot shows how much the standard is being exceeded. We will try to lower the total nitrogen concentrations to meet the standard by adjusting nonpoint loading rates.

Use the generated reports to help you focus on the land use segments that contribute the largest total nitrogen loads. It might be useful to make large adjustments at first to ‘bracket’ the desired maximum concentration value.

The TMDL can be determined by (1) identifying the day on which the maximum value of the total nitrogen concentration lies just below the 4.5mg/L standard and then (2) determining the corresponding daily load. To determine the maximum concentration and corresponding date, select **Listing** from the **View** menu on your plot. A list will appear that includes each date, nitrogen concentration, and nitrogen load shown in the plot. Once you have identified the maximum concentration and the day on which it occurs, you can find the corresponding daily load in the same list. This daily load can be considered your TMDL.

This hypothetical example is considerably simplified in order to demonstrate the overall calculation process. In most real-world TMDLs, the calculations will need to be done over a number of years, including varying flow and climate conditions especially if NPSs are dominant and represent a large fraction of the total load. Many states may require analysis of WQ standard exceedances and associated probabilities as defined by their WQ regulations. The procedures demonstrated above can be used to establish the loads associated with each exceedance, and the corresponding probability can be calculated as the ‘% of time’ the standard is exceeded.

Apply several BMP iterations to each land use segment. The goal is for the highest (simulated) daily total nitrogen concentration to be just below 4.5 mg/L. After each run, regenerate the plot described above to check your results.

If time allows, you can re-do the TMDL calculation under an increased urbanization condition (as simulated earlier) to see how the TMDL might change under projected future conditions.