APPENDIX B

EXAMPLE WATERSHED CONFIGURATIONS

The watershed configuration file defines the spatial relationship of objects within the watershed. The three techniques used to subdivide a watershed are the subwatershed discretization, the hillslope discretization, and the grid cell discretization. The following sections describe how to set up the watershed configuration file for each of the different discretization techniques.

B.1 SUBWATERSHED DISCRETIZATION

The subwatershed discretization divides the watershed into subbasins based on topographic features of the watershed. This technique preserves the natural flow paths, boundaries, and channels required for realistic routing of water, sediment and chemicals. **All of the GIS interfaces developed for SWAT use the subwatershed discretization to divide a watershed.**

The number of subbasins chosen to model the watershed depends on the size of the watershed, the spatial detail of available input data and the amount of detail required to meet the goals of the project. When subdividing the watershed, keep in mind that topographic attributes (slope, slope length, channel length, channel width, etc.) are calculated or summarized at the subbasin level. The subbasin delineation should be detailed enough to capture significant topographic variability within the watershed.

Once the subbasin delineation has been completed, the user has the option of modeling a single soil/land use/management scheme for each subbasin or partitioning the subbasins into multiple hydrologic response units (HRUs). Hydrologic response units are unique soil/land use/management combinations within the subbasin which are modeled without regard to spatial positioning. When multiple HRUs are modeled within a subbasin, the land phase of the hydrologic cycle is modeled for each HRU and then the loadings from all HRUs within the subbasin are summed. The net loadings for the subbasin are then routed through the watershed channel network. HRUs are set up in the subbasin general attribute file (.sub).

The following sections demonstrate how to manually create a SWAT watershed configuration file using the subwatershed discretization.

B.1.1 SUBWATERSHED DISCRETIZATION: 3 SUBBASINS

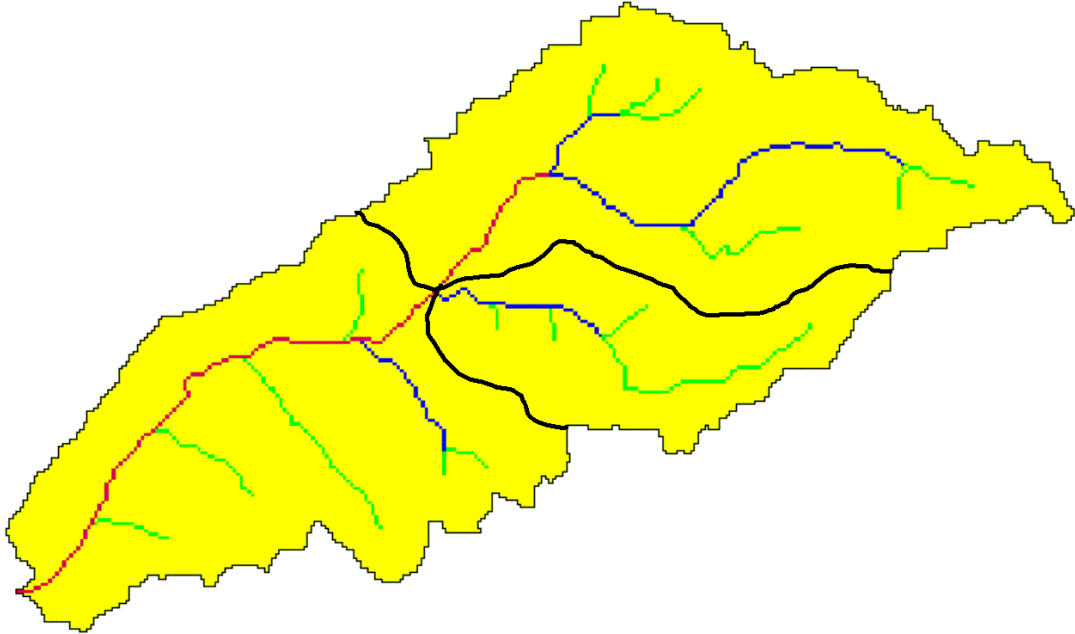Assume we have a watershed with 3 subbasins as illustrated in Figure B-1.

Figure B-1: Subwatershed delineation

Step 1: Write the subbasin command for each subbasin. (This command simulates the land phase of the hydrologic cycle.)

space 1-10	column 1 space 11-16	column 2 space 17-22	column 3 space 23-28	column 4 space 29-34	column 5 space 35-40	column 6 space 41-46	column 7 space 47-55
subbasin	1	1	1				
	ex01.sub						
subbasin	1	2	2				
	ex02.sub						
subbasin	1	3	3				
	ex03.sub						

Writing **subbasin** in space 1-10 is optional. The model identifies the configuration command by the code in column 1. The option of writing the command in space 1-10 is provided to assist the user in interpreting the configuration file.

Column 2 is the hydrograph storage location number (array location) where data for the loadings (water, sediment, chemicals) from the subbasin are stored.

Column 3 is the subbasin number. Unique numbers must be assigned to each subbasin.

The second line of the subbasin command lists the subbasin general input data file (.sub).

Step 2a: Route the stream loadings through the reach network. Begin by routing the headwater subbasin loadings through the main channel of the respective subbasin. (Headwater subbasins are those with no subbasins upstream.) Referring to Figure B-1, assume that subbasins 1 and 2 are upstream of subbasin 3. This would make subbasins 1 and 2 headwater subbasins.

space 1-10	column 1 space 11-16	column 2 space 17-22	column 3 space 23-28	column 4 space 29-34	column 5 space 35-40	column 6 space 41-46	column 7 space 47-55
subbasin	1	1	1				
	ex01.sub						
subbasin	1	2	2				
	ex02.sub						
subbasin	1	3	3				
	ex03.sub						
route	2	4	1	1		0.000	
	ex01.rte		ex01.swq				
route	2	5	2	2		0.000	
	ex02.rte		ex02.swq				

As mentioned in the last step, column 1 is used to identify the command. Column 2 is the hydrograph storage location number identifying the location where results from the route simulation are placed.

Column 3 provides the number of the reach, or main channel, the inputs are routed through. The number of the reach in a particular subbasin is the same as the number of the subbasin.

Column 4 lists the number of the hydrograph storage location containing the data to be routed through the reach. The loadings from subbasin 1 are stored in hydrograph storage #1 and the loadings from subbasin 2 are stored in hydrograph storage #2.

Column 6 lists the fraction of overland flow. For the subwatershed discretization, this value will always be zero—flow is always considered to be channelized before entering the next subbasin.

The second line of the route command lists the names of the routing input data file (.rte) and the stream water quality data file (.swq).

Step 2b: Route the stream loadings through the reach network. Use the add and route commands to continue routing through the watershed. For this example, the water, sediment and chemicals flowing out of subbasins 1 and 2 and the loadings from subbasin 3 must be added together and routed through the main channel of subbasin 3. The loadings from the outlet of subbasin 1 are stored in hydrograph location #4; the loadings from the outlet of subbasin 2 are stored in hydrograph

location #5; and the loadings from subbasin 3 are stored in hydrograph location #3.

space 1-10	column 1 space 11-16	column 2 space 17-22	column 3 space 23-28	column 4 space 29-34	column 5 space 35-40	column 6 space 41-46	column 7 space 47-55
subbasin	1	1	1				
	ex01.sub						
subbasin	1	2	2				
	ex02.sub						
subbasin	1	3	3				
	ex03.sub						
route	2	4	1	1		0.000	
	ex01.rte		ex01.swq				
route	2	5	2	2		0.000	
	ex02.rte		ex02.swq				
add	5	6	4	5			
add	5	7	6	3			
route	2	8	3	7		0.000	
	ex03.rte		ex03.swq				

The add command is specified in column 1 by the number 5. The hydrograph storage location numbers of the 2 data sets to be added are listed in columns 3 and 4. The summation results are stored in the hydrograph location number given in column 2.

Step 3: Once the stream loadings have been routed to the watershed outlet, append a finish command line to signify the end of the watershed routing file.

space 1-10	column 1 space 11-16	column 2 space 17-22	column 3 space 23-28	column 4 space 29-34	column 5 space 35-40	column 6 space 41-46	column 7 space 47-55
subbasin	1	1	1				
	ex01.sub						
subbasin	1	2	2				
	ex02.sub						
subbasin	1	3	3				
	ex03.sub						
route	2	4	1	1		0.000	
	ex01.rte		ex01.swq				
route	2	5	2	2		0.000	
	ex02.rte		ex02.swq				
add	5	6	4	5			
add	5	7	6	3			
route	2	8	3	7		0.000	
	ex03.rte		ex03.swq				
finish	0						

B.1.2 SUBWATERSHED DISCRETIZATION: SAVING SIMULATION RESULTS FOR DOWNSTREAM RUNS

If the watershed of interest is split up into subwatersheds that are modeled with separate SWAT runs, the outflow from the upstream subwatersheds must be saved in a file using the save command. This data will then be input into the SWAT simulation of the downstream portion of the watershed using a recday command.

In example B.1.1, the outflow from the watershed is stored in hydrograph location #8, so this is the data we need to store in a daily file for use in another SWAT simulation. The watershed configuration modified to store outflow data is:

space 1-10	column 1 space 11-16	column 2 space 17-22	column 3 space 23-28	column 4 space 29-34	column 5 space 35-40	column 6 space 41-46	column 7 space 47-55
subbasin	1	1	1				
	ex01.sub						
subbasin	1	2	2				
	ex02.sub						
subbasin	1	3	3				
	ex03.sub						
route	2	4	1	1		0.000	
	ex01.rte		ex01.swq				
route	2	5	2	2		0.000	
	ex02.rte		ex02.swq				
add	5	6	4	5			
add	5	7	6	3			
route	2	8	3	7		0.000	
	ex03.rte		ex03.swq				
save	9	8	1	0	0		
	wshd.eve						
finish	0						

The save command is specified in column 1 by the number 9. Column 2 lists the hydrograph storage location of the data to be saved in the event output file. Column 3 lists the number of the output file. Each save command must use a unique file number between 1 and 10. Column 4 lists the code that governs the print frequency of output in the file (daily or hourly). Column 5 lists the print format (SWAT ASCII or SWAT/AV interface). The name of the event output file is listed on the second line of the save command and usually possesses the .eve file extension. Up to 10 save commands are allowed in a simulation.

The event file output is the same as that described for the rechour or recday input files in Chapter 31.

B.1.3 SUBWATERSHED DISCRETIZATION: INCORPORATING POINT SOURCE/UPSTREAM SIMULATION DATA

Point source and upstream simulation data may be incorporated into a run using one of four record commands: recday, recmon, recyear, and reccnst. The recday command reads data from a file containing loadings of different constituents for each day of simulation. The recmon command reads data from a file containing average daily loadings for each month. The recyear command reads data from a file containing average daily loadings for each year. The reccnst command reads in average annual daily loadings. The record command chosen to read in the data is a function of the detail of data available. To read in upstream simulation data, the recday command is always used.

Assuming the subbasin delineation in Figure B-1 is used with one point source (sewage treatment plants) per subbasin, the watershed configuration file is:

space 1-10	column 1 space 11-16	column 2 space 17-22	column 3 space 23-28	column 4 space 29-34	column 5 space 35-40	column 6 space 41-46	column 7 space 47-55
subbasin	1	1	1				
		ex01.sub					
subbasin	1	2	2				
		ex02.sub					
subbasin	1	3	3				
		ex03.sub					
recday	10	4	1				
		sub1.pnt					
add	5	5	4	1			
route	2	6	1	5		0.000	
		ex01.rte		ex01.swq			
recday	10	7	2				
		sub2.pnt					
add	5	8	7	2			
route	2	9	2	8		0.000	
		ex02.rte		ex02.swq			
add	5	10	6	9			
recday	10	11	3				
		sub3.pnt					
add	5	12	11	10			
add	5	13	12	3			
route	2	14	3	13		0.000	
		ex03.rte		ex03.swq			
finish	0						

All of the record commands require 2 lines. On the first line, column 1 contains the command code for the specific record command, column 2 contains the hydrologic storage location where the data from the file is stored, and column 3 contains the file number. A different file number must be used for each point source of a specific type (e.g., all recday commands must have unique file numbers). The second line lists the name of the file containing the input data.

A description of the four types of record files is given in Chapter 31.

B.1.4 SUBWATERSHED DISCRETIZATION: INCORPORATING RESERVOIRS

Water bodies located along the main channel are modeled using reservoirs. To incorporate a reservoir into a simulation, a routres command is used. There is no limitation on the number of reservoirs modeled.

Assuming the subbasin delineation in Figure B-1 is used with one reservoir located at the outlet, the watershed configuration file is:

space 1-10	column 1 space 11-16	column 2 space 17-22	column 3 space 23-28	column 4 space 29-34	column 5 space 35-40	column 6 space 41-46	column 7 space 47-55
subbasin	1	1	1				
	ex01.sub						
subbasin	1	2	2				
	ex02.sub						
subbasin	1	3	3				
	ex03.sub						
route	2	4	1	1		0.000	
	ex01.rte		ex01.swq				
route	2	5	2	2		0.000	
	ex02.rte		ex02.swq				
add	5	6	4	5			
add	5	7	6	3			
route	2	8	3	7		0.000	
	ex03.rte		ex03.swq				
routres	3	9	1	8	3		
	lakefork.res		lakefork.lwq				
finish	0						

The routres command requires 2 lines. On the first line, the routres command is identified with the number 3 in column 1. Column 2 gives the hydrograph storage location where outflow data from the reservoir is stored. Column 3 lists the reservoir number. A different reservoir number must be assigned to each reservoir and the numbers should be sequential beginning with 1. Column 4 gives the hydrograph storage location of the data to be routed through the reservoir. Column 5 lists the subbasin with which the reservoir is associated. The second line lists two file names, the reservoir input file (.res) and the reservoir water quality file (.lwq).

B.1.5 SUBWATERSHED DISCRETIZATION: SAVING SIMULATION RESULTS FOR ONE LOCATION

Users often need to compare streamflow, sediment, nutrient and/or pesticide levels predicted by the model with levels measured in the stream. To save daily or hourly model output data for a particular location on the stream, the saveconc command is used.

Assume there is a stream gage at the outlet of the watershed shown in Figure B-1 and that we want to compare simulated and measured streamflow for this location. Hydrograph storage location #8 stores the flow data for this location in the watershed, so this is the data we need to process to create the saveconc output file. The watershed configuration modified to process data for this location is:

space 1-10	column 1 space 11-16	column 2 space 17-22	column 3 space 23-28	column 4 space 29-34	column 5 space 35-40	column 6 space 41-46	column 7 space 47-55
subbasin	1	1	1				
	ex01.sub						
subbasin	1	2	2				
	ex02.sub						
subbasin	1	3	3				
	ex03.sub						
route	2	4	1	1		0.000	
	ex01.rte		ex01.swq				
route	2	5	2	2		0.000	
	ex02.rte		ex02.swq				
add	5	6	4	5			
add	5	7	6	3			
route	2	8	3	7		0.000	
	ex03.rte		ex03.swq				
saveconc	14	8	1	0			
	strgage.out						
finish	0						

The saveconc command requires 2 lines. On the first line, the saveconc command is identified with the number 14 in column 1. Column 2 gives the hydrograph storage location of the data to be processed for the saveconc output file. Column 3 lists the file number. Column 4 gives the print frequency (daily or hourly). More than one saveconc command may be used in a simulation. A different file number must be assigned to each saveconc output file and the file numbers should be sequential beginning with 1. The second line lists the name of the saveconc output file.

The saveconc command differs from the save command in that it converts the mass amounts of water, sediment, and chemicals to units that are commonly used to report measured values. Output files produced by the saveconc command cannot be read into another SWAT run—the save command must be used to produce input for another simulation.

B.2 HILLSLOPE DISCRETIZATION

The hillslope discretization allows overland flow from one subbasin to flow onto the land area of another subbasin. As the name implies, this discretization allows SWAT to model hillslope processes.

The hillslope discretization incorporates more detail into the watershed configuration file than the subwatershed discretization. The number of subbasins chosen to model the watershed will depend on the size of the watershed, the spatial relationship of different land uses to one another, the spatial detail of available input data and the amount of detail required to meet the goals of the project. Because this discretization scheme places more emphasis on land use, the subbasins are delineated so that there is one land use and soil per subbasin.

The hillslope discretization can be combined with the subwatershed discretization to provide detailed modeling of particular land use areas while modeling the remaining land use areas with the more generalized approach.

Useful applications of this discretization include: watersheds with concentrated animal feeding operations, watersheds where detailed modeling of filter strips is desired, and microwatersheds where the scale of the simulation allows detail about relative land use positions to be incorporated.

B.2.1 HILLSLOPE DISCRETIZATION: MODELING A DAIRY OPERATION

Assume a microwatershed containing a concentrated animal feeding operation with several different areas of land use and management is being modeled. Milking cows are confined in stalls. All waste produced by the milking cows is collected and applied over manure application fields also located in the microwatershed. The dry cows are kept in pastures. The pastured cows keep the areas adjacent to the farm buildings denuded of grass. Runoff from the denuded areas flows onto the pasture. Runoff from the pasture flows into a filter strip or buffer zone. Runoff exiting the filter strip enters the stream. The manure application fields are isolated from the rest of the dairy operation. Runoff from the application fields flows into a filter strip, and then enters the steam. Figure B-2 illustrates the relationship of land areas in the dairy operation. Areas of the microwatershed outside of the daily operation are forested.

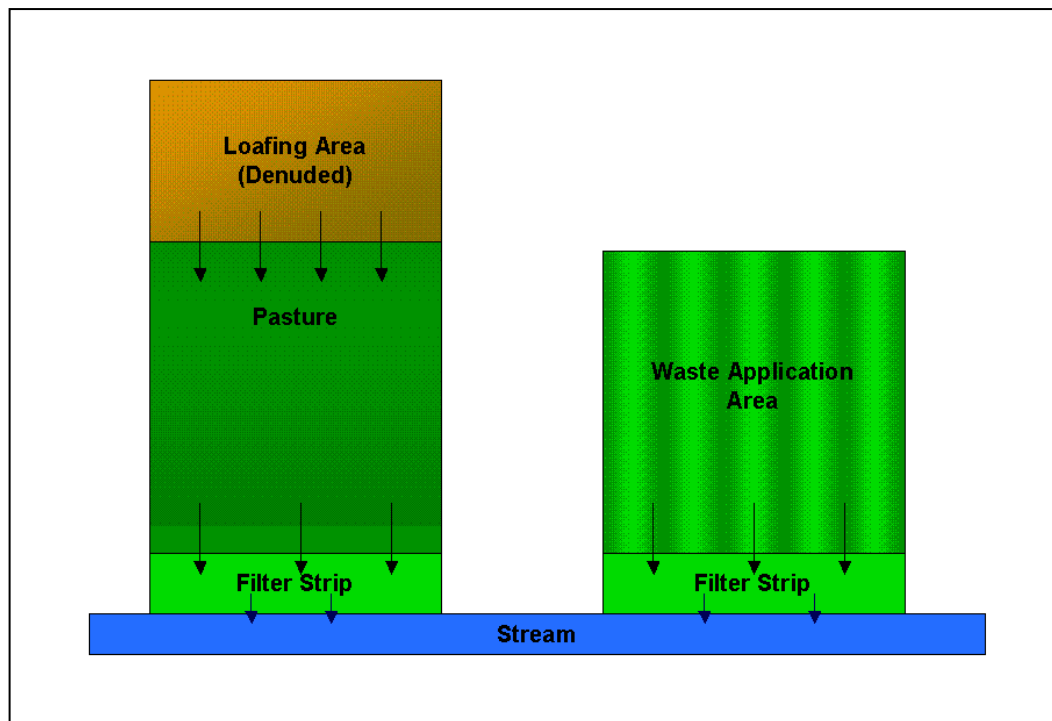
Figure B-2: Spatial positioning of land areas in dairy operation.

This microwatershed will be divided into 6 subbasins:
  Subbasin 1: loafing area
  Subbasin 2: pasture
  Subbasin 3: filter strip associated with pasture
  Subbasin 4: waste application area
  Subbasin 5: filter strip associated with waste application area
  Subbasin 6: completely channelized stream and forest in microwatershed

Step 1: Write the subbasin command for each subbasin. (This command simulates the land phase of the hydrologic cycle.)

space 1-10	column 1 space 11-16	column 2 space 17-22	column 3 space 23-28	column 4 space 29-34	column 5 space 35-40	column 6 space 41-46	column 7 space 47-55
subbasin	1	1	1				
	dairy01.sub						
subbasin	1	2	2				
	dairy02.sub						
subbasin	1	3	3				
	dairy03.sub						
subbasin	1	4	4				
	dairy04.sub						
subbasin	1	5	5				
	dairy05.sub						
subbasin	1	6	6				
	dairy06.sub						

Writing **subbasin** in space 1-10 is optional. The model identifies the configuration command by the code in column 1. The option of writing the command in space 1-10 is provided to assist the user in interpreting the configuration file.

Column 2 is the hydrograph storage location number (array location) where data for the loadings (water, sediment, chemicals) from the subbasin are stored.

Column 3 is the subbasin number. Unique numbers must be assigned to each subbasin.

The second line of the subbasin command lists the subbasin general input data file (.sub).

Step 2: Route the stream loadings.

The hillslope discretization differs from the subwatershed discretization primarily in the method used to route loadings through the watershed. Loadings from subbasins are not routed through the subbasin if the flow leaving the subbasin is not completely channelized. For our example, subbasin 6 is the only subbasin completely channelized.

Assume that runoff from the denuded areas (subbasin 1) is sheet flow, i.e. there are no rills, gullies or any other evidence of channelized flow in the denuded area. Runoff from the denuded area will be routed to the pasture (subbasin 2) using the route command:

space 1-10	column 1 space 11-16	column 2 space 17-22	column 3 space 23-28	column 4 space 29-34	column 5 space 35-40	column 6 space 41-46	column 7 space 47-55
route	2	7	2	1		1.000	
	dairy02.rte		dairy02.swq				

As mentioned in the last step, column 1 is used to identify the command. Column 2 is the hydrograph storage location number identifying the location where

results from the channelized portion of the route simulation are placed. In this instance, because there is no channelized flow, this storage location will contain no data.

Column 3 provides the number of the reach or subbasin the inputs are routed through. (The number of the reach in a particular subbasin is the same as the number of the subbasin.) The fraction of the loadings classified as overland flow are applied to the subbasin land area while the fraction of the loadings classified as channelized flow are routed through the main channel of the subbasin and are exposed to in-stream processes. Channelized flow has no interaction with the land area in the subbasin.

Column 4 lists the number of the hydrograph storage location containing the data to be routed through the reach. The loadings from subbasin 1 are stored in hydrograph storage #1.

Column 6 lists the fraction of overland flow. For completely channelized flow this fraction is zero. For 100% overland flow, this fraction is 1.00.

The entire watershed configuration to this point looks like:

space 1-10	column 1 space 11-16	column 2 space 17-22	column 3 space 23-28	column 4 space 29-34	column 5 space 35-40	column 6 space 41-46	column 7 space 47-55
subbasin	1	1	1				
	dairy01.sub						
subbasin	1	2	2				
	dairy02.sub						
subbasin	1	3	3				
	dairy03.sub						
subbasin	1	4	4				
	dairy04.sub						
subbasin	1	5	5				
	dairy05.sub						
subbasin	1	6	6				
	dairy06.sub						
route	2	7	2	1		1.000	
	dairy02.rte		dairy02.swq				

Assume that runoff from the pasture is slightly channelized (10% channels).

space 1-10	column 1 space 11-16	column 2 space 17-22	column 3 space 23-28	column 4 space 29-34	column 5 space 35-40	column 6 space 41-46	column 7 space 47-55
subbasin	1	1	1				
	dairy01.sub						
subbasin	1	2	2				
	dairy02.sub						
subbasin	1	3	3				
	dairy03.sub						
subbasin	1	4	4				
	dairy04.sub						
subbasin	1	5	5				
	dairy05.sub						
subbasin	1	6	6				
	dairy06.sub						
route	2	7	2	1		1.000	
	dairy02.rte		dairy02.swq				
route	2	8	3	2		0.900	
	dairy03.rte		dairy03.swq				

space 1-10	column 1 space 11-16	column 2 space 17-22	column 3 space 23-28	column 4 space 29-34	column 5 space 35-40	column 6 space 41-46	column 7 space 47-55
subbasin	1	1	1				
	dairy01.sub						
subbasin	1	2	2				
	dairy02.sub						
subbasin	1	3	3				
	dairy03.sub						
subbasin	1	4	4				
	dairy04.sub						
subbasin	1	5	5				
	dairy05.sub						
subbasin	1	6	6				
	dairy06.sub						
route	2	7	2	1		1.000	
	dairy02.rte		dairy02.swq				
route	2	8	3	2		0.900	
	dairy03.rte		dairy03.swq				

Flow from the pasture is routed to the filter strip (subbasin 3) using the next route command:

As mentioned previously, hydrograph storage location #7 contains no data because none of the runoff entering subbasin 2 is channelized. Consequently, when routing runoff leaving subbasin 2, this hydrograph storage location can be ignored. For subbasin 3, however, there will be data in hydrograph storage location #8 from the 10% of flow that is channelized in that subbasin. Loadings from subbasin 3 will enter the main stream in subbasin 6. The total loadings from

the denuded area/pasture/filter strip section of the microwatershed are determined by adding the runoff generated from subbasin 3 and the channelized flow routing results.

space 1-10	column 1 space 11-16	column 2 space 17-22	column 3 space 23-28	column 4 space 29-34	column 5 space 35-40	column 6 space 41-46	column 7 space 47-55
subbasin	1	1	1				
	dairy01.sub						
subbasin	1	2	2				
	dairy02.sub						
subbasin	1	3	3				
	dairy03.sub						
subbasin	1	4	4				
	dairy04.sub						
subbasin	1	5	5				
	dairy05.sub						
subbasin	1	6	6				
	dairy06.sub						
route	2	7	2	1		1.000	
	dairy02.rte		dairy02.swq				
route	2	8	3	2		0.900	
	dairy03.rte		dairy03.swq				
add	5	9	3	8			

The loadings from simulation of the land phase of the hydrologic cycle in subbasin 3 are stored in hydrograph storage location #3 and the loadings from simulation of the channelized flow in subbasin 3 are stored in hydrograph location #8. The add command is specified in column 1 by the number 5. The hydrograph storage location numbers of the 2 data sets to be added are listed in columns 3 and 4. The summation results are stored in the hydrograph location number given in column 2. Net loadings from the denuded area/pasture/filter strip is stored in hydrograph location #9.

Assume that the manure application area (subbasin 4) is well managed and all runoff from this area is overland flow (no channelized flow). To route flow from the application area to the associated filter strip (subbasin 5) a route command will be appended to the end of the configuration:

Hydrograph storage location #10 contains no data because none of the runoff entering subbasin 5 is channelized. Consequently, when routing runoff leaving subbasin 5, this hydrograph storage location can be ignored. Net loadings from the waste application area/filter strip section of the watershed is stored in hydrograph location #5.

space 1-10	column 1 space 11-16	column 2 space 17-22	column 3 space 23-28	column 4 space 29-34	column 5 space 35-40	column 6 space 41-46	column 7 space 47-55
subbasin	1	1	1				
	dairy01.sub						
subbasin	1	2	2				
	dairy02.sub						
subbasin	1	3	3				
	dairy03.sub						
subbasin	1	4	4				
	dairy04.sub						
subbasin	1	5	5				
	dairy05.sub						
subbasin	1	6	6				
	dairy06.sub						
route	2	7	2	1		1.000	
	dairy02.rte		dairy02.swq				
route	2	8	3	2		0.900	
	dairy03.rte		dairy03.swq				
add	5	9	3	8			
route	2	10	5	4		1.000	
	dairy05.rte		dairy05.swq				

Flow through subbasin 6, which contains the stream, is completely channelized. All of the loadings for the stream must be summed together and then routed through the stream. There are 3 sources of loading to the stream: the denuded area/pasture/filter strip (hydrograph location #9), the waste application area/filter strip (hydrograph location #10), and the forest land area (hydrograph location #6). Add commands are used to sum the loadings.

space 1-10	column 1 space 11-16	column 2 space 17-22	column 3 space 23-28	column 4 space 29-34	column 5 space 35-40	column 6 space 41-46	column 7 space 47-55
subbasin	1	1	1				
	dairy01.sub						
subbasin	1	2	2				
	dairy02.sub						
subbasin	1	3	3				
	dairy03.sub						
subbasin	1	4	4				
	dairy04.sub						
subbasin	1	5	5				
	dairy05.sub						
subbasin	1	6	6				
	dairy06.sub						
route	2	7	2	1		1.000	
	dairy02.rte		dairy02.swq				
route	2	8	3	2		0.900	
	dairy03.rte		dairy03.swq				
add	5	9	3	8			
route	2	10	5	4		1.000	
	dairy05.rte		dairy05.swq				
add	5	11	9	5			
add	5	12	6	11			

Flow is routed through the stream using a route command:

space 1-10	column 1 space 11-16	column 2 space 17-22	column 3 space 23-28	column 4 space 29-34	column 5 space 35-40	column 6 space 41-46	column 7 space 47-55
subbasin	1	1	1				
	dairy01.sub						
subbasin	1	2	2				
	dairy02.sub						
subbasin	1	3	3				
	dairy03.sub						
subbasin	1	4	4				
	dairy04.sub						
subbasin	1	5	5				
	dairy05.sub						
subbasin	1	6	6				
	dairy06.sub						
route	2	7	2	1		1.000	
	dairy02.rte		dairy02.swq				
route	2	8	3	2		0.900	
	dairy03.rte		dairy03.swq				
add	5	9	3	8			
route	2	10	5	4		1.000	
	dairy05.rte		dairy05.swq				
add	5	11	9	5			
add	5	12	6	11			
route	2	13	6	12		0.000	
	dairy06.rte		dairy06.swq				

Step 3: Once the stream loadings have been routed to the watershed outlet, append a finish command line to signify the end of the watershed routing file.

space 1-10	column 1 space 11-16	column 2 space 17-22	column 3 space 23-28	column 4 space 29-34	column 5 space 35-40	column 6 space 41-46	column 7 space 47-55
subbasin	1	1	1				
	dairy01.sub						
subbasin	1	2	2				
	dairy02.sub						
subbasin	1	3	3				
	dairy03.sub						
subbasin	1	4	4				
	dairy04.sub						
subbasin	1	5	5				
	dairy05.sub						
subbasin	1	6	6				
	dairy06.sub						
route	2	7	2	1		1.000	
	dairy02.rte		dairy02.swq				
route	2	8	3	2		0.900	
	dairy03.rte		dairy03.swq				
add	5	9	3	8			
route	2	10	5	4		1.000	
	dairy05.rte		dairy05.swq				
add	5	11	9	5			
add	5	12	6	11			
route	2	13	6	12		0.000	
	dairy06.rte		dairy06.swq				
finish	0						

B.2.2 HILLSLOPE DISCRETIZATION:
COMBINING WITH SUBWATERSHED DISCRETIZATION

The hillslope discretization is a very detailed discretization scheme and is suited to small watersheds. However, it can be used in combination with the subwatershed discretization to provide detailed simulation of certain land uses in a large watershed whose spatial relationships are important to the study.

As an example, assume that the dairy operation described in Section B.2.1 is located in a headwater region of the watershed example used in Section B.1. Figure B-3 illustrates the location of the dairy in the larger watershed. (Assume the microwatershed modeled in Section B.2.1 is subbasin B in Figure B-3.)
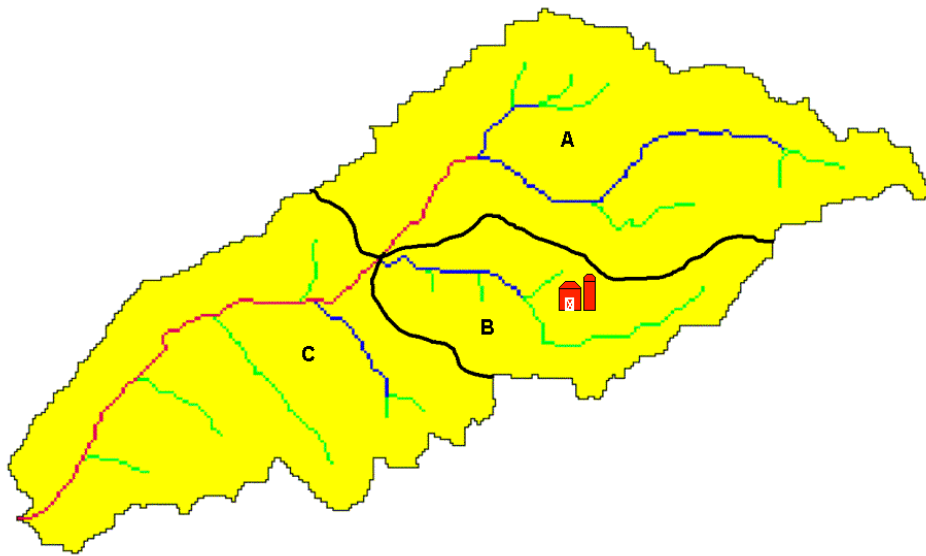
Figure B-3: Watershed with dairy operation

There are two options that may be used to combine the detailed modeling of the dairy with the less detailed modeling of the other land uses in the watershed. The first option is to model the dairy in a separate simulation and save the loadings from the microwatershed using the save command. These daily loadings will then be read into the simulation of the larger watershed using a recday command. The second option is to merge the watershed configuration given in Section B.2.1 with the watershed configuration given Section B.1.1

Option 1: Two separate runs.

The watershed configuration file for simulation of the microwatershed with the dairy will be modified to save the outflow data to an event file. The name of the event file is specified as "dairy.eve" in the save command.

space 1-10	column 1 space 11-16	column 2 space 17-22	column 3 space 23-28	column 4 space 29-34	column 5 space 35-40	column 6 space 41-46	column 7 space 47-55
subbasin	1	1	1				
	dairy01.sub						
subbasin	1	2	2				
	dairy02.sub						
subbasin	1	3	3				
	dairy03.sub						
subbasin	1	4	4				
	dairy04.sub						
subbasin	1	5	5				
	dairy05.sub						
subbasin	1	6	6				
	dairy06.sub						
route	2	7	2	1		1.000	
	dairy02.rte		dairy02.swq				
route	2	8	3	2		0.900	
	dairy03.rte		dairy03.swq				
add	5	9	3	8			
route	2	10	5	4		1.000	
	dairy05.rte		dairy05.swq				
add	5	11	9	5			
add	5	12	6	11			
route	2	13	6	12		0.000	
	dairy06.rte		dairy06.swq				
save	9	13	1	0	0		
	dairy.eve						
finish	0						

Because the area in subbasin B is modeled in the microwatershed simulation, the area will not be directly modeled in the large watershed simulation. Instead, the data in the file dairy.eve will be read in and routed.

space 1-10	column 1 space 11-16	column 2 space 17-22	column 3 space 23-28	column 4 space 29-34	column 5 space 35-40	column 6 space 41-46	column 7 space 47-55
subbasin	1	1	1				
	A.sub						
subbasin	1	2	2				
	C.sub						
route	2	3	1	1		0.000	
	A.rte			A.swq			
recday	10	4	1				
	dairy.eve						
add	5	5	3	4			
add	5	6	5	2			
route	2	7	2	6		0.000	
	C.rte			C.swq			
finish	0						

In the above configuration, subbasin A is subbasin 1, subbasin C is subbasin 2 and outflow from subbasin B is read in with the recday command.

Option 2: A combined simulation.

In this simulation, the routing for the entire watershed is contained in one configuration file. We will include comment lines in this watershed configuration to identify the different portions of the watershed being simulated. Subbasin B will be divided into 6 separate subbasins numbered 1-6 with the same land use assignments listed in section B.2.1. Subbasin A is subbasin 7 in this simulation while subbasin C is subbasin 8.

space 1-10	column 1 space 11-16	column 2 space 17-22	column 3 space 23-28	column 4 space 29-34	column 5 space 35-40	column 6 space 41-46	column 7 space 47-55
* land phase for subbasin B							
subbasin	1	1	1				
		dairy01.sub					
subbasin	1	2	2				
		dairy02.sub					
subbasin	1	3	3				
		dairy03.sub					
subbasin	1	4	4				
		dairy04.sub					
subbasin	1	5	5				
		dairy05.sub					
subbasin	1	6	6				
		dairy06.sub					
* land phase for subbasin A							
subbasin	1	7	7				
		A.sub					
* land phase for subbasin C							
subbasin	1	8	8				
		C.sub					
* route flow through subbasin A							
route	2	9	7	7		0.000	
		A.rte		A.swq			
* route flow through subbasin B							
route	2	10	2	1		1.000	
		dairy02.rte		dairy02.swq			
route	2	11	3	2		0.900	
		dairy03.rte		dairy03.swq			
add	5	12	3	11			
route	2	13	5	4		1.000	
		dairy05.rte		dairy05.swq			
add	5	14	12	5			
add	5	15	6	14			
route	2	16	6	15		0.000	
		dairy06.rte		dairy06.swq			
* add outflow from subbasin A and B to loadings from subbasin C							
add	5	17	9	16			
add	5	18	8	17			
* route flow through subbasin C							
route	2	19	8	18		0.000	
		C.rte		C.swq			
finish	0						

Comment lines are denoted by an asterisk in the first space. When SWAT reads an asterisk in this location it knows the line is a comment line and does not process the line.

B.3 GRID CELL DISCRETIZATION

The grid cell discretization allows a user to capture a high level of spatial heterogeneity or variability in the simulation. The grid cells should be small enough to obtain homogenous land use, soil, and topographic characteristics for the area in each cell but large enough to keep the amount of data required for the run at a reasonable level.

The routing methodology for the grid cell discretization is the same as that for the subwatershed discretization. The difference between the two discretization schemes lies in the average size of the subbasin and the method used to define subbasin boundaries.

The GIS interfaces are currently not able to delineate a watershed using a grid cell discretization. However, there are plans to create a GIS tool capable of generating a grid cell discretization.

B.3.1 GRID CELL DISCRETIZATION: 9 CELLS

To illustrate the grid cell discretization, a simple nine-cell example will be used.
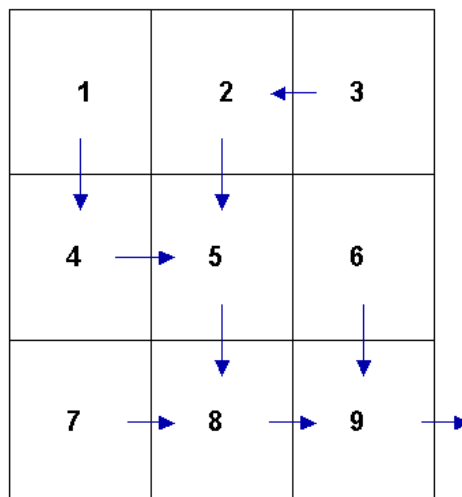
Figure B-4: Grid cell delineation with flow paths shown.

Step 1: Write the subbasin command for each cell. (This command simulates the land phase of the hydrologic cycle.)

space 1-10	column 1 space 11-16	column 2 space 17-22	column 3 space 23-28	column 4 space 29-34	column 5 space 35-40	column 6 space 41-46	column 7 space 47-55
subbasin	1	1	1				
	cell1.sub						
subbasin	1	2	2				
	cell2.sub						
subbasin	1	3	3				
	cell3.sub						
subbasin	1	4	4				
	cell4.sub						
subbasin	1	5	5				
	cell5.sub						
subbasin	1	6	6				
	cell6.sub						
subbasin	1	7	7				
	cell7.sub						
subbasin	1	8	8				
	cell8.sub						
subbasin	1	9	9				
	cell9.sub						

Writing **subbasin** in space 1-10 is optional. The model identifies the configuration command by the code in column 1. The option of writing the command in space 1-10 is provided to assist the user in interpreting the configuration file.

Column 2 is the hydrograph storage location number (array location) where data for the loadings (water, sediment, chemicals) from the subbasin are stored.

Column 3 is the subbasin number. Each subbasin number must be unique.

Step 2a: Route the stream loadings through the flow path network. Begin by routing the headwater subbasin loadings through the main channel of the respective subbasin. (Headwater subbasins are those with no subbasins upstream.) Referring to Figure B-4, subbasins 1, 3, 6 and 7 are headwater subbasins.

space 1-10	column 1 space 11-16	column 2 space 17-22	column 3 space 23-28	column 4 space 29-34	column 5 space 35-40	column 6 space 41-46	column 7 space 47-55
subbasin	1	1	1				
	cell1.sub						
subbasin	1	2	2				
	cell2.sub						
subbasin	1	3	3				
	cell3.sub						
subbasin	1	4	4				
	cell4.sub						
subbasin	1	5	5				
	cell5.sub						
subbasin	1	6	6				
	cell6.sub						
subbasin	1	7	7				
	cell7.sub						
subbasin	1	8	8				
	cell8.sub						
subbasin	1	9	9				
	cell9.sub						
route	2	10	1	1		0.000	
	cell1.rte		cell1.swq				
route	2	11	3	3		0.000	
	cell3.rte		cell3.swq				
route	2	12	6	6		0.000	
	cell6.rte		cell6.swq				
route	2	13	7	7		0.000	
	cell7.rte		cell7.swq				

As mentioned in the last step, column 1 is used to identify the command. Column 2 is the hydrograph storage location number identifying the location where results from the route simulation are placed.

Column 3 provides the number of the reach, or main channel, the inputs are routed through. The number of the reach in a particular subbasin is the same as the number of the subbasin.

Column 4 lists the number of the hydrograph storage location containing the data to be routed through the reach.

Column 6 lists the fraction of overland flow. For the grid cell discretization, this value will always be zero.

Step 2b: Route the stream loadings through the reach network. Use the add and route commands to continue routing through the watershed.

First, add the outflow from subbasin 1 to the loadings from subbasin 4 and route the total through the channel in subbasin 4.

space 1-10	column 1 space 11-16	column 2 space 17-22	column 3 space 23-28	column 4 space 29-34	column 5 space 35-40	column 6 space 41-46	column 7 space 47-55
subbasin	1	1	1				
	cell1.sub						
subbasin	1	2	2				
	cell2.sub						
subbasin	1	3	3				
	cell3.sub						
subbasin	1	4	4				
	cell4.sub						
subbasin	1	5	5				
	cell5.sub						
subbasin	1	6	6				
	cell6.sub						
subbasin	1	7	7				
	cell7.sub						
subbasin	1	8	8				
	cell8.sub						
subbasin	1	9	9				
	cell9.sub						
route	2	10	1	1		0.000	
	cell1.rte		cell1.swq				
route	2	11	3	3		0.000	
	cell3.rte		cell3.swq				
route	2	12	6	6		0.000	
	cell6.rte		cell6.swq				
route	2	13	7	7		0.000	
	cell7.rte		cell7.swq				
add	5	14	10	4			
route	2	15	4	14		0.000	
	cell4.rte		cell4.swq				

The loadings from the outlet of subbasin 1 are stored in hydrograph location #10; the loadings from subbasin 4 are stored in hydrograph location #4.

The add command is specified in column 1 by the number 5. The hydrograph storage location numbers of the 2 data sets to be added are listed in columns 3 and 4. The summation results are stored in the hydrograph location number given in column 2.

Next, add the outflow from subbasin 3 to the loadings from subbasin 2 and route the total through the channel in subbasin 2.

space 1-10	column 1 space 11-16	column 2 space 17-22	column 3 space 23-28	column 4 space 29-34	column 5 space 35-40	column 6 space 41-46	column 7 space 47-55
subbasin	1	1	1				
	cell1.sub						
subbasin	1	2	2				
	cell2.sub						
subbasin	1	3	3				
	cell3.sub						
subbasin	1	4	4				
	cell4.sub						
subbasin	1	5	5				
	cell5.sub						
subbasin	1	6	6				
	cell6.sub						
subbasin	1	7	7				
	cell7.sub						
subbasin	1	8	8				
	cell8.sub						
subbasin	1	9	9				
	cell9.sub						
route	2	10	1	1		0.000	
	cell1.rte		cell1.swq				
route	2	11	3	3		0.000	
	cell3.rte		cell3.swq				
route	2	12	6	6		0.000	
	cell6.rte		cell6.swq				
route	2	13	7	7		0.000	
	cell7.rte		cell7.swq				
add	5	14	10	4			
route	2	15	4	14		0.000	
	cell4.rte		cell4.swq				
add	5	16	11	2			
route	2	17	2	16		0.000	
	cell2.rte		cell2.swq				

Next, add the outflow from subbasin 2 and 4 to the loadings from subbasin 5 and route the total through the channel in subbasin 5.

space 1-10	column 1 space 11-16	column 2 space 17-22	column 3 space 23-28	column 4 space 29-34	column 5 space 35-40	column 6 space 41-46	column 7 space 47-55
subbasin	1	1	1				
	cell1.sub						
subbasin	1	2	2				
	cell2.sub						
subbasin	1	3	3				
	cell3.sub						
subbasin	1	4	4				
	cell4.sub						
subbasin	1	5	5				
	cell5.sub						
subbasin	1	6	6				
	cell6.sub						
subbasin	1	7	7				
	cell7.sub						
subbasin	1	8	8				
	cell8.sub						
subbasin	1	9	9				
	cell9.sub						
route	2	10	1	1		0.000	
	cell1.rte		cell1.swq				
route	2	11	3	3		0.000	
	cell3.rte		cell3.swq				
route	2	12	6	6		0.000	
	cell6.rte		cell6.swq				
route	2	13	7	7		0.000	
	cell7.rte		cell7.swq				
add	5	14	10	4			
route	2	15	4	14		0.000	
	cell4.rte		cell4.swq				
add	5	16	11	2			
route	2	17	2	16		0.000	
	cell2.rte		cell2.swq				
add	5	18	15	17			
add	5	19	18	5			
route	2	20	5	19		0.000	
	cell5.rte		cell5.swq				

Next, add the outflow from subbasin 5 and 7 to the loadings from subbasin 8 and route the total through the channel in subbasin 8.

space 1-10	column 1 space 11-16	column 2 space 17-22	column 3 space 23-28	column 4 space 29-34	column 5 space 35-40	column 6 space 41-46	column 7 space 47-55
subbasin	1	1	1				
	cell1.sub						
subbasin	1	2	2				
	cell2.sub						
subbasin	1	3	3				
	cell3.sub						
subbasin	1	4	4				
	cell4.sub						
subbasin	1	5	5				
	cell5.sub						
subbasin	1	6	6				
	cell6.sub						
subbasin	1	7	7				
	cell7.sub						
subbasin	1	8	8				
	cell8.sub						
subbasin	1	9	9				
	cell9.sub						
route	2	10	1	1		0.000	
	cell1.rte		cell1.swq				
route	2	11	3	3		0.000	
	cell3.rte		cell3.swq				
route	2	12	6	6		0.000	
	cell6.rte		cell6.swq				
route	2	13	7	7		0.000	
	cell7.rte		cell7.swq				
add	5	14	10	4			
route	2	15	4	14		0.000	
	cell4.rte		cell4.swq				
add	5	16	11	2			
route	2	17	2	16		0.000	
	cell2.rte		cell2.swq				
add	5	18	15	17			
add	5	19	18	5			
route	2	20	5	19		0.000	
	cell5.rte		cell5.swq				
add	5	21	20	13			
add	5	22	21	8			
route	2	23	8	22		0.000	
	cell8.rte		cell8.swq				

Next, add the outflow from subbasin 8 and 6 to the loadings from subbasin 9, route the total through the channel in subbasin 9, and append a finish command line to signify the end of the watershed routing file.

space 1-10	column 1 space 11-16	column 2 space 17-22	column 3 space 23-28	column 4 space 29-34	column 5 space 35-40	column 6 space 41-46	column 7 space 47-55
subbasin	1	1	1				
		cell1.sub					
subbasin	1	2	2				
		cell2.sub					
subbasin	1	3	3				
		cell3.sub					
subbasin	1	4	4				
		cell4.sub					
subbasin	1	5	5				
		cell5.sub					
subbasin	1	6	6				
		cell6.sub					
subbasin	1	7	7				
		cell7.sub					
subbasin	1	8	8				
		cell8.sub					
subbasin	1	9	9				
		cell9.sub					
route	2	10	1	1		0.000	
		cell1.rte		cell1.swq			
route	2	11	3	3		0.000	
		cell3.rte		cell3.swq			
route	2	12	6	6		0.000	
		cell6.rte		cell6.swq			
route	2	13	7	7		0.000	
		cell7.rte		cell7.swq			
add	5	14	10	4			
route	2	15	4	14		0.000	
		cell4.rte		cell4.swq			
add	5	16	11	2			
route	2	17	2	16		0.000	
		cell2.rte		cell2.swq			
add	5	18	15	17			
add	5	19	18	5			
route	2	20	5	19		0.000	
		cell5.rte		cell5.swq			
add	5	21	20	13			
add	5	22	21	8			
route	2	23	8	22		0.000	
		cell8.rte		cell8.swq			
add	5	24	23	12			
add	5	25	24	9			
route	2	26	9	25		0.000	
		cell9.rte		cell9.swq			
finish	0						

As illustrated in section B.2.2 for the hillslope discretization, it is possible to combine the grid cell discretization with the subwatershed discretization to provide detailed modeling of portions of a large watershed while treating less significant areas in the more generalized approach used in the subwatershed discretization.