CHAPTER **FILE.CIO**

SWAT+ INPUT DATA:

File management is performed with the master watershed file (file.cio). The master watershed file contains the file names for the simulation run.

The master watershed file is divided into several sections. A brief description of the variables in the master watershed file follows. They are grouped by section and listed in the order they appear within the file.

SWAT+ Model:

Over the past 20 years, the Soil and Water Assessment Tool (SWAT) has become widely used across the globe. The large numbers of applications across the globe have also revealed limitations and identified model development needs. Numerous additions and modifications of the model and its individual components have made the code increasingly difficult to manage and maintain. In order to face present and future challenges in water resources modeling SWAT code has undergone major modifications over the past few years, resulting in SWAT+, a completely revised version of the model. Even though the basic algorithms used to calculate the processes in the model have not changed, the structure and organization of both the code (object based) and the input files (relational based) have undergone considerable modification. This is expected to facilitate model maintenance, future code modifications, and foster collaboration with other researchers to integrate new science into SWAT modules. SWAT+ provides a more flexible spatial representation of interactions and processes within a watershed.

Descriptions of the SWAT+ input data files are listed and described in this document.

X.1 FILE.CIO

Variable name	Definition
TITLE	The first line of 'file.cio' is reserved for a description of the simulation run. The description may take up to 80 spaces. The description is optional, the line is required.

X.2 GENERAL INFORMATION

SIMULATION – The simulation section of file.cio contains filenames for the entire simulation run. The list of the filenames are listed below with a brief description of the inputs within each file.

file.cio:	Filenames	(input/output)															
SIMULATION	time.sim	print.prt	object.prt	object.cnt	CONSTITUENTS.CS												
BASIN	codes.bsn	parameters.bsn															
CLIMATE	weather-sta.cli	weather-wgn.cli	wind-dir.cli	pcp.cli	tmp.cli	slr.cli	hmd.cli	wnd.cli	atmodep.cli								
CONNECT	hru.con	hru-lte.con	rout_unit.con	modflow.con	aquifer.con	aquifer2d.con	channel.con	reservoir.con	recall.con	exco.con	delratio.con	outlet.con	chandeg.con				
CHANNEL	initial.cha	channel.cha	hydrology.cha	sediment.cha	nutrients.cha	pesticide.cha	PATHOGENS.CHA	METALS.CHA	SALT.CHA	channel-lte.cha							
RESERVOIR	initial.res	reservoir.res	hydrology.res	nutrients.res	pesticide.res	PATHOGENS.RES	METALS.RES	SALT.RES	sediment.res	weir.res	wetland.wet	hydrology.wet					
ROUT_UNIT	rout_unit.def	rout_unit.ele	rout_unit.ru	rout_unit.dr													
HRU	hru-data.hru	hru-lte.hru															
EXCO	exco.exc	EXCO_OM.EXC	EXCO_PEST.EXC	EXCO_PATH.EXC	EXCO_HMET.EXC	EXCO_SALT.EXC											
RECALL	recall.rec																
DR	delratio.del	DR_OM.DEL	DR_PEST.DEL	DR_PATH.DEL	DR_HMET.DEL	DR_SALT.DEL											
AQUIFER	aquifer.aqu																
HERD	animal.hrd	herd.hrd	ranch.hrd														
WATER_RIGHTS	define.wro	element.wro	water_rights.wro														
LINK	chan-surf.lin	chan-aqu.lin															
HYDROLOGY	hydrology.hyd	topography.hyd	field.fld														
STRUCTURAL	tiledrain.str	septic.str	filterstrip.str	grassedww.str	bmpuser.str												
HRU_PARM_DB	plants.plt	fertilizer.frt	tillage.til	pesticide.pst	PATHOGENS.PTH	METALS.MTL	SALTS.SLT	urban.urb	septic.sep	snow.sno							
OPS	harv.ops	graze.ops	irr.ops	chem_app.ops	fire.ops	sweep.ops											
LUM	landuse.lum	management.sch	cntable.lum	cons_practice.lum	ovn_table.lum												
CHG	codes.cal	cal_parms.cal	calibration.cal	ls_parms.cal	ls_regions.cal	ch_orders.cal	ch_parms.cal	pl_parms.cal	pl_regions.cal								
INIT	plant.ini	PEST_SOIL.INI	PEST_WATER.INI	PATH_SOIL.INI	PATH_WATER.INI	HMET_SOIL.INI	HMET_WATER.INI	SALT_SOIL.INI	SALT_WATER.INI								
SOILS	soils.sol	nutrients.sol															
DECISION_TABLE	dtable.dtl																
REGIONS	ls_unit.ele	ls_unit.def	ls_reg.ele	ls_reg.def	ls_cal.reg	ch_catunit.ele	ch_catunit.def	ch_reg.def	aqu_catunit.ele	aqu_catunit.def	aqu_reg.def	res_catunit.ele	res_catunit.def	res_reg.def	rec_catunit.ele	rec_catunit.def	rec_reg.def
PATH_PCP	null																
PATH_TMP	null																
PATH_SLR	null																
PATH_HMD	null																

TIME.SIM

The time simulation file includes the number of years to run the simulation and time step and is space delimited. Below is a sample TIME.SIM file:

time.sim:				
DAY_START	YRC_START	DAY_END	YRC_END	STEP
0	2006	0	2007	0

Variable name	Definition
TITLE	Description of the time.sim file (may be blank)
HEADER	
DAY_START	Beginning Julian day of simulation. With this variable, SWAT is able to begin a simulation at any time of the year. If the variable is left blank or set to zero, the model starts the simulation on January 1st. Required.
YRC_START	Beginning year of simulation (for example, 1980). The value entered for this variable is not important unless measured data (e.g. weather) is used in the run. When measured data is used, the model uses YR_START to locate the beginning year within the data file. Required.
DAY_END	Ending Julian day of simulation. With this variable, SWAT is able to end a simulation at any time of the year. If the variable is left blank or set to zero, the model ends the simulation on December 31st. Required.
YRC_END	Ending year of simulation
STEP	Timestep of the simulation. 0 = daily; 1=increment (12 hrs); 24=hourly; 96-15 mins; 1440 = minute) Required.

PRINT.PRT

The print file controls the occurrence of the output files and is space delimited. Below is a sample PRINT.PRT file. Some pointers:

- The user will input the actual start and stop julian day for daily printing.
- NYSKIP will not print until NYSKIP is over.
- When time crosses the end of the year, the print will continue to increment the print INTERVAL.
- Daily printing of all files could cause very large output files (exceeding hard drive capabilities)

print.prt:	Output	print	settings		
NYSKIP	DAY_START	YRC_START	DAY_END	YRC_END	INTERVAL
0	0	0	0	0	1
AA_NUMINT					
0					
CSV	DB	NETCDF			
n	n	n			
SOIL	MGT	HYDCON	FDC		
n	n	n	n		
OBJECTS	DAILY	MONTHLY	YEARLY	AVANN	
basin_wb	y	n	n	y	
basin_nb	n	n	y	n	
basin_ls	y	n	n	n	
basin_pw	n	y	n	n	
basin_aqu	n	n	n	n	
basin_res	n	n	n	n	
basin_cha	n	n	n	n	
basin_sd_cha	y	n	n	y	
basin_psc	n	n	n	n	
region_wb	n	n	n	n	
region_nb	n	n	n	n	
region_ls	n	n	n	n	
region_pw	n	n	n	n	
region_aqu	n	n	n	n	
region_res	n	n	n	n	
region_cha	n	n	n	n	
region_sd_cha	n	n	n	n	
region_psc	n	n	n	n	
lsunit_wb	n	n	n	n	
lsunit_nb	n	n	n	n	
lsunit_ls	n	n	n	n	
lsunit_pw	n	n	n	n	
hru_wb	n	n	y	n	
hru_nb	n	y	n	n	
hru_ls	n	y	n	n	
hru_pw	n	n	n	y	
hru-lte_wb	n	n	n	n	
hru-lte_nb	n	n	n	n	
hru-lte_ls	n	n	n	n	
hru-lte_pw	n	n	n	n	
channel	n	n	n	n	
channel_sd	y	n	n	n	
aquifer	n	n	n	n	

reservoir	n	n	n	n	
recall	n	n	n	n	
hyd	y	n	n	n	
ru	n	n	n	n	

Variable name	Definition
TITLE	Description of the print.prt file
HEADER	Headings
NYSKIP	Number of years to ***not*** print output. The options are 0 print output for all years of the simulation 1 print output after the first year of simulation 2 print output after the second year of simulation ⋮ nbyr no output will be printed Some simulations will need a warm-up or equilibration period. The use of an equilibration period becomes more important as the simulation period of interest shortens. For 30-year simulations, an equilibrium period is optional. For a simulation covering 5 years or less, an equilibrium period is recommended. An equilibration period of one year is usually adequate to get the hydrologic cycle fully operational. Examples: If NYSKIP =2, the model will skip printing the first two years regardless of the starting year. In other words, if YRC_START = 2000, we start printing in 2002. If YRC_START = 2005, printing starts in 2007. Notes: The daily print start and end time has nothing to do with NYSKIP. If the daily print time is skipped, it simply won't print the daily output. The start year of printing is max(YRC_START+NYSKIP).
DAY_START	Beginning Julian day of simulation to start printing output files for daily printing only
YRC_START	Beginning year of simulation to start printing files.
DAY_END	Ending Julian day of simulation to stop printing output files for daily printing only
YRC_END	Ending year of simulation to stop printing output files.

INTERVAL	Daily print within the period Specifies the interval within the specified printing time (i.e., INTERVAL =2) will print every other day.
HEADER	Headings
AA_NUMINT	Number of print intervals for ave annual output Example: If AA_NUMINT == 1955 1965 1975, Average annual results will be printed for the time periods ending in 1955, 1965, 1975. Leaving the first number zero on this line will print average annual for the entire period (after NYSKIP).
AA_YEARS	End years for aveage annual output
HEADER	Header
CSVOUT	Code to print .csv files n=no print; y = print
DBOUT	Code to print database (db) files n=no print; y = print (not currently active)
CDFOUT	Code to print netcdf (cdf) files n=no print; y = print (not currently active)
HEADER	Header
SNUTC	Soil nutrients carbon output file (soil_nutcarb_out.txt); input should be character - d(daily; m/(monthly); y(yearly); aa(ave annual);
MGTOUT	Management output file (print codes apply) (mgt_out.txt)
HYDCON	Hydrograph connect output file (hydcon.out)
FDCOUT	Flow duration curve output file (flow_duration_curve.out) n=no print; avann=print
HEADER	Header. All of the following codes are entered as : ‘y’ (yes) or ‘n’ (no) to print on a daily, monthly, yearly or avann timestep.
BASIN_WB	Water balance BASIN output variables
BASIN_NB	Nutrient balance BASIN output variables
BASIN_LS	Losses BASIN output variables
BASIN_PW	Plant weather BASIN output variables
BASIN_AQU	Aquifer BASIN output variables
BASIN_RES	Reservoir BASIN output file variables
BASIN_CHA	Channel BASIN output file variables
BASIN_SD_CHA	CHANDEG BASIN output file variables
BASIN_PSC	Point source BASIN output file variables
REGION_WB	Water balance REGION output variables
REGION_NB	Nutrient balance REGION output variables
REGION_LS	Losses REGION output variables
REGION_PW	Plant weather REGION output variables
REGION_AQU	Aquifer REGION output variables

REGION_RES	Reservoir REGION output variables
REGION_CHA	Channel REGION output variables
REGION_SD_CHA	SWATDEG Channel REGION output variables
REGION_PSC	Point source REGION output variables
LSUNIT_WB	Water balance ROUTING UNIT output variables
LSUNIT_NB	Nutrient balance ROUTING UNIT output variables
LSUNIT_LS	Losses ROUTING UNIT output variables
LSUNIT_PW	Plant weather ROUTING UNIT output variables
HRU_WB	Water balance HRU output variables
HRU_NB	Nutrient balance HRU output variables
HRU_LS	Losses HRU output variables
HRU_PW	Plant weather HRU output variables
HRU_LTE_WB	Water balance HRU-LTE output variables
HRU_LTE_NB	Nutrient balance HRU-LTE output variables
HRU_LTE_LS	Losses HRU-LTE output variables
HRU_LTE_PW	Plant weather HRU-LTE output variables
CHANNEL	Channel output variables
CHANNEL_SD	SWAT DEG (lte) channel output variables
AQUIFER	Aquifer output variables
RESERVOIR	Reservoir output variables
RECALL	Recall output variables
HYD	Hydin output and hydout_output variables
RU	Routing Unit output variables

OBJECT.PRT

The object print file allows the user to define output and is space delimited. Below is a sample OBJECT.PRT file:

object.prt:				
NUMB	OBTYP	OBTYPNO	HYDTYP	FILENAME
1	sdc	1	tot	two_stage.out

Variable name	Definition
TITLE	Description of the object print file
HEADER	Header
NUMB	The sequential number
OBTYP	Type of object to print (“hru”, “hlt”, “ru”, ‘res”, “cha”, “exc”, “dr”, “out”, “sdc”) (hru, hru_lte, routing unit, reservoir, channel, export coefficient, delivery ratio, outlet, swat-deg channel)
OBTYPNO	Object type number
HYDTYP	Hydrograph type to print (“tot”, “rhg”, “sur”, “lat”, “til”) (total flow, recharge, surface, lateral, tile)

FILENAME	Filename of output file (user defined).

OBJECT.CNT

The object count file contains the total counts for the watershed simulation and is space delimited. Below is a sample OBJECT.CNT file:

object.cnt:																			
NAME	AREA_LS_HA	AREA_TOT_HA	OBJ	HRU	LTE	RU	MODFLOW	AQU	CHA	RES	REC	EXCO	DR	CANAL	PUMP	OUT	CHANDEG	2DAQU
2_stage	30	33	3	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0

Variable name	Definition
TITLE	Description of the object count file
HEADER	Header to describe the following inputs; Not used in model;
NAME	Name of the watershed
AREA_LS_HA	Area of the landscape units (ha)
AREA_TOT_HA	Total area of the watershed (ha)
OBJS	Total number of objects (sum of all following objects)
HRU	Total number of HRU's
HRU_LTE	Total number of HRU LTE (SWAT-DEG)
RU	Total number of routing units
MODFLOW	Total number of modflow
AQU	Total number of aquifers
CHAN	Total number of channels
RES	Total number of reservoirs
RECALL	Total number of recdays
EXCO	Total number of export coefficients
DR	Total number of delivery ratios
CANAL	Total number of canals
PUMP	Total number of pumps
OUTLET	Total number of outlets
CHANDEG	Total number of LTE channels (SWAT-DEG)
AQU2D	Total number of 2D aquifers

CONSTITUENTS.CS

The CONSTITUENTS.CS file contains the input variables for the pesticide constituents. Below is a sample CONSTITUENTS.CS file:

constituents.cs				
4	!pesticides			
aatrex	banvel	prowl	roundup	
2	!pathogens			
fecal_col_form	e_coli			
1	!metals			
mercury				
2	!salts			
sodium	magnesium			

Variable name	Definition
TITLE	The first line of the file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
NUM_PESTS	Number of pesticides simulated
NAME_PATHS	Pesticide names (for each NUM_PESTS)
NUM_PATHS	Number of pathogens simulated
NAME_PATHS	Pathogen names (for each NUM_PATHS)
NUM_METALS	Number of heavy metals simulated
NAME_METALS	Heavy metal names (for each NUM_METALS)
NUM_SALTS	Number of salts simulated
NAME_SALTS	Salt names (for each NUM_SALTS)

BASIN – General watershed attributes are defined in the basin input file. These attributes control a diversity of physical processes at the watershed level. The interfaces will automatically set these parameters to the "default" or recommended values listed in the variable documentation. Users can use the default values or change them to better reflect what is happening in a given watershed. Variables governing bacteria or pesticide transport need to be initialized only if these processes are being modeled in the watershed. Even if nutrients are not being studied in a watershed, some attention must be paid to these variables because nutrient cycling impacts plant growth which in turn affects the hydrologic cycle.

CODES.BSN

Below is a partial sample CODES.BSN FILE:

codes.bsn:	Basin contro			-																				
PETFILE	WWQFILE	PET	EVENT	CRK	SUBWQ	SED_DET	RTE	DEG	WQ	RTPEST	CN	CFAC	CSWAT	BF_FLG	UHYD	SED_CH	TDRN	WTDN	P_MODEL	ABSTR	ATMO	SMAX	I_SUBHW
test.pet	test.wwq	1	0	0	1	1	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0

Variable name	Definition
TITLE	The first line is reserved for user comments. This line is not processed by the model and may be left blank. Optional.
HEADER	Headers for the codes.bsn file.
PETFILE	Potential ET filename
WWQFILE	Watershed stream water quality filename
PET	Potential evapotranspiration (PET) method. There are four options for potential ET calculations: 0 Priestley-Taylor method 1 Penman/Monteith method 2 Hargreaves method 3 read in potential ET values Numerous methods exist to calculate potential evapotranspiration. Three of the most popular or widely-used are included in SWAT. However, if a method other than Priestley-Taylor, Penman/Monteith, or Hargreaves is recommended for the area in which the watershed is located, the user can calculate daily PET values with the recommended method and import them into SWAT. A discussion of Priestley-Taylor, Penman-Monteith and Hargreaves PET methods is found in Chapter 2:2 of the theoretical documentation. Required.
EVENT	Rainfall/runoff/routing option: 0 daily rainfall/curve number runoff/daily routing 1 sub-daily rainfall/Green & Ampt infiltration/sub-daily routing Option 0 is the default option. Required.
CRK	Crack flow code. There are two options: 0 do not model crack flow in soil 1 model crack flow in soil Crack, or bypass, flow is a newer feature in SWAT and has been tested on a limited basis in simulations of some areas in Texas. This type of flow should be modeled only on soils classified as Vertisols. The default option is to model the watershed without crack flow. Required.

SUBWQ

Subbasin water quality code.

The algorithms used to calculate loadings of algae, organic carbonaceous biological oxygen demand and dissolved oxygen to the stream network (see Chapter 4:4 in Theoretical Documentation) were derived from results of limited studies and are still in the testing phase. ISUBWQ allows the user to choose to apply or not apply the algorithms.

0 do not calculate algae/CBOD loadings and set dissolved oxygen to saturated oxygen concentration

1 calculate algae/CBOD/dissolved oxygen loadings using algorithms documented in Theoretical Documentation

The default option is ISUBWQ=0.
Required.

SED_DET

Code governing calculation of daily maximum half-hour rainfall value:

0 generate daily value using triangular distribution
1 use monthly maximum half-hour rainfall value for all days in month

The user has the option of using the monthly maximum half-hour rainfall for all days in the month. The randomness of the triangular distribution used to generated daily values causes the maximum half-hour rainfall value to jump around. For small plots or microwatersheds in particular, the variability of the triangular distribution is unrealistic.
Required.

RTE

Channel water routing method:

0 variable storage method
1 Muskingum method

The user must be careful to define MSK_CO1, MSK_CO2 and MSK_X when the Muskingum method is chosen.

The default option is IRTE=0.
Required.

DEG

Channel degradation code.

There are two options:
0 channel dimensions are not updated as a result of degradation (the dimensions remain constant for the entire simulation)
1 channel dimensions are updated as a result of degradation

Traditionally, channel dimensions remain fixed, or constant, throughout the simulation. The change in channel dimensions with time is a new feature in SWAT that is still in the testing phase. The recommended option is to keep the channel dimensions constant.
Required.

WQ	In-stream water quality code. The variable identifies whether in-stream transformation of nutrients using the QUAL2E algorithms and in-stream transformation of pesticides is allowed to occur. 0 do not model in-stream nutrient and pesticide transformations 1 model in-stream nutrient and pesticide transformations The default option is IWQ=0. Required.
RTPEST	Redefined to the sequence number -- changed to no nutrient stress of pest in NPNO(:)to be routed through the watershed
CN	Daily curve number calculation method: 0 calculate daily CN value as a function of soil moisture 1 calculate daily CN value as a function of plant evapotranspiration 2 use traditional SWAT method which bases CN on soil moisture but retention is adjusted for mildly-sloped tiled-drained watersheds Option 0 was the only method used to calculate the daily CN value in versions of SWAT prior to SWAT2012. Calculation of the daily CN value as a function of plant evapotranspiration was added because the soil moisture method was predicting too much runoff in shallow soils. By calculating daily CN as a function of plant evapotranspiration, the value is less dependent on soil storage and more dependent on antecedent climate. Required.
CFAC	CFAC = 0 for C-factor calculation using Cmin. = 1 for new C-factor calculation. (0-1)
CSWAT	Code for new carbon routines: 0 = original routines 1 = new carbon routines
BF_FLG	Baseflow distribution factor during the day for subdaily runs. 0 = baseflow evenly distributed to each time step during the day 0.5 = even weights between even distribution and rainfall pattern 1= profile of baseflow in a day follows rainfall pattern
UHYD	Unit hydrograph method: 1 = triangular UH 2 = gamma function UH
SED_CH	Instream sediment model, 0=Bagnold model, 1=Brownlie model, 2=Yang model

TDRN	Tile drainage equations flag/code Tile drainage routines flag/code: 1 = DRAINMOD tile equations (Subroutine DRAINS) 1 simulate tile flow using subroutine drains(wt_shall) 0 simulate tile flow using subroutine origtile(wt_shall,d)
WTDN	water table depth algorithms flag/code 1 simulate wt_shall using subroutine new water table depth routine 0 simulate wt_shall using subroutine original water table depth routine
SOL_P_MODEL	Soil phosphorus model 0 = original soil phosphorus model 1 = new soil phosphorus model
ABSTR	Initial abstraction on impervious cover (mm)
ATMO	Atmospheric deposition interval (character) ‘m’ = monthly ‘y’ = yearly ‘a’ = annual
SMAX	Maximum depressional storage code; 1=dynamic stmaxd computed as a function of random roughness and rain intensity by depstor.f; 0 = static stmaxd from .bsn for global value or .sdr for specific HRU’s
I_SUBHW	Code for routing headwaters

PARAMETERS.BSN

General watershed attributes are defined in the basin input file. These attributes control a diversity of physical processes at the watershed level. The interfaces will automatically set these parameters to the “default” or recommended values listed in the variable documentation. Users can use the default values or change them to better reflect what is happening in a given watershed. Variables governing bacteria or pesticide transport need to be initialized only if these processes are being modeled in the watershed. Even if nutrients are not being studied in a watershed, some attention must be paid to these variables because nutrient cycling impacts plant growth which in turn affects the hydrologic cycle.

Below is a sample PARAMETERS.BSN FILE:

parameter	Basin para														
NAME	EVLAI	FFCB	SURLAG	ADJ_PKR	PRF	SPCON	SPEXP	CMN	N_UPDIS	P_UPDIS	NPERCO	PPERCO	PHOSKD	PSP	RSDCO
LREW	3	1	4	0.7	0	0.005	1	0.004	0	5	0	0	120	100	0.2

NAME	PERCOP	MSK_CO1	MSK_C02	MSK_X	TRNSRCH	EVRCH	CNCOEF	CDN	SDNCO	3ACT_SWF	TB_ADJ	CN_FROZ	DORM_HR	SMXCO	FIXCO
LREW	0	0	0	0	1	0	1.5	0	0	0	0	0.004	0	0	0

NAME	NFIXMX	DECR_MIN	D_COVCO	VCRIT	_STLR_CO	UHALPHA	ERO_SPL	ILL_MULT	ROS_EXPO	C_FACTOR	CH_D50	SIG_G	R2ADJ	IGEN
LREW	0	0	0	0	0	0	1	0.7	1.2	0.3	50	1.57	0	0

Variable name	**Definition**
TITLE	The first line is reserved for user comments. This line is not processed by the model and may be left blank. Optional.

HEADER	Headers
NAME	Name
EVLAI	Leaf area index at which no evaporation occurs from water surface. EVLAI is used in HRUs where a plant is growing in a ponded environment (e.g. rice). Currently, this is simulated only in HRUs defined as depressional areas/potholes. Evaporation from the water surface is allowed until the leaf area of the plant reaches the value specified for EVLAI. Chapter 8:1 in the Theoretical Documentation provides more detail on the use of this parameter. EVLAI should be set between 0.0 and 10.0. If no value for EVLAI is entered, the model will set EVLAI = 3.0. Required if depressional areas/potholes are modeled in the watershed.
FFCB	Initial soil water storage expressed as a fraction of field capacity water content. All soils in the watershed will be initialized to the same fraction. FFCB should be between 0.0 and 1.0. If FFCB is not set to a value, the model will calculate it as a function of average annual precipitation. The default method is to allow the model to calculate FFCB (set FFCB = 0.0). We recommend using a 1 year equilibration period for the model where the watershed simulation is set to start 1 year prior to the period of interest. This allows the model to get the water cycling properly before any comparisons between measured and simulated data are made. When an equilibration period is incorporated, the value for FFCB is not going to impact model results. Required.

SURLAG

Surface runoff lag coefficient.

In large subbasins with a time of concentration greater than 1 day, only a portion of the surface runoff will reach the main channel on the day it is generated. SWAT incorporates a surface runoff storage feature to lag a portion of the surface runoff release to the main channel.

SURLAG controls the fraction of the total available water that will be allowed to enter the reach on any one day. Figure 4-7 plots the fraction of total available water entering the reach at different values for *surlag* and t_{conc}.

Note that for a given time of concentration, as *surlag* decreases in value more water is held in storage. The delay in release of surface runoff will smooth the streamflow hydrograph simulated in the reach.

If no value for SURLAG is entered, the model will set SURLAG = 4.0.

Required.

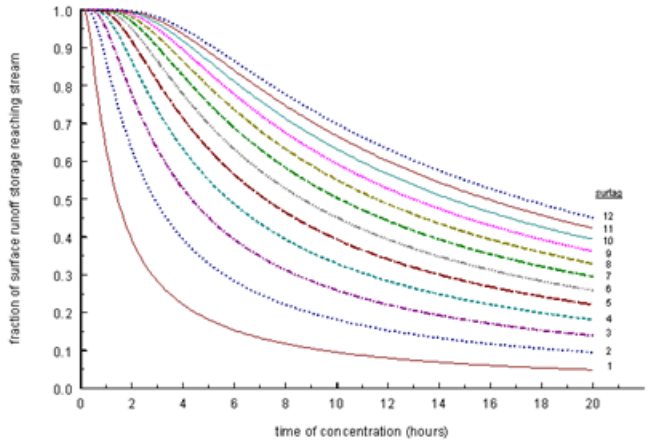


Figure 4-7: Influence of *surlag* and t_{conc} on fraction of surface runoff released.

ADJ_PKR

Peak rate adjustment factor for sediment routing in the *subbasin (tributary channels).*

Sediment routing is a function of peak flow rate and mean daily flow. Because SWAT originally could not directly calculate the sub-daily hydrograph due to the use of precipitation summarized on a daily basis, this variable was incorporated to allow adjustment for the effect of the peak flow rate on sediment routing. This factor is used in the MUSLE equation and impacts the amount of erosion generated in the HRUs.

If no value for ADJ_PKR is entered, the model will set ADJ_PKR=1.0.

Required.

PRF	Peak rate adjustment factor for sediment routing in the main channel. Sediment routing is a function of peak flow rate and mean daily flow. Because SWAT originally could not directly calculate the sub-daily hydrograph, this variable was incorporated to allow adjustment for the effect of the peak flow rate on sediment routing. This variable impacts channel degradation. If no value for PRF is entered, the model will set PRF = 1.0. Required.
SPCON	Linear parameter for calculating the maximum amount of sediment that can be reentrained during channel sediment routing. The maximum amount of sediment that can be transported from a reach segment is calculated $conc_{sed,ch,mx} = c_{sp} \cdot v_{ch,pk}^{spexp}$ where concsed,ch,mx is the maximum concentration of sediment that can be transported by the water (ton/m3 or kg/L), csp is a coefficient defined by the user, vch,pk is the peak channel velocity (m/s), and spexp is an exponent defined by the user. SPCON should be between 0.0001 and 0.01. If no value for SPCON is entered, the model will set SPCON = 0.0001. Required.
SPEXP	Exponent parameter for calculating sediment reentrained in channel sediment routing The maximum amount of sediment that can be transported from a reach segment is calculated $conc_{sed,ch,mx} = c_{sp} \cdot v_{ch,pk}^{spexp}$ where concsed,ch,mx is the maximum concentration of sediment that can be transported by the water (ton/m3 or kg/L), csp is a coefficient defined by the user, vch,pk is the peak channel velocity (m/s), and spexp is an exponent defined by the user. The exponent, spexp, normally varies between 1.0 and 2.0 and was set at 1.5 in the original Bagnold stream power equation (Arnold et al., 1995). If no value for SPEXP is entered, the model will set SPEXP = 1.0. Required.
CMN	Rate factor for humus mineralization of active organic nutrients (N and P). Chapters 3:1 and 3:2 of the Theoretical Documentation describe the use of this parameter in the mineralization calculations. If no value for CMN is specified, the model will set CMN = 0.0003. Required.

N_UPDIS

Nitrogen uptake distribution parameter.

Root density is greatest near the surface, and plant nitrogen uptake in the upper portion of the soil will be greater than in the lower portion. The depth distribution of nitrogen uptake is controlled by β_n, the nitrogen uptake distribution parameter.

The importance of the nitrogen uptake distribution parameter lies in its control over the maximum amount of nitrate removed from the upper layers. Because the top 10 mm of the soil profile interacts with surface runoff, the nitrogen uptake distribution parameter will influence the amount of nitrate available for transport in surface runoff. The model allows lower layers in the root zone to fully compensate for lack of nitrate in the upper layers, so there should not be significant changes in nitrogen stress with variation in the value used for β_n.

If no value for N_UPDIS is entered, the model will set N_UPDIS = 20.0.

Figure 4-9 illustrates nitrogen uptake as a function of depth for four different uptake distribution parameter values.

Required.

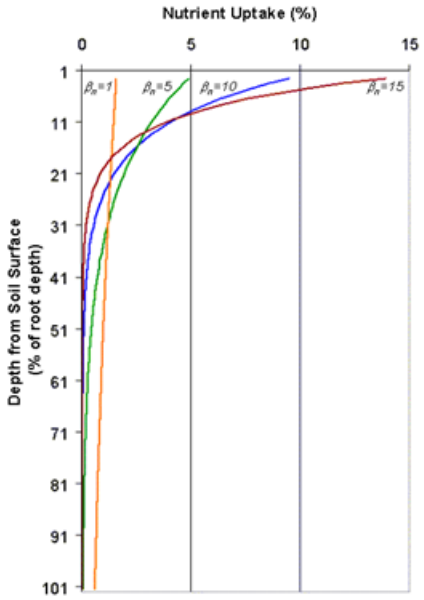


Figure 4-9: Depth distribution of nitrogen uptake

P_UPDIS — Phosphorus uptake distribution parameter.

This parameter controls plant uptake of phosphorus from the different soil horizons in the same way that UBN controls nitrogen uptake. The illustration of nitrogen uptake as a function of depth for four different uptake distribution parameter values in Figure 4-9 is valid for phosphorus uptake as well.

Phosphorus removed from the soil by plants is taken from the solution phosphorus pool. The importance of the phosphorus uptake distribution parameter lies in its control over the maximum amount of solution P removed from the upper layers. Because the top 10 mm of the soil profile interacts with surface runoff, the phosphorus uptake distribution parameter will influence the amount of labile phosphorus available for transport in surface runoff. The model allows lower layers in the root zone to fully compensate for lack of solution P in the upper layers, so there should not be significant changes in phosphorus stress with variation in the value used for β_p.

If no value for P_UPDIS is entered, the model will set P_UPDIS = 20.0.

Required.

NPERCO — Nitrate percolation coefficient.

NPERCO controls the amount of nitrate removed from the surface layer in runoff relative to the amount removed via percolation.

The value of NPERCO can range from 0.01 to 1.0. As NPERCO → 0.0, the concentration of nitrate in the runoff approaches 0. As NPERCO → 1.0, surface runoff has the same concentration of nitrate as the percolate.

If no value for NPERCO is entered, the model will set NPERCO = 0.20.

Required.

PPERCO — Phosphorus percolation coefficient (10 m^3/Mg).

The phosphorus percolation coefficient is the ratio of the solution phosphorus concentration in the surface 10 mm of soil to the concentration of phosphorus in percolate.

The value of PPERCO can range from 10.0 to 17.5 If no value for PPERCO is entered, the model will set PPERCO = 10.0.

Required.

PHOSKD

Phosphorus soil partitioning coefficient (m3/Mg).

The phosphorus soil partitioning coefficient is the ratio of the soluble phosphorus concentration in the surface 10 mm of soil to the concentration of soluble phosphorus in surface runoff.

The primary mechanism of phosphorus movement in the soil is by diffusion. Diffusion is the migration of ions over small distances (1-2 mm) in the soil solution in response to a concentration gradient. Due to the low mobility of solution phosphorus, surface runoff will only partially interact with the solution P stored in the top 10 mm of soil.

If no value for PHOSKD is entered, the model will set PHOSKD = 175.0.

Required.

PSP

Phosphorus availability index.

Many studies have shown that after an application of soluble P fertilizer, solution P concentration decreases rapidly with time due to reaction with the soil. This initial "fast" reaction is followed by a much slower decrease in solution P that may continue for several years (Barrow and Shaw, 1975; Munns and Fox, 1976; Rajan and Fox, 1972; Sharpley, 1982). In order to account for the initial rapid decrease in solution P, SWAT assumes a rapid equilibrium exists between solution P and an "active" mineral pool. The subsequent slow reaction is simulated by the slow equilibrium assumed to exist between the "active" and "stable" mineral pools. The algorithms governing movement of inorganic phosphorus between these three pools are taken from Jones et al. (1984).

Equilibration between the solution and active mineral pool is governed by the phosphorus availability index. This index specifies the fraction of fertilizer P which is in solution after an incubation period, i.e. after the rapid reaction period.

A number of methods have been developed to measure the phosphorus availability index. Jones et al. (1984) recommends a method outlined by Sharpley et al. (1984) in which various amounts of phosphorus are added in solution to the soil as K_2HPO_4. The soil is wetted to field capacity and then dried slowly at 25°C. When dry, the soil is rewetted with deionized water. The soil is exposed to several wetting and drying cycles over a 6-month incubation period. At the end of the incubation period, solution phosphorus is determined by extraction with anion exchange resin.

The P availability index is then calculated:

$$pai = \frac{P_{solution,f} - P_{solution,i}}{fert_{minP}}$$

where pai is the phosphorus availability index, $P_{solution,f}$ is the amount of phosphorus in solution after fertilization and incubation, $P_{solution,I}$ is the amount of phosphorus in solution before fertilization, and $fert_{minP}$ is the amount of soluble P fertilizer added to the sample.

If no value for PSP is entered, the model will set PSP = 0.40.

Required.

RSDCO

Residue decomposition coefficient.

The fraction of residue which will decompose in a day assuming optimal moisture, temperature, C:N ratio and C:P ratio.

If no value for RSDCO is entered, the model will set RSDCO = 0.05.

Required.

PERCOP	Pesticide percolation coefficient. PERCOP controls the amount of pesticide removed from the surface layer in runoff and lateral flow relative to the amount removed via percolation. The value of PERCOP can range from 0.01 to 1.0. As PERCOP → 0.0, the concentration of pesticide in the runoff and lateral flow approaches 0. As PERCOP → 1.0, surface runoff and lateral flow has the same concentration of pesticide as the percolate. If no value for PERCOP is entered, the model will set PERCOP = 0.50. Required if pesticide transport is of interest.
MSK_CO1	Calibration coefficient used to control impact of the storage time constant (K_m) for normal flow (where normal flow is when river is at bankfull depth) upon the K_m value calculated for the reach. Required only if IRTE = 1.
MSK_CO2	Calibration coefficient used to control impact of the storage time constant (K_m) for low flow (where low flow is when river is at 0.1 bankfull depth) upon the K_m value calculated for the reach. Required only if IRTE = 1.
MSK_X	MSK_X is a weighting factor that controls the relative importance of inflow and outflow in determining the storage in a reach. The weighting factor has a lower limit of 0.0 and an upper limit of 0.5. This factor is a function of the wedge storage. For reservoir-type storage, there is no wedge and X = 0.0. For a full-wedge, X = 0.5. For rivers, X will fall between 0.0 and 0.3 with a mean value near 0.2. If no value for MSK_X is entered, the model will set MSK_X = 0.2. Required only if IRTE = 1.
TRNSRCH	Fraction of transmission losses from main channel that enter deep aquifer. The remainder if the transmission losses enter bank storage. In arid watersheds, transmission losses from the main channel network may be permanently lost due to transmission to aquifers that do not contribute flow back to the stream network. This variable allows the user to specify the fraction of transmission losses from the channel network that is permanently lost. TRNSRCH varies between 0.00 and 1.00. The default value for TRNSRCH is 0.00. Required.

EVRCH — Reach evaporation adjustment factor.

The evaporation coefficient is a calibration parameter for the user and is allowed to vary between 0.0 and 1.0. This coefficient was created to allow reach evaporation to be dampened in arid regions. The original equation tends to overestimate evaporation in these areas.

If no value for EVRCH is entered, the model will set EVRCH = 1.00.

Required.

CNCOEF — Plant ET curve number coefficient.

ET weighting coefficient used to calculate the retention coefficient for daily curve number calculations dependent on plant evapotranspiration.

This value can vary between 0.5 and 2.0. If no value is entered for CNCOEF, the model will set CNCOEF = 1.0.

Required if ICN = 1.

CDN — Denitrification exponential rate coefficient.

This coefficient allows the user to control the rate of denitrification.

Acceptable values for CDN range from 0.0 to 3.0. If no value for CDN is specified, the model will set CDN = 1.4.

Required.

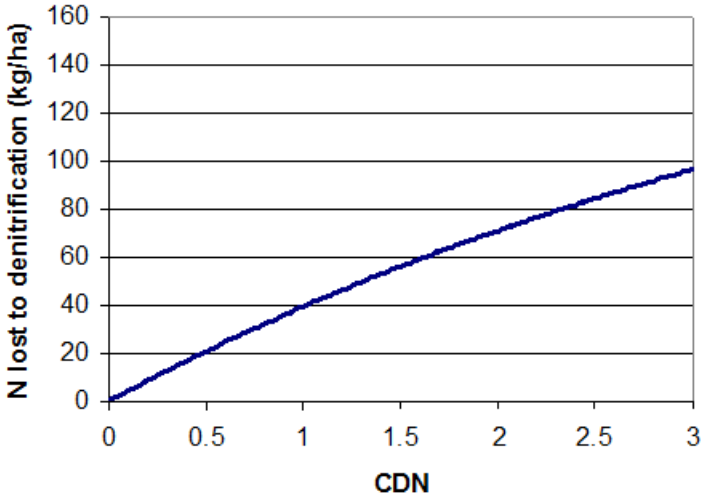


Fig 4-8: Impact of CDN value on amount of nitrogen lost to denitrification assuming initial nitrate content in layer is 200 kg/ha, temperature of layer is 10 °C, and organic carbon content of layer is 2%.

SDNCO	Denitrification threshold water content. Fraction of field capacity water content above which denitrification takes place. Denitrification is the bacterial reduction of nitrate, NO_3^-, to N_2 or N_2O gases under anaerobic (reduced) conditions. Because SWAT does not track the redox status of the soil layers, the presence of anaerobic conditions in a soil layer is defined by this variable. If the soil water content calculated as fraction of field capacity is ≥ SDNCO, then anaerobic conditions are assumed to be present and denitrification is modeled. If the soil water content calculated as a fraction of field capacity is < SDNCO, then aerobic conditions are assumed to be present and denitrification is not modeled. If no value for SDNCO is specified, the model will set SDNCO = 1.10. Required.
BACT_SWF	Fraction of manure applied to land areas that has active colony forming units. If no value for BACT_SWF is specified, the model will set BACT_SWF = 0.15. Required if bacteria processes are of interest.
TB_ADJ	*New variable in testing.* *Adjustment factor for subdaily unit hydrograph basetime.*
CN_FROZ	Parameter for frozen soil adjustment on infiltration/runoff. If no value for CNFROZ_BSN is entered, the model will set CNFROZ_BSN = 0.000862. Optional.
DORM_HR	Time threshold used to define dormancy (hours). The maximum day length minus DORM_HR is equal to when dormancy occurs. Optional.
SMXCO	Adjustment factor for maximum curve number S factor. Coefficient curve number method that uses antecedent climate. Optional.
FIXCO	Nitrogen fixation coefficient. (0.0 – 1.0) 1.0 = fixes 100% of nitrogen demand. 0.0 = fixes none of nitrogen demand.
NFIXMX	Maximum daily-n fixation (kg/ha). (1.0 – 20.0)
DECR_MIN	Minimum daily residue decay (fraction 0.0 – 0.05)
RSD_COVCO	Residue cover factor for computing fraction of cover. (0.1 – 0.5)

VCRIT	Critical velocity
RES_STR_CO	Reservoir sediment settling coefficient (0.09 – 0.27)
UHALPHA	Alpha coefficient for gamma function unit hydrograph. Required if iuh = 2 is selected
EROS_SPL	Splash erosion coefficient (0.9 – 3.1)
RILL_MULT	Rill erosion coefficient – multiplier to USLE_K for soil susceptible to rill erosion (0.5-2.0)
EROS_EXPO	Exponential coefficient for overland flow – (1.5-3.0)
C_FACTOR	Scaling parameter for cover and management factor for overland flow erosion (0.03/0.001/0.45)
CH_D50	Median particle diameter of main channel (mm) (50/10/100)
SIG_G	Geometric standard deviation of particle size (1.57/1.0/5.0)
R2ADJ	Curve number retention parameter adjustment for low gradient, non-draining soils (dimensionless) (0-3)
	Random generator seed code. A set of random numbers is needed by SWAT to generate weather data. SWAT has a set of default random numbers embedded in the code. To use the default random numbers, the user should set IGN = 0. This is the default value for IGN. In some situations, a user may wish to vary the weather sequence between runs. One method to do this is to set IGN to a different number every time the model is run. This code will activate a random number generator, which will replace the default set of random numbers with a new set. The value to which IGN is set determines the number of times the random number generator is cycled before the simulation begins. The seeds produced by the random number generator are then utilized by the weather generator instead of the default values. Measured weather data read into the model is not affected by this variable. However, if the measured data contains missing values, the weather generator is activated to produce data to replace the missing values. The data produced to replace missing values will be affected by this variable. Required.
IGEN	Randon generator code 0 = use default number; 1 = generate new numbers in every simulation

CLIMATE – The CLIMATE section of file.cio contains filenames for the entire simulation run. The list of the filenames are listed below with a brief description of the inputs within each file.

WEATHER-STA.CLI

The weather station climate file contains the weather stations that will be included in the simulation and is space delimited. Below is a sample WEATHER-STA.CLI file:

weather-sta.cli								
NAME	WGN	PGAGE	TGAGE	SGAGE	HGAGE	WGAGE	WNDIR	ATMODEP
wea1	wgn001	mentone.pcp	mentone.tmp	sim	sim	sim	null	atmo_2
wea2	wgn001	warsaw.pcp	warsaw.tmp	sim	sim	sim	null	atmo_3

Variable name	Definition
TITLE	Title of the weather station.
HEADER	Headings
WST_NAME	The weather station name
WGN	The weather generator station name (from the weather-wgn.cli file)
PGAGE	The precipitation station name (from pcp.cli file). If precipitation is generated, 'sim' should be input.
TGAGE	The temperature station name (from tmp.cli file). If temperature will be generated, 'sim' should be input.
SGAGE	The solar radiation station name (from slr.cli file). If solar radiation will be generated, 'sim' should be input.
HGAGE	The relative humidity station name (from hmd.cli file). If relative humidity will be generated, 'sim' should be input.
WGAGE	The wind station name (from wnd.cli file). If wind will be generated, 'sim' should be input.
WNDIR	The wind direction name (from wind-dir.cli file). If wind direction will be generated, 'null' should be input.
ATMODEP	The atmospheric deposition file name. If no atmospheric deposition file is used, 'null' should be input.

WEATHER-WGN.CLI

The weather generator climate file contains the weather generator stations that will be included in the simulation and is space delimited. Below is a sample WEATHER-WGN.CLI file:

weather-w	Weather												
wgn001	43.07	-94.3	374.9	31									
TMPMX	TMPMN	TMPSTDM	TMPTDMN	PCPMM	PCPSTD	PCPSKW	PR_WD	PR_WW	PCPD	RAINHMX	SOLARAV	DEWPT	WINDAV
-3.9	-13.52	6.76	7.5	18.5	4.01	2.09	0.12	0.32	4.48	3.35	7.12	-11.06	5.61
-1.22	-10.79	7.04	7.72	18	4.6	2.72	0.12	0.25	3.83	4.43	10.81	-8.92	5.59
5.8	-4.3	7.36	6.22	43.4	8.24	1.81	0.15	0.33	5.6	6.5	15	-3.91	5.8
14.81	2.12	7.32	4.87	80.4	9.58	1.69	0.22	0.39	7.83	18.45	17.93	0.87	6.04
21.53	8.87	5.64	4.55	107.3	11.83	2.31	0.25	0.46	9.9	24.11	20.78	4.12	5.47
26.52	14.38	4.49	3.74	128.6	17.15	2.84	0.28	0.39	9.47	40.11	22.84	6.66	4.78
28.12	16.55	3.58	3.16	107.4	12.61	1.59	0.25	0.32	8.37	35.16	23.21	15.92	3.89
26.69	15.22	3.67	3.48	105.3	18	4.34	0.21	0.36	7.77	39.17	20.41	15.27	3.57
23.15	10.25	5.33	4.86	72.6	12.77	2.61	0.2	0.33	6.8	15.72	15.92	5.13	4.22
15.74	3.41	6.44	5.13	59.2	9.29	1.59	0.15	0.41	6.44	12.93	11.1	1.54	4.9
6.07	-3.99	7.17	5.86	39.8	8.97	2.6	0.13	0.36	5.17	5.93	7.16	-3.25	5.42
-2.17	-11.12	7.07	7.4	24.6	4.88	1.77	0.13	0.23	4.62	3.21	5.66	-8.88	5.48

Variable name	Definition
TITLE	Description of the weather-wgn.cli file
WGN_NAME	The weather station name (to be referenced in weather-sta.cli file.
LATITUDE	Latitude of weather station used to create statistical parameters (degrees). The latitude is expressed as a real number with minutes and seconds converted to fractions of a degree.
LONGITUDE	Longitude of weather station (degrees).
ELEV	Elevation of weather station (m). Required if elevation bands are modeled in watershed.
RAIN_YRS	The number of years of maximum monthly 0.5 h rainfall data used to define values for RAIN_HHMX(1) - RAIN_HHMX(12). If no value is input for RAIN_YRS, SWAT will set RAIN_YRS = 10. Required.

TMPMX(MON) Average or mean daily maximum air temperature for month (ºC).

This value is calculated by summing the maximum air temperature for every day in the month for all years of record and dividing by the number of days summed:

$$\mu mx_{mon} = \frac{\sum_{d=1}^{N} T_{mx,mon}}{N}$$

where μmxmon is the mean daily maximum temperature for the month (°C), Tmx,mon is the daily maximum temperature on record d in month mon (°C), and N is the total number of daily maximum temperature records for month mon.

Required.

TMPMN(MON) Average or mean daily minimum air temperature for month (ºC).

This value is calculated by summing the minimum air temperature for every day in the month for all years of record and dividing by the number of days summed:

$$\mu mn_{mon} = \frac{\sum_{d=1}^{N} T_{mn,mon}}{N}$$

where μmn_{mon} is the mean daily minimum temperature for the month (°C), $T_{mn,mon}$ is the daily minimum temperature on record *d* in month *mon* (°C), and *N* is the total number of daily minimum temperature records for month *mon*.

Required.

TMPSTDMX(MON) Standard deviation for daily maximum air temperature in month (ºC).
This parameter quantifies the variability in maximum temperature for each month. The standard deviation is calculated:

$$\sigma mx_{mon} = \sqrt{\left(\frac{\sum_{d=1}^{N} \left(T_{mx,mon} - \mu mx_{mon} \right)^2}{N-1} \right)}$$

where σmx_{mon} is the standard deviation for daily maximum temperature in month *mon* (ºC), $T_{mx,mon}$ is the daily maximum temperature on record *d* in month *mon* (°C), μmx_{mon} is the average daily maximum temperature for the month (°C), and *N* is the total number of daily maximum temperature records for month *mon*.

Required.

TMPSTDMN(MON) Standard deviation for daily minimum air temperature in month (ºC).

This parameter quantifies the variability in minimum temperature for each month. The standard deviation is calculated:

$$\sigma mn_{mon} = \sqrt{\left(\frac{\sum_{d=1}^{N} \left(T_{mn,mon} - \mu mn_{mon} \right)^2}{N-1} \right)}$$

where σmn_{mon} is the standard deviation for daily minimum temperature in month *mon* (ºC), $T_{mn,mon}$ is the daily minimum temperature on record *d* in month *mon* (°C), μmn_{mon} is the average daily minimum temperature for the month (°C), and *N* is the total number of daily minimum temperature records for month *mon*.

Required.

PCPMM(MON) Average or mean total monthly precipitation (mm H_2O).

$$\overline{R}_{mon} = \frac{\sum_{d=1}^{N} R_{day,mon}}{yrs}$$

where $\overline{R}_{mon}$ is the mean monthly precipitation (mm H_2O), $R_{day,mon}$ is the daily precipiation for record *d* in month *mon* (mm H_2O), *N* is the total number of records in month *mon* used to calculate the average, and *yrs* is the number of years of daily precipitation records used in calculation.

Required.

PCPSTD(MON) Standard deviation for daily precipitation in month (mm H_2O/day).

This parameter quantifies the variability in precipitation for each month. The standard deviation is calculated:

$$\sigma_{mon} = \sqrt{\left(\frac{\sum_{d=1}^{N} \left(R_{day,mon} - \overline{R}_{mon} \right)^2}{N-1} \right)}$$

where σ_{mon} is the standard deviation for daily precipitation in month *mon* (mm H_2O), $R_{day,mon}$ is the amount of precipitation for record *d* in month *mon* (mm H_2O), $\overline{R}_{mon}$ is the average precipitation for the month (mm H_2O), and *N* is the total number of daily precipitation records for month *mon*. (Note: daily precipitation values of 0 mm are included in the standard deviation calculation).

Required.

PCPSKW(MON) Skew coefficient for daily precipitation in month.

This parameter quantifies the symmetry of the precipitation distribution about the monthly mean. The skew coefficient is calculated:

$$g_{mon} = \frac{N \cdot \sum_{d=1}^{N} \left(R_{day,mon} - \overline{R}_{mon} \right)^3}{(N-1) \cdot (N-2) \cdot (\sigma_{mon})^3}$$

where g_{mon} is the skew coefficient for precipitation in the month, *N* is the total number of daily precipitation records for month *mon*, $R_{day,mon}$ is the amount of precipitation for record *d* in month *mon* (mm H_2O), $\overline{R}_{mon}$ is the average precipitation for the month (mm H_2O), and σ_{mon} is the standard deviation for daily precipitation in month *mon* (mm H_2O). (Note: daily precipitation values of 0 mm are included in the skew coefficient calculation).

Required.

PR_WD(MON) Probability of a wet day following a dry day in the month.

This probability is calculated:

$$P_i(W/D) = \frac{days_{W/D,i}}{days_{dry,i}}$$

where $P_i(W/D)$ is the probability of a wet day following a dry day in month i, $days_{W/D,i}$ is the number of times a wet day followed a dry day in month i for the entire period of record, and $days_{dry,i}$ is the number of dry days in month i during the entire period of record. A dry day is a day with 0 mm of precipitation. A wet day is a day with > 0 mm precipitation.

Required.

PR_WW(MON) Probability of a wet day following a wet day in the month.

This probability is calculated:

$$P_i(W/W) = \frac{days_{W/W,i}}{days_{wet,i}}$$

where $P_i(W/W)$ is the probability of a wet day following a wet day in month i, $days_{W/W,i}$ is the number of times a wet day followed a wet day in month i for the entire period of record, and $days_{wet,i}$ is the number of wet days in month i during the entire period of record. A dry day is a day with 0 mm of precipitation. A wet day is a day with > 0 mm precipitation.

Required.

PCPD(MON) Average number of days of precipitation in month.

This parameter is calculated:

$$\bar{d}_{wet,i} = \frac{days_{wet,i}}{yrs}$$

where $\bar{d}_{wet,i}$ is the average number of days of precipitation in month i, $days_{wet,i}$ is the number of wet days in month i during the entire period of record, and yrs is the number of years of record.

Required.

RAINHMX(MON) Maximum 0.5 hour rainfall in entire period of record for month (mm H_2O).

This value represents the most extreme 30-minute rainfall intensity recorded in the entire period of record.

Required.

SOLARAV(MON) Average daily solar radiation for month (MJ/m^2/day).

This value is calculated by summing the total solar radiation for every day in the month for all years of record and dividing by the number of days summed:

$$\mu rad_{mon} = \frac{\sum_{d=1}^{N} H_{day,mon}}{N}$$

where μrad_{mon} is the mean daily solar radiation for the month (MJ/m^2/day), $H_{day,mon}$ is the total solar radiation reaching the earth's surface for day *d* in month *mon* (MJ/m^2/day), and *N* is the total number of daily solar radiation records for month *mon*.

Required.

DEWPT(MON) Average daily dew point temperature for each month (ºC) or relative humidity (fraction) can be input.

If all twelve months are less than one, the model assumes relative humidity is input. Relative humidity is defined in equation 1:3.5.1 in the SWAT Theoretical documentation as the amount of water vapor in the air as a fraction of saturation humidity. If any month has a value greater than 1.0, the model assumes dewpoint temperature is input.

Dew point temperature is the temperature at which the actual vapor pressure present in the atmosphere is equal to the saturation vapor pressure. This value is calculated by summing the dew point temperature for every day in the month for all years of record and dividing by the number of days summed:

$$\mu dew_{mon} = \frac{\sum_{d=1}^{N} T_{dew,mon}}{N}$$

where μdew_{mon} is the mean daily dew point temperature for the month (ºC), $T_{dew,mon}$ is the dew point temperature for day *d* in month *mon* (ºC), and *N* is the total number of daily dew point records for month *mon*. Dew point is converted to relative humidity using equations 1:3.5.1 and 1:3.5.2 in the Theoretical Documentation.

Required for Penman-Monteith potential evaporation equation.

WINDAV(MON) Average daily wind speed in month (m/s).

This value is calculated by summing the average or mean wind speed values for every day in the month for all years of record and dividing by the number of days summed:

$$\mu wnd_{mon} = \frac{\sum_{d=1}^{N} \mu_{wnd,mon}}{N}$$

where μwnd_{mon} is the mean daily wind speed for the month (m/s), $\mu_{wnd,mon}$ is the average wind speed for day *d* in month *mon* (m/s), and *N* is the total number of daily wind speed records for month *mon*.

Required.

WIND-DIR.CLI

This file contains the wind direction values that will be included in the simulation and is space delimited. Below is a sample WIND-DIR.CLI file:

wind-dir.cl											
2											
AL_BAN											
0	0										
3.46	3.47	3.64	3.3	2.55	2.26	2.09	2.06	2.44	2.37	2.8	3.11
10	10	8	7	8	7	6	9	13	14	12	11
4	5	4	4	4	4	4	6	9	8	6	5
4	4	4	4	6	6	6	8	9	8	6	5
3	4	4	4	5	6	6	7	9	8	5	4
5	6	5	5	6	8	8	9	12	10	6	7
5	5	5	4	5	6	6	5	7	6	4	7
9	7	7	7	7	7	7	6	7	6	8	8
9	7	8	9	7	7	7	5	5	5	6	7
12	9	11	13	11	10	12	8	6	5	7	8
7	6	7	9	8	8	9	5	4	3	5	4
3	4	4	5	6	6	7	5	3	2	3	3
2	3	3	4	4	5	5	4	2	2	3	3
3	4	5	4	5	5	6	5	2	3	4	5
6	7	7	7	5	5	4	4	2	4	7	6
9	8	8	7	6	6	4	6	4	7	10	8
7	8	8	7	6	5	4	6	7	9	9	8

Variable name	Definition
TITLE	Description of the wind direction file (may be blank)
MWND_DIR	The maximum number of wind direction stations in the file.
NAME	Wind Station name
SKIP	Next 2 lines are not read in by the model
WND_DIR	The monthly wind directions input data (16 lines/directions)

PCP.CLI

This file contains the information on the precipitation gages included in the simulation and is space delimited. A path has been added to file.cio to enable the daily files to be present in another folder; if path is null daily is in same project folder as other data. Below is a sample PCP.CLI file:

pcp.cli
FILENAME
mentone.pcp
warsaw.pcp

Variable name	Definition
TITLE	Description of the precipitation climate file (may be blank)
HEADER	The header information for the pcp.cli file
PCP_FILENAME	The name of the precipitation file containing daily precipitation input data (description of the pcp_filename data follows)

PCP_FILENAME

The pcp_filename is input in the pcp.cli file. The description of the 'pcp_filename' contains the daily precipitation amounts for the simulation and is space delimited. A path has been added to file.cio to enable the daily files to be present in another folder; if path is null daily is in same project folder as other data. Below is a sample of the file (partial listing):

mentone.pcp				
NBYR	TSTEP	LAT	LONG	ELEV
114	0	41.14	-85.98	268
1900	1	0.3		
1900	2	0		
1900	3	0		
1900	4	0		
1900	5	0		
1900	6	0.6		
1900	7	0.5		
1900	8	0		
1900	9	3.6		
1900	10	3.5		
1900	11	2.3		

Variable name	Definition
TITLE	Description of the precipitation file (may be blank)
HEADER	
NBYR	The header information for the file
TSTEP	Timestep of the simulation
LAT	Latitude of the precipitation gage
LONG	Longitude of the precipitation gage
ELEV	Elevation of the precipitation gage
IYR	The year of the precipitation amount
ISTEP	The step (day, sub-daily) of the precipitation amount
PCP	The amount of precipitation amount (mm) for istep (enter -99.0 for missing days)

TMP.CLI

This file contains information on the maximum and minimum temperatures included in the simulation and is space delimited. A path has been added to file.cio to enable the daily files to be present in another folder; if path is null daily is in same project folder as other data. Below is a sample TMP.CLI file:

tmp.cli
FILENAME
mentone.tmp
warsaw.tmp

Variable name	Definition
TITLE	Description of the maximum and minimum temperature file (may be blank)
HEADER	The header information for the tmp.cli file
TMP_FILENAME	The name of the temperature file containing daily maximum and minimum temperatures.

TMP_FILENAME

The tmp_filename is input in the tmp.cli file. The description of the 'tmp_filename' contains the daily maximum and minimum temperatures for the simulation and is space delimited. Below is a sample of the file:

mentone.tmp			
NBYR	LAT	LONG	ELEV
114	41.14	-85.98	268
1900	1	-99	-99
1900	2	-99	-11.5
1900	3	-99	-7.5
1900	4	3.1	-9.4
1900	5	5.7	-0.2
1900	6	6.8	-0.1
1900	7	11.2	2.6
1900	8	7.7	-99
1900	9	8	-3.4
1900	10	4.9	1.3
1900	11	-99	-1.2

Variable name	Definition
TITLE	Description of the temperature file (may be blank)
HEADER	Headings
NBYR	The header information for the file
LAT	Latitude of the temperature gage
LONG	Longitude of the temperature gage
ELEV	Elevation of the temperature gage
IYR	The year of the temperature data
ISTEP	Timestep
TMP_MAX	The maximum temperatures for istep (enter -99.0 for missing days)
TMP_MIN	The minimum temperatures for istep (enter -99.0 for missing days)

SLR.CLI

This file contains the information on the solar radiation daily data included in the simulation and is space delimited. A path has been added to file.cio to enable the daily files to be present in another folder; if path is null daily is in same project folder as other data. Below is a sample SLR.CLI file:

slr.cli	
NUMB	FILENAME
1	gage1.slr

Variable name	Definition
TITLE	Description of the solar radiation file (may be blank)
HEADER	The header information for the slr.cli file
SLR_FILENAME	The name of the solar radiation file containing values of solar radiation

SLR_FILENAME

The slr_filename is input in the slr.cli file. The description of the 'slr_filename' contains the daily solar radiation values for the simulation and is space delimited. Below is a sample of the file (partial listing):

gage1.slr			
NBYR	LAT	LONG	ELEV
25	0.0	0.0	0.0
1988	1	12.9	
1988	2	27.4	
1988	3	22.7	
1988	4	0	
1988	5	9.7	

Variable name	Definition
TITLE	Description of the solar radiation file (may be blank)
HEADER	Headings
NBYR	The header information for the file
LAT	Latitude of the solar radiation gage
LONG	Longitude of the solar radiation gage
ELEV	Elevation of the solar radiation gage
IYR	The year of the solar radiation data
ISTEP	Timestep
SLR	The solar radiation value for istep (MJ/m^2; -99.0 to generate missing days)

HMD.CLI

This file contains the information on the relative humidity stations included in the simulation and is space delimited. A path has been added to file.cio to enable the daily files to be present in another folder; if path is null daily is in same project folder as other data. Below is a sample HMD.CLI file:

HMD.CLI	
NUMB	FILENAME
1	gage1.hmd

Variable name	Definition
TITLE	Description of the relative humidity file (may be blank)
HEADER	The header information for the hmd.cli file
HMD_FILENAME	The name of the relative humidity file containing daily relative humidity input data

HMD_FILENAME

The hmd_filename is input in the hmd.cli file. The description of the 'hmd_filename' contains the daily relative humidity values for the simulation and is space delimited. Below is a sample of the file (partial listing):

gage1.HMD			
NBYR	LAT	LONG	ELEV
25	0.0	0.0	0.0
1988	1	1	
1988	2	0.8	
1988	3	0.7	
1988	4	1	
1988	5	0.5	

Variable name	Definition
TITLE	Description of the relative humidity file (may be blank)
HEADER	Headings
NBYR	The header information for the file
LAT	Latitude of the relative humidity gage
LONG	Longitude of the relative humidity gage
ELEV	Elevation of the relative humidity gage
IYR	The year of the relative humidity data
ISTEP	Timestep
RELHUM	The relative humidity value for istep (-99.0 to generate missing days)

WND.CLI

This file contains the information on the windspeed input data included in the simulation and is space delimited. A path has been added to file.cio to enable the daily files to be present in another folder; if path is null daily is in same project folder as other data. Below is a sample WND.CLI file (partial listing):

WND.CLI	
NUMB	FILENAME
1	gage1.wnd

Variable name	Definition
TITLE	Description of the wnd.cli file (may be blank)
HEADER	The header information for the wnd.cli file
WND_FILENAME	The name of the precipitation file containing daily windspeed input data

WND_FILENAME

The wnd_filename is input in the wnd.cli file. The description of the 'wnd_filename' contains the daily wind values for the simulation and is space delimited. Below is a sample of the file (partial listing):

gage1.WND			
NBYR	LAT	LONG	ELEV
25	0.0	0.0	0.0
1988	1	3.8	
1988	2	4.4	
1988	3	2.8	
1988	4	2	
1988	5	3.1	

Variable name	Definition
TITLE	Description of the windspeed file (may be blank)
HEADER	Headings
NBYR	The header information for the file
LAT	Latitude of the windspeed gage
LONG	Longitude of the windspeed gage
ELEV	Elevation of the windspeed gage
IYR	The year of the windspeed data
ISTEP	Timestep
WNDSPD	The windspeed value for istep (-99.0 to generate missing days)

ATMO.CLI

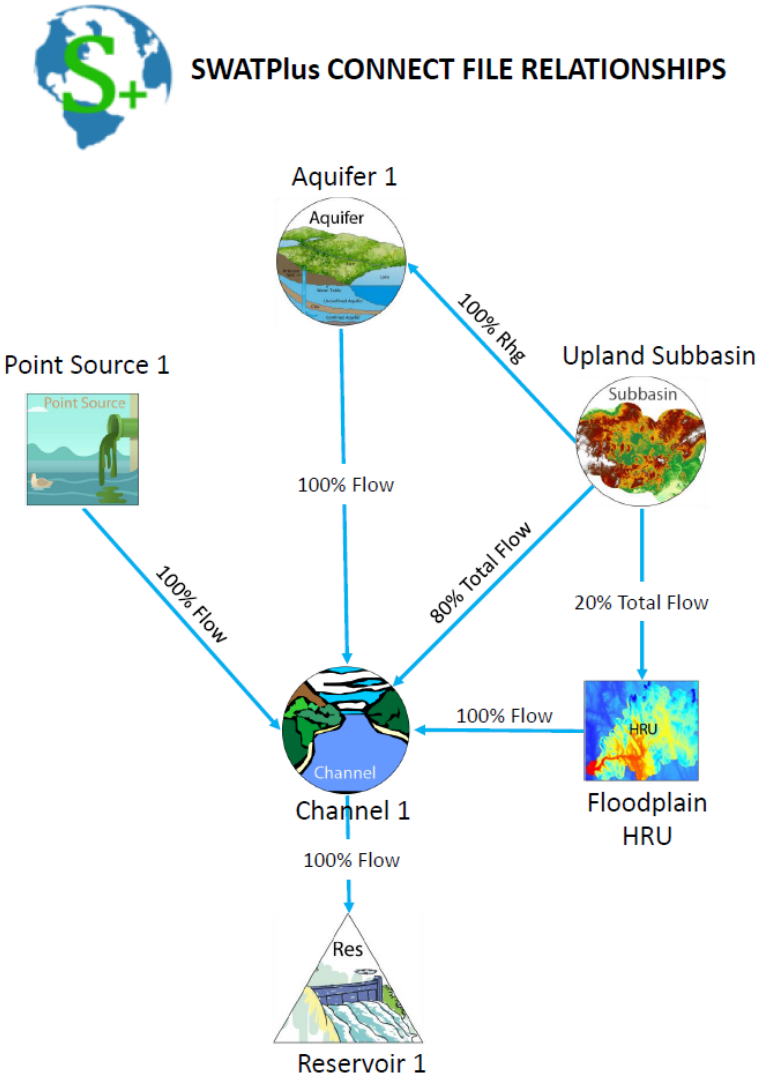
The ATMO.CLI file contains the input variables for atmospheric deposition. The atmospheric deposition input file contains annual average atmospheric nitrogen deposition values including ammonium, nitrate, dry ammonium and dry nitrate and can be read in as average annual, yearly or monthly. This file is optional. An example annual file is listed below:

atmo_annual.dat						
NUM_STA	TIMESTEP	MO_INIT	YR_INIT	NUM_AA		
3	aa	0	0	0		
atmo_1						desc_not read
	0.35					(NH4_RF)
	3.24					(NO3_RF)
	0.13					(NH4_DRY)
	0.12					(NO3_DRY)
atmo_2						
	0.35					(NH4_RF)
	3.24					(NO3_RF)
	0.13					(NH4_DRY)
	0.12					(NO3_DRY)
atmo_3						
	0.35					(NH4_RF)
	3.24					(NO3_RF)
	0.13					(NH4_DRY)
	0.12					(NO3_DRY)

Variable name	Definition
TITLE	The first line is reserved for user comments. The title line is not processed by the model and may be left blank.
HEADER	The second line is the header for the inputs. This line is not processed by the model.
NUM_STA	Total number of deposition stations in the file
TIMESTEP	There are three different timesteps for the file to be read and should be character. 'aa' = annual average (constant) 'mo' = monthly 'yr' = yearly
MO_INIT	Initial month of the input data (applies to month option only) input 0 for other options;
YR_INIT	Initial year of the input data (applies to year and monthly option only) input 0 for annual;
NUM_AA	Number of average annual values in file;
NAME	Initial month of the input data (applies to month option only) input 0 for other options;

NH4_RF	Ammonia in rainfll (mg/l)
NO3_RF	Nitrate in rainfall (mg/l)
NH4_DRY	Ammonia deposition (kg/ha/yr)
NO3_DRY	Nitrate dry deposition (kg/ha/yr)

CONNECT – The CONNECT section of file.cio contains the filenames for the object connectivity for the simulation run. **All** connect (.con) files read in the same input variables, only differing in the connect units (HRU, HRU-LTE, ROUT_UNIT, modflow, aquifer, aquifer2d, channel, reservoir, recall, exco, delivery ratio, outlet and chandeg).



EXPLANATION OF SPATIAL OBJECTS

SUBBASIN

The subbasin is defined by the DEM in the GIS interface as it always has been. All flow within the subbasin drains to the subbasin outlet.

LANDSCAPE UNIT

A landscape unit is defined as a collection of HRU's and can be defined as a subbasin, or it could be a flood plain or upland unit, or it could be a grid cell with multiple HRU's. The landscape unit is not routed, it only used for output. The landscape unit output files (waterbal, nutbal, losses, and plant weather) are output for HRU's, landscape units, and for the basin. Two input files are required: 1) landscape elements and, 2) landscape define. The elements file includes HRU's and their corresponding LSU fraction and basin fractions. The define file specifies which HRU's are contained in each LSU.

ROUTING UNIT

A routing unit is a collection of hydrographs that can be routed to any spatial object. The routing unit can be configured as a subbasin, then total flow (surface, lateral and tile flow) from the routing unit can be sent to a channel and all recharge from the routing unit sent to an aquifer. This is analogous to the current approach in SWAT. However, SWAT+ gives us much more flexibility in configuring a routing unit. For example, in CEAP, we are routing each HRU (field) through a small channel (gully or grass waterway) before it reaches the main channel. In this case, the routing unit is a collection of flow from the small channels. We also envision simulating multiple representative hillslopes to define a routing unit. Also, we are setting up scenarios that define a routing unit using tile flow from multiple fields and sending that flow to a wetland.

The routing unit is the spatial unit SWAT+ that allows us to lump outputs and route the outputs to any other spatial object. It gives us considerably more flexibility than the old subbasin lumping approach in SWAT, and will continue to be a convenient way of spatial lumping until we can simulate individual fields or cells in each basin.

HRU.CON

The HRU.CON file contains the connectivity for the HRU spatial objects within the watershed that will be included in the simulation and is space delimited. Below is a sample HRU.CON file:

hru.con												
NUMB	NAME	GIS_ID	AREA	LAT	LONG	ELEV	HRU	WST	CONST_TYPE	OVERFLOW	RULESET	OUT_TOT
1	bench	1	0.48	0	0	0	1	wea1	0	0	0	0
2	field	2	495.27	0	0	0	2	wea2	0	0	0	0

Variable name	Definition
TITLE	Description of the connect file
HEADER	The header information for the HRU connect file
NUMB	Number of object unit
NAME	Name of the object connect
GIS_ID	ID number (used for GIS_ID number for manipulating databases)
AREA_HA	Area of the object (ha)
LAT	Latitude of the object
LONG	Longitude of the object
ELEV	Elevation of the object
PROPS	Object properties number (Spatial objects for PROPS abbreviations - HRU, HLT, RU, MFL, AQU, CHA, RES, REC, EXC, DR, OUT, SDC)
WST	Weather station number ('weather-sta.cli' file)
CONSTIT	Constituent data pointer (pesticides, pathogens, heavy metals, salts)
PROPS2(OVERFLOW)	Overbank connectivity pointer to landscape units
RULESET	Ruleset pointer for flow fraction of hydrograph
SRC_TOT	Total number of incoming (source) objects
OBTYP_OUT	Outflow object type ('hru';'hlt','ru';'mfl'; aqu'; 'cha'; 'res'; 'exc'; 'dr'; 'out';'sdc') (default == 'null')

SPATIAL OBJECTS	
HRU	HYDROLOGIC RESPONSE UNIT
HLT	HRU LITE
RU	ROUTING UNIT
MFL	MODFLOW
AQU	AQUIFER

CHA	CHANNEL
RES	RESERVOIR
REC	RECALL
EXC	EXPORT COEFFICIENTS
DR	DELIVERY RATIO
CAN	CANAL
PUM	PUMP
OUT	OUTLET
SDC	SWAT DEG CHANNEL

OBTYPNO_OUT Outflow object type name

HTYP_OUT Outflow hydrograph (1='tot'; 2='rhg';3='sur';4='lat';5='til';

(default = 'null')

OUTFLOW HYDROGRAPHS	
TOT	TOTAL
RHG	RECHARGE
SUR	SURFACE
LAT	LATERAL
TIL	TILLAGE

FRAC_OUT Fraction of hydrograph

CHANNEL – The CHANNEL section of file.cio contains the filenames for simulation of a channel in the model. In order to simulate the physical processes affecting the flow of water and transport of sediment in the channel network of the watershed, SWAT requires information on the physical characteristics of the main channel within each subbasin. The channel input files summarizes the physical characteristics of the channel which affect water flow and transport of sediment, nutrients and pesticides.

INITIAL.CHA

The INITIAL.CHA file contains the input variables for the initialization of a channel. Below is a partial sample INITIAL.CHA file:

Variable name	Definition
TITLE	Title of the initial channel file
HEADER	The header information for the initial channel file
NAME	Name of the channel
VOL	Reservoir volume (m^3)
SED	Amount of sediment in reservoir (kg/L)
ORGN	Amount of organic nitrogen in reservoir (kg N)
NO3	Amount of nitrate in reservoir (kg N)
NO2	Amount of nitrite in reservoir (kg N)
NH3	Amount of ammonia in reservoir (kg)
ORGP	Amount of organic phosphorous in reservoir (kg P)
SOLP	Amount of soluble phosphorous in reservoir (kg P)
SECI	Secci-disk depth (m)
SAN	Amount of sand in reservoir (kg/L)
SIL	Amount of silt in reservoir (kg/L)
CLA	Amount of clay in reservoir (kg/L)
SAG	Amount of small aggregates in reservoir (kg/L)
LAG	Amount of large aggregates in reservoir (kg/L)
GRA	Amount of gravel in reservoir (kg/L)
CHLA	Amount of chlorophyll-a in reservoir (kg chl-a)
PSOL	Amount of soluble phosphorous in reservoir (kg/L)
PSOR	Amount of sorbed phosphorous in reservoir (kg/L)
BACTLP	Less persistent bacteria stored in reservoir (# cfu/100ml)
BACTP	Persistent bacteria stored in reservoir (# cfu/100ml)

CHANNEL.CHA

The CHANNEL.CHA file contains the input variables for the initialization of a channel. Below is a sample CHANNEL.CHA file:

channel.cha								
CHA_NUMB	CHA_NAME	CHA_INI	CHA_HYD	CHA_SED	CHA_NUT	CHA_PST	CHA_LS_LNK	A_AQU_LNK
1	cha1	null	cha1	null	null	null	0	0
2	cha2	null	cha2	null	null	null	0	0
3	cha3	null	cha3	null	null	null	0	0
4	cha4	null	cha4	null	null	null	0	0
5	cha5	null	cha5	null	null	null	0	0
6	cha6	null	cha6	null	null	null	0	0
7	cha7	null	cha7	null	null	null	0	0
8	cha8	null	cha8	null	null	null	0	0
9	cha9	null	cha9	null	null	null	0	0
10	cha10	null	cha10	null	null	null	0	0
11	cha11	null	cha11	null	null	null	0	0

Variable name	Definition
TITLE	Description of the channel file
HEADER	The header information for the channel file
NUMB	Number of the channel
NAME	Name of the channel
INIT	Initial data (points to initial.cha)
HYD	Channel hydrology inputs (points to hydrology.cha)
SED	Channel sediment inputs (points to sediment.cha)
NUT	Channel nutrient inputs (points to nutrients.cha)
PST	Channel pesticide inputs (points to pesticide.cha)
LS_LNK	Landscape linkage (points to chan-surf.lin)
AQU_LNK	Aquifer linkage (points to chan-aqu.lin)

HYDROLOGY.CHA

The HYDROLOGY.CHA file contains the input variables for the hydrology inputs of a channel. Below is a sample HYDROLOGY.CHA file:

hydrology.cha									
CHA_HYD_NAME	CHA_WD	CHA_DP	CHA_SLP	CHA_LEN	CHA_MANN	CHA_K	CHA_WDR	ALPHA_BNK	SIDE_SLP
cha1	3.29	0.338	0.002	0.794	0.075	0	9.73	0	0
cha2	2.719	0.301	0.008	0.474	0.075	0	9.026	0	0
cha3	4.286	0.397	0.004	3.042	0.075	0	10.802	0	0
cha4	2.566	0.291	0.004	0.48	0.075	0	8.82	0	0
cha5	3.254	0.336	0.006	1.474	0.075	0	9.688	0	0
cha6	2.729	0.302	0.005	0.674	0.075	0	9.038	0	0
cha7	2.881	0.312	0.005	0.764	0.075	0	9.234	0	0
cha8	3.038	0.322	0.006	1.444	0.075	0	9.429	0	0
cha9	4.254	0.395	0.004	2.63	0.075	0	10.77	0	0
cha10	2.536	0.289	0.005	0.517	0.075	0	8.78	0	0
cha11	3.288	0.338	0.003	1.693	0.075	0	9.728	0	0

Variable name	Definition
TITLE	Description of the channel hydrology file
HEADER	The header information for the channel hydrology file
NAME	Name of the channel hydrology
W	Average width of the main channel (m)
D	Average depth of the main channel (m)
S	Average slope of the main channel (m/m)
L	Main channel length (km)
N	Manning's "n" value for the main channel
K	Effective hydraulic conductivity of main channel alluvium (mm/hr)
WDR	Channel width to depth ratio (m/m)
ALPHA_BNK	Alpha factor for bank storage recession curve (days)
SIDE	Change in horizontal distance per unit

SEDIMENT.CHA

The SEDIMENT.CHA file contains the input variables for the sediment inputs of a channel. Below is a sample SEDIMENT.CHA file:

sediment.cha:														
CHA_SED_NAM	SED_EQN	ER_FACT	COV_FACT	BNK_BD	BED_BD	BNK_KD	BED_KD	BNK_D50	BED_D50	BNK_CSS	BED_CSS	EROD1	EROD2	
null	0	0	0	1.5	1.5	0.5	0.5	1.5	1.5	0.05	0.05	0	0	

Variable name	Definition
TITLE	Description of the sediment channel file
HEADER	The header information for the sediment channel file
NAME	Name of the sediment channel
EQN	Sediment routine methods: 0 = original SWAT method; 1 Bagnold's 2 Kodatie 3 Molinas WU 4 Yang
COV1	Channel erodibility factor (0.0-1.0)
COV2	Channel cover factor (0.0-1.0)
BNK_BD	Bulk density of channel bank sediment (g/cc)
BED_BD	Bulk density of channel bed sediment (g/cc)
BNK_KD	Erodibility of channel bank sediment by jet test
BED_KD	Erodibility of channel bed by jet test
BNK_D50	D50 (median) particle size diameter of channel bank
BED_D50	D50 (median) particle size diameter of channel bed
TC_BNK	Critical shear stress of channel bank (N/m^2)
TC_BED	Critical shear stress of channel bed (N/m^2)
EROD1-12	Value of 0.0 indicates a non-erosive channel while a value of 1.0 indicates no resistance to erosion

NUTRIENTS.CHA

The NUTRIENTS.CHA file contains the input variables for the nutrients of a channel. Below is a sample partial NUTRIENTS.CHA file:

nutrients.cha:																																						
NAME	ONCO	OPCO	RS1	RS2	RS3	RS4	RS5	RS6	RS7	RK1	RK2	RK3	RK4	RK5	RK6	BC1	BC2	BC3	BC4	LAO	IGROPT	AI0	AI2	AI3	AI4	AI5	AI6	MUMAX	RHOQ	TFACT	K_I	K_N	K_P	LAMBDA0	LAMBDA1	LAMDA2	P_N
nut_cha1	0	0	1	0.05	0.5	0.05	0.05	2.5	2.5	1.71	1	2	0	1.71	1.71	0.55	1.1	0.21	0.35	2	2	AI1	0.08	0.01	1.6	2	3.5	1.07	2	2.5	0.4	0.75	0.02	0.025	1	0.03	0.054

Variable name	Definition
TITLE	The first line is reserved for user comments. This line is not processed by the model and may be left blank. Optional.
HEADER	Headers for the nutrients.cha file.
NAME	Name of the nutrients channel
ONCO	Channel organic N concentration (ppm)
OPCO	Channel organic P concentration (ppm)
RS1	Local algal settling rate in the reach at 20º C (m/day). If routing is performed on an hourly time step (see IEVENT in .bsn file), the units of RS1 are converted to m/hr by the model. Values for RS1 should fall in the range 0.15 to 1.82 m/day. If no value for RS1 is entered, the model sets RS1 = 1.0 m/day. Required if in-stream nutrient cycling is being modeled.
RS2	Benthic (sediment) source rate for dissolved phosphorus in the reach at 20º C (mg dissolved P/(m^2·day)). If routing is performed on an hourly time step (see IEVENT in .bsn file), the units of RS2 are converted to mg dissolved P/(m^2·hr) by the model. If no value for RS2 is entered, the model sets RS2 = 0.05 mg dissolved P/(m^2·day). Required if in-stream nutrient cycling is being modeled.
RS3	Benthic source rate for NH_4-N in the reach at 20º C (mg NH_4-N/(m^2·day)). If routing is performed on an hourly time step (see IEVENT in .bsn file), the units of RS3 are converted to mg NH_4-N/(m^2·hr) by the model. If no value for RS3 is entered, the model sets RS3 = 0.5 mg NH_4-N/(m^2·day). Required if in-stream nutrient cycling is being modeled.

Variable name	Definition
RS4	Rate coefficient for organic N settling in the reach at 20º C (day^{-1}). If routing is performed on an hourly time step (see IEVENT in .bsn file), the units of RS4 are converted to hr^{-1} by the model. Values for RS4 should fall in the range 0.001 to 0.10 day^{-1}. If no value for RS4 is entered, the model sets RS4 = 0.05 day^{-1}. Required if in-stream nutrient cycling is being modeled.
RS5	Organic phosphorus settling rate in the reach at 20º C (day^{-1}). If routing is performed on an hourly time step (see IEVENT in .bsn file), the units of RS5 are converted to hr^{-1} by the model. Values for RS5 should fall in the range 0.001 to 0.1 day^{-1}. If no value for RS5 is entered, the model sets RS5 = 0.05 day^{-1}. Required if in-stream nutrient cycling is being modeled.
RS6	Rate coefficient for settling of arbitrary non-conservative constituent in the reach at 20º C (day^{-1}). If no value for RS6 is entered, the model sets RS6 = 2.5. *Not currently used by the model*.
RS7	Benthic source rate for arbitrary non-conservative constituent in the reach at 20º C (mg ANC/(m^2·day)). If no value for RS7 is entered, the model sets RS7 = 2.5. *Not currently used by the model*.
RK1	Carbonaceous biological oxygen demand deoxygenation rate coefficient in the reach at 20º C (day^{-1}). If routing is performed on an hourly time step (see IEVENT in .bsn file), the units of RK1 are converted to hr^{-1} by the model. Values for RK1 should fall in the range 0.02 to 3.4 day^{-1}. If no value for RK1 is entered, the model sets RK1 = 1.71 day^{-1}. Required if in-stream nutrient cycling is being modeled.

Variable name	Definition
RK2	Oxygen reaeration rate in accordance with Fickian diffusion in the reach at 20º C (day^{-1}). Numerous methods have been developed to calculate the reaeration rate at 20°C, κ2,20. A few of the methods are listed below. Brown and Barnwell (1987) provide additional methods. Using field measurements, Churchill, Elmore and Buckingham (1962) derived the relationship: $\kappa_{2,20} = 5.03 \cdot v_c^{0.969} \cdot depth^{-1.673}$ where κ2,20 is the reaeration rate at 20°C (day^{-1}), v_c is the average stream velocity (m/s), and depth is the average stream depth (m). O'Connor and Dobbins (1958) incorporated stream turbulence characteristics into the equations they developed. For streams with low velocities and isotropic conditions, $\kappa_{2,20} = 294 \cdot \frac{(D_m \cdot v_c)^{0.5}}{depth^{1.5}}$ where $\kappa_{2,20}$ is the reaeration rate at 20°C (day^{-1}), D_m is the molecular diffusion coefficient (m^2/day), v_c is the average stream velocity (m/s), and *depth* is the average stream depth (m). For streams with high velocities and nonisotropic conditions, $\kappa_{2,20} = 2703 \cdot \frac{D_m^{0.5} \cdot slp^{0.25}}{depth^{1.25}}$ where $\kappa_{2,20}$ is the reaeration rate at 20°C (day^{-1}), D_m is the molecular diffusion coefficient (m^2/day), *slp* is the slope of the streambed (m/m), and *depth* is the average stream depth (m). The molecular diffusion coefficient is calculated $D_m = 177 \cdot 1.037^{\overline{T}_{water}-20}$ where D_m is the molecular diffusion coefficient (m^2/day), and $\overline{T}_{water}$ is the average water temperature (°C).

Variable name	Definition
RK2, cont.	Owens et al. (1964) developed an equation to determine the reaeration rate for shallow, fast moving streams where the stream depth is 0.1 to 3.4 m and the velocity is 0.03 to 1.5 m/s. $\kappa_{2,20} = 5.34 \cdot \frac{v_c^{0.67}}{depth^{1.85}}$ where $\kappa_{2,20}$ is the reaeration rate at 20°C (day^{-1}), v_c is the average stream velocity (m/s), and *depth* is the average stream depth (m). If routing is performed on an hourly time step (see IEVENT in .bsn file), the units of RK2 are converted to hr^{-1} by the model. Values for RK2 should fall in the range 0.01 to 100.0 day^{-1}. If no value for RK2 is entered, the model sets RK2 = 50.0 day^{-1}. Required if in-stream nutrient cycling is being modeled.
RK3	Rate of loss of carbonaceous biological oxygen demand due to settling in the reach at 20º C (day^{-1}). Values for RK3 should fall in the range -0.36 to 0.36 day^{-1}. The recommended default for RK3 is 0.36 day^{-1} (not set by model). Required if in-stream nutrient cycling is being modeled.
RK4	Benthic oxygen demand rate in the reach at 20º C (mg O_2/(m^2·day)). If routing is performed on an hourly time step (see IEVENT in .bsn file), the units of RK4 are converted to (mg O_2/(m^2·hr)) by the model. If no value for RK4 is entered, the model sets RK4 = 2.0 mg O_2/(m^2·day). Required if in-stream nutrient cycling is being modeled.
RK5	Coliform die-off rate in the reach at 20º C (day^{-1}). Values for RK5 should fall in the range 0.05 to 4.0. If no value for RK5 is entered, the model sets RK5 = 2.0. *Not currently used by the model*.
RK6	Decay rate for arbitrary non-conservative constituent in the reach at 20º C (day^{-1}). If no value for RK6 is entered, the model sets RK6 = 1.71. *Not currently used by the model*.

Variable name	Definition
BC1	Rate constant for biological oxidation of NH_4 to NO_2 in the reach at 20º C in well-aerated conditions (day^{-1}). If routing is performed on an hourly time step (see IEVENT in .bsn file), the units of BC1 are converted to hr^{-1} by the model. Values for BC1 should fall in the range 0.1 to 1.0 day^{-1}. If no value for BC1 is entered, the model sets BC1 = 0.55 day^{-1}. Required if in-stream nutrient cycling is being modeled.
BC2	Rate constant for biological oxidation of NO_2 to NO_3 in the reach at 20º C in well-aerated conditions (day^{-1}). If routing is performed on an hourly time step (see IEVENT in .bsn file), the units of BC2 are converted to hr^{-1} by the model. Values for BC2 should fall in the range 0.2 to 2.0 day^{-1}. If no value for BC2 is entered, the model sets BC2 = 1.1 day^{-1}. Required if in-stream nutrient cycling is being modeled.
BC3	Rate constant for hydrolysis of organic N to NH_4 in the reach at 20º C (day^{-1}). If routing is performed on an hourly time step (see IEVENT in .bsn file), the units of BC3 are converted to hr^{-1} by the model. Values for BC3 should fall in the range 0.2 to 0.4 day^{-1}. If no value for BC3 is entered, the model sets BC3 = 0.21 day^{-1}. Required if in-stream nutrient cycling is being modeled.
BC4	Rate constant for mineralization of organic P to dissolved P in the reach at 20º C (day^{-1}). If routing is performed on an hourly time step (see IEVENT in .bsn file), the units of BC4 are converted to hr^{-1} by the model. Values for BC4 should fall in the range 0.01 to 0.70 day^{-1}. If no value for BC4 is entered, the model sets BC4 = 0.35 day^{-1}. Required if in-stream nutrient cycling is being modeled.

LAO

Qual2E light averaging option. Qual2E defines four light averaging options.

1 Depth-averaged algal growth attenuation factor for light (FL) is computed from one daylight average solar radiation value calculated in the steady state temperature heat balance.

2 FL is computed from one daylight average solar radiation value supplied by the user.

3 FL is obtained by averaging the hourly daylight values of FL computed from the hourly daylight values of solar radiation calculated in the steady state temperature heat balance.

4 FL is obtained by averaging the hourly daylight values of FL computed from the hourly daylight values of solar radiation calculated from a single value of total daily, photosynthetically active, solar radiation and an assumed cosine function.

The only option currently active in SWAT is 2.

Required if in-stream nutrient cycling is being modeled.

IGROPT

Qual2E algal specific growth rate option. Qual2E provides three different options for computing the algal growth rate.

1 Multiplicative: the effects of nitrogen, phosphorus and light are multiplied together to calculate the net effect on the local algal growth rate

2 Limiting nutrient: the local algal growth rate is limited by light and one of the nutrients (nitrogen or phosphorus)

3 Harmonic mean: the local algal growth rate is limited by light and the harmonic mean of the nutrient interactions

Variable name	Definition
IGROPT, cont.	The multiplicative option multiplies the growth factors for light, nitrogen and phosphorus together to determine their net effect on the local algal growth rate. This option has its biological basis in the mutiplicative effects of enzymatic processes involved in photosynthesis. The limiting nutrient option calculates the local algal growth rate as limited by light and either nitrogen or phosphorus. The nutrient/light effects are multiplicative, but the nutrient/nutrient effects are alternate. The algal growth rate is controlled by the nutrient with the smaller growth limitation factor. This approach mimics Liebig's law of the minimum. The harmonic mean is mathematically analogous to the total resistance of two resistors in parallel and can be considered a compromise between the multiplicative and limiting nutrient options. The algal growth rate is controlled by a multiplicative relation between light and nutrients, while the nutrient/nutrient interactions are represented by a harmonic mean. The default option is the limiting nutrient option (2). Required if in-stream nutrient cycling is being modeled.
AI0	Ratio of chlorophyll-a to algal biomass (μg-chla/mg algae). Values for AI0 should fall in the range 10-100. If no value for AI0 is entered, the model will set AI0 = 50.0. Required if in-stream nutrient cycling is being modeled.
AI1	Fraction of algal biomass that is nitrogen (mg N/mg alg). Values for AI1 should fall in the range 0.07-0.09. If no value for AI1 is entered, the model will set AI1 = 0.08. Required if in-stream nutrient cycling is being modeled.
AI2	Fraction of algal biomass that is phosphorus (mg P/mg alg). Values for AI2 should fall in the range 0.01-0.02. If no value for AI2 is entered, the model will set AI2 = 0.015. Required if in-stream nutrient cycling is being modeled.
AI3	The rate of oxygen production per unit of algal photosynthesis (mg O_2/mg alg). Values for AI3 should fall in the range 1.4-1.8. If no value for AI3 is entered, the model will set AI3 = 1.6. Required if in-stream nutrient cycling is being modeled.

Variable name	Definition
AI4	The rate of oxygen uptake per unit of algal respiration (mg O_2/mg alg). Values for AI4 should fall in the range 1.6-2.3. If no value for AI4 is entered, the model will set AI4 = 2.0. Required if in-stream nutrient cycling is being modeled.
AI5	The rate of oxygen uptake per unit of NH_3-N oxidation (mg O_2/mg NH_3-N). Values for AI5 should fall in the range 3.0-4.0. If no value for AI5 is entered, the model will set AI5 = 3.5. Required if in-stream nutrient cycling is being modeled.
AI6	The rate of oxygen uptake per unit of NO_2-N oxidation (mg O_2/mg NO_2-N). Values for AI6 should fall in the range 1.00-1.14. If no value for AI6 is entered, the model will set AI6 = 1.07. Required if in-stream nutrient cycling is being modeled.
MUMAX	Maximum specific algal growth rate at 20º C (day^{-1}). If routing is performed on an hourly time step (see IEVENT in .bsn file), MUMAX is converted to (hr^{-1}) by the model. Values for MUMAX should fall in the range 1.0-3.0. If no value for MUMAX is entered, the model will set MUMAX = 2.0. Required if in-stream nutrient cycling is being modeled.
RHOQ	Algal respiration rate at 20º C (day^{-1}). If routing is performed on an hourly time step (see IEVENT in .bsn file), RHOQ is converted to (hr^{-1}) by the model. Values for RHOQ should fall in the range 0.05-0.50. If no value for RHOQ is entered, the model will set RHOQ = 0.30. Required if in-stream nutrient cycling is being modeled.
TFACT	Fraction of solar radiation computed in the temperature heat balance that is photosynthetically active. Values for TFACT should fall in the range 0.01-1.0. If no value for TFACT is entered, the model will set TFACT = 0.3. Required if in-stream nutrient cycling is being modeled.

Variable name	Definition
K_L	Half-saturation coefficient for light (kJ/(m^2·min)). Values for K_L should fall in the range 0.2227-1.135. If no value for K_L is entered, the model will set K_L = 0.75. Required if in-stream nutrient cycling is being modeled.
K_N	Michaelis-Menton half-saturation constant for nitrogen (mg N/L). The Michaelis-Menton half-saturation constant for nitrogen and phosphorus define the concentration of N or P at which algal growth is limited to 50% of the maximum growth rate. Typical values for K_N range from 0.01 to 0.30 mg N/L. Values for K_N should fall in the range 0.01-0.30. If no value for K_N is entered, the model will set K_N = 0.02. Required if in-stream nutrient cycling is being modeled.
K_P	Michaelis-Menton half-saturation constant for phosphorus (mg P/L). The Michaelis-Menton half-saturation constant for nitrogen and phosphorus define the concentration of N or P at which algal growth is limited to 50% of the maximum growth rate. Typical values for K_P will range from 0.001 to 0.05 mg P/L. If no value for K_P is entered, the model will set K_P = 0.025. Required if in-stream nutrient cycling is being modeled.
LAMBDA0	Non-algal portion of the light extinction coefficient (m^{-1}). The light extinction coefficient, k_ℓ, is calculated as a function of the algal density using the nonlinear equation: $k_\ell = k_{\ell,0} + k_{\ell,1} \cdot \alpha_0 \cdot algae + k_{\ell,2} \cdot (\alpha_0 \cdot algae)^{2/3}$ where $k_{\ell,0}$ is the non-algal portion of the light extinction coefficient (m^{-1}), $k_{\ell,1}$ is the linear algal self shading coefficient (m^{-1} (µg-chla/L)$^{-1}$), $k_{\ell,2}$ is the nonlinear algal self shading coefficient (m^{-1} (µg-chla/L)$^{-2/3}$), α_0 is the ratio of chlorophyll *a* to algal biomass (µg chla/mg alg), and *algae* is the algal biomass concentration (mg alg/L).

Variable name	Definition
LAMBDA0, cont.	This equation allows a variety of algal, self-shading, light extinction relationships to be modeled. When $k_{\ell,1} = k_{\ell,2} = 0$, no algal self-shading is simulated. When $k_{\ell,1} \neq 0$ and $k_{\ell,2} = 0$, linear algal self-shading is modeled. When $k_{\ell,1}$ and $k_{\ell,2}$ are set to a value other than 0, non-linear algal self-shading is modeled. The Riley equation (Bowie et al., 1985) defines $k_{\ell,1} = 0.0088\ \text{m}^{-1}\left(\mu\text{g - chla/L}\right)^{-1}$ and $k_{\ell,2} = 0.054\ \text{m}^{-1}\left(\mu\text{g - chla/L}\right)^{-2/3}$. If no value for LAMBDA0 is entered, the model will set LAMBDA0 = 1.0. Required if in-stream nutrient cycling is being modeled.
LAMBDA1	Linear algal self-shading coefficient ($m^{-1}\cdot(\mu g\ chla/L)^{-1}$). See explanation for LAMBDA0 for more information on this variable. Values for LAMBDA1 should fall in the range 0.0065-0.065. If no value for LAMBDA1 is entered, the model will set LAMBDA1 = 0.03. Required if in-stream nutrient cycling is being modeled.
LAMBDA2	Nonlinear algal self-shading coefficient ($m^{-1}\cdot(\mu g\ chla/L)^{-2/3}$). See explanation for LAMBDA0 for more information on this variable. The recommended value for LAMBDA2 is 0.0541. If no value for LAMBDA2 is entered, the model will set LAMBDA2 = 0.054. Required if in-stream nutrient cycling is being modeled.
P_N	Algal preference factor for ammonia. Values for P_N should fall in the range 0.01-1.0. If no value for P_N is entered, the model will set P_N = 0.5. Required if in-stream nutrient cycling is being modeled.

PESTICIDE.CHA

The PESTICIDE.CHA file contains the input variables for the nutrients of a channel. Below is a sample partial PESTICIDE.CHA file:

pesticide.cha										
CHA_PST_NAME	PST_REAC	PST_VOLAT	PST_KOC	PST_MIX	PST_RSP	PST_STL	SEDPST_ACT	SEDPST_BUR	SEDPST_CONC	SEDPST_REAC
cha_pst1	0.007	0.01	0	0.001	0	1	0.03	0.002	0	0.05

Variable name	Definition
TITLE	This line is reserved for the pesticide section title. This line is not processed by the model and may be left blank.
HEADER	Headings
NAME	Name of the pesticide channel
PST_REA	Pesticide reaction coefficient in reach (day^{-1}). The rate constant is related to the aqueous half-life: $k_{p,aq} = \frac{0.693}{t_{1/2,aq}}$ where $k_{p,aq}$ is the rate constant for degradation or removal of pesticide in the water (1/day), and $t_{1/2,aq}$ is the aqueous half-life for the pesticide (days). If no value for CHPST_REA is entered, the model will set CHPST_REA = 0.007 day^{-1}. Required if in-stream pesticide cycling is being modeled.
PST_VOL	Pesticide volatilization coefficient in reach (m/day). The volatilization mass-transfer coefficient can be calculated based on Whitman's two-film or two-resistance theory (Whitman, 1923; Lewis and Whitman, 1924 as described in Chapra, 1997). While the main body of the gas and liquid phases are assumed to be well-mixed and homogenous, the two-film theory assumes that a substance moving between the two phases encounters maximum resistance in two laminar boundary layers where transfer is a function of molecular diffusion. In this type of system the transfer coefficient or velocity is: $v_v = K_l \cdot \frac{H_e}{H_e + R \cdot T_K \cdot \left(K_l / K_g\right)}$ where v_v is the volatilization mass-transfer coefficient (m/day), K_l is the mass-transfer velocity in the liquid laminar layer (m/day), K_g is the mass-transfer velocity in the gaseous laminar layer (m/day), H_e is Henry's constant (atm m^3 $mole^{-1}$), R is the universal gas constant (8.206×10^{-5} atm m^3 $(K\ mole)^{-1}$), and T_K is the temperature (K). For rivers where liquid flow is turbulent, the transfer coefficients are estimated using the surface renewal theory (Higbie, 1935; Danckwerts, 1951; as described by Chapra, 1997). The surface renewal model visualizes the system as

Variable name	Definition
PST_VOL, cont.	consisting of parcels of water that are brought to the surface for a period of time. The fluid elements are assumed to reach and leave the air/water interface randomly, i.e. the exposure of the fluid elements to air is described by a statistical distribution. The transfer velocities for the liquid and gaseous phases are calculated: $K_l = \sqrt{r_l \cdot D_l}$ $K_g = \sqrt{r_g \cdot D_g}$ where K_l is the mass-transfer velocity in the liquid laminar layer (m/day), K_g is the mass-transfer velocity in the gaseous laminar layer (m/day), D_l is the liquid molecular diffusion coefficient (m^2/day), D_g is the gas molecular diffusion coefficient (m^2/day), r_l is the liquid surface renewal rate (1/day), and r_g is the gaseous surface renewal rate (1/day). O'Connor and Dobbins (1956) defined the surface renewal rate as the ratio of the average stream velocity to depth. $r_l = \frac{86400 \cdot v_c}{depth}$ where r_l is the liquid surface renewal rate (1/day), v_c is the average stream velocity (m/s) and *depth* is the depth of flow (m). If no value for CHPST_VOL is entered, the model will set CHPST_VOL = 0.01. Required if in-stream pesticide cycling is being modeled.
PST_KOC	Pesticide partition coefficient between water and sediment in reach (m^3/g). The pesticide partition coefficient can be estimated from the octanol-water partition coefficient (Chapra, 1997): $K_d = 3.085 \times 10^{-8} \cdot K_{ow}$ where K_d is the pesticide partition coefficient (m^3/g) and K_{ow} is the pesticide's octanol-water partition coefficient ($\mathrm{mg\,m^{-3}_{octanol}}\left(\mathrm{mg\,m^{-3}_{water}}\right)^{-1}$).

Variable name	Definition
PST_KOC	Values for the octanol-water partition coefficient have been published for many chemicals. If a published value cannot be found, it can be estimated from solubility (Chapra, 1997): $\log(K_{ow}) = 5.00 - 0.670 \cdot \log(pst'_{sol})$ where pst'_{sol} is the pesticide solubility (μmoles/L). The solubility in these units is calculated: $pst'_{sol} = \frac{pst_{sol}}{MW} \cdot 10^3$ where pst'_{sol} is the pesticide solubility (μmoles/L), pst_{sol} is the pesticide solubility (mg/L) and MW is the molecular weight (g/mole). If no value for CHPST_KOC is entered, the model will set CHPST_KOC = 0. Required if in-stream pesticide cycling is being modeled.
PST_MIX	Mixing velocity (diffusion/dispersion) for pesticide in reach (m/day). The diffusive mixing velocity, vd, can be estimated from the empirically derived formula (Chapra, 1997): $v_d = \frac{69.35}{365} \cdot \phi \cdot MW^{-2/3}$ where vd is the rate of diffusion or mixing velocity (m/day), ϕ is the sediment porosity, and MW is the molecular weight of the pesticide compound. If no value for CHPST_MIX is entered, the model will set CHPST_MIX = 0.001. Required if in-stream pesticide cycling is being modeled.
PST_RSP	Resuspension velocity for pesticide sorbed to sediment (m/day). If no value for CHPST_RSP is entered, the model will set CHPST_RSP = 0.002. Required if in-stream pesticide cycling is being modeled.
PST_STL	Settling velocity for pesticide sorbed to sediment (m/day). If no value for CHPST_STL is entered, the model will set CHPST_STL = 1.0. Required if in-stream pesticide cycling is being modeled.

SEDPST_ACT	Depth of active sediment layer for pesticide (m). If no value for SEDPST_ACT is entered, the model will set SEDPST_ACT = 0.03. Required if in-stream pesticide cycling is being modeled.
SEDPST_BRY	Pesticide burial velocity in reach bed sediment (m/day). If no value for SEDPST_BRY is entered, the model will set SEDPST_BRY = 0.002. Required if in-stream pesticide cycling is being modeled.
SEDPST_CONC	Initial pesticide concentration in reach bed sediment (mg/m^3 sediment). We recommend using a 1 year equilibration period for the model where the watershed simulation is set to start 1 year prior to the period of interest. This allows the model to get the water cycling properly before any comparisons between measured and simulated data are made. When an equilibration period is incorporated, the value for SEDPST_CONC is not going to be important if a pesticide with a short half-life is being modeled. For pesticides with a long half-life, this variable is important. Required if in-stream pesticide cycling is being modeled.
SEDPST_REA	Pesticide reaction coefficient in reach bed sediment (day^{-1}). The rate constant is related to the sediment half-life: $k_{p,sed} = \frac{0.693}{t_{1/2,sed}}$ where $k_{p,sed}$ is the rate constant for degradation or removal of pesticide in the sediment (1/day), and $t_{1/2,sed}$ is the sediment half-life for the pesticide (days). If no value for SEDPST_REA is entered, the model will set SEDPST_REA = 0.05. Required if in-stream pesticide cycling is being modeled.

PATHOGENS.CHA (NEEDS ADDRESSING)

The PATHOGENS.CHA file contains the input variables for the nutrients of a channel. Below is a sample partial PATHOGENS.CHA file:

Variable name	Definition
TITLE	This line is reserved for the pesticide section title. This line is not processed by the model and may be left blank.
HEADER	Headings
NAME	Name of the pathogens channel

METALS.CHA(NEEDS ADDRESSING)

The METALS.CHA file contains the input variables for the nutrients of a channel. Below is a sample partial METALS.CHA file:

Variable name	Definition
TITLE	This line is reserved for the pesticide section title. This line is not processed by the model and may be left blank.
HEADER	Headings
NAME	Name of the metals channel

SALT.CHA (NEEDS ADDRESSING)

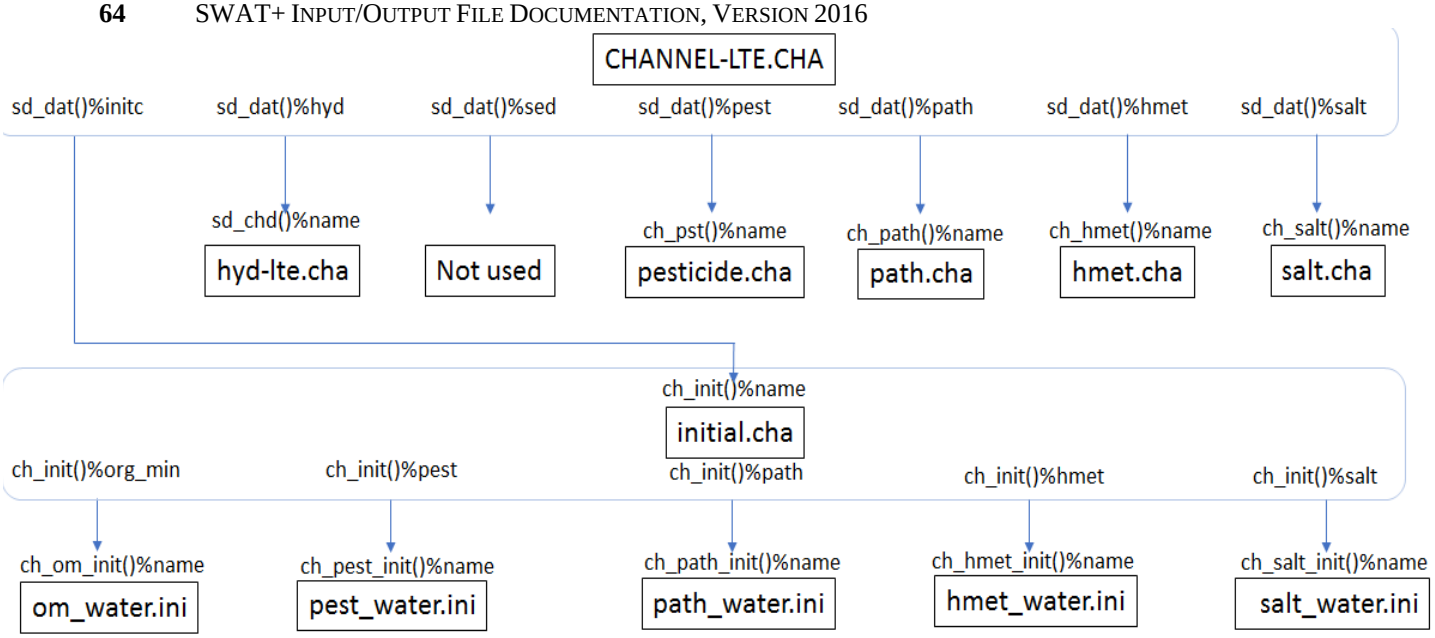
The SALT.CHA file contains the input variables for the nutrients of a channel. Below is a sample partial SALT.CHA file:

Variable name	Definition
TITLE	This line is reserved for the pesticide section title. This line is not processed by the model and may be left blank.
HEADER	Headings
NAME	Name of the salt channel

CHANNEL-LTE.CHA

The CHANNEL-LTE.CHA file contains the input variables for the nutrients of a channel. Below is a sample CHANNEL-LTE.CHA file:

channel-lte.cha																						
NAME	ORDER	RTE_DB	CHW	CHD	CHS	CHL	CHN	CHK	CHEROD	CHCOV	HC_COV	CHSEQ	D50	CLAY	BD	CHSS	BEDLD	TC	HEAR_BNK	HC_KH	HC_HGT	HC_INI
BcGully_MainTrib	null	null	8.373	3.8	0.0231	0.229	0.05	1	0.2	0.05	0.95	0.0115	0.005	46	1.87	0.53	0.2	39	0.75	0.188	1	0

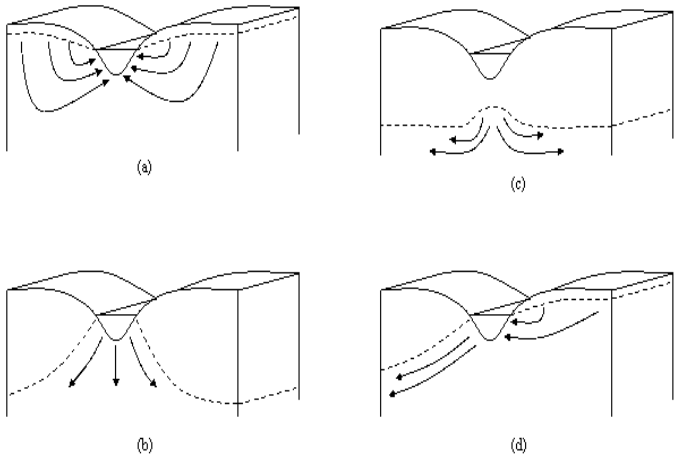


Variable name	Definition
TITLE	The first line is reserved for user comments. This line is not processed by the model and may be left blank. Optional.
HEADER	Headers for the channel-lte file.
NAME	Name of the nutrients channel
ORDER	
ROUTE_DB	Pointer to routing_nut_data (nutrients.cha)
CHW	Average width of main channel at top of bank (m). Required.
CHD	Depth of main channel from top of bank to bottom (m). Required.
CHS	Average slope of main channel along the channel length (m/m). Required.
CHL	Length of main channel (km). Required.
CHN	Manning's "n" value for the main channel. Required.

Table 25-1: Values of Manning's roughness coefficient, *n*, for channel flow (Chow, 1959).[1]

Characteristics of Channel	Median	Range
Excavated or dredged		
Earth, straight and uniform	0.025	0.016-0.033
Earth, winding and sluggish	0.035	0.023-0.050
Not maintained, weeds and brush	0.075	0.040-0.140
Natural streams		
Few trees, stones or brush	0.050	0.025-0.065
Heavy timber and brush	0.100	0.050-0.150

[1] Chow (1959) has a very extensive list of Manning's roughness coefficients. These values represent only a small portion of those he lists in his book.

Variable name	Definition
CHK	Effective hydraulic conductivity in main channel alluvium (mm/hr). Required. Streams may be categorized by their relationship to the groundwater system. A stream located in a discharge area that receives groundwater flow is a gaining or effluent stream (Figure 25-1a). This type of stream is characterized by an increase in discharge downstream. A stream located in a recharge area is a losing or influent stream. This type of stream is characterized by a decrease in discharge downstream. A losing stream may be connected to (Figure 25-1b) or perched above (Figure 25-1c) the groundwater flow area. A stream that simultaneously receives and loses groundwater is a flow-through stream (Figure 25-1d).  Figure 25-1: Stream-groundwater relationships: a) gaining stream receiving water from groundwater flow; b) losing stream connected to groundwater system; c) losing stream perched above groundwater system; and d) flow-through stream (After Dingman, 1994). Typical values for K_{ch} for various alluvium materials are given in Table 25-2. For perennial streams with continuous groundwater contribution, the effective conductivity will be zero.

Variable name	Definition

CHK cont.

Table 25-2: Example hydraulic conductivity values for various bed materials (from Lane, 1983).

Bed material group	Bed material characteristics	Hydraulic conductivity
1 Very high loss rate	Very clean gravel and large sand	> 127 mm/hr
2 High loss rate	Clean sand and gravel, field conditions	51-127 mm/hr
3 Moderately high loss rate	Sand and gravel mixture with low silt-clay content	25-76 mm/hr
4 Moderate loss rate	Sand and gravel mixture with high silt-clay content	6-25 mm/hr
5 Insignificant to low loss rate	Consolidated bed material; high silt-clay content	0.025-2.5 mm/hr

CHEROD

CHEROD is set to a value between 0.0 and 1.0. A value of 0.0 indicates a non-erosive channel while a value of 1.0 indicates no resistance to erosion.

COV

If CH_EQ is 0 the

CH_COV1 – Channel erodibility factor.

0 = non-erosive channel

1 = no resistance to erosion

The channel erodibility factor is conceptually similar to the soil erodibility factor used in the USLE equation. Channel erodibility is a function of properties of the bed or bank materials.

If CH_EQN ≠ 0:
Channel bank vegetation coefficient for critical shear stress

(Julian and Torres, 2006)

Bank Vegetation	CH_COV1
None	1.00
Grassy	1.97
Sparse trees	5.40
Dense trees	19.20

Required.

Variable name	Definition
HC_COV	Head cut cover factor
CHSEQ	Equilibrium channel slope (m/m)
D50	Channel median sediment size (%)
CLAY	Clay percent of bank and bed (%)
BD	Dry bulk density (t/m3)
CHSS	Channel side slope
BEDLDCOEF	Percent of sediment entering the channel that is bed material
TC	Time of concentration
SHEAR_BNK	Bank shear coefficient – fraction of bottom shear
HC_KH	Headcut erodibility
HC_HGT	Headcut height (m)
HC_INI	Initial channel length for gullies (km)

RESERVOIR – The RESERVOIR section of file.cio contains the filenames for simulation of a reservoirs in the model. Reservoirs are impoundments located on the main channel network of the watershed. Reservoirs receive loadings from all upstream subbasins. The reservoir input file (.res) contains input data to simulate water and sediment processes.

INITIAL.RES

The INITIAL.RES file contains the input variables for the initialization of a channel. Below is a sample partial INITIAL.RES file:

initial.res:																					
NAME	VOL	SED	ORGN	NO3	NO2	NH3	ORGP	SOLP	SECI	SAN	SIL	CLA	SAG	LAG	GRA	CHLA	PST_MASS	PST_MASS	BACTLP	BACTP	
res_init1	0.9	200	10	2	0.2	0.1	1	0.1	1	0	1	9	0	0	0	0.1	0.01	0	0	0	

Variable name	Definition
TITLE	The first line is reserved for user comments. This line is not processed by the model and may be left blank. Optional.
HEADER	Headers for the initial_res file.
NAME	Initial name of the reservoir
VOL	Initial reservoir volume. If the reservoir is in existence at the beginning of the simulation period, the initial reservoir volume is the volume on the first day of simulation. If the reservoir begins operation in the midst of a SWAT simulation, the initial reservoir volume is the volume of the reservoir the day the reservoir becomes operational (10^4 m^3).
SED	Initial sediment concentration in the reservoir (mg/L). If the reservoir is in existence at the beginning of the simulation period, the initial sediment concentration is the concentration on the first day of simulation. If the reservoir begins operation in the midst of a SWAT simulation, the initial sediment concentration is the concentration the day the reservoir becomes operational (mg/L).
ORGN	Amount of organic N in reservoir
NO3	Initial concentration of NO_3-N in reservoir (mg N/L).
NO2	Initial concentration of NO_2-N in reservoir (mg N/L).
NH3	Initial concentration of NH_3-N (ammonia) in reservoir (mg N/L).
ORGP	Initial concentration of organic P in reservoir (mg P/L). We recommend using a 1 year equilibration period for the model where the watershed simulation is set to start 1 year prior to the period of interest. This allows the model to get the water cycling properly before any comparisons between measured and simulated data are made. When an equilibration period is incorporated, the value for ORGP is not going to be important if the reservoir is in operation at the beginning of the simulation. However, if the reservoir starts operation in the middle of a simulation, this value needs to be reasonably accurate.
SOLP	Amount of soluble phosphorus in the reservoir (read in as mg/L and converted to kg/L) See comment for ORGP.

SECI	Secchi-disk depth(m)
SAN	Amount of sand in the reservoir (read in as mg/L and converted to kg/L)
SIL	Amount of silt in the reservoir (read in as mg/L and converted to kg/L)
CLA	Amount of clay in the reservoir (read in as mg/L and converted to kg/L)
SAG	Amount of small aggregates in the reservoir (read in as mg/L and converted to kg/L)
LAG	Amount of large aggregates in the reservoir (read in as mg/L and converted to kg/L)
GRA	Amount of gravel in the reservoir (read in as mg/L and converted to kg/L)
CHLA	Amount of chlorophyll-s in the reservoir (read in as mg/L and converted to kg/L)
PSOL	Amount of pest in res (read inas mg/L and converted to kg/L)
PSOR	Amount of pest in res (read inas mg/L and converted to kg/L)
BACTLP	Less persistent bacteria stored in the reservoir (# cfu/100ml)
BACTP	Persistent bacteria stored in the reservoir (# cfu/100ml)

RESERVOIR.RES

The reservoir input file (.res) contains input data to simulate water and sediment processes while the lake water quality file (.lwq) contains input data to simulate nutrient and pesticide cycling in the water body.
Below is a sample RESERVOIR.RES file:

reservoir.res							
RES_NUMB	RES_NAME	RES_INI	RES_HYD	RELEASE	RES_SED	RES_NUT	RES_PST
1	pnd1	res001	pnd1	lrew_sm_res	res001	res001	res001
2	pnd2	res001	pnd2	lrew_sm_res	res001	res001	res001
3	pnd3	res001	pnd3	lrew_sm_res	res001	res001	res001
4	pnd4	res001	pnd4	lrew_sm_res	res001	res001	res001
5	pnd5	res001	pnd5	lrew_sm_res	res001	res001	res001

Variable name	Definition
TITLE	The first line is reserved for user comments. This line is not processed by the model and may be left blank. Optional.
HEADER	Headers for the reservoir.res file.
NUMB	The number of the reservoir
NAME	The name of the reservoir

VARIABLE NAME	The initial reservoir data name (points to initial.res)
INIT	Initial reservoir data (points to initial.res)
HYD	Hydraulic conductivity of the reservoir bottom (mm/hr). (points to hydrology.res file) If seepage occurs in the water body, the hydraulic conductivity must be set to a value other than 0. Required.
RELEASE	Average daily principal spillway release rate (m^3/s). (points to release.res) The name for this variable is slightly misleading. SWAT uses this variable when the volume of water in the reservoir is between the principal and emergency spillway volumes. If the amount of water exceeding the principal spillway volume can be released at a rate ≤ REL, than all of the water volume in excess of the principal spillway volume is released. Otherwise the release rate, REL is used.
SED	Initial sediment concentration in the reservoir (mg/L). (points to sediment.res) If the reservoir is in existence at the beginning of the simulation period, the initial sediment concentration is the concentration on the first day of simulation. If the reservoir begins operation in the midst of a SWAT simulation, the initial sediment concentration is the concentration the day the reservoir becomes operational (mg/L). Required.
NUT	Nutrient reservoir inputs (points to nutrients.res)
PST	Pesticide reservoir inputs (points to pesticide.res file)

HYDROLOGY.RES

Reservoirs are impoundments located on the main channel network of the watershed. Reservoirs receive loadings from all upstream subbasins. The reservoir input file (.res) contains input data to simulate water and sediment processes while the lake water quality file (.lwq) contains input data to simulate nutrient and pesticide cycling in the water body.

Below is a sample HYDROLOGY.RES file:

hydrology.res										
RES_HYD_NAME	YR_OP	MON_OP	AREA_PS	VOL_PS	AREA_ES	VOL_ES	RES_K	EVAP_CO	SHP_CO_1	SHP_CO_2
pnd1	0	0	4.95	12.375	5.445	13.613	0	1	0	0
pnd2	0	0	4.41	11.025	4.851	12.128	0	1	0	0
pnd3	0	0	3.06	7.65	3.366	8.415	0	1	0	0
pnd4	0	0	8.55	21.375	9.405	23.513	0	1	0	0
pnd5	0	0	2.16	5.4	2.376	5.94	0	1	0	0
pnd6	0	0	2.52	6.3	2.772	6.93	0	1	0	0

Variable name	Definition
TITLE	The first line is reserved for user comments. This line is not processed by the model and may be left blank. Optional.
HEADER	Headers for the hydrology.res file.
NAME	The name of the reservoir
IYRES	Year the reservoir became operational (eg 1980). If 0 is input for MORES and IYRES, the model assumes the reservoir is in operation at the beginning of the simulation. Required.
MORES	Month the reservoir became operational (0-12). If 0 is input for MORES and IYRES, the model assumes the reservoir is in operation at the beginning of the simulation. Required.
PSA	Reservoir surface area when the reservoir is filled to the principal spillway (ha). See comment for ESA. Required.
PVOL	Volume of water needed to fill the reservoir to the principal spillway (10^4 m^3). See comment for RES_ESA. Required.
ESA	Reservoir surface area when the reservoir is filled to the emergency spillway (ha). For SWAT to calculate the reservoir surface area each day the surface area at two different water volumes must to be defined. Variables referring to the principal spillway can be thought of as variables referring to the normal reservoir storage volume while variables referring to the emergency spillway can be thought of as variables referring to maximum reservoir storage volume. Required.

EVOL	Volume of water needed to fill the reservoir to the emergency spillway (10^4 m^3). See comment for RES_ESA. Required.
K	Hydraulic conductivity of the reservoir bottom (mm/hr). If seepage occurs in the water body, the hydraulic conductivity must be set to a value other than 0. Required.
EVRSV	Lake evaporation coefficient. Default = 0.6 Required.
BR1	Vol_surface area coefficient for reservoirs (model estimates if zero)
BR2	Vol_surface area coefficient for reservoirs (model estimates if zero)

NUTRIENTS.RES

While water quality is a broad subject, the primary areas of concern are nutrients, organic chemicals—both agricultural (pesticide) and industrial, heavy metals, bacteria and sediment levels in streams and large water bodies. SWAT is able to model processes affecting nutrient, pesticide and sediment levels in the main channels and reservoirs.

Below is a sample partial NUTRIENTS.RES file:

nutrients.res:												
RES_NUT_NAME	MID_BEG	MID_END	MID_N_STL	N_STL	MID_P_STL	P_STL	CHLA_CO	SECCI_CO	THETA_N	THETA_P	CONC_NMIN	CONC_PMIN
res001	4	10	0.5	2	1	0.5	1	1	1	1	0.1	0.01

Variable name	Definition
TITLE	The first line is reserved for user comments. This line is not processed by the model and may be left blank. Optional.
HEADER	Headers for the nutrients.res file.
NAME	The name of the reservoir
IRES1	Beginning month of mid-year nutrient settling period. The model allows the user to define two settling rates for each nutrient and the time of the year during which each settling rate is used. A variation in settling rates is allowed

so that impact of temperature and other seasonal factors may be accounted for in the modeling of nutrient settling. To use only one settling rate for the entire year, both variables for the nutrient may be set to the same value. Setting all variables to zero will cause the model to ignore settling of nutrients in the water body.

Required.

IRES2	Ending month of mid-year nutrient settling period. See comment for IRES1. Required.
NSETLR1	Nitrogen settling rate in reservoir for months IRES1 through IRES2 (m/year). See explanation for PSETLR1 for more information about this parameter. Required if nutrient cycling is being modeled.
NSETLR2	Nitrogen settling rate in reservoir for months other than IRES1-IRES2 (m/year). See explanation for PSETLR1 for more information about this parameter. Required if nutrient cycling is being modeled.
PSETLR1	Phosphorus settling rate in reservoir for months IRES1 through IRES2 (m/year). The apparent settling velocity is most commonly reported in units of m/year and this is how the values are input to the model. For natural lakes, measured phosphorus settling velocities most frequently fall in the range of 5 to 20 m/year although values less than 1 m/year to over 200 m/year have been reported (Chapra, 1997). Panuska and Robertson (1999) noted that the range in apparent settling velocity values for man-made reservoirs tends to be significantly greater than for natural lakes. Higgins and Kim (1981) reported phosphorus apparent settling velocity values from –90 to 269 m/year for 18 reservoirs in Tennessee with a median value of 42.2 m/year. For 27 Midwestern reservoirs, Walker and Kiihner (1978) reported phosphorus apparent settling velocities ranging from –1 to 125 m/year with an average value of 12.7 m/year. A negative settling rate indicates that the reservoir sediments are a source of N or P; a positive settling rate indicates that the reservoir sediments are a sink for N or P. Table 30-1 summarizes typical ranges in phosphorus settling velocity for different systems. Required if nutrient cycling is being modeled.

Table 30-1: Recommended apparent settling velocity values for phosph
(Panuska and Robertson, 1999)

Nutrient Dynamics	*Range in settling vel values (m/year)*
Shallow water bodies with high net internal phosphorus flux	$v \leq 0$
Water bodies with moderate net internal phosphorus flux	$1 < v <$
Water bodies with minimal net internal phosphorus flux	$5 < v <$
Water bodies with high net internal phosphorus removal	$v > 1($

PSETLR2	Phosphorus settling rate in reservoir for months other than IRES1-IRES2 (m/year). See explanation for PSETLR1 for more information about this parameter. Required if nutrient cycling is being modeled.
CHLAR	Chlorophyll *a* production coefficient for reservoir. Chlorophyll *a* concentration in the reservoir is calculated from the total phosphorus concentration. The equation assumes the system is phosphorus limited. The chlorophyll *a* coefficient was added to the equation to allow the user to adjust results to account for other factors not taken into account by the basic equation such as nitrogen limitations. The default value for CHLAR is 1.00, which uses the original equation. Required if nutrient cycling is being modeled.
SECCIR	Water clarity coefficient for the reservoir. The clarity of the reservoir is expressed by the secci-disk depth (m) which is calculated as a function of chlorophyll *a*. Because suspended sediment also can affect water clarity, the water clarity coefficient has been added to the equation to allow users to adjust for the impact of factors other than chlorophyll *a* on water clarity. The default value for SECCIR is 1.00, which uses the original equation. Required if nutrient cycling is being modeled.
THETA_N	Temperature adjustment for nitrogen loss (settling)
THETA_P	Temperature adjustment for phosphorus loss (settling)
CONC_NMIN	Minimum nitrogen concentration for settling (ppm)
CONC_PMIN	Minimum phosphorus concentration for settling (ppm)

PESTICIDE.RES

Reservoirs are impoundments located on the main channel network of the watershed. Reservoirs receive loadings from all upstream subbasins. The reservoir input file (.res) contains input data to simulate water and sediment processes while the lake water quality file (.lwq) contains input data to simulate nutrient and pesticide cycling in the water body.

Below is a sample partial PESTICIDE.RES file:

pesticide.res:											
RES_PST_NAME	PST_CON	PST_KOC	PST_MIX	PST_REA	PST_RSP	PST_STL	PST_VOL	SEDPST_ACT	SEDPST_BRY	DPST_CONC	SEDPST_REA
res001	0	0.5	0.01	0.02	0.01	0.2	0.01	0.2	0.05	0.01	1

Variable name	Definition
TITLE	The first line is reserved for user comments. This line is not processed by the model and may be left blank. Optional.
HEADER	Headers for the nutrients.res file.
NAME	Reservoir pesticide Name
PST_CONC	Initial pesticide concentration in the Lake water for the pesticide defined by IRTPEST (mg/m^3). We recommend using a 1 year equilibration period for the model where the watershed simulation is set to start 1 year prior to the period of interest. This allows the model to get the water cycling properly before any comparisons between measured and simulated data are made. When an equilibration period is incorporated, the value for ORGP is not going to be important if the reservoir is in operation at the beginning of the simulation. However, if the reservoir starts operation in the middle of a simulation, this value needs to be reasonably accurate. Required if pesticide cycling is being modeled.

PST_KOC

Pesticide partition coefficient between water and sediment (m^3/g).

The pesticide partition coefficient can be estimated from the octanol-water partition coefficient (Chapra, 1997):

$$K_d = 3.085 \times 10^{-8} \cdot K_{ow}$$

where K_d is the pesticide partition coefficient (m^3/g) and K_{ow} is the pesticide's octanol-water partition coefficient ($\text{mg m}^{-3}_{\text{octanol}} \left(\text{mg m}^{-3}_{\text{water}}\right)^{-1}$). Values for the octanol-water partition coefficient have been published for many chemicals. If a published value cannot be found, it can be estimated from solubility (Chapra, 1997):

$$\log(K_{ow}) = 5.00 - 0.670 \cdot \log(pst'_{sol})$$

where pst'_{sol} is the pesticide solubility (μmoles/L). The solubility in these units is calculated:

$$pst'_{sol} = \frac{pst_{sol}}{MW} \cdot 10^3$$

where pst'_{sol} is the pesticide solubility (μmoles/L), pst_{sol} is the pesticide solubility (mg/L) and MW is the molecular weight (g/mole).

PST_KOC ranges between 10^{-4} to 10 m^3/g.

Required if pesticide cycling is being modeled.

PST_MIX

Pesticide diffusion or mixing velocity (m/day)

The diffusive mixing velocity, v_d, can be estimated from the empirically derived formula (Chapra, 1997):

$$v_d = \frac{69.35}{365} \cdot \phi \cdot MW^{-2/3}$$

where v_d is the rate of diffusion or mixing velocity (m/day), ϕ is the sediment porosity, and MW is the molecular weight of the pesticide compound.

Required if pesticide cycling is being modeled.

PST_REA

Reaction coefficient of the pesticide in lake water (day^{-1})

The rate constant is related to the aqueous half-life:

$$k_{p,aq} = \frac{0.693}{t_{1/2,aq}}$$

where $k_{p,aq}$ is the rate constant for degradation or removal of pesticide in the water (1/day), and $t_{1/2,aq}$ is the aqueous half-life for the pesticide (days).

Required if pesticide cycling is being modeled.

PST_RSP

Resuspension velocity of pesticide sorbed to sediment (m/day).

Pesticide in the sediment layer is available for resuspension which transfers it back into the water.

Required if pesticide cycling is being modeled.

PST_STL

Settling velocity of pesticide sorbed to sediment (m/day).

Pesticide in the particulate phase may be removed from the water layer by settling. Settling transfers pesticide from the water to the sediment layer.

Required if pesticide cycling is being modeled.

PST_VOL

Volatilization coefficient of the pesticide from the lake water (m/day).

The volatilization mass-transfer coefficient can be calculated based on Whitman's two-film or two-resistance theory (Whitman, 1923; Lewis and Whitman, 1924 as described in Chapra, 1997). While the main body of the gas and liquid phases are assumed to be well-mixed and homogenous, the two-film theory assumes that a substance moving between the two phases encounters maximum resistance in two laminar boundary layers where transfer is a function of molecular diffusion. In this type of system the transfer coefficient or velocity is:

$$v_v = K_l \cdot \frac{H_e}{H_e + R \cdot T_K \cdot \left(K_l / K_g\right)}$$

where v_v is the volatilization mass-transfer coefficient (m/day), K_l is the mass-transfer velocity in the liquid laminar layer (m/day), K_g is the mass-transfer velocity in the gaseous laminar layer (m/day), H_e is Henry's constant (atm m^3 $mole^{-1}$), R is the universal gas constant (8.206×10^{-5} atm m^3 $(K\ mole)^{-1}$), and T_K is the temperature (K).
For lakes, the transfer coefficients are estimated using a stagnant film approach:

$$K_l = \frac{D_l}{z_l} \qquad K_g = \frac{D_g}{z_g}$$

where K_l is the mass-transfer velocity in the liquid laminar layer (m/day), K_g is the mass-transfer velocity in the gaseous laminar layer (m/day), D_l is the liquid molecular diffusion coefficient (m^2/day), D_g is the gas molecular diffusion coefficient (m^2/day), z_l is the thickness of the liquid film (m), and z_g is the thickness of the gas film (m).

Alternatively, the transfer coefficients can be estimated with the equations:

$$K_l = K_{l,O_2} \cdot \left(\frac{32}{MW}\right)^{0.25} \qquad K_g = 168 \cdot \mu_w \cdot \left(\frac{18}{MW}\right)^{0.25}$$

where K_l is the mass-transfer velocity in the liquid laminar layer (m/day), K_g is the mass-transfer velocity in the gaseous laminar layer (m/day), K_{l,O_2} is the oxygen transfer coefficient (m/day), MW is the molecular weight of the compound, and μ_w is the wind speed (m/s). Chapra (1997) lists several different equations that can be used to calculate K_{l,O_2}.

Required if pesticide cycling is being modeled.

SPST_ACT	Depth of active sediment layer in reservoir (m). Required if pesticide cycling is being modeled.
SPST_BRY	Burial velocity of pesticide in lake bed sediment (m/day). Pesticide in the sediment layer may be lost by burial. Required if pesticide cycling is being modeled.
SPST_CONC	Initial pesticide concentration in the lake bed sediments. (mg/m^3). We recommend using a 1 year equilibration period for the model where the watershed simulation is set to start 1 year prior to the period of interest. This allows the model to get the water cycling properly before any comparisons between measured and simulated data are made. When an equilibration period is incorporated, the value for SPST_CONC is not going to be important if a pesticide with a short half-life is being modeled. For pesticides with a long half-life, this variable is important. Required if pesticide cycling is being modeled.
SPST_REA	Reaction coefficient of pesticide in reservoir bottom sediment (day^{-1}) The rate constant is related to the sediment half-life: $k_{p,sed} = \frac{0.693}{t_{1/2,sed}}$ where $k_{p,sed}$ is the rate constant for degradation or removal of pesticide in the sediment (1/day), and $t_{1/2,sed}$ is the sediment half-life for the pesticide (days). Required if pesticide cycling is being modeled.

PATHOGENS.RES (NEEDS ADDRESSING)

The PATHOGENS.RES file contains the input variables for the nutrients of a channel. Below is a sample partial PATHOGENS.RES file:

Variable name	Definition
TITLE	This line is reserved for the pesticide section title. This line is not processed by the model and may be left blank.
HEADER	Headings
NAME	Name of the pathogens reservoir

METALS.RES (NEEDS ADDRESSING)

The METALS.CHA file contains the input variables for the nutrients of a channel. Below is a sample partial METALS.CHA file:

Variable name	Definition
TITLE	This line is reserved for the pesticide section title. This line is not processed by the model and may be left blank.
HEADER	Headings
NAME	Name of the metals reservoir

SALT.RES (NEEDS ADDRESSING)

The SALT.RES file contains the input variables for the nutrients of a channel. Below is a sample partial SALT.RES file:

Variable name	Definition
TITLE	This line is reserved for the pesticide section title. This line is not processed by the model and may be left blank.
HEADER	Headings
NAME	Name of the salt reservoir

SEDIMENT.RES

Reservoirs are impoundments located on the main channel network of the watershed. Reservoirs receive loadings from all upstream subbasins. The reservoir input file (.res) contains input data to simulate water and sediment processes while the lake water quality file (.lwq) contains input data to simulate nutrient and pesticide cycling in the water body. Below is a sample SEDIMENT.RES file:

sediment.res:				
RES_SED_NAME	SED_AMT	RES_D50	SED_STL	STL_VEL
res001	100	20	10	2

Variable name	Definition

TITLE	The first line is reserved for user comments. This line is not processed by the model and may be left blank. Optional.
HEADER	Headers for the sediment.res file.
NAME	The name of the reservoir
NSED	Equilibrium sediment concentration in the reservoir (mg/L). The amount of suspended solid settling that occurs in the water body on a given day is calculated as a function of concentration. Settling occurs only when the sediment concentration in the water body exceeds the equilibrium sediment concentration specified by the user. Required.

D50 Median particle diameter of sediment (μm).

Sediment Class	Size (μm)	Approx. Size
Boulders	> 256,000	> Volley ball
Cobbles	> 64,000	> Tennis ball
Pebbles	> 2,000	> Match Head
Sand		
V. Course	1,500	
Medim	375	
V. Fine	94	
Silt		
V. Coarse	47	
Medium	11.7	No longer visible to the huma
V. Fine	4.9	
Clay	1.95	

SWAT calculates the median sediment particle diameter for impoundments located within a subbasin using the equation:

$$d_{50} = \exp\left(0.41 \cdot \frac{m_c}{100} + 2.71 \cdot \frac{m_{silt}}{100} + 5.7 \cdot \frac{m_s}{100}\right)$$

where d_{50} is the median particle size of the sediment (μm), m_c is percent clay in the surface soil layer, m_{silt} is the percent silt in the surface soil layer, m_s is the percent sand in the surface soil layer.

Because reservoirs are located on the main channel network and receive sediment from the entire area upstream, defaulting the sand, silt, and clay fractions to those of a single subbasin or HRU in the upstream area is not appropriate. Instead the user is allowed to set the median particle size diameter to a representative value.

If no value is defined for the median particle diameter, the model will set RES_D50 = 10 μm.
Required.

SED_STLR Sediment settling rate

VELSETLR Sediment settling velocity

WEIR.RES

Below is a sample WEIR.RES file:

weir.res:						
WEIR_NAME	NUM_STEPS	C	K	W	BCOEF	CCOEF
shape001	24	1	15000	2	1.75	1

Variable name	Definition
TITLE	The first line is reserved for user comments. This line is not processed by the model and may be left blank. Optional.
HEADER	Headers for the weir.res file.
NAME	The name of the reservoir
NUM_STEPS	The number of time steps in day for weir routing
C	Weir discharge coefficient
K	Energy coefficient (broad_crested-147,000' sharp crested=153,000)
W	The width of the weir (m)
BCOEF	Velocity exponent coefficient for bedding material
CCOEF	Depth exponent coefficient for bedding material

WETLAND.WET

Below is a sample WETLAND.WET file:

wetland.wet							
NUMB	NAME	INIT	HYD	RELEASE	SED	NUT	PST
1	wetland1	wetland001	pnd1	null	res001	res001	res001
2	wetland2	wetland001	pnd1	null	res001	res001	res001
3	wetland3	wetland001	pnd1	null	res001	res001	res001
4	wetland4	wetland001	pnd1	null	res001	res001	res001
5	wetland5	wetland001	pnd1	null	res001	res001	res001
6	wetland6	wetland001	pnd1	null	res001	res001	res001

Variable name	Definition
TITLE	The first line is reserved for user comments. This line is not processed by the model and may be left blank. Optional.
HEADER	Headers for the wetland.wet file.
NAME	The name of the wetland
INIT	Initial wetland data
HYD	Hydrology wetland data
RELEASE	0 = simulated; 1 = measured outflow
SED	Sediment wetland data
NUT	Nutrient wetland data
PST	Pesticide wetland data

HYDROLOGY.WET

Below is a sample HYDROLOGY.WET file:

hydrology.wet										
NAME	PSA	PVOL	ESA	EVOL	K	EVRSV	ACOEF	BCOEF	CCOEF	FRAC
pnd1	0.5	12.25125	0.9	14.82401	0.02	0.6	0	0	1	0.5

Variable name	Definition
TITLE	The first line is reserved for user comments. This line is not processed by the model and may be left blank.
	Optional.
HEADER	Headers for the hydrology.wet file.
NAME	The name of the hydrology
PSA	Fraction of hru area at principal spillway (ie: when surface inlet riser flow starts) (frac)
PVOL	Average depth of water at principal spillway (mm)
ESA	Fraction of hru area at emergency spillway (ie: when starts to spill into ditch)
EVOL	Average depth of water at emergency spillway (mm)
K	Hydraulic conductivity of the res bottom (mm/hr)
EVRSV	Lake evap coeff
ACOEF	Vol-surface area coefficient for hru impoundment
BCOEF	Vol-depth coefficient for hru impoundment
CCOEF	Vol-depth coefficient for hru impoundment
FRAC	Fraction of hru that drains into impoundment

ROUTING UNIT

The subbasin general input file contains information related to a diversity of features within the subbasin. Data contained in the subbasin input file can be grouped into the following categories: subbasin size and location, specification of climatic data used within the subbasin, the amount of topographic relief within the subbasin and its impact on the climate, properties of tributary channels within the subbasin, variables related to climate change, the number of HRUs in the subbasin and the names of HRU input files.

ROUT_UNIT.DEF

The rout_unit.def file contains data that defines HRU's in the subbasin.
Below is a sample rout_unit.def file:

rout_unit.def				
RTU_NUMB	TU_NAME	ELEM_TOT	ELEM1	ELEM2
1	sub1	2	1	-21
2	sub2	2	22	-28
3	sub3	2	29	-39
4	sub4	2	40	-42
5	sub5	2	43	-62
6	sub6	2	63	-67
7	sub7	2	68	-87
8	sub8	2	88	-92

Variable name	Definition
TITLE	The title of the rout_unit.def file
HEADER	Headers for the rout_unit.def file.
NUMB	Routing unit number
NAMEDUM	The name of the subbasin
NSPU	Total number of elements to follow
ELEM_CNT1	Starting element
ELEM_CNT2	Ending element

ROUT_UNIT.ELE

Below is a sample ROUT_UNIT.ELE file:

Rout_unit.ele						
NUMB	NAME	OBTYP	OBTYPNO	HTYP	FRAC	IDR
1	hru1	hru	1	tot	0.082	0
2	hru2	hru	2	tot	0.005	0
3	hru3	hru	3	tot	0.478	0
4	hru4	hru	4	tot	0.003	0
5	hru5	hru	5	tot	0.016	0
6	hru6	hru	6	tot	0.011	0

Variable name	Definition
TITLE	The title of the rout_unit.ele file
HEADER	Headers for the rout_unit.ele file.
NUMB	The number of the connect (routing) unit
NAME	The name of the connect (routing) unit

OBTYP	Outflow object type (1=hru;2=hru_lte,3=subbasin;5=aquifer;6=channel; 11=export coefficients; 12=delivery ratios; outlet=15)
OBTYPNO	Number of HRU_LTE's or 1st HRU lte command. Points to the exco_connect.dat object.
HTYP	Hydrograph type (1=tot, 2-surface). Points to del_ratio.dat file.
FRAC	Fraction of element in the subbasin (expansion factor -1.0 = 100%)
IDR	Delivery ratio through the aquifer. The subsurface flow that is delivered through the aquifer. Points to del_ratio.dat file.

ROUT_UNIT.RTU

Below is a sample ROUT_UNIT.RTU file:

rout_unit.rtu					
NUMB	NAME	ELEM_DEF	ELEM_DR	TOPOSUB_DB	FIELD_DB
1	sub1	sub1	null	top1	fld1
2	sub2	sub2	null	top2	fld2
3	sub3	sub3	null	top3	fld3
4	sub4	sub4	null	top4	fld4
5	sub5	sub5	null	top5	fld5
6	sub6	sub6	null	top6	fld6

Variable name	Definition
TITLE	The title of the rout_unit.rtu file
HEADER	Headers for the rout_unit.rtu file.
NUMB	Number of the subbasin
NAME	The name of the parm unit
ELEM_DEF	Points to define.sub
ELEM_DR	Delivery ratio definition
TOPOSUB_DB	Topography link
FIELD_DB	Field database definition (points to field.fld)

ROUT_UNIT.DR

Below is a partial sample ROUT_UNIT.DR file:

Variable name	Definition

TITLE	The title of the rout_unit.dr file
HEADER	Headers for the rout_unit.dr file.
FLO	Volume of water (m^3)
SED	sediment (metric tons)
ORGN	Organic N (kg N)
SEDP	Organic P (kg P)
NO3	NO3-N (kg N)
SOLP	Mineral (soluble P) (kg P)
PSOL	Pesticide in solution (mg pst)
PSOR	Pesticide sorbed to sediment (mg pst)
CHLA	Chlorophyll-a (kg)
NH3	NH3 (kg N)
NO2	NO2 (kg N)
CBOD	Carbonaceous biological oxygen demand (kg)
DOX	Dissolved oxygen (kg)
BACP	Persistent bacteria (# cfu/100ml)
BACLP	Less persistent bacteria (# cfu/100ml)
MET1	Conservative metal #1 (kg)
MET2	Conservative metal #2 (kg)
MET3	Conservative metal #3 (kg)
SAN	Detached sand (tons)
SIL	Detached silt (tons)
CLA	Detached clay (tons)
SAG	Detached small ag (tons)
LAG	Detached large ag (tons)
GRV	gravel (tons)
TEMP	Temperature (deg c)

HRU – HRU's are now defined by weather, topography, soil, landuse, operational management, potholes, subsurface drainage, structural operations, septic systems, plant community, initial soil chemistry, pesticides, bacteria, impoundments, snow and atmospheric deposition. Each HRU points to objects in each of the associated data files. HRU's consist of plants and soils on the landscape and now are not associated with aquifers and ponds and wetlands. HRUs are defined as contiguous areas (ie fields or grid cells) and a delivery from edge-of-field to subbasin outlet is computed in the subbasin module. This is not necessary when landscape units or grid cells are used. Several inputs for each HRU are required in addition to pointing to data files, including drainage area. These variables may be moved to a calibration file.

HRU-DATA.HRU

Below is a sample HRU-DATA.HRU file:

hru-data.h									
NUMB	NAME	TOPO	HYD	SOIL	AND_USE_MGT	OIL_NUTR_INIT	URF_STOR	SNOW	FIELD
1	hru1	top1	hyd1	soil003	lrew_ag04	soilnut001	null	snow001	null
2	hru2	top2	hyd2	soil004	lrew_ag04	soilnut001	null	snow001	null
3	hru3	top3	hyd3	soil005	lrew_ag03	soilnut001	null	snow001	null
4	hru4	top4	hyd4	soil006	lrew_ag01	soilnut001	null	snow001	null
5	hru5	top5	hyd5	soil008	lrew_ag04	soilnut001	null	snow001	null
6	hru6	top6	hyd6	soil009	lrew_ag04	soilnut001	null	snow001	null

Variable name	Definition
TITLE	The first line is reserved for user comments. This line is not processed by the model and may be left blank. Optional.
HEADER	Headers for the hru-data.hru file.
NUMB	HRU Number
NAME	Name of the HRU
TOPO	Topographic data (points to topography.hyd)
HYD	Hydrologic data (points to hydrology.hyd)
SOIL	Soil name (points to soils.sol)
LAND_USE_MGT	Landuse name (points to landuse.lum)
SOIL_NUTR_INIT	Initial soil chemical properties (points to nutrients.sol)
SURF_STOR	Surface storage name
SNOW	Snow name (points to snow.sno)
FIELD	Field name (points to field.fld)

HRU-LTE.HRU

Below is a sample HRU-LTE.HRU file:

hru-lte.hru																															
NUMB	NAME	DAKM2	CN2	CN3_SWF	TC	SOILDEP	PERCO	SLOPE	SLOPELEN	ETCO	SY	ABF	REVAPC	PERCC	SW	GW	GWFLOW	GWDEEP	SNOW	XLAT	TEXT	TROPICAL	IGROW1	IGROW2	IPLANT	STRESS	IPET	IRR	IRRSC	TDRAIN	USLEK	USLEC	USLEP	USLELS
1	BcGully_MainTrib	0.0572	85	0	60	1330	1	0.02	229	1	0.05	0.05	0	0.01	0.5	3	0	300	0	31.5	clay_loam	non_trop	grow_sum	end_sum	berm	1	p_t	no_irr	tside_bsn	0	0.37	0.2	0.6	0.32

Variable name	Definition
TITLE	The first line is reserved for user comments. This line is not processed by the model and may be left blank. Optional.
HEADER	Headers for the hru-lte.hru file.
NUMB	Number
NAME	Name of the SWAT-DEG hru file
DAKM2	Drainage area (km^2)
CN2	Condition II curve number
CN3_SWF	Soil water factor for cn3 (used in calibration) 0 =fc; 1=saturation (porosity)
TC	Time of concentration (min)
SOILDEP	Soil profile depth (mm)
SLOPE	Land surface slope (m/m)

SLOPELEN	Land surface slope length (m)
SY	Specific yld of the shallow aquifer
ABF	Alpha factor groundwater
REVAPC	Revap coefficient-amt of et from shallow aquifer
PERCC	Percolation coeff from shallow to deep
SW	Initial soil water (frac of awc) (fraction)
GW	Initial shallow aquifer storage (mm)
GWFLOW	Initial shallow aquifer flow (mm)
GWDEEP	Initial deep aquifer flow (mm)
SNOW	Initial snow water equivalent (mm)
XLAT	Latitude
TEXT	Soil texture (character): sand; loamy_sand; sandy_loam; loam; silt_loam; silt; silty_clay; clay_loam; sandy_clay_loam; sandy_clay; silty_clay; clay;
TROPICAL	Tropics (character): 'non_trop' = non-tropical 'trop' = tropical
IGROW1	Start of growing season (character – from dtable.dtl file): 'pl_grow_sum' 'pl_end_sum' 'pl_grow_win' 'pl_end_win'
IGROW2	End of growing season 'pl_grow_sum' 'pl_end_sum' 'pl_grow_win' 'pl_end_win'
PLANT	Plant type (as listed in plants.plt)
STRESS	Plant stress – pest, root restriction, soil quality, nutrient, (non water, temp)
IPET	Potential evapotranspiration (PET) method (character): 'harg' = Hargreaves method 'p_t' = Priestley-Taylor method Numerous methods exist to calculate potential evapotranspiration. Three of the most popular or widely-used are included in SWAT. However, if a method other than Priestley-Taylor, Penman/Monteith, or Hargreaves is recommended for the area in which the watershed is located, the user can calculate daily PET values with the recommended method and import them into SWAT. A discussion of Priestley-Taylor, Penman-Monteith and Hargreaves PET methods is found in Chapter 2:2 of the theoretical documentation. Required.

IRR	Irrigation code (character): 'no_irr' = no irrigation 'irr' = irrigation Water applied to an HRU is obtained from one of five types of water sources: a reach, a reservoir, a shallow aquifer, a deep aquifer, or a source outside the watershed. In addition to the type of water source, the model must know the location of the water source (unless the source is outside the watershed). For the reach, shallow aquifer or deep aquifer, SWAT needs to know the subbasin number in which the source is located. If a reservoir is used to supply water, SWAT must know the reservoir number. This variable, along with IRRNO, specifies the source of irrigation water applied in the HRU. Irrigation water may be diverted from anywhere in the watershed or outside the watershed. IRRSC tells the model what type of water body the irrigation water is being diverted from.
IRRSRC	Irrigation source (character): 'outside_bsn' = outside basin 'shal_aqu' = shallow aquifer 'deep_aqu' = deep aquifer Irrigation source location. Water applied to an HRU is obtained from one of five types of water sources: a reach, a reservoir, a shallow aquifer, a deep aquifer, or a source outside the watershed. In addition to the type of water source, the model must know the location of the water source (unless the source is outside the watershed). For the reach, shallow aquifer or deep aquifer, SWAT needs to know the subbasin number in which the source is located. If a reservoir is used to supply water, SWAT must know the reservoir number
TDRAIN	Design subsurface tile drain time (hr)
USLEK	USLE equation soil erodibility (K) factor (units: 0.013 (metric ton m2 hr)/(m3-metric ton cm)). Some soils erode more easily than others even when all other factors are the same. This difference is termed soil erodibility and is caused by the properties of the soil itself. Wischmeier and Smith (1978) define the soil erodibility factor as the soil loss rate per erosion index unit for a specified soil as measured on a unit plot. A unit plot is 22.1-m (72.6-ft) long, with a uniform length-wise slope of

USLEK, cont.

9-percent, in continuous fallow, tilled up and down the slope. Continuous fallow is defined as land that has been tilled and kept free of vegetation for more than 2 years. The units for the USLE soil erodibility factor in MUSLE are numerically equivalent to the traditional English units of 0.01 (ton acre hr)/(acre ft-ton inch).

Wischmeier and Smith (1978) noted that a soil type usually becomes less erodible with decrease in silt fraction, regardless of whether the corresponding increase is in the sand fraction or clay fraction.

Direct measurement of the erodibility factor is time consuming and costly. Wischmeier et al. (1971) developed a general equation to calculate the soil erodibility factor when the silt and very fine sand content makes up less than 70% of the soil particle size distribution.

USLEK, cont.

$$K_{USLE} = \frac{0.00021 \cdot M^{1.14} \cdot (12 - OM) + 3.25 \cdot (c_{soilstr} - 2) + 2.5 \cdot (c_{perm} - 3)}{100}$$

USLEK, cont.

where KUSLE is the soil erodibility factor, M is the particle-size parameter, OM is the percent organic matter (%), csoilstr is the soil structure code used in soil classification, and cperm is the profile permeability class.

The particle-size parameter, M, is calculated

$$M = (m_{silt} + m_{vfs}) \cdot (100 - m_c)$$

where msilt is the percent silt content (0.002-0.05 mm diameter particles), mvfs is the percent very fine sand content (0.05-0.10 mm diameter particles), and mc is the percent clay content (< 0.002 mm diameter particles).
The percent organic matter content, OM, of a layer can be calculated:

$$OM = 1.72 \cdot orgC$$

where orgC is the percent organic carbon content of the layer (%).

USLEK, cont.

Soil structure refers to the aggregation of primary soil particles into compound particles which are separated from adjoining aggregates by surfaces of weakness. An individual natural soil aggregate is called a ped. Field description of soil structure notes the shape and arrangement of peds, the size of peds, and the distinctness and durability of visible peds. USDA Soil Survey terminology for structure consists of separate sets of terms defining each of these three qualities. Shape and arrangement of peds are designated as type of soil structure; size of peds as class; and degree of distinctness as grade.

Angular Blocky: bounded by planes intersecting at relatively sharp angles

Subangular Blocky: having mixed rounded and plane faces with vertices mostly rounded

The soil-structure codes for the equation are defined by the type and class of soil structure present in the layer. There are four primary types of structure, several of which are further broken down into subtypes:

-Platy, with particles arranged around a plane, generally horizontal

-Prismlike, with particles arranged around a verticle line and bounded by relatively flat vertical surfaces

Prismatic: without rounded upper ends

Columnar: with rounded caps

-Blocklike or polyhedral, with particles arranged around a point and bounded by flat or rounded surfaces which are casts of the molds formed by the faces of surrounding peds

-Spheroidal or polyhedral, with particles arranged around a point and bounded by curved or very irregular surfaces that are not accomodated to the adjoining aggregates

Granular: relatively non-porous

Crumb: very porous

The size criteria for the class will vary by type of structure and are summarized in Table 22-2.

USLEK, cont.

Definition

Table 22-2: Size classes of soil structure

	Shape of structure			
Size Classes	**Platy**	**Prismatic and Columnar**	**Blocky**	**Granular**
Very fine	< 1 mm	< 10 mm	< 5 mm	< 1 mm
Fine	1-2 mm	10-20 mm	5-10 mm	1-2 mm
Medium	2-5 mm	20-50 mm	10-20 mm	2-5 mm
Coarse	5-10 mm	50-100 mm	20-50 mm	5-10 mm
Very coarse	> 10 mm	> 100 mm	> 50 mm	> 10 mm

USLEK, cont.

The codes assigned to $c_{soilstr}$ are:

1 very fine granular
2 fine granular
3 medium or coarse granular
4 blocky, platy, prismlike or massive

Permeability is defined as the capacity of the soil to transmit water and air through the most restricted horizon (layer) when moist. The profile permeability classes are based on the lowest saturated hydraulic conductivity in the profile. The codes assigned to c_{perm} are:

1 rapid (> 150 mm/hr)
2 moderate to rapid (50-150 mm/hr)
3 moderate (15-50 mm/hr)
4 slow to moderate (5-15 mm/hr)
5 slow (1-5 mm/hr)
6 very slow (< 1 mm/hr)

Williams (1995) proposed an alternative equation:

$$K_{USLE} = f_{csand} \cdot f_{cl-si} \cdot f_{orgc} \cdot f_{hisand}$$

where f_{csand} is a factor that gives low soil erodibility factors for soils with high coarse-sand contents and high values for soils with little sand, $f_{cl\text{-}si}$ is a factor that gives low soil erodibility factors for soils with high clay to silt ratios, f_{orgc} is a factor that reduces soil erodibility for soils with high organic carbon content, and f_{hisand} is a factor that reduces soil erodibility for soils with extremely high sand contents. The factors are calculated:

$$f_{csand} = \left(0.2 + 0.3 \cdot \exp\left[-0.256 \cdot m_s \cdot \left(1 - \frac{m_{silt}}{100}\right)\right]\right)$$

USLEK, cont.

$$f_{cl-si} = \left(\frac{m_{silt}}{m_c + m_{silt}}\right)^{0.3}$$

USLEK, cont.

$$f_{orgc} = \left(1 - \frac{0.0256 \cdot orgC}{orgC + \exp\left[3.72 - 2.95 \cdot or\right.}\right.$$

$$f_{hisand} = \left(1 - \frac{0.7 \cdot \left(1 - \frac{1}{1}\right.}{\left(1 - \frac{m_s}{100}\right) + \exp\left[-5.51 +\right.}\right.$$

where m_s is the percent sand content (0.05-2.00 mm diameter particles), m_{silt} is the percent silt content (0.002-0.05 mm diameter particles), m_c is the percent clay content (< 0.002 mm diameter particles), and *orgC* is the percent organic carbon content of the layer (%).

Required.

USLEC — USLE cover factor

USLEP — USLE equation support practice factor.

The support practice factor, P_{USLE}, is defined as the ratio of soil loss with a specific support practice to the corresponding loss with up-and-down slope culture. Support practices include contour tillage, stripcropping on the contour, and terrace systems. Stabilized waterways for the disposal of excess rainfall are a necessary part of each of these practices.

Contour tillage and planting provides almost complete protection against erosion from storms of low to moderate intensity, but little or no protection against occasional severe storms that cause extensive breakovers of contoured rows. Contouring is most effective on slopes of 3 to 8 percent. Values for P_{USLE} and slope-length limits for contour support practices are given in Table 20-4.

USLEP, cont.

Table 20-4: P factor values and slope-length limits for contouring (Wischmeier and Smith, 1978).

Land slope (%)	P_{USLE}
1 to 2	0.60
3 to 5	0.50
6 to 8	0.50
9 to 12	0.60
13 to 16	0.70
17 to 20	0.80
21 to 25	0.90

Stripcropping is a practice in which contoured strips of sod are alternated with equal-width strips of row crop or small grain. Recommended values for contour stripcropping are given in Table 20-5.

USLEP, cont.

Table 20-5: P factor values, maximum strip width and slope-length limits for contour stripcropping (Wischmeier and Smith, 1978).

Land slope	P_{USLE} values[1]			S
(%)	A	B	C	
1 to 2	0.30	0.45	0.60	
3 to 5	0.25	0.38	0.50	
6 to 8	0.25	0.38	0.50	
9 to 12	0.30	0.45	0.60	
13 to 16	0.35	0.52	0.70	
17 to 20	0.40	0.60	0.80	
21 to 25	0.45	0.68	0.90	

[1]P values:

A: For 4-year rotation of row crop, small grain with meadow seeding, and 2 years of meadow. A second row crop can replace the small grain if meadow is established in it.

B: For 4-year rotation of 2 years row crop, winter grain with meadow seeding, and 1-year meadow.

C: For alternate strips of row crop and winter grain

USLEP, cont.

Terraces are a series of horizontal ridges made in a hillside. There are several types of terraces. Broadbase terraces are constructed on gently sloping land and the channel and ridge are cropped the same as the interterrace area. The steep backslope terrace, where the backslope is in sod, is most common on steeper land. Impoundment terraces are terraces with underground outlets.

USLEP, cont.

Terraces divide the slope of the hill into segments equal to the horizontal terrace interval. With terracing, the slope length is the terrace interval. For broadbase terraces, the horizontal terrace interval is the distance from the center of the ridge to the center of the channel for the terrace below. The horizontal terrace interval for steep backslope terraces is the distance from the point where cultivation begins at the base of the ridge to the base of the frontslope of the terrace below.

Values for P_{USLE} for contour farming terraced fields are listed in Table 20-6. These values apply to broadbase, steep backslope and level terraces. Keep in mind that the values given in Table 20-6 do not account for all erosion control benefits of terraces. The shorter slope-length used in the calculation of the length-slope factor will produce additional reduction.

Required.

USLEP, cont.

Table 20-6: P factor values for contour-farmed terraced fields[1]

Land slope (%)	Farm planning		Con
	Contour P factor[2]	Stripcrop P factor	Grad chan sod ou
1 to 2	0.60	0.30	0.1
3 to 8	0.50	0.25	0.1
9 to 12	0.60	0.30	0.1
13 to 16	0.70	0.35	0.1
17 to 20	0.80	0.40	0.1
21 to 25	0.90	0.45	0.1

[1]Slope length is the horizontal terrace interval. The listed values are for contour farming. No additional contouring factor is used in the computation.

[2] Use these values for control of interterrace erosion within specified soil loss tolerances.

[3] These values include entrapment efficiency and are used for control of offsite sediment within limits and for estimating the field's contribution to watershed sediment yield.

USLELS USLE equation length slope (LS) factor

EXCO – Export Coefficient

EXCO.EXC

The EXCO.EXC file contains the input variables for the nutrients of a channel. Below is a sample EXCO.EXC file:

exco.exc					
NAME	OM	PEST	PATH	HMET	SALT
exco1	exco_om1	exco_pest1	exco_path1	exco_hmet1	exco_salt1
exco2	exco_om2	exco_pest2	exco_path2	exco_hmet2	exco_salt2

Variable name	Definition

TITLE	The title of the exco.exc file
HEADER	Headers for the exco.exc file
NAME	Name of the export coefficient (in exco.con file)
OM_NAME	Name of the organic matter (in exco_om.exc file)
PEST_NAME	Name of the pesticides (in exco_pest.exc file)
PATH_NAME	Name of the pathogens (in exco_path.exc file)
SALT_NAME	Name of the salt (in exco_salt.exc file)

EXCO_OM_EXC

The EXCO_OM_EXC file contains the input variables for the nutrients of a channel. Below is a sample EXCO_OM.EXC file:

exco_om.exc																									
	flo	sed	orgn	sedp	no3	solp	psol	psor	chla	nh3	no2	cbod	dox	bacp	bacpl	met1	met2	met3	san	sil	cla	sag	lag	grv	temp
exco_om1	12.5	100	90	80	70	60	50	40	30	20	10	9	8	7	6	5	4	3	2	1	100	90	80	70	60
exco_om2	22.5	110	99	88	77	66	55	44	33	22	11	19	28	37	46	55	64	73	82	91	190	98	87	76	65

Variable name	Definition
TITLE	The title of the exco_om.exc file
HEADER	Headers for the exco_om.exc file
NAME	Name of the organic matter (exco.exc file)

FLO	Volume of water (m^3)
SED	sediment (metric tons)
ORGN	Organic N (kg N)
SEDP	Organic P (kg P)
NO3	NO3-N (kg N)
SOLP	Mineral (soluble P) (kg P)
PSOL	Pesticide in solution (mg pst)
PSOR	Pesticide sorbed to sediment (mg pst)
CHLA	Chlorophyll-a (kg)
NH3	NH3 (kg N)
NO2	NO2 (kg N)
CBOD	Carbonaceous biological oxygen demand (kg)
DOX	Dissolved oxygen (kg)
BACP	Persistent bacteria (# cfu/100ml)
BACPL	Less persistent bacteria (# cfu/100ml)
MET1	Conservative metal #1 (kg)
MET2	Conservative metal #2 (kg)
MET3	Conservative metal #3 (kg)
SAN	Detached sand (tons)
SIL	Detached silt (tons)
CLA	Detached clay (tons)
SAG	Detached small ag (tons)
LAG	Detached large ag (tons)
GRV	gravel (tons)
TEMP	Temperature (deg c)

EXCO_PEST.EXC

exco_pest.exc								
	aatrex_sol	aatrex_sor	banvel_sol	banvel_sor	prowl_sol	prowl_sor	roundup_sol	roundup_sor
exco_pest1	12.5	100	90	80	70	60	50	40
exco_pest2	22.5	110	99	88	77	66	55	44

The EXCO_PEST.EXC file contains the input variables for the nutrients of a channel. Below is a sample EXCO_PEST.EXC file:

Variable name	Definition
TITLE	The title of the exco_pest.exc file
HEADER	Headers for the exco_pest.exc file
NAME	Name of the pesticide (exco.exc file)
EXCO_PEST_SOL	Pesticide soluble constituent mass
EXCO_PEST_SOR	Pesticide sorbed constituent mass

EXCO_PATH.EXC

The EXCO_PATH.EXC file contains the input variables for the nutrients of a channel. Below is a sample EXCO_PATH.EXC file:

exco_path.exc				
	fecals_sol	fecals_sor	e_coli_sol	e_coli_sor
exco_path1	12.5	100	90	80
exco_path2	22.5	110	99	88

Variable name	Definition
TITLE	The title of the exco_path.exc file
HEADER	Headers for the exco_path.exc file
NAME	Name of the pathogens (exco.exc file)
EXCO_PATH_SOL	Pathogen soluble constituent mass
EXCO_PATH_SOR	Pathogen sorbed constituent mass

EXCO_HMET.EXC

The EXCO_HMET.EXC file contains the input variables for the nutrients of a channel. Below is a sample EXCO_HMET.EXC file:

exco_hmet.exc		
	mercury_sol	mercury_sor
exco_hmet1	12.5	100
exco_hmet2	22.5	110

Variable name	Definition
TITLE	The title of the exco_hmet.exc file
HEADER	Headers for the exco_hmet.exc file
NAME	Name of the heavy metals (exco.exc file)
EXCO_HMET_SOL	Heavy metal soluble constituent mass
EXCO_HMET_SOL	Heavy metal sorbed constituent mass

EXCO_SALT.EXC

The EXCO_SALT.EXC file contains the input variables for the nutrients of a channel. Below is a sample EXCO_SALT.EXC file:

exco_salt.exc				
	sodium_sol	sodium_sor	magnesium_sol	magnesium_sor
exco_salt1	12.5	100	90	80
exco_salt2	22.5	110	99	88

Variable name	Definition
TITLE	The title of the exco_salt.exc file
HEADER	Headers for the exco_salt.exc file
NAME	Name of salt (exco.exc file)
EXCO_HMET_SOL	Salt soluble constituent mass
EXCO_HMET_SOL	Salt sorbed constituent mass

RECALL

RECALL.REC

The RECALL.REC file contains the input variables for the nutrients of a channel. Below is a sample RECALL.REC file:

recall.rec			
NUMB	NAME	TYP	FILENAME
1	daily	1	recall_day.rec

Variable name	Definition
TITLE	This line is reserved for the recall record title. This line is not processed by the model and may be left blank.
HEADER	Headers
NUMB	Sequential number of recall
NAME	Daily, monthly, annual
TYP	1==daily; 2=monthly; 3=annual;
FILENAME	Name of recall file to be read

EXAMPLE RECALL_DAY.REC FILE:

recall_day.rec																												
11																												
IYR	ISTEP	flo	sed	orgn	sedp	no3	solp	psol	psor	chla	nh3	C	no2	cbod	dox	bacp	bacpl	met1	met2	met3	san	sil	cla	sag	lag	grv	temp	
2006	1	10167.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	2	10059.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	3	9233.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	4	7760.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Variable name	Definition
TITLE	This line is reserved for the recall daily, monthly or annual title. This line is not processed by the model and may be left blank.
NBYR	Number of years of recall data
IYR	Current year of input data
ISTEP	Current day of input data

Variable name	Definition
FLO	Volume of water (m^3)
SED	sediment (metric tons)
ORGN	Organic N (kg N)
SEDP	Organic P (kg P)
NO3	NO3-N (kg N)
SOLP	Mineral (soluble P) (kg P)
PSOL	Pesticide in solution (mg pst)
PSOR	Pesticide sorbed to sediment (mg pst)
CHLA	Chlorophyll-a (kg)
NH3	NH3 (kg N)
NO2	NO2 (kg N)
CBOD	Carbonaceous biological oxygen demand (kg)
DOX	Dissolved oxygen (kg)
BACP	Persistent bacteria (# cfu/100ml)
BACLP	Less persistent bacteria (# cfu/100ml)
MET1	Conservative metal #1 (kg)
MET2	Conservative metal #2 (kg)
MET3	Conservative metal #3 (kg)
SAN	Detached sand (tons)
SIL	Detached silt (tons)
CLA	Detached clay (tons)
SAG	Detached small ag (tons)
LAG	Detached large ag (tons)
GRV	gravel (tons)
TEMP	Temperature (deg c)

DR –Delivery Ratio

DELRATIO.DEL

The DELRATIO.DEL file contains the input variables for the nutrients of a channel. Below is a sample DELRATIO.DEL file:

delratio.del					
NAME	OM_FILE	PEST_FILE	PATH_FILE	HMET_FILE	SALTS_FILE
dr01	dr_om.del	dr_pest.del	dr_path.del	dr_hmet.del	dr_salt.del

Variable name	Definition
TITLE	The title of the delratio.del file
HEADER	Headers for the delratio.del file
NAME	Name of the export coefficient (in delratio.con file)
OM_NAME	Name of the organic matter (in dr_om.del file)
PEST_NAME	Name of the pesticides (in dr_pest.del file)
PATH_NAME	Name of the pathogens (in dr_path.del file)
SALT_NAME	Name of the salt (in dr_salt.del file)

DR_OM.DEL

The DR_OM.DEL file contains the input variables for the nutrients of a channel. Below is a sample DR_OM.DEL file:

dr_om.del																										
	flo	sed	orgn	sedp	no3	solp	psol	psor	chla	nh3	no2	cbod	dox	bacp	bacpl	met1	met2	met3	san	sil	cla	sag	lag	grv	temp	C
dr_om1	0.125	0.1	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0.1	0.9	0.8	0.7	0.6	0.5
dr_om2	0.225	0.11	0.99	0.88	0.77	0.66	0.55	0.44	0.33	0.22	0.11	0.19	0.28	0.37	0.46	0.55	0.64	0.73	0.82	0.91	0.19	0.98	0.87	0.76	0.65	0.54

Variable name	Definition
TITLE	The title of the dr_om.del file
HEADER	Headers for the dr_om.del file
NAME	Name of the organic matter (delratio.del file)

FLO	Volume of water (m^3)
SED	sediment (metric tons)
ORGN	Organic N (kg N)
SEDP	Organic P (kg P)
NO3	NO3-N (kg N)
SOLP	Mineral (soluble P) (kg P)
PSOL	Pesticide in solution (mg pst)
PSOR	Pesticide sorbed to sediment (mg pst)
CHLA	Chlorophyll-a (kg)
NH3	NH3 (kg N)
NO2	NO2 (kg N)
CBOD	Carbonaceous biological oxygen demand (kg)
DOX	Dissolved oxygen (kg)
BACP	Persistent bacteria (# cfu/100ml)
BACPL	Less persistent bacteria (# cfu/100ml)
MET1	Conservative metal #1 (kg)
MET2	Conservative metal #2 (kg)
MET3	Conservative metal #3 (kg)
SAN	Detached sand (tons)
SIL	Detached silt (tons)
CLA	Detached clay (tons)
SAG	Detached small ag (tons)
LAG	Detached large ag (tons)
GRV	gravel (tons)
TEMP	Temperature (deg c)

DR_PEST.DEL

The DR_PEST.DEL file contains the input variables for the nutrients of a channel. Below is a sample DR_PEST.DEL file:

dr_pest.del								
	aatrex_sol	aatrex_sor	banvel_sol	banvel_sor	prowl_sol	prowl_sor	roundup_sol	roundup_sor
dr_pest1	0.125	0.1	0.9	0.8	0.7	0.6	0.5	0.4
dr_pest2	0.225	0.11	0.99	0.88	0.77	0.66	0.55	0.44

The DR_PEST.DEL file contains the input variables for the nutrients of a channel. Below is a sample partial DR_PEST_DEL file:

Variable name	Definition
TITLE	The title of the DR_PEST.DEL file
HEADER	Headers for the DR_PEST.DEL file
NAME	Name of the pesticide
DR_PEST_SOL	Pesticide soluble constituent mass
DR_PEST_SOR	Pesticide sorbed constituent mass

DR_PATH.DEL

The DR_PATH.DEL file contains the input variables for the nutrients of a channel. Below is a sample DR_PATH.DEL file:

dr_path.del				
	fecals_sol	fecals_sor	e_coli_sol	e_coli_sor
dr_path1	0.125	0.1	0.9	0.8
dr_path2	0.225	0.11	0.99	0.88

Variable name	Definition
TITLE	The title of the dr_path.del file
HEADER	Headers for the dr_path.del file
NAME	Name of the pathogens (delratio.del file)
DR_PATH_SOL	Pathogen soluble constituent mass
DR_PATH_SOR	Pathogen sorbed constituent mass

DR_HMET.DEL

The DR_HMET.DEL file contains the input variables for the nutrients of a channel. Below is a sample DR_HMET.DEL file:

dr_hmet.del		
	mercury_sol	mercury_sor
dr_hmet1	0.125	0.1
dr_hmet2	0.225	0.11

Variable name	Definition
TITLE	The title of the dr_hmet.exc file
HEADER	Headers for the dr_hmet.exc file
NAME	Name of the heavy metals (delratio.del file)
DR_HMET_SOL	Heavy metal soluble constituent mass
DR_HMET_SOL	Heavy metal sorbed constituent mass

DR_SALT.DEL

The DR_SALT.DEL file contains the input variables for the nutrients of a channel. Below is a sample EXCO_DR_SALT.DEL file:

dr_salt.del				
	sodium_sol	sodium_sor	magnesium_sol	magnesium_sor
dr_salt1	0.125	0.1	0.9	0.8
dr_salt2	0.225	0.11	0.99	0.88

Variable name	Definition
TITLE	The title of the dr_salt.del file
HEADER	Headers for the dr_salt.del file
NAME	Name of salt (delratio.del file)
DR_HMET_SOL	Salt soluble constituent mass
DR_HMET_SOL	Salt sorbed constituent mass

AQUIFER –

AQUIFER.AQU

Below is a sample AQUIFER.AQU file:

aquifer.aqu:																
NUMB	AQUNM	FLO	STOR	HGT	NO3	MINP	ORGN	ORGP	DELAY	ALPHA	REVAP	SEEP	SPYLD	HLIFE_N	FLO_MIN	REVAP_MIN
1	aqu1	2500	1000	1	0	0	0	0	31	0.048	0.02	0.05	0.003	0	1000	750
2	aqu2	2500	1000	1	0	0	0	0	31	0.048	0.02	0.05	0.003	0	1000	750
3	aqu3	2500	1000	1	0	0	0	0	31	0.048	0.02	0.05	0.003	0	1000	750
4	aqu4	2500	1000	1	0	0	0	0	31	0.048	0.02	0.05	0.003	0	1000	750
5	aqu5	2500	1000	1	0	0	0	0	31	0.048	0.02	0.05	0.003	0	1000	750
6	aqu6	2500	1000	1	0	0	0	0	31	0.048	0.02	0.05	0.003	0	1000	750

Variable name	Definition
TITLE	The first line is reserved for user comments. This line is not processed by the model and may be left blank. Optional.
HEADER	Headings for the aquifer.aqu file.
NUMB	Number

AQUNM	Name
FLO	Initial depth of water in the shallow aquifer (mm H_2O). We recommend using a 1 year equilibration period for the model where the watershed simulation is set to start 1 year prior to the period of interest. This allows the model to get the water cycling properly before any comparisons between measured and simulated data are made. When an equilibration period is incorporated, the value for FLO is not that important.
STOR	Initial depth of water in the deep aquifer (mm H_2O). We recommend using a 1 year equilibration period for the model where the watershed simulation is set to start 1 year prior to the period of interest. This allows the model to get the water cycling properly before any comparisons between measured and simulated data are made. When an equilibration period is incorporated, the value for STOR is not that important. In watersheds where there is no irrigation with water from the deep aquifer, this variable has no impact at all. If no value for STOR is entered, the model sets STOR = 1000.0 mm.
HGT	Initial groundwater height (m). Steady-state groundwater flow and the height of the water table are linearly proportional. The equations used to calculate the change in groundwater height with change in flow are included in SWAT. However, the groundwater height is not currently printed out in any of the output files. *This variable is not active.*
NO3	Initial concentration of nitrate in shallow aquifer. (mg N/L or ppm). Nitrate levels in the shallow aquifer are modeled, allowing for variation in nitrate concentration and groundwater loadings of nitrate contributed to streamflow in the subbasin. Optional.
MINP	Concentration of soluble phosphorus in groundwater contribution to streamflow from subbasin (mg P/L or ppm). This is a fixed concentration used throughout the entire period of simulation. Optional.
ORGN	Organic N in the base flow (mg/L) (range 0.0 – 200.0) default = 0.0 Optional.
ORGP	Organic P in the base flow (mg/L) (range 0.0 – 200.0) default = 0.0 Optional.

DELAY

The delay time, δ_{gw}, cannot be directly measured. It can be estimated by simulating aquifer recharge using different values for δ_{gw} and comparing the simulated variations in water table level with observed values. Johnson (1977) developed a simple program to iteratively test and statistically evaluate different delay times for a watershed. Sangrey et al. (1984) noted that monitoring wells in the same area had similar values for δ_{gw}, so once a delay time value for a geomorphic area is defined, similar delay times can be used in adjoining watersheds within the same geomorphic province.
Required.

ALPHA

Baseflow alpha factor (1/days).

The baseflow recession constant, α_{gw}, is a direct index of groundwater flow response to changes in recharge (Smedema and Rycroft, 1983). Values vary from 0.1-0.3 for land with slow response to recharge to 0.9-1.0 for land with a rapid response. Although the baseflow recession constant may be calculated, the best estimates are obtained by analyzing measured streamflow during periods of no recharge in the watershed.

It is common to find the baseflow days reported for a stream gage or watershed. This is the number of days for base flow recession to decline through one log cycle. When baseflow days are known, the alpha factor can be calculated:

$$\alpha_{gw} = \frac{1}{N} \cdot \ln\left[\frac{Q_{gw,N}}{Q_{gw,0}}\right] = \frac{1}{BFD} \cdot \ln[10] = \frac{2.3}{BFD}$$

where α_{gw} is the baseflow recession constant, and *BFD* is the number of baseflow days for the watershed.
Required.

REVAP

Groundwater "revap" coefficient.

Water may move from the shallow aquifer into the overlying unsaturated zone. In periods when the material overlying the aquifer is dry, water in the capillary fringe that separates the saturated and unsaturated zones will evaporate and diffuse upward. As water is removed from the capillary fringe by evaporation, it is replaced by water from the underlying aquifer. Water may also be removed from the aquifer by deep-rooted plants which are able to uptake water directly from the aquifer.
This process is significant in watersheds where the saturated zone is not very far below the surface or where deep-rooted plants are growing. Because the type of plant cover will affect the importance of revap in the water balance, the parameters governing revap can be varied by land use.

As REVAP approaches 0, movement of water from the shallow aquifer to the root zone is restricted. As REVAP approaches 1, the rate of transfer from the shallow aquifer to the root zone approaches the rate of potential evapotranspiration. The value for REVAP should be between 0.02 and 0.20.

This variable, along with REVAPMN, is the reason a different groundwater file is created for each HRU rather than each subbasin.
Required.

SEEP

Deep aquifer percolation fraction.

The fraction of percolation from the root zone which recharges the deep aquifer. The value for RCHRG_DP should be between 0.0 and 1.0.
Required.

SPYLD

Specific yield of the shallow aquifer (m^3/m^3).
Specific yield is defined as the ratio of the volume of water that drains by gravity

to the total volume of rock.

Specific yield is required to calculate groundwater height fluctuations.
This variable is not active

HLIFE_N	Half-life of nitrate in the shallow aquifer (days). Nitrate in the shallow aquifer may be removed by uptake by bacteria present in the aquifer or by chemical conversion to other compounds in regions of the aquifer that are depleted in oxygen (reduced environment). The half-life, as for half-life values reported for pesticides, is the time period required for the concentration of nitrate to drop to one-half its original value. The reduction is a net reduction by all processes occurring in the shallow aquifer. Optional.
FLO_MIN	Minimum aquifer storage to allow return flow [m]
REVAP_MIN	Threshold depth of water in the shallow aquifer for "revap" or percolation to the deep aquifer to occur (mm H_2O). Movement of water from the shallow aquifer to the unsaturated zone is allowed only if the volume of water in the shallow aquifer is equal to or greater than REVAPMN. This variable, along with GW_REVAP, is the reason a different groundwater file is created for each HRU rather than each subbasin. Required.

HERD – (not currently active)

ANIMAL.HRD

HERD.HRD

RANCH.HRD

WATER_RIGHTS – (not currently active)

DEFINE.WRO

ELEMENT.WRO

WATER_RIGHTS.WRO

LINK –

CHAN-SURF.LIN

Below is a sample CHAN_SURF.LIN FILE:

chan-surf.l							
1							
NUMB	NAME	NSPU	OBTYP	OBTYP_NO	OBTYP	OBTYP_NO	
1	chan1	1	hru	1			
2	chan2	1	sub	1			
8	chan3	2	sub	3	sub	4	
9	chan4	2	hru	5	hru	6	

Variable name	Definition
TITLE	The title line for the chan-surf.lin file (optional)
MCHA_SP	Total number of channel links in file
HEADER	Headings for the chan-surf.lin file
NUMB	The sequential number of the channel links
NAME	The unique name of the channel link
NUM	The total objects following
OBTYP	The object type (1=hru; 2=hru_lte; 11=export coeff;
OBTYPNO	Number of hru_lte's or 1st hru_lte command

CHAN-AQU.LIN

Below is a sample CHAN-AQU.LIN FILE:

chan-aqu.lin					
4					
NUMB	NAME	NSPU	AQU1	AQU2	AQU3
1	chan1	3	1	2	3
2	chan2	1	4		
8	chan3	2	5	6	
9	chan4	2	8	9	

Variable name	Definition
TITLE	The title line for the chan-aqu.lin file (may be blank)
MCHA_SP	Total number of channel aquifer links in file
HEADER	Headings
NUMB	The sequential number of the channel aquifer links
NAME	The unique name of the channel link
NSPU	The total objects following
AQU_NO	The aquifer number

HYDROLOGY –

HYDROLOGY.HYD

Data contained in the hydrology.dat data file can be grouped into the following categories: topographic characteristics, water flow, erosion, land cover, and depressional storage areas.

Below is a partial sample HYDROLOGY.HYD FILE:

hydrology.hyd															
NAME	LAT_TIME	LAT_SED	CANMX	ESCO	EPCO	ERORGN	ERORGP	CN3_SWF	BIOMIX	DEP_IMP	AT_ORGN	LAT_ORG	HARG_PET	CNCOEF	PERCO
HRU0010104	0	0	0	0.95	1	0	0	0	0.2	5000	0	0	0.0023	0.3	1
HRU0010105	0	0	0	0.95	1	0	0	0	0.2	5000	0	0	0.0023	0.3	1
HRU0010108	0	0	0	0.95	1	0	0	0	0.2	5000	0	0	0.0023	0.3	1
HRU0010109	0	0	0	0.95	1	0	0	0.5	0.2	5000	0	0	0.0023	0.3	1
HRU0010110	0	0	0	0.95	1	0	0	0.5	0.2	5000	0	0	0.0023	0.3	1

Variable name	Definition
NAME	Name
TITLE	The first line is reserved for user comments. This line is not processed by the model and may be left blank. Optional.
HEADER	Headers for the nutrients.res file.
NAME	Name
LAT_TTIME	Lateral flow travel time (days). Setting LAT_TTIME = 0.0 will allow the model to calculate the travel time based on soil hydraulic properties. This variable should be set to a specific value only by hydrologists familiar with the base flow characteristics of the watershed. Required.
LAT_SED	Sediment concentration in lateral and groundwater flow (mg/L). Sediment concentration in lateral and groundwater flow is usually very low and does not contribute significantly to total sediment yields unless return flow is very high. Optional.

CANMX

Maximum canopy storage (mm H_2O).
The plant canopy can significantly affect infiltration, surface runoff and evapotranspiration. As rain falls, canopy interception reduces the erosive energy of droplets and traps a portion of the rainfall within the canopy. The influence the canopy exerts on these processes is a function of the density of plant cover and the morphology of the plant species.

When calculating surface runoff, the SCS curve number method lumps canopy interception in the term for initial abstractions. This variable also includes surface storage and infiltration prior to runoff and is estimated as 20% of the retention parameter value for a given day (see Chapter 2:1). When the Green and Ampt infiltration equation is used to calculate infiltration, the interception of rainfall by the canopy must be calculated separately.

SWAT allows the maximum amount of water that can be held in canopy storage to vary from day to day as a function of the leaf area index. CANMX is the maximum amount of water that can be trapped in the canopy when the canopy is fully developed (mm H_2O).
Required.

ESCO

Soil evaporation compensation factor.

This coefficient has been incorporated to allow the user to modify the depth distribution used to meet the soil evaporative demand to account for the effect of capillary action, crusting and cracks. ESCO must be between 0.01 and 1.0. As the value for ESCO is reduced, the model is able to extract more of the evaporative demand from lower levels.

The change in depth distribution resulting from different values of *esco* are graphed in Figure 19-1.

If no value for ESCO is entered, the model will set ESCO = 0.95. The value for ESCO may be set at the watershed or HRU level (ESCO in .bsn, see Chapter 4).

Required.

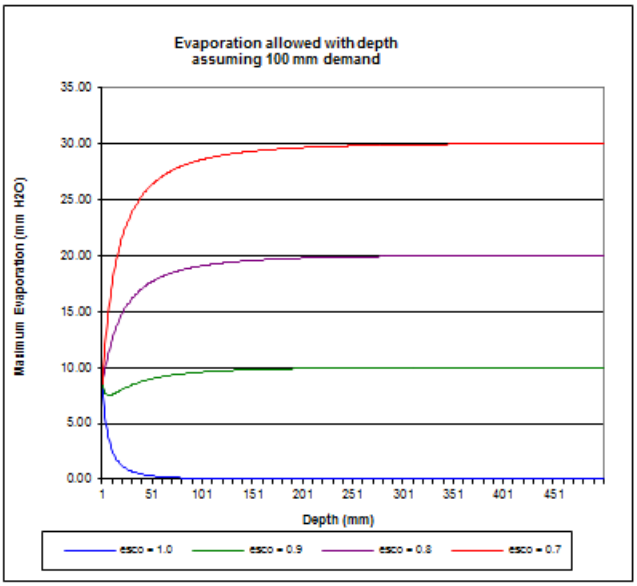


Figure 19-1: Soil evaporative demand distribution with depth

EPCO

Plant uptake compensation factor.

The amount of water uptake that occurs on a given day is a function of the amount of water required by the plant for transpiration, E_t, and the amount of water available in the soil, *SW*. If upper layers in the soil profile do not contain enough water to meet the potential water uptake, users may allow lower layers to compensate. The plant uptake compensation factor can range from 0.01 to 1.00. As *epco* approaches 1.0, the model allows more of the water uptake demand to be met by lower layers in the soil. As *epco* approaches 0.0, the model allows less variation from the original depth distribution to take place.

If no value for EPCO is entered, the model will set EPCO = 1.0. The value for EPCO may be set at the watershed or HRU level (EPCO in .bsn, see Chapter 4).

Required.

ERORGN

Organic N enrichment ratio for loading with sediment.

As surface runoff flows over the soil surface, part of the water's energy is used to pick up and transport soil particles. The smaller particles weigh less and are more easily transported than coarser particles. When the particle size distribution of the transported sediment is compared to that of the soil surface layer, the sediment load to the main channel has a greater proportion of clay sized particles. In other words, the sediment load is enriched in clay particles. Organic nitrogen in the soil is attached primarily to colloidal (clay) particles, so the sediment load will also contain a greater proportion or concentration of organic N than that found in the soil surface layer.

The enrichment ratio is defined as the ratio of the concentration of organic nitrogen transported with the sediment to the concentration in the soil surface layer. SWAT will calculate an enrichment ratio for each storm event, or allow the user to define a particular enrichment ratio for organic nitrogen that is used for all storms during the simulation. To calculate the enrichment ratio, the value for ERORGN is set to zero. The default option is to allow the model to calculate the enrichment ratio.

Required.

ERORGP	Phosphorus enrichment ratio for loading with sediment. The enrichment ratio is defined as the ratio of the concentration of phosphorus transported with the sediment to the concentration of phosphorus in the soil surface layer. SWAT will calculate an enrichment ratio for each storm event, or allow the user to define a particular enrichment ratio for phosphorus attached to sediment that is used for all storms during the simulation. If the value for ERORGP is set to zero, the model will calculate an enrichment ratio for every storm event. The default option is to allow the model to calculate the enrichment ratio. Required.
CN3_SWF	Pothole evaporation coefficient
BIOMIX	Biological mixing efficiency. Biological mixing is the redistribution of soil constituents as a result of the activity of biota in the soil (e.g. earthworms, etc.). Studies have shown that biological mixing can be significant in systems where the soil is only infrequently disturbed. In general, as a management system shifts from conventional tillage to conservation tillage to no-till there will be an increase in biological mixing. SWAT allows biological mixing to occur to a depth of 300 mm (or the bottom of the soil profile if it is shallower than 300 mm). The efficiency of biological mixing is defined by the user and is conceptually the same as the mixing efficiency of a tillage implement. The redistribution of nutrients by biological mixing is calculated using the same methodology as that used for a tillage operation. Biological mixing is performed at the end of every calendar year. If no value for BIOMIX is entered, the model will set BIOMIX = 0.20. Optional.
DEP_IMP	Depth to the bottom of soil profile (mm). default = 5000. Perched water tables are created when water percolating through the soil profile reaches a layer of low hydraulic conductivity that causes water to pond at the upper boundary of the impervous layer. This variable defines the depth to the impervious layer in the soil profile and is required if perched water tables, depressional storage areas/potholes, or tile drainage is being modeled in the HRU (or subbasin for depressional storage areas). If perched water tables do not occur in the HRU leave this variable set to 0. If a generic depth is defined using DEPIMP_BSN (.bsn), set DEP_IMP = 0 to use the basin-level value.

LAT_ORGN	If no value for BIOMIX is entered, the model will set BIOMIX = 0.20. Optional.
LAT_ORGP	Organic P in the base flow (mg/L) (range 0.0 – 200.0) default = 0.0 Optional.
HARG_PET	Coefficient related to radiation used in Hargreaves equation
CNCOEF	Plant ET curve number coefficient. ET weighting coefficient used to calculate the retention coefficient for daily curve number calculations dependent on plant evapotranspiration. This value can vary between 0.5 and 2.0. If no value is entered for CNCOEF, the model will set CNCOEF = 1.0. Required if ICN = 1.
PERCO	Percolation coefficient - adjusts soil moisture for perc to occur (1.0 = fc)

TOPOGRAPHY.HYD

Data contained in the topo.dat data file can be grouped into the following categories: topographic characteristics, water flow, erosion, land cover, and depressional storage areas.

Below is a sample TOPOGRAPHY.HYD FILE:

topography.hyd					
NAME	SLOPE	SLOPE_LEN	LAT_LEN	DIS_STREAM	DEP_CO
hru00101	0.0377	91.46342	50	35	0.5
hru00101	0.0333	91.46342	50	35	0.5
hru00101	0.0255	91.46342	0	35	0.5
hru00101	0.0505	91.46342	0	35	0.5
hru00101	0.0232	91.46342	0	35	0.5
hru00101	0.0089	91.46342	0	35	0.5
hru00103	0.0368	91.46342	0	35	0.5

Variable name	Definition
TITLE	The first line is reserved for user comments. This line is not processed by the model and may be left blank. Optional.
HEADER	Headers for the topography.hyd file.
NAME	Sequential number of topo in file
SLOPE	Average slope steepness in HRU (m/m)
SLOPE_LEN	Average slope length for erosion (m)
LAT_LEN	Slope length for lateral subsurface flow (m)
DIS_STREAM	Average distance to stream (m)

DEP_CO	Deposition coefficient

FIELD.FLD

Below is a sample FIELD.FLD FILE:

field.fld			
NAME	LENGTH	WIDTH	ANGLE
ditch_bench	600	8	30

Variable name	Definition
TITLE	The first line is reserved for user comments. This line is not processed by the model and may be left blank. Optional.
HEADER	Headers for the field.fld file.
NAME	Name of the field
LENGTH	Field length for wind erosion (m)
WID	Field width for wind erosion (m)
ANG	Field angle for wind erosion (m)

STRUCTURAL –

TILEDRAIN.STR

Tile drains remove excess water for an area to optimize plant growth. Drains may be added at the beginning of the simulation in the .mgt file. To account for the installation of tile drains mid-simulation, the option was included as a schedulable operation.

Below is a sample TILEDRAIN.STR FILE:

tiledrain.str								
NAME	DEPTH	TIME	LAG	RADIUS	DIST	DRAIN_CO	PUMPCAP	LATKSAT
mw24_1000	1000	24	96	100	30	10	1	2

Variable name	Definition
TITLE	The first line of the file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
HEADER	Headings for variables
NAME	Name
DEPTH	Depth of drain tube from the soil surface
TIME	Time to drain soil to field capacity

LAG	Drain tile lag time
RADIUS	Effective radius of drains (mm)
	Range (3.0 – 40.0 mm)
DIST	Distance between two drain tubes or tiles (mm)
	Range (7600 – 30000 mm)
DRAIN_CO	Daily drainage coefficient (mm day^{-1}).
	Tile drainage routines flag/code: 1 = DRAINMOD tile equations (Subroutine DRAINS)
	Range (10-51 mm day^{-1})
PUMPCAP	Pump capacity (mm h^{-1})
	Default value = 1.042 mm h^{-1} or 22 mm day^{-1}
LATKSAT	Multiplication factor to determine lateral ksat (conk(j1,j)) from SWAT ksat input value (sol_k(j1,j)) for HRU
	Range (0.01 - 4.00)

SEPTIC.STR

The Onsite Wastewater Systems (OWSs) input file contains information related to a diversity of features of OWSs within the subbasin. Data contained in the septic.dat data file are: type of septic system, geometry of biozone, characteristics of biomass, and bio-physical reaction coefficients occurring in the biozone (Adapted from Siegrist et al., 2005).

Below is a partial sample SEPTIC.STR FILE: (ALL VARIABLES NOT INCLUDED IN SAMPLE):

septic.str											
NAME	TYP	YR	OPT	CAP	AREA	TFAIL	DEPTH	THK	STRM_DIS	DENSITY	BD
standard	1	0	0	2.5	100	70	500	50	0.5	1.5	1000
failing	1	0	0	2.5	100	1	500	50	0.5	1.5	1000

TITLE	The first line of the file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
HEADER	Headings for variables
NAME	Name

TYP — The type of septic system

Type	Definition
1	Generic type conventional system
2	Generic type advanced system
3	Septic tank with conventional drainfield
4	Septic tank with SAS[a] type 1
5	Septic tank with SAS type 2
6	Septic tank with in-tank N removal and SAS
7	Septic tank with effluent N removal recycle
8	Septic tank with corrugated plastic trickling Filter
9	Septic tank with open-cell form trickling filter
10	Single pass sand filter 1
11	Single pass sand filter 2
12	Single pass sand filter 3
13	Single pass sand filter 4
14	At grade recirculating sand filter
15	Maryland style RSF[b]
16	RSF
17	Septic tank w/ constructed wetland and surface water discharge
18	Municipal wastewater w/ constructed wetland and surface water discharge 1
19	Municipal wastewater w/ constructed wetland and surface water discharge 2
20	Municipal wastewater w/ constructed wetland
21	Municipal wastewater w/ lagoon and constructed wetland
22	Waterloo biofilter (plastic media) 1
23	Waterloo biofilter (plastic media) 2
24	Peat biofilter
25	Recirculating textile filter
26	Foam or textile filter effluent
27	Septic, recirculating gravel filter, UV disinfection
28	Untreated Effluent - Texas A&M reference

YR — Year the septic system became operational (eg 1980).

If 0 is input for *isep_iyr*, the model assumes the septic system is in operation at the beginning of the simulation

OPT	Initial septic HRU operational condition. User can define the default condition of a septic HRU as either active (sep_opt=1), failing (sep_opt=2), or non-septic (sep_opt=0). An active system automatically becomes failing as biozone layer gets clogged over time. A failing system turns to an active system after user specified "number of days for rehabilitation" defined by *isep_tfail*.
CAP	Number of permanent residents in the house. SEP_cap for a typical US residence is 2.5 and ranges 1~10000.
AREA	Average area of drainfield of individual septic systems (m^2). Typically recommended drainfield area per person is about 40 to 70 (m^2). This varies from state to state in the United States. For a household with 2.5 people, generally a drainfield area of 100 (m^2) is recommended. User can modify the bz_area based on the number of people in a household. The bz_area and sep_cap may be modified appropriately to study the effects of larger population size using septic systems.
TFAIL	Time until failing systems gets fixed (days). An active system becomes failing as the biozone gets clogged and hydraulic failure occurs. A failing system automatically turns active during the simulation and septic parameters are re-initialized to default values after the user specified number of days (days assigned for isep_tfail) for rehabilitation. The default value for *isep_tfail* is 70 days but it can range between 10~100000 days. For testing long term failure, isep_tfail can be increased as per the failing duration. isep_opt should be set at 2 for simulating failing conditions..
Z	Depth to the top of biozone layer from the ground surface (mm). The thickness includes top soil layer and septic tank effluent (STE) distribution chamber including perforated pipe. The default is 500mm and the depth typically ranges between 10-10000mm.
THK	Thickness of the biozone layer (mm). The biozone layer is thin soil layer underneath the STE distribution chamber where pollutants are degraded by naturally existing live biomass bacteria. The default thickness is 50mm and ranges 5~100mm.
STRM_DIST	Distance to the stream from the septic HRU (km) Currently not available.
DENSITY	Number of septic systems per square kilometer. Currently not available.
BD	Density of biomass (kg/m^3), typically in the range of 900~1100 kg/m^3. The default is 1000 kg/m^3.

BOD_DC	BOD decay rate coefficient. Biozone BOD coefficient is normalized by the volume of biomass in the formula. The default value is 0.5 and the value ranges 0.1~ 5.
BOD_CONV	A conversion factor representing the proportion of mass bacterial growth and mass BOD degraded in the STE. The default value is 0.32 and the value ranges 0.1~ 0.5.
FC1	Linear coefficient for calculation of field capacity in the biozone. The default value is 30 and the value ranges 0~ 50.
FC2	Exponential coefficient for calculation of field capacity in the biozone. The default value is 0.8 and the value ranges 0.5~ 1.
FECAL	Fecal coliform bacteria decay rate coefficient. Biozone fecal coliform coefficient is normalized by the volume of biomass in the formula. The default value is 1.3 and the value ranges 0.5~ 2.
PLQ	Conversion factor for plaque from total dissolved solids. The default value is 0.1 and the value ranges 0.08~ 0.95.
MRT	Mortality rate coefficient. The default value is 0.5 and the value ranges 0.01~ 1.
RSP	Respiration rate coefficient. The default value is 0.16 and the value ranges 0.01~ 1.
SLG1	Linear coefficient for calculating the rate of biomass sloughing. The default value is 0.3 and the value ranges 0.01~ 0.5.
SLG2	Exponential coefficient for calculating the rate of biomass sloughing. The default value is 0.5 and the value ranges 0.1~ 2.5.
NITR	Nitrification rate coefficient. Biozone nitrification rate coefficient is normalized by the volume of biomass in the formula. The default value is 1.5 and the value ranges 0.1~ 300.
DENITR	Denitrification rate coefficient. Biozone denitrification rate coefficient is normalized by the volume of biomass in the formula. The default value is 0.32 and the value ranges 0.1~50.
PDISTRB	Linear P sorption distribution coefficient (L/kg). The default value is 128 and the value ranges 1.4~478.
PSORPMAX	Maximum P sorption capacity (mg P/kg Soil). The default value is 850 and the value ranges 0~17600.
SOLPSLP	Slope of the linear effluent soluble P equation. The default value is 0.04 and the value ranges 0~0.3.
SOLPINTC	Intercept of the linear effluent soluble P equation. The default value is 3.1 and the value ranges 0~10.

FILTERSTRIP.STR

A filter strip is a strip of dense vegetation located to intercept runoff from upslope pollutant sources and filter it. Filter strips remove contaminants by reducing overland flow velocity which results in the deposition of

particulates. The filter strip area also acts as an area of increased infiltration, reducing both the runoff volume and non-particulate contaminants. The filter strip used algorithm used in SWAT was derived from White and Arnold (2009). Filter strips reduce sediment, nutrients, bacteria, and pesticides, but do not affect surface runoff in SWAT. The variables which may be entered on the pesticide application line are listed and described below.

Below is a sample FILTERSTRIP.STR FILE:

filterstrip.str								
NAME	VFSRATIO	VFSCON	VFSCH					
field_border	0.1	0.003	0.2		Field_border			
high_engineered	0.1	0.001	0.05		Highly_engineered_low_channelized			

Variable name	Definition
TITLE	The first line of the file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
HEADER	Headings for variables
NAME	Name
VFSI	Flag for the simulation of filter strips (VFSI = 1/0 active/inactive).
VFSRATIO	Ratio of field area to filter strip area (unitless). Ranges from 0 to 300 with values from 30-60 being most common. Default value is 40
VFSCON	Fraction of the HRU which drains to the most concentrated ten percent of the filters strip area. Runoff generated upslope a filter strip is not uniformly distributed across the entire length of the strip. Ten percent of the filter strip can receive between 0.25 and 0.75 of the runoff from the entire filed. Default value is 0.5.
VFSCH	Fraction of the flow within the most concentrated ten percent of the filter strip which is fully channelized (dimensionless). Flow which is fully channelized is not subject to filtering or infiltration effects. Default value is 0.0

GRASSEDWW.STR

Grassed waterways are vegetated channels which transport runoff from a field. Vegetation within the waterways reduces flow velocities, and protects the waterway from the scouring potential of concentrated flow. These are generally broad and shallow channels; the channel simulated in SWAT has a side slope of 8:1. Grasses waterways trap sediment and other contaminants by reducing flow velocities which increases deposition of particulate contaminates.

Below is a sample GRASSEDWW.STR FILE:

grassedww.str								
NAME	MAN_N	SPCON	DEPTH	WIDTH	LENGTH	SLOPE		
grwway_high	0.05	0.02	1	4	0.5	0.1		Slope_>8
grwway_med	0.05	0.02	0.75	3	0.75	0.035		Slope_2-5
grwway_low	0.05	0.02	0.5	2	1	0.01		Slope_0-2

Variable name	Definition
TITLE	The first line of the file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
HEADER	Headings for variables
NAME	Name
GRWAT_I	On/off Flag for waterway simulation
GRWAT_N	Mannings's n for grassed waterway
GRWAT_SPCON	sediment transport coefficient defined by user
GRWAT_D	depth of Grassed waterway (m)
GRWAT_W	width of grass waterway
GRWAT_L	length of Grass Waterway (km)
GRWAT_S	slope of grass waterway (m/m)

BMPUSER.STR

There are many conservation practices for which approximate removal efficiencies have been established which are unsupported by SWAT or any other existing model. To allow these practices to be included, this generic conservation practice operation allows fixed removal efficiencies to be specified by constituent.

Below is a sample BMPUSER.STR FILE:

bmpuser.str - Little River Experimental Watershed							
NAME	BMP_FLAG	BMP_SED	BMP_PP	BMP_SP	BMP_PN	BMP_SN	BMP_BAC
bmpusr1	1	0.2	0.2	0.2	0.2	0.2	0.2

Variable name	Definition
TITLE	The first line of the file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
HEADER	Headings for variables
NAME	User BMP Name
BMP_FLAG	Code to turn on/off user BMP (range 0-1)(mgt1i)
BMP_SED	Sediment removal by BMP (%) (range 0-100)
BMP_PP	Particulate (Organic) phosphorous removal by BMP (%) (range 0-100)
BMP_SP	Soluble phosphorous removal by BMP (%) (range 0-100)

BMP_PN	Particulate (Organic) nitrogen removal by BMP (%) (range 0-100)
BMP_SN	Soluble nitrogen removal by BMP (%) (range 0-100)
BMP_BAC	Bacteria removed by BMP (%) (range 0-100)

HRU_PARM_DB– The parameters database files are supplied with the model containing Input parameters for most of the common plants, fertilizers, pesticides, urban, are included in the database files with the option for the user to add new parameters to each file.

PLANTS.PLT

Information required to simulate plant growth is stored by plant species in the plant growth database file. This database file is supplied with the model. The plant growth database distributed with SWAT includes parameters for most of the common plant species. If a user needs to model a land use or plant not included in the database, please feel free to contact the SWAT development team for assistance in determining plant parameters. Appendix A documents the source of parameter values in the distributed database file. Below is a partial sample PLANTS.PLT file (see plants.plt in example input dataset directory for complete file):

plants.plt:												
name	plnt_typ	plnt_hu	bm_e	harv_idx	lai_pot	frac_hu1	lai_max1	frac_hu2	lai_max2	hu_lai_dec	can_ht_ma	rt_dp_max
agrl	warm_ann	2000	33.5	0.45	3	0.15	0.05	0.5	0.95	0.64	1	2
agrr	warm_ann	2000	39	0.5	3	0.15	0.05	0.5	0.95	0.7	2.5	2
agrc	cold_annu	2000	30	0.4	4	0.05	0.05	0.45	0.95	0.5	0.9	1.3
orcd	trees	2000	15	0.1	4	0.1	0.15	0.5	0.75	0.99	3.5	2
hay	perennial	2000	35	0.9	4	0.05	0.05	0.49	0.95	0.99	0.5	2
frst	trees	2000	15	0.76	5	0.05	0.05	0.4	0.95	0.99	6	3.5
frsd	trees	2000	15	0.76	5	0.05	0.05	0.4	0.95	0.99	6	3.5
frse	trees	2000	15	0.76	5	0.15	0.7	0.25	0.99	0.99	10	3.5
wetl	perennial	2000	47	0.9	6	0.1	0.2	0.2	0.95	0.7	2.5	2.2
wetf	trees	2000	15	0.76	5	0.05	0.05	0.4	0.95	0.99	6	3.5
wetn	perennial	2000	47	0.9	6	0.1	0.2	0.2	0.95	0.7	2.5	2.2

Variable name	Definition
TITLE	The first line of the file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
HEADER	Headings for variables

PLANTNM

A four character code to represent the land cover/plant name.

The 4-letter codes in the plant growth and urban databases are used by the GIS interfaces to link land use/land cover maps to SWAT plant types. This code is printed to the output files.

When adding a new plant species or land cover category, the four letter code for the new plant must be unique.

Required.

PLNT_TYP

Land cover/plant classification (read in as character):

warm_annual_legume
cold_annual_legume
perennial_legume
warm_annual
cold_annual
perennial
trees
tropical_trees
tropical_grasses

Processes modeled differently for the 7 groups are:

1 warm season annual legume
   - simulate nitrogen fixation
   - root depth varies during growing season due to root growth

2 cold season annual legume
   - simulate nitrogen fixation
   - root depth varies during growing season due to root growth

fall-planted land covers will go dormant when daylength is less than the threshold daylength

Variable name	Definition
IDC, cont.	3 perennial legume • simulate nitrogen fixation • root depth always equal to the maximum allowed for the plant species and soil • plant goes dormant when daylength is less than the threshold daylength 4 warm season annual • root depth varies during growing season due to root growth 5 cold season annual • root depth varies during growing season due to root growth • fall-planted land covers will go dormant when daylength is less than the threshold daylength 6 perennial • root depth always equal to the maximum allowed for the plant species and soil • plant goes dormant when daylength is less than the threshold daylength 7 trees • root depth always equal to the maximum allowed for the plant species and soil • partitions new growth between leaves/needles (20%) and woody growth (80%). At the end of each growing season, a fraction of the biomass is converted to residue Required.
PHU	Total number of heat units to bring crop to maturity
BIO_E	Radiation-use efficiency or biomass-energy ratio ((kg/ha)/(MJ/m^2)). Radiation-use efficiency (RUE) is the amount of dry biomass produced per unit intercepted solar radiation. The radiation-use efficiency is assumed to be independent of the plant's growth stage. BIO_E represents the potential or unstressed growth rate (including roots) per unit of intercepted photosynthetically active radiation.

Variable name	Definition
BIO_E, cont.	Determination of RUE is commonly performed and a literature review will provide those setting up experiments with numerous examples. The following overview of the methodology used to measure RUE was summarized from Kiniry et al (1998) and Kiniry et al (1999). To calculate RUE, the amount of photosynthetically active radiation (PAR) intercepted and the mass of aboveground biomass is measured several times throughout a plant's growing season. The frequency of the measurements taken will vary but in general 4 to 7 measurements per growing season are considered to be adequate. As with leaf area determinations, the measurements should be performed on non-stressed plants. Intercepted radiation is measured with a light meter. Whole spectrum and PAR sensors are available and calculations of RUE will be performed differently depending on the sensor used. A brief discussion of the difference between whole spectrum and PAR sensors and the difference in calculations is given in Kiniry (1999). The use of a PAR sensor in RUE studies is strongly encouraged. When measuring radiation, three to five sets of measurements are taken rapidly for each plant plot. A set of measurements consists of 10 measurements above the leaf canopy, 10 below, and 10 more above. The light measurements should be taken between 10:00 am and 2:00 pm local time. The measurements above and below the leaf canopy are averaged and the fraction of intercepted PAR is calculated for the day from the two values. Daily estimates of the fraction of intercepted PAR are determined by linearly interpolating the measured values.

Variable name	Definition
BIO_E, cont.	The *fraction* of intercepted PAR is converted to an *amount* of intercepted PAR using daily values of incident total solar radiation measured with a standard weather station. To convert total incident radiation to total incident PAR, the daily solar radiation values are multiplied by the percent of total radiation that has a wavelength between 400 and 700 mm. This percent usually falls in the range 45 to 55% and is a function of cloud cover. 50% is considered to be a default value. Once daily intercepted PAR values are determined, the total amount of PAR intercepted by the plant is calculated for each date on which biomass was harvested. This is calculated by summing daily intercepted PAR values from the date of seedling emergence to the date of biomass harvest. To determine biomass production, aboveground biomass is harvested from a known area of land within the plot. The plant material should be dried at least 2 days at 65°C and then weighed. RUE is determined by fitting a linear regression for aboveground biomass as a function of intercepted PAR. The slope of the line is the RUE. Figure 14-1 shows the plots of aboveground biomass and summed intercepted photosynthetically active radiation for Eastern gamagrass. (Note that the units for RUE values in the graph, as well as values typically reported in literature, are different from those used by SWAT. To obtain the value used in SWAT, multiply by 10.) This parameter can greatly change the rate of growth, incidence of stress during the season and the resultant yield. This parameter should be one of the last to be adjusted. Adjustments should be based on research results. Care should be taken to make adjustments based only on data with no drought, nutrient or temperature stress. Required.

Variable name	Definition

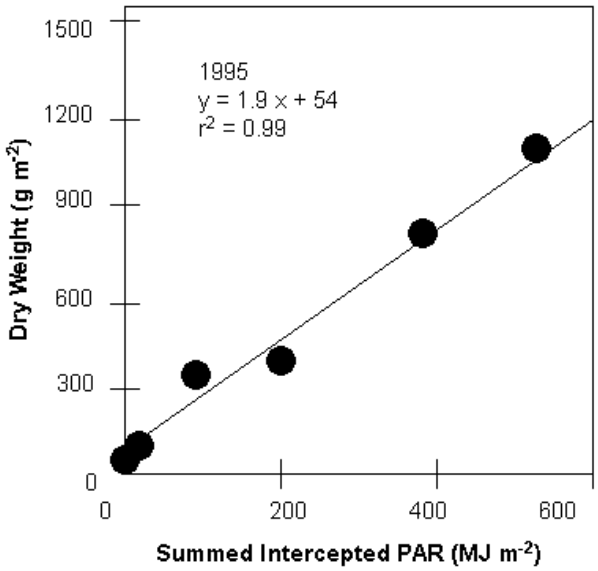


Figure 14-1: Aboveground biomass and summed intercepted photosynthetically active radiation for Eastern gamagrass (after Kiniry et al.,1999).

HVSTI	Harvest index for optimal growing conditions. The harvest index defines the fraction of the aboveground biomass that is removed in a harvest operation. This value defines the fraction of plant biomass that is "lost" from the system and unavailable for conversion to residue and subsequent decomposition. For crops where the harvested portion of the plant is aboveground, the harvest index is always a fraction less than 1. For crops where the harvested portion is belowground, the harvest index may be greater than 1. Two harvest indices are provided in the database, the harvest index for optimal growing conditions (HVSTI) and the harvest index under highly stressed growing conditions (WSYF).

Variable name	Definition
HVSTI, cont.	To determine the harvest index, the plant biomass removed during the harvest operation is dried at least 2 days at 65°C and weighed. The total aboveground plant biomass in the field should also be dried and weighed. The harvest index is then calculated by dividing the weight of the harvested portion of the plant biomass by the weight of the total aboveground plant biomass. Plants will need to be grown in two different plots where optimal climatic conditions and stressed conditions are produced to obtain values for both harvest indices. Required.
BLAI	Maximum potential leaf area index. BLAI is one of six parameters use to quantify leaf area development of a plant species during the growing season. Figure 14-2 illustrates the relationship of the database parameters to the leaf area development modeled by SWAT.

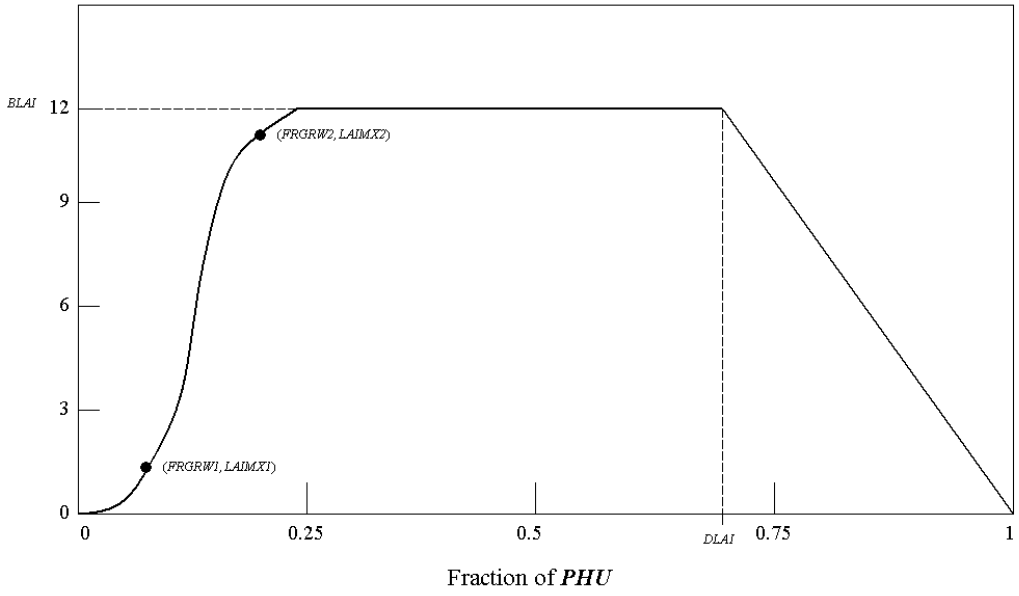


Figure 14-2: Leaf area index as a function of fraction of growing season for Alamo switchgrass

Variable name	Definition
BLAI, cont.	To identify the leaf area development parameters, record the leaf area index and number of accumulated heat units for the plant species throughout the growing season and then plot the results. For best results, several years worth of field data should be collected. At the very minimum, data for two years is recommended. It is important that the plants undergo no water or nutrient stress during the years in which data is collected. The leaf area index incorporates information about the plant density, so field experiments should either be set up to reproduce actual plant densities or the maximum LAI value for the plant determined from field experiments should be adjusted to reflect plant densities desired in the simulation. Maximum LAI values in the default database correspond to plant densities associated with rainfed agriculture. The leaf area index is calculated by dividing the green leaf area by the land area. Because the entire plant must be harvested to determine the leaf area, the field experiment needs to be designed to include enough plants to accommodate all leaf area measurements made during the year. Although measuring leaf area can be laborious for large samples, there is no intrinsic difficulty in the process. The most common method is to obtain an electronic scanner and feed the harvested green leaves and stems into the scanner. Older methods for estimating leaf area include tracing of the leaves (or weighed subsamples) onto paper, the use of planimeters, the punch disk method of Watson (1958) and the linear dimension method of Duncan and Hesketh (1968). Chapter 5:1 in the Theoretical Documentation reviews the methodology used to calculate accumulated heat units for a plant at different times of the year as well as determination of the fraction of total, or potential, heat units that is required for the plant database.

Variable name	Definition
BLAI, cont.	The values for BLAI in the plant growth database are based on average plant densities in dryland (rainfed) agriculture. BLAI may need to be adjusted for drought-prone regions where planting densities are much smaller or irrigated conditions where densities are much greater. Required.
FRGRW1	Fraction of the plant growing season or fraction of total potential heat units corresponding to the 1st point on the optimal leaf area development curve. Please see Figure 14-2 and the explanation given for parameter BLAI to obtain additional information about this parameter and methods used to measure it. Required.
LAIMX1	Fraction of the maximum leaf area index corresponding to the 1st point on the optimal leaf area development curve. Please see Figure 14-2 and the explanation given for parameter BLAI to obtain additional information about this parameter and methods used to measure it. Required.
FRGRW2	Fraction of the plant growing season or fraction of total potential heat units corresponding to the 2nd point on the optimal leaf area development curve. Please see Figure 14-2 and the explanation given for parameter BLAI to obtain additional information about this parameter and methods used to measure it. Required.
LAIMX2	Fraction of the maximum leaf area index corresponding to the 2nd point on the optimal leaf area development curve. Please see Figure 14-2 and the explanation given for parameter BLAI to obtain additional information about this parameter and methods used to measure it. Required.

Variable name	Definition
DLAI	Fraction of growing season when leaf area begins to decline. Please see Figure 14-2 and the explanation given for parameter BLAI to obtain additional information about this parameter and methods used to measure it. Required.
CHTMX	Maximum canopy height (m). Maximum canopy height is a straightforward measurement. The canopy height of non-stressed plants should be recorded at intervals throughout the growing season. The maximum value recorded is used in the database. Required.
RDMX	Maximum root depth (m). To determine maximum rooting depth, plant samples need to be grown on soils without an impermeable layer. Once the plants have reached maturity, soil cores are taken for the entire depth of the soil. Each 0.25 meter increment is washed and the live plant material collected. Live roots can be differentiated from dead roots by the fact that live roots are whiter and more elastic and have an intact cortex. The deepest increment of the soil core in which live roots are found defines the maximum rooting depth. Required.
T_OPT	Optimal temperature for plant growth (ºC). Both optimal and base temperatures are very stable for cultivars within a species. Optimal temperature for plant growth is difficult to measure directly. Looking at Figure 14-3, one might be tempted to select the temperature corresponding to the peak of the plot as the optimal temperature. This would not be correct.

Variable name	Definition
T_OPT, cont.	The peak of the plot defines the optimal temperature for leaf development—not for plant growth. If an optimal temperature cannot be obtained through a review of literature, use the optimal temperature listed for a plant already in the database with similar growth habits. Review of temperatures for many different plants have provided generic values for base and optimal temperatures as a function of growing season. In situations, where temperature information is unavailable, these values may be used. For warm season plants, the generic base temperature is ~8ºC and the generic optimal temperature is ~25ºC. For cool season plants, the generic base temperature is ~0ºC and the generic optimal temperature is ~13ºC. Required.
T_BASE	Minimum (base) temperature for plant growth (ºC). SWAT uses the base temperature to calculate the number of heat units accrued every day. The minimum or base temperature for plant growth varies with growth stage of the plant. However, this variation is ignored by the model—SWAT uses the same base temperature throughout the growing season. Base temperature is measured by growing plants in growth chambers at several different temperatures. The rate of leaf tip appearance as a function of temperature is plotted. Extrapolating the line to the leaf tip appearance rate of 0.0 leaves/day gives the base or minimum temperature for plant growth. Figure 14-3 plots data for corn. (Note that the line intersects the x-axis at 8°C.) Required.

Variable name	Definition
T_BASE, cont.	

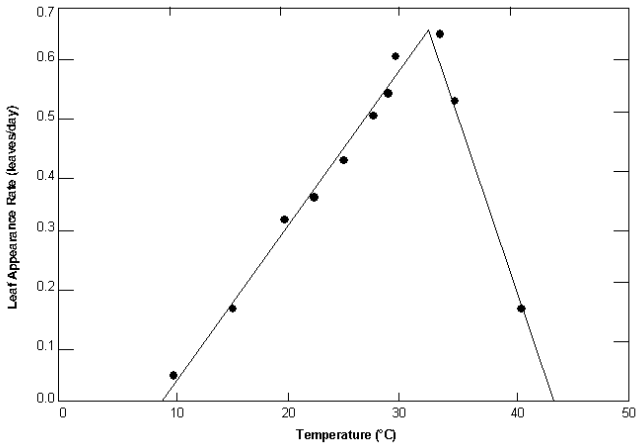


Figure 14-3: Rate of leaf tip appearance as a function of temperature for corn (after Kiniry et al, 1991)

CNYLD	Normal fraction of nitrogen in yield (kg N/kg yield). In addition to the amount of plant biomass removed in the yield, SWAT needs to know the amount of nitrogen and phosphorus removed in the yield. The harvested portion of the plant biomass is sent to a testing laboratory to determine the fraction of nitrogen and phosphorus in the biomass. This value is estimated on a dry weight basis. Required.
CPYLD	Normal fraction of phosphorus in yield (kg P/kg yield). In addition to the amount of plant biomass removed in the yield, SWAT needs to know the amount of nitrogen and phosphorus removed in the yield. The harvested portion of the plant biomass is sent to a testing laboratory to determine the fraction of nitrogen and phosphorus in the biomass. This value is estimated on a dry weight basis. Required.

Variable name	Definition
PLTNFR1	Nitrogen uptake parameter #1: normal fraction of nitrogen in plant biomass at emergence (kg N/kg biomass) In order to calculate the plant nutrient demand throughout a plant's growing cycle, SWAT needs to know the fraction of nutrient in the total plant biomass (on a dry weight basis) at different stages of crop growth. Six variables in the plant database provide this information: PLTNFR(1), PLTNFR(2), PLTNFR(3), PLTPFR(1), PLTPFR(2), and PLTPFR(3). Plant samples are analyzed for nitrogen and phosphorus content at three times during the growing season: shortly after emergence, near the middle of the season, and at maturity. The plant samples can be sent to testing laboratories to obtain the fraction of nitrogen and phosphorus in the biomass. Ideally, the plant samples tested for nutrient content should include the roots as well as the aboveground biomass. Differences in partitioning of nutrients to roots and shoots can cause erroneous conclusions when comparing productivity among species if only the aboveground biomass is measured. Required.
PLTNFR2	Nitrogen uptake parameter #2: normal fraction of nitrogen in plant biomass at 50% maturity (kg N/kg biomass) Please read the explanation for parameter PLTNFR(1) to obtain additional information about this parameter and methods used to measure it. Required.
PLTNFR3	Nitrogen uptake parameter #3: normal fraction of nitrogen in plant biomass at maturity (kg N/kg biomass) Please read the explanation for parameter PLTNFR(1) to obtain additional information about this parameter and methods used to measure it. Required.

Variable name	Definition
PLTPFR1	Phosphorus uptake parameter #1: normal fraction of phosphorus in plant biomass at emergence (kg P/kg biomass) Please read the explanation for parameter PLTNFR(1) to obtain additional information about this parameter and methods used to measure it. Required.
PLTPFR2	Phosphorus uptake parameter #2: normal fraction of phosphorus in plant biomass at 50% maturity (kg P/kg biomass) Please read the explanation for parameter PLTNFR(1) to obtain additional information about this parameter and methods used to measure it. Required.
PLTPFR3	Phosphorus uptake parameter #3: normal fraction of phosphorus in plant biomass at maturity (kg P/kg biomass) Please read the explanation for parameter PLTNFR(1) to obtain additional information about this parameter and methods used to measure it. Required.
WSYF	Lower limit of harvest index ((kg/ha)/(kg/ha)). The value between 0.0 and HVSTI which represents the lowest harvest index expected due to water stress. Please read the explanation for parameter HVSTI to obtain additional information about this parameter and methods used to measure it. Required.

Variable name	Definition
USLE_C	Minimum value of USLE C factor for water erosion applicable to the land cover/plant. The minimum C factor can be estimated from a known average annual C factor using the following equation (Arnold and Williams, 1995): $C_{USLE,mn} = 1.463 \ln[C_{USLE,aa}] + 0.1034$ where $C_{USLE,mn}$ is the minimum C factor for the land cover and $C_{USLE,aa}$ is the average annual C factor for the land cover. Required.
GSI	Maximum stomatal conductance at high solar radiation and low vapor pressure deficit (m·s-1). Stomatal conductance of water vapor is used in the Penman-Monteith calculations of maximum plant evapotranspiration. The plant database contains three variables pertaining to stomatal conductance that are required only if the Penman-Monteith equations are chosen to model evapotranspiration: maximum stomatal conductance (GSI), and two variables that define the impact of vapor pressure deficit on stomatal conductance (FRGMAX, VPDFR). Körner et al (1979) defines maximum leaf diffusive conductance as the largest value of conductance observed in fully developed leaves of well-watered plants under optimal climatic conditions, natural outdoor CO2 concentrations and sufficient nutrient supply. Leaf diffusive conductance of water vapor cannot be measured directly but can be calculated from measurements of transpiration under known climatic conditions. A number of different methods are used to determine diffusive conductance: transpiration measurements in photosynthesis cuvettes, energy balance measurements or weighing experiments, ventilated diffusion porometers and non-ventilated porometers. Körner (1977) measured diffusive conductance using a ventilated diffusion porometer.

Variable name	Definition
GSI, cont.	To obtain maximum leaf conductance values, leaf conductance is determined between sunrise and late morning until a clear decline or no further increase is observed. Depending on phenology, measurements are taken on at least three bright days in late spring and summer, preferably just after a rainy period. The means of maximum leaf conductance of 5 to 10 samples each day are averaged, yielding the maximum diffusive conductance for the species. Due to the variation of the location of stomata on plant leaves for different plant species, conductance values should be calculated for the total leaf surface area. Required.
VPDFR	Vapor pressure deficit (kPa) corresponding to the second point on the stomatal conductance curve. (The first point on the stomatal conductance curve is comprised of a vapor pressure deficit of 1 kPa and the fraction of maximum stomatal conductance equal to 1.00.) As with radiation-use efficiency, stomatal conductance is sensitive to vapor pressure deficit. Stockle et al (1992) compiled a short list of stomatal conductance response to vapor pressure deficit for a few plant species. Due to the paucity of data, default values for the second point on the stomatal conductance vs. vapor pressure deficit curve are used for all plant species in the database. The fraction of maximum stomatal conductance (FRGMAX) is set to 0.75 and the vapor pressure deficit corresponding to the fraction given by FRGMAX (VPDFR) is set to 4.00 kPa. If the user has actual data, they should use those values, otherwise the default values are adequate. Required.

Variable name	Definition
GMAXFR	Fraction of maximum stomatal conductance corresponding to the second point on the stomatal conductance curve. (The first point on the stomatal conductance curve is comprised of a vapor pressure deficit of 1 kPa and the fraction of maximum stomatal conductance equal to 1.00.) Please read the explanation for parameter VPDFR to obtain additional information about this parameter and methods used to measure it. Required.
WAVP	Rate of decline in radiation use efficiency per unit increase in vapor pressure deficit. Stockle and Kiniry (1990) first noticed a relationship between RUE and vapor pressure deficit and were able to explain a large portion of within-species variability in RUE values for sorghum and corn by plotting RUE values as a function of average daily vapor pressure deficit values. Since this first article, a number of other studies have been conducted that support the dependence of RUE on vapor pressure deficit. However, there is still some debate in the scientific community on the validity of this relationship. If the user does not wish to simulate a change in RUE with vapor pressure deficit, the variable WAVP can be set to 0.0 for the plant. To define the impact of vapor pressure deficit on RUE, vapor pressure deficit values must be recorded during the growing seasons that RUE determinations are being made. It is important that the plants are exposed to no other stress than vapor pressure deficit, i.e. plant growth should not be limited by lack of soil water and nutrients. Vapor pressure deficits can be calculated from relative humidity (see Chapter 1:2 in Theoretical Documentation) or from daily maximum and minimum temperatures using the technique of Diaz and Campbell (1988) as described by Stockle and Kiniry (1990). The change in RUE with vapor pressure deficit is determined by fitting a linear regression for RUE as a function of vapor pressure deficit. Figure 14-4 shows a plot of RUE as a function of vapor pressure deficit for grain sorghum.

Variable name	Definition

WAVP, cont.

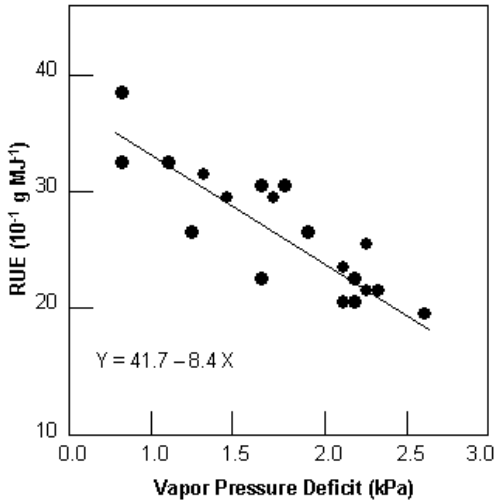


Figure 14-4: Response of radiation-use efficiency to mean daily vapor pressure deficit for grain sorghum (after Kiniry, 1999).

From Figure 14-4, the rate of decline in radiation-use efficiency per unit increase in vapor pressure deficit, Δrue_{dcl}, for sorghum is 8.4×10^{-1} g·MJ^{-1}·kPa^{-1}. When RUE is adjusted for vapor pressure deficit, the model assumes the RUE value reported for BIO_E is the radiation-use efficiency at a vapor pressure deficit of 1 kPa.

The value of WAVP varies among species, but a value of 6 to 8 is suggested as an approximation for most plants.

Required.

CO2HI

Elevated CO_2 atmospheric concentration (μL CO_2/L air) corresponding the 2nd point on the radiation use efficiency curve.

(The 1st point on the radiation use efficiency curve is comprised of the ambient CO_2 concentration, 330 μL CO_2/L air, and the biomass-energy ratio reported for BIO_E)

Variable name	Definition
CO2HI, cont.	In order to assess the impact of climate change on agricultural productivity, SWAT incorporates equations that adjust RUE for elevated atmospheric CO_2 concentrations. Values must be entered for CO2HI and BIOEHI in the plant database whether or not the user plans to simulate climate change. For simulations in which elevated CO_2 levels are not modeled, CO2HI should be set to some number greater than 330 ppmv and BIOEHI should be set to some number greater than BIO_E. To obtain radiation-use efficiency values at elevated CO_2 levels for plant species not currently in the database, plants should be established in growth chambers set up in the field or laboratory where CO_2 levels can be controlled. RUE values are determined using the same methodology described in the explanation of BIO_E. Required.
BIOEHI	Biomass-energy ratio corresponding to the 2nd point on the radiation use efficiency curve. (The 1st point on the radiation use efficiency curve is comprised of the ambient CO_2 concentration, 330 μL CO_2/L air, and the biomass-energy ratio reported for BIO_E.) Please read the explanation for parameter CO2HI and BIO_E to obtain additional information about this parameter and methods used to measure it. Required.
RSDCO_PL	Plant residue decomposition coefficient. The plant residue decomposition coefficient is the fraction of residue that will decompose in a day assuming optimal moisture, temperature, C:N ratio, and C:P ratio. This variable was originally in the basin input file (.bsn), but was added to the crop database so that users could vary decomposition by plant species. A default value of 0.05 is used for all plant species in the database. Required.

Variable name	Definition
ALAI_MIN	Minimum leaf area index for plant during dormant period (m^2/m^2). This variable pertains to perennials and trees only. (The value is never used for other types of plants.) In versions of SWAT prior to SWAT2012, the minimum leaf area index for plants during the dormant period was always set to 0.75. Because this value was not ideal for all plants (trees in particular), users are now allowed to vary the minimum LAI for dormancy. Please see the explanation given for parameter BLAI to obtain additional information about this parameter and methods used to measure it. Required.
LAIXCO_TREE	Fraction of tree biomass accumulated each year that is converted to residue during dormancy. This variable pertains to trees only. (The value is never used for other types of plants.) BIO_LEAF governs the amount of biomass that falls off the tree and is converted to residue when the plant goes dormant in the winter. In versions of SWAT prior to SWAT2012, the fraction of biomass converted to residue at the beginning of dormancy was always defined as 0.30. Required if land cover is classified as a tree (see IDC).
MAT_YRS	Number of years required for tree species to reach full development (years). This variable pertains to trees only. (The value is never used for other types of plants.) Required if land cover is classified as a tree (see IDC).
BMX_PEREN	Maximum biomass for a forest (metric tons/ha). This variable pertains to trees only. (The value is never used for other types of plants.) The maximum biomass for a mature forest stand generally falls in the range of 30-50 metric tons/ha. Required if land cover is classified as a tree (see IDC).
EXT_COEF	Light extinction coefficient. This coefficient is used to calculate the amount of intercepted photosynthetically active radiation. In versions of SWAT prior to SWAT2012, the light extinction coefficient was always defined as 0.65.

EXT_COEF (CONT)

Differences in canopy structure for a species are described by the number of leaves present (leaf area index) and the leaf orientation. Leaf orientation has a significant impact on light interception and consequently on radiation-use efficiency. More erect leaf types spread the incoming light over a greater leaf area, decreasing the average light intensity intercepted by individual leaves (Figure 14-5). A reduction in light intensity interception by an individual leaf favors a more complete conversion of total canopy-intercepted light energy into biomass.

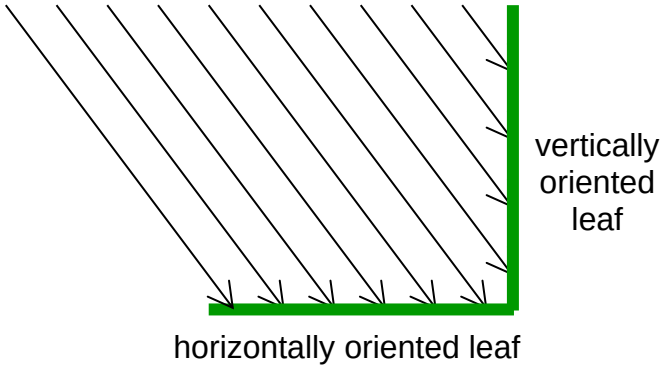


Figure 14-5: Light intensity interception as a function of leaf orientation. The vertically oriented leaf intercepts 4 units of light while a horizontally oriented leaf of the same length intercepts 6 units of light.

Using the light extinction coefficient value (k_ℓ) in the Beer-Lambert formula (equation 5:2.1.1) to quantify efficiency of light interception per unit leaf area index, more erect leaf types have a smaller k_ℓ.

To calculate the light extinction coefficient, the amount of photosynthetically active radiation (PAR) intercepted and the mass of aboveground biomass (LAI) is measured several times throughout a plant's growing season using the methodology described in the previous sections. The light extinction coefficient is then calculated using the Beer-Lambert equation:

$$\frac{TPAR}{PAR} = \left(1 - \exp\left(-k_\ell \cdot LAI\right)\right) \quad \text{or} \quad k_\ell = -\ln\left(\frac{TPAR}{PAR}\right) \cdot \frac{1}{LAI}$$

where *TPAR* is the transmitted photosynthetically active radiation, and *PAR* is the incoming photosynthetically active radiation.

LEAF_TOV_MIN Perennial leaf turnover rate with minimum stress (months)

LEAF_TOV_MAX Perennial leaf turnover rate with maximum stress (months)

BM_DIEOFF	Biomass dieoff fraction. This coefficient is the fraction above ground biomass that dies off at dormancy. Default value = 0.10.
RSR1	Initial root to shoot ration at the beginning of the growing season. Default = 0.40.
RSR2	Root to shoot ration at the end of the growing season. Default = 0.20.
POP1	Plant population corresponding to the 1st point on the population lai curve (plants/m^2)
FRLAI1	Frac of max leaf area index corresponding to the 1st point on the leaf area development curve (frac)
POP2	Plant population corresponding to the 2nd point on the population lai curve (plants/m^2)
FRLAI2	Frac of max leaf area index corresponding to the 2nd point on the leaf area development curve (frac)
FRSW_GRO	Frac of field capacity to initiate growth of tropical plants during monsoon season - pcom()%plcur()%iseason (frac)
WIND_STL	Wind erosion factor for standing live biomass
WIND_STD	Wind erosion factor for standing dead residue
WIND_FLAT	Wind erosion factor for flat residue

FERTILIZER.FRT

The fertilizer database summarizes the relative fractions of nitrogen and phosphorus pools in the different fertilizers. Information on levels of bacteria in manure is also stored in this file. Appendix A documents the source of parameter values in the database file provided with the model. Below is a partial listing of the fertilizer.frt file.

fertilizer.fr										
FERT_NAM	FR_MINN	FR_MINP	FR_ORGN	FR_ORGP	FR_NH3n	BACT_PER	BACT_LPE	BACT_KD	FR_WEP	FERT_TYPE
elem-n	1	0	0	0	0	0	0	0	0	0
elem-p	0	1	0	0	0	0	0	0	0	0
anh-nh3	0.82	0	0	0	1	0	0	0	0	0

Variable name	Definition
TITLE	The first line is reserved for user comments. This line is not processed by the model and may be left blank. Optional.
HEADER	Headers for the fertilizer.frt file.
FERTNM	Name of fertilizer/manure (up to 8 characters allowed). Required.
FMINN	Fraction of mineral N (NO_3 and NH_4) in fertilizer (kg min-N/kg fertilizer). Value should be between 0.0 and 1.0. Required.
FMINP	Fraction of mineral P in fertilizer (kg min-P/kg fertilizer). Value should be between 0.0 and 1.0. Required.
FORGN	Fraction of organic N in fertilizer (kg org-N/kg fertilizer). Value should be between 0.0 and 1.0. Required.
FORGP	Fraction of organic P in fertilizer (kg org-P/kg fertilizer). Value should be between 0.0 and 1.0. Required.
FNH3N	Fraction of mineral N in fertilizer applied as ammonia (kg NH_3-N/kg min-N). Value should be between 0.0 and 1.0. Required.
BACTPDB	Concentration of persistent bacteria in manure/fertilizer (# cfu/g manure). Optional.

Variable name	Definition
BACTLPDB	Concentration of less-persistent bacteria in manure/fertilizer (# cfu/g manure). Optional.
BACTKDDB	Fraction of bacteria in solution. Value should be between 0.0 and 1.0. As the bacteria partition coefficient approaches 0.0, bacteria is primarily sorbed to soil particles. As the bacteria partition coefficient approaches 1.0, bacteria is primarily in solution. Optional.

TILLAGE.TIL

Tillage operations redistribute nutrients, pesticide and residue in the soil profile. Appendix A documents the source of parameter values in the database file provided with the model.

Below is a partial listing of the tillage.til file.

tillage.til:								
TILLNM	EFFMIX	DEPTIL	RANRNS	RIDGE_HT	RIDGE_SP		Description	
fallplow	0.95	150	75	0	0		genericfallplowingoperation	
sprgplow	0.5	125	50	0	0		genericspringplowingoperation	
constill	0.25	100	40	0	0		genericconservationtillage	
zerotill	0.05	25	10	0	0		genericno-tillmixing	
duckftc	0.55	100	15	0	0		duckfootcultivator	
fldcult	0.3	100	20	0	0		fieldcultivator	
furowout	0.75	25	15	0	0		furrow-outcultivator	
marker	0.45	100	15	0	0		marker(cultivator)	
rollcult	0.5	25	15	0	0		rollingcultivator	
rowcult	0.25	25	15	0	0		rowcultivator	
discovat	0.5	25	15	0	0		discovator	
leveler	0.5	25	15	0	0		leveler	

Variable name	Definition
TITLE	The first line is reserved for user comments. This line is not processed by the model and may be left blank. Optional.
HEADER	Headers for the tillage.til.res file.
TILLNM	Name of fertilizer/manure (up to 8 characters allowed). Required.
EFFMIX	Mixing efficiency of tillage operation. The mixing efficiency specifies the fraction of materials (residue, nutrients and pesticides) on the soil surface which are mixed uniformly throughout the soil depth specified by DEPTIL. The remaining fraction of residue and nutrients is left in the original location (soil surface or layer). Required.
DEPTIL	Depth of mixing caused by the tillage operation (mm). Required.
RANRNS	Random roughness (mm) Required.
RIDGE_HT	Ridge height (mm) Required.
RIDGE_SP	Ridge interval (mm) Required.

PESTICIDE.PST

The pesticide database contains parameters that govern pesticide fate and transport in the HRUs. Appendix A documents the source of parameter values in the database file provided with the model. Below is a partial listing of the pesticide.pst file.

pesticide.p										
PESTNM	SKOC	PST_WOF	HLIFE_F	HLIFE_S	AP_EF	PST_WSOL		Description		
245-tp	2600	0.4	5	20	0.75	2.5		Silvex Amine		
2plus2	20	0.95	10	21	0.75	660000		Mecoprop		
aatrex	171	0.45	5	60	0.75	33		Atrazine		
abate	100000	0.65	5	30	0.75	0		Abate		
acaraben	2000	0.05	10	20	0.75	13		Chlorobenzilate Salt		
accelera	20	0.9	7	7	0.75	100000		Endothall		
acclaim	9490	0.2	5	9	0.75	0.8		Fenoxaprop-Ethyl Sodium Salt		
alanap	20	0.95	7	14	0.75	231000		Naptalam		
alar	10	0.95	4	7	0.75	100000		Daminozide		
aldrin	300	0.05	2	28	0.75	0.1		Aldrin		

Variable name	Definition
TITLE	The first line is reserved for user comments. This line is not processed by the model and may be left blank. Optional.
HEADER	Headers for the pestidide.pst file.
PESTNM	Name of pesticide/toxin. (up to 17 characters allowed) Required.
SKOC	Soil adsorption coefficient normalized for soil organic carbon content (mg/kg)/(mg/L). Pesticide in the soil environment can be transported in solution or attached to sediment. The partitioning of a pesticide between the solution and soil phases is defined by the soil adsorption coefficient for the pesticide. The soil adsorption coefficient is the ratio of the pesticide concentration in the soil or solid phase to the pesticide concentration in the solution or liquid phase: $K_p = \frac{C_{solidphase}}{C_{solution}}$ where K_p is the soil adsorption coefficient ((mg/kg)/(mg/L) or m^3/ton), $C_{solidphase}$ is the concentration of the pesticide sorbed to the solid phase (mg chemical/kg solid material or g/ton), and $C_{solution}$ is the concentration of the pesticide in solution (mg chemical/L solution or g/ton). The definition of the soil adsorption coefficient in this equation assumes that the pesticide sorption process is linear with concentration and instantaneously reversible. Because the partitioning of pesticide is dependent upon the amount of organic material in the soil, the soil adsorption coefficient input to the model is normalized for soil organic carbon content. The relationship between the soil adsorption coefficient and the soil adsorption coefficient normalized for soil organic carbon content is: $K_p = K_{oc} \cdot \frac{orgC}{100}$

Variable name	Definition
SKOC, cont.	where K_p is the soil adsorption coefficient ((mg/kg)/(mg/L)), K_{oc} is the soil adsorption coefficient normalized for soil organic carbon content ((mg/kg)/(mg/L) or m^3/ton), and *orgC* is the percent organic carbon present in the soil. Required.
PST_WOF	Wash-off fraction. The wash-off fraction quantifies the fraction of pesticide on the plant canopy that may be dislodged. The wash-off fraction is a function of the nature of the leaf surface, plant morphology, pesticide solubility, polarity of the pesticide molecule, formulation of the commercial product and timing and volume of the rainfall event. Required.
HLIFE_F	Degradation half-life of the chemical on the foliage (days). The half-life for a pesticide defines the number of days required for a given pesticide concentration to be reduced by one-half. The half-life entered for a pesticide is a lumped parameter that includes the net effect of volatilization, photolysis, hydrolysis, biological degradation and chemical reactions. For most pesticides, the foliar half-life is much less than the soil half-life due to enhanced volatilization and photodecomposition. If the foliar half-life is available for the pesticide this value should be used. If the foliar half-life is not available, the foliar half-life can be estimated using the following rules: 1) Foliar half-life is assumed to be less than the soil half-life by a factor of 0.5 to 0.25, depending on vapor pressure and sensitivity to photodegradation. 2) Foliar half-life is adjusted downward for pesticides with vapor pressures less than 10^{-5} mm Hg. 3) The maximum foliar half-life assigned is 30 days. Required.

Variable name	Definition
HLIFE_S	Degradation half-life of the chemical in the soil (days). The half-life for a pesticide defines the number of days required for a given pesticide concentration to be reduced by one-half. The soil half-life entered for a pesticide is a lumped parameter that includes the net effect of volatilization, photolysis, hydrolysis, biological degradation and chemical reactions. Required.
AP_EF	Application efficiency. The fraction of pesticide applied which is deposited on the foliage and soil surface (0.1-1.0). The remainder is lost. The application efficiency for all pesticides listed in the database is defaulted to 0.75. This variable is a calibration parameter. Required.
PST_WSOL	Solubility of the chemical in water (mg/L or ppm) The water solubility value defines the highest concentration of pesticide that can be reached in the runoff and soil pore water. While this is an important characteristic, researchers have found that the soil adsorption coefficient, K_{oc}, tends to limit the amount of pesticide entering solution so that the maximum possible concentration of pesticide in solution is seldom reached. Reported solubility values are determined under laboratory conditions at a constant temperature, typically between 20°C and 30°C. Required.

PATHOGENS.PTH

Below is a sample partial PATHOGENS.PTH:

bacteria.bac:																		
BACTNM	DO_SOLN	GR_SOLN	DO_SORB	GR_SORB	KD	T_ADJ	WASHOFF	DO_PLNT	GR_PLNT	_MANURE	PERCO	T_THRSHD	)_STREAM	R_STREAM	DO_RES	GR_RES	SWF	ONC_MIN
path_01	10	5	12	6	0.05	1.05	0.1	100	1	0.9	10	100	0	0	0	0	0.15	100

Variable name	Definition
TITLE	The first line is reserved for user comments. This line is not processed by the model and may be left blank. Optional.
HEADER	Headers for the bacteria.bac file.
BACTNM	Name of bacteria

DO_SOLN	Die-off factor for persistent bacteria in soil solution at 20°C. (1/day) SWAT allows two different bacteria types to be modeled in a given simulation. In the input/output files these two types are referred to as 'persistent' and 'less persistent'. These terms are purely descriptive and are used solely to differentiate between the two types. The bacteria input variables in the .bsn file govern the actual persistence of the two bacteria types. The user may choose to model no, one, or two types of bacteria. Required if bacteria processes are of interest.
GR_SOLN	Growth factor for persistent bacteria in soil solution at 20°C. (1/day) Required if bacteria processes are of interest.
DO_SORB	Die-off factor for persistent bacteria adsorbed to soil particles at 20°C. (1/day) Required if bacteria processes are of interest.
GR_SORB	Growth factor for persistent bacteria adsorbed to soil particles at 20°C. (1/day) Required if bacteria processes are of interest.
KD	Bact part coeff bet sol and sorbed phase in surf runoff
T_ADJ	Temperature adjustment factor for bacteria die-off/growth. If no value for THBACT is entered, the model will set THBACT = 1.07. Required if bacteria processes are of interest.
WASHOFF	Wash-off fraction for persistent bacteria. Fraction of persistent bacteria on foliage that washes off during a rainfall event. Required if bacteria processes are of interest.
DO_PLNT	Die-off factor for persistent bacteria on foliage at 20°C. (1/day) Required if bacteria processes are of interest.
GR_PLNT	Growth factor for persistent bacteria on foliage at 20°C. (1/day) Required if bacteria processes are of interest.
FR_MANURE	Fraction of manure applied to land areas that has active colony forming units. If no value for SWF is specified, the model will set SWF = 0.15. Required if bacteria processes are of interest.

PERCO	Bacteria percolation coefficient (10 m^3/Mg). The bacteria percolation coefficient is the ratio of the solution bacteria concentration in the surface 10 mm of soil to the concentration of bacteria in percolate. The value of BACTMIX can range from 7.0 to 20.0. If no value for BACTMIX is entered, the model will set BACTMIX = 10.0. Required if bacteria processes are of interest.
DET_THRSHD	Threshold detection level for less persistent bac when bacteria levels drop to this amount the model considers bacteria in the soil to be insignificant and sets the levels to zero
DO_STREAM	Die-off factor for persistent bacteria in streams (moving water) at 20°C. (1/day) Required if bacteria processes are of interest.
GR_STREAM	growth factor for persistent bacteria in streams
DO_RES	Die-off factor for less persistent bacteria in streams (moving water) at 20°C. (1/day) Required if bacteria processes are of interest.
GR_RES	growth factor for less persistent bacteria in reservoirs
SWF	fraction of manure containing active colony forming units
CONC_MIN	

METALS.MTL (ENTIRE FILE NEEDS ATTENTION)

SALTS.STL (ENTIRE FILE NEEDS ATTENTION)

URBAN.URB

The urban database summarizes parameters used by the model to simulate different types of urban areas. Appendix A documents the source of parameter values in the database file provided with the model. Below is a partial listing of the urban.urb file.

urban.urb:													
urbnm	fimp	fcimp	curbden	urbcoef	dirtmx	thalf	tnconc	tpconc	tno3conc	urbcn2			
residen_high_den	0.6	0.44	0.24	0.18	225	0.75	550	223	7.2	98		Residentia	Density
residen_med_den	0.38	0.3	0.24	0.18	225	0.75	550	223	7.2	98		Residentia	Density
residen_ml_den	0.2	0.17	0.24	0.18	225	0.75	460	196	6	98		Residentia	Density
residen_low_den	0.12	0.1	0.24	0.18	225	0.75	460	196	6	98		Residentia	Density
commercial	0.67	0.62	0.28	0.18	200	1.6	420	240	5.5	98		Commercial	
industrial	0.84	0.79	0.14	0.18	400	2.35	430	104	5.6	98		Industrial	
transportation	0.98	0.95	0.12	0.18	340	3.9	480	212	6.3	98		Transportation	
institutional	0.51	0.47	0.12	0.18	340	3.9	480	212	6.3	98		Institutional	
residential	0.38	0.3	0.24	0.18	225	0.75	550	223	7.2	98		Residential	

Variable name	Definition
TITLE	The first line of the file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
HEADER	Headings for the variables
URBNM	4-character code for urban land type. The 4-letter codes in the plant growth and urban databases are used by the GIS interfaces to link land use/land cover maps to SWAT plant types. This code is printed to the output files. When adding a new urban category, the four letter code for the new urban land type must be unique. Required.
FIMP	Fraction total impervious area in urban land type. This includes directly and indirectly connected impervious areas. Urban areas differ from rural areas in the fraction of total area that is impervious. Construction of buildings, parking lots and paved roads increases the impervious cover in a watershed and reduces infiltration. With development, the spatial flow pattern of water is altered and the hydraulic efficiency of flow is increased through artificial channels, curbing, and storm drainage and collection systems. Required.
FCIMP	Fraction directly connected impervious area in urban land type.

Variable name	Definition
FCIMP, cont.	Impervious areas can be differentiated into two groups—the area that is hydraulically connected to the drainage system and the area that is not directly connected. As an example, assume there is a house surrounded by a yard where runoff from the roof flows into the yard and is able to infiltrate into the soil. The rooftop is impervious but it is not hydraulically connected to the drainage system. In contrast, a parking lot whose runoff enters a storm water drain is hydraulically connected. When modeling urban areas the connectedness of the drainage system must be quantified. The best methods for determining the fraction total and directly connected impervious areas is to conduct a field survey or analyze aerial photographs. Required.
CURBDEN	Curb length density in urban land type (km/ha). Curb length may be measured directly by scaling the total length of streets off of maps and multiplying by two. To calculate the density, the curb length is divided by the area represented by the map. Required.
URBCOEF	Wash-off coefficient for removal of constituents from impervious area (mm^{-1}). Wash off is the process of erosion or solution of constituents from an impervious surface during a runoff event. The original default value for urb_{coef} was calculated as 0.18 mm^{-1} by assuming that 13 mm of total runoff in one hour would wash off 90% of the initial surface load (Huber and Heaney, 1982). Using sediment transport theory, Sonnen (1980) estimated values for the wash-off coefficient ranging from 0.002-0.26 mm^{-1}. Huber and Dickinson (1988) noted that values between 0.039 and 0.390 mm^{-1} for the wash-off coefficient give sediment concentrations in the range of most observed values. This variable is used to calibrate the model to observed data. Required.
DIRTMX	Maximum amount of solids allowed to build up on impervious areas (kg/curb km). Required.

Variable name	Definition
THALF	Number of days for amount of solids on impervious areas to build up from 0 kg/curb km to half the maximum allowed, i.e. 1/2 DIRTMX (days). Required.
TNCONC	Concentration of total nitrogen in suspended solid load from impervious areas (mg N/kg sed). Required.
TPCONC	Concentration of total phosphorus in suspended solid load from impervious areas (mg P/kg sed). Required.
TNO3CONC	Concentration of nitrate in suspended solid load from impervious areas (mg NO_3-N/kg sed). Required.
URBCN2	Curve number for moisture condition II in impervious areas of urban land type. Required.

SEPTIC.SEP

Information of water quality or effluent characteristics required to simulate different types of Onsite Wastewater Systems (OWSs) is stored in the septic water quality database. The database file distributed with SWAT includes water quality data for most of conventional, advanced, and failing septic systems. Information contained in the septic water quality database is septic tank effluent flow rate for per capita and effluent characteristics of various septic systems. The database is developed based on the field data summarized by Siegrist et al. (2005), McCray et al. (2005) and OWTS 201 (2005). Below is a partial listing of the septic.sep file.

septic.sep			-							
SEPNM	QS	ODCONCS	TSSCONCS	IH4CONCS	IO3CONCS	IO2CONCS	GNCONCS	MINPS	ORGPS	FCOLIS
GCON	0.227	170	75	42.4	0	0	10	6	1	10000000
GADV	0.227	22	14	18.9	9.6	0	3	5.1	0.9	543
COND	0.227	170	75	58	0.2	0	14	9	1	10000000
SAS1	0.227	170	75	60	0	0	10	8.5	1.5	10000000
SAS2	0.227	170	75	0	0	0	0	9	1	10000000

Variable name	Definition
TITLE	The first line is reserved for user comments. This line is not processed by the model and may be left blank.
	Optional.
HEADER	Headers for the septic.sep file.

SEPNM

Abridged name of a septic system

sptname	Definition
GCON	Generic type conventional system
GADV	Generic type advanced system
COND	Septic tank with conventional drainfield
SAS1	Septic tank with SAS[a] type 1
SAS2	Septic tank with SAS type 2
SAS3	Septic tank with in-tank N removal and SAS
SAS4	Septic tank with effluent N removal recycle
SAS5	Septic tank with corrugated plastic trickling Filter
SAS6	Septic tank with open-cell form trickling filter
SPF1	Single pass sand filter 1
SPF2	Single pass sand filter 2
SPF3	Single pass sand filter 3
SPF4	Single pass sand filter 4
RCF1	At grade recirculating sand filter
RCF2	Maryland style RSF[b]
RCF3	RSF
CWT1	Septic tank w/ constructed wetland and surface water discharge
CWT2	Municipal wastewater w/ constructed wetland and surface water discharge 1
CWT3	Municipal wastewater w/ constructed wetland and surface water discharge 2
CWT4	Municipal wastewater w/ constructed wetland
CWT5	Municipal wastewater w/ lagoon and constructed wetland
BFL1	Waterloo biofilter (plastic media) 1
BFL2	Waterloo biofilter (plastic media) 2
BFL3	Peat biofilter
TXF1	Recirculating textile filter
TXF2	Foam or textile filter effluent
GFL1	Septic, recirculating gravel filter, UV disinfection
USPT	Untreated Effluent - Texas A&M reference

a: Sand absorption system

b: Recirculating sand filter

QS

Septic tank effluent (STE) flow rate (m^3/capita/day). McCray et al. (2005) proposed 0.227 m^3/capita/day as the median value for USA based on the data collected from various sources.

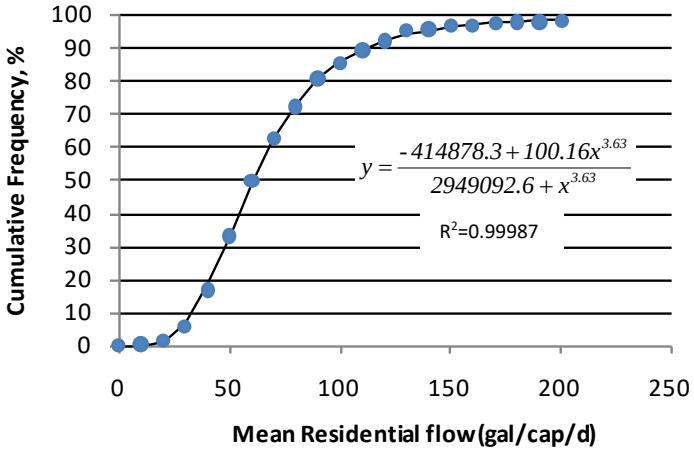


Figure 34.1 Cumulative frequency distribution for residential septic tank effluent flow rate (after McCray et al., 2005)

BODCONCS

7 day Biochemical oxygen demand in STE (mg/L). BOD for a conventional system is typically 170 mg/L. The value varies greatly for different types of septic systems (See Table A-1 of Siegrist et al., 2005).

Required.

TSSCONCS

Total suspended solids in STE (mg/L). TSS for a conventional system is typically 75 mg/L. The value varies greatly for different types of septic systems (See Table A-1 of Siegrist et al., 2005).

Required.

Variable name	Definition
NH4CONCS	Ammonium nitrogen in STE (mg-N/L). NH_4 for a conventional system is typically 60 mg-N/L (ranging 17~78 mg-N/L). The value varies greatly for different types of septic systems (See Table A-1 of Siegrist et al., 2005).

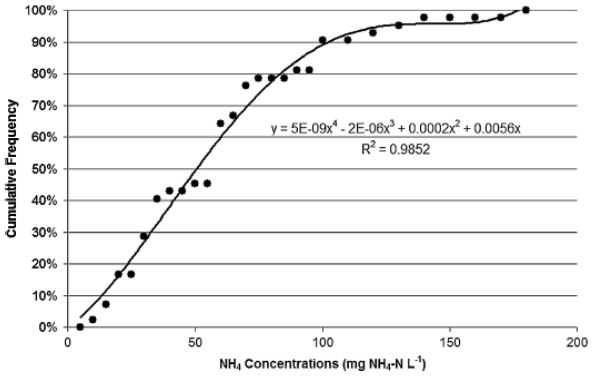


Figure 34.2 Cumulative frequency distribution for ammonium concentration in the septic tank effluent flow rate (after McCray et al., 2005)

Required.

NO3CONCS	Nitrate nitrogen in STE (mg-N/L). NO_3 for a conventional system ranges 0~1.94 mg-N/L. The value varies for different types of septic systems (See Table A-1 of Siegrist et al., 2005).

Required.

NO2CONCS	Nitrite nitrogen in STE (mg-N/L). NO_2 for a conventional system is typically very low.

Required.

ORGNCONCS	Organic nitrogen in STE (mg-N/L). ORGN for a conventional system ranges 9.4~15 mg-N/L.

Required.

Variable name	Definition

MINPS	Concentration of mineral phosphorus in the septic tank effluent (mg/L). Required.
ORGPS	Organic phosphorus in STE (mg-P/L). ORGP for a conventional system is typically 1 mg-p/L. Required.
FCOLIS	Total number of fecal coliform in STE (cfu/100mL). FCOLI for a conventional system is typically 1E7 cfu/100mL. The value varies greatly for different types of septic systems (See Table A-1 of Siegrist et al., 2005). Required.

SNOW.SNO

The SNOW.SNO file contains the input variables for snow. Below is a partial listing of the snow.sno file.

snow.sno								
NAME	FALLTMP	MELTTMP	MELTMX	MELTMN	TIMP	COVMX	COV50	INIT_MM
snow001	1.0	2.0	6.0	3.0	1.0	0.0	0.0	0.0

Variable name	Definition
TITLE	The first line is reserved for user comments. This line is not processed by the model and may be left blank. Optional.
HEADER	Headers for the snow.sno file.
NAME	Name of the snow parameters
FALLTMP	Snowfall temperature (ºC). Mean air temperature at which precipitation is equally likely to be rain as snow/freezing rain. The snowfall temperature should be between –5 ºC and 5 ºC. A default recommended for this variable is SFTMP = 1.0. Required in watersheds where snowfall is significant.
MELTTMP	Snow melt base temperature (ºC). The snow pack will not melt until the snow pack temperature exceeds a threshold value, T_{mlt}. The snow melt base temperature should be between –5 ºC and 5 ºC. A default recommended for this variable is SMTMP = 0.50. Required in watersheds where snowfall is significant.

MELTMX Melt factor for snow on June 21 (mm H_2O/ºC-day).

If the watershed is in the Northern Hemisphere, SMFMX will be the maximum melt factor. If the watershed is in the Southern Hemisphere, SMFMX will be the minimum melt factor. SMFMX and SMFMN allow the rate of snow melt to vary through the year. The variables account for the impact of snow pack density on snow melt.

In rural areas, the melt factor will vary from 1.4 to 6.9 mm H_2O/day-°C (Huber and Dickinson, 1988). In urban areas, values will fall in the higher end of the range due to compression of the snow pack by vehicles, pedestrians, etc. Urban snow melt studies in Sweden (Bengston, 1981; Westerstrom, 1981) reported melt factors ranging from 3.0 to 8.0 mm H_2O/day-°C. Studies of snow melt on asphalt (Westerstrom, 1984) gave melt factors of 1.7 to 6.5 mm H_2O/day-°C.

If no value for SMFMX is entered, the model will set SMFMX = 4.5.

Required in watersheds where snowfall is significant.

Variable name	Definition
MELTMN	Melt factor for snow on December 21 (mm H_2O/ºC-day). If the watershed is in the Northern Hemisphere, SMFMN will be the minimum melt factor. If the watershed is in the Southern Hemisphere, SMFMN will be the maximum melt factor. SMFMX and SMFMN allow the rate of snow melt to vary through the year. The variables account for the impact of snow pack density on snow melt. In rural areas, the melt factor will vary from 1.4 to 6.9 mm H_2O/day-°C (Huber and Dickinson, 1988). In urban areas, values will fall in the higher end of the range due to compression of the snow pack by vehicles, pedestrians, etc. Urban snow melt studies in Sweden (Bengston, 1981; Westerstrom, 1981) reported melt factors ranging from 3.0 to 8.0 mm H_2O/day-°C. Studies of snow melt on asphalt (Westerstrom, 1984) gave melt factors of 1.7 to 6.5 mm H_2O/day-°C. If no value for SMFMN is entered, the model will set SMFMN = 4.5. Required in watersheds where snowfall is significant.
TIMP	Snow pack temperature lag factor. The influence of the previous day's snow pack temperature on the current day's snow pack temperature is controlled by a lagging factor, ℓ_{sno}. The lagging factor inherently accounts for snow pack density, snow pack depth, exposure and other factors affecting snow pack temperature. TIMP can vary between 0.01 and 1.0. As ℓ_{sno} approaches 1.0, the mean air temperature on the current day exerts an increasingly greater influence on the snow pack temperature and the snow pack temperature from the previous day exerts less and less influence. As TIMP goes to zero, the snow pack's temperature will be less influenced by the current day's air temperature. If no value for TIMP is entered, the model will set TIMP = 1.0. Required in watersheds where snowfall is significant.
COVMX	Minimum snow water content (mm H20)
COV50	Fraction of COVMX
INIT_MM	Initial snow water content at start of simulation

OPS– The OPS files contain management operations for fertilizer, pesticide, grazing, harvest, irrigation and sweep.

HARV.OPS

The inputs for grazing are found in the HARV.OPS file. This operation harvests the portion of the plant designated as yield and removes the yield from the HRU, but allows the plant to continue growing. This operation is used for hay cuttings. A sample HARV.OPS file is listed below.

harv.ops				
NAME	TYP	HI_OVR	EFF	BM_MIN
grain	grain	0	0.95	0
grass_mulch	biomass	0.5	0	2000
grass_bag	biomass	0.5	1	2000
silage	biomass	0.9	0.95	0
forest_cut	tree	0.95	0.99	0
stover_high	residue	0.9	1	1000
stover_med	residue	0.6	1	2000
stover_los	residue	0.3	1	3000
hay_cut_high	biomass	0.8	1	3000
hay_cut_low	biomass	0.8	1	1000
potatoes	tuber	1.1	0.95	0
peanuts	tuber	1.1	0.95	0

Variable name	Definition
TITLE	The first line of the file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
HEADER	Headings for variables

NAME	Name of harvest operation
TYP	grain;biomass;residue;tree;tuber;
HI_OVR	Harvest index override ((kg/ha)/(kg/ha)) This variable will force the ratio of yield to total aboveground biomass to the specified value. For grain harvest, the harvest index in the plant growth database (plant.dat) is used that assumes that only the seed is being harvested (HI_OVR is not used in grain harvest). If biomass is cut and removed (for example, in hay cuttings), HIOVR must be used to specify the amount of biomass cut. Optional.
EFF	Harvest efficiency. For grain harvest, the harvest efficiency defines the fraction of yield biomass removed by the harvesting equipment, with the remaining yield lost. For biomass harvest, if HARVEFF is close to zero, the cutting or clipping are left on the ground and if HARVEFF is 1.0, all cut biomass (yield) is removed. If the harvest efficiency is not set or 0.00 is entered, the model assumes the user wants to ignore harvest efficiency and sets the fraction to 1.00 so that the entire yield is removed from the HRU. Optional.
BM_MIN	minimum biomass to allow harvest (kg/ha)

GRAZE.OPS

The inputs for grazing are found in the GRAZE.OPS file. This operation removes plant biomass at a specified rate and allows simultaneous application of manure. A sample GRAZE.OPS file is listed below.

graze.ops						
NAME	FERTNM	DAYS	EAT	TRAMP	MANURE	BIO_MIN
fr_gr	dairy_fr	365	10	5	5	500
fr_congr	dairy_fr	365	10	5	5	4000

Variable name	Definition
TITLE	The first line of the file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
HEADER	Headings for variables

NAME	Name of grazing operation
FERTNM	Name of grazing operation from fertilizer database
EAT	Dry weight of biomass consumed daily ((kg/ha)/day
TRAMP	Dry weight of biomass trampled daily ((kg/ha)/day) Trampling becomes significant as the number of animals grazing per hectare increases. This is a very subjective value which is typically set equal to BIO_EAT, i.e. the animals trample as much as they eat.
MANURE	Dry weight of manure deposited daily ((kg/ha)/day).
BIO_MIN	Minimum plant biomass for grazing (kg/ha)

IRR.OPS

The inputs for irrigation are found in the IRR.OPS file. This operation applies water to the HRU on the specified day. A sample IRR.OPS file is listed below:

irr.ops						
IRR_OP_NAME	IRR_EFF	RQ_RATIO	DEPTH	IRR_SALT	IRR_NO3	IRR_PO4
surface	0.5	0.4	0	0	0	0
sprinkler	0.7	0.1	0	0	0	0
drip	0.9	0	0	0	0	0
subsurface	1	0	150	0	0	0

Variable name	**Definition**
TITLE	The first line of the file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
HEADER	Headings for variables
NAME	Name of irrigation operation
EFF	Irrigation in-field efficiency (0-1).
SURQ	Surface runoff ratio (0-1). (.1 is 10% surface runoff) (fraction)
DEP_MM	Depth of irrigation water applied on HRU (mm). Required.
SALT	Concentration of salt in irrigation (mg/kg). Not currently operational.
NO3	Concentration of nitrate in irrigation (mg/kg)
PO4	Concentration of phosphate in irrigation

CHEM_APP.OPS

The inputs for sweeping operations are found in the CHEM_APP.OPS file. A sample CHEM_APP.OPS file is listed below:

chem_app.ops								
PEST_OP_NAME	FORM	OPERATION	APP_EFF	FOLIAR_EFF	INJECT_DEP	SURF_FRAC	DRIFT_POT	AERIAL_UNIF
broadcast	solid	spread	0.9	0	0	1	0	1
band	solid	spread	0.9	0	0	1	0	0.5
foliar	liquid	spray	0.8	0.7	0	1	0	1
inject	liquid	inject	0.95	0	150	0.2	0	1
aerial_liquid	liquid	spray	0.7	0.7	0	1	0.5	1
aerial_solid	solid	spread	0.9	0	0	1	0.1	1
drill	solid	inject	0.95	0	50	0.05	0	1
side_dress	solid	spread	0.9	0	0	1	0	0.5
fertigate	liquid	spray	0.9	0.5	0	1	0.2	1
basal	liquid	spread	0.9	0	0	1	0	0.1
rope_wick	liquid	direct	1	0.95	0	1	0	1
tree_inject	liquid	inject	0.95	0	300	0	0	0.01

Variable name	Definition
TITLE	The first line of the file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
HEADER	Headings for variables
NAME	Name of chemical application operation
FORM	solid; liquid
OP_TYP	operation type-spread; spray; inject; direct
APP_EFF	application efficiency
FOLIAR_EFF	foliar efficiency
INJECT_DEP	injection depth (mm)
SURF_FRAC	surface fraction-amount in upper 10 mm
DRIFT_POT	drift potential
AERIAL_UNIF	aerial uniformity

FIRE.OPS

The inputs for sweeping operations are found in the FIRE.OPS file. A sample FIRE.OPS file is listed below.

fire.ops		
NAME	CN2_UPD	FRAC_BURN
grass	8	1
tree_intense	8	0.9
tree_low	6	0.7

Variable name	Definition
TITLE	The first line of the file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.

HEADER	Headings for variables
NAME	Name of fire operation
CN2_UPD	change in SCS curve number II value
FR_BURN	fraction burned

SWEEP.OPS

The inputs for sweeping operations are found in the SWEEP.OPS file. A sample SWEEP.OPS file is listed below:

sweep.ops		
SWP_OP_NAME	SWP_EFF	FR_CURB
high_eff	0.8	0.9

Variable name	Definition
TITLE	The first line of the file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
HEADER	Headings for the variables
NAME	Street sweeping operation name
EFF	Removal efficiency of sweeping operation The removal efficiency of street sweeping is a function of the type of sweeper, whether flushing is a part of the street cleaning process, the quantity of total solids, the frequency of rainfall events and the constituents considered. Removal efficiency can vary depending on the constituent being considered, with efficiencies being greater for particulate constituents. The removal efficiencies for nitrogen and phosphorus are typically less than the solid removal efficiency (Pitt, 1979). Because SWAT assumes a set concentration of nutrient constituents in the solids, the same removal efficiency is in effect used for all constituents. Table 20-7 provides removal efficiencies for various street cleaning programs. SWEEPEFF is a fraction that ranges between 0.0 and 1.0. A value of 0.0 indicates that none of the built-up sediments are removed while a value of 1.0 indicates that all of the built-up sediments are removed. Required.
FR_CURB	Fraction of curb length available for sweeping. The availability factor, fr_{av}, is the fraction of the curb length that is sweepable. The entire curb length is often not available for sweeping due to the presence of cars and other obstacles. FR_CURB can range from 0.01 to 1.00. If no value is entered for FR_CURB (FR_CURB left blank or set to 0.0, the model will assume 100% of the curb length is available for sweeping. Required.

LUM – A primary goal of environmental modeling is to assess the impact of human activities on a given system. Central to this assessment is the itemization of the land and water management practices taking place within the system. The primary file used to summarize these practices is the HRU management file (.sch). This file contains input data for planting, harvest, irrigation applications, nutrient applications, pesticide applications, and tillage operations. Information regarding tile drains and urban areas is also stored in this file.

LANDUSE.LUM

Below is a sample LANDUSE.LUM FILE:

landuse.lum:													
NAME	CAL_GROUP	PLANT_COV	MGT_OPS	CN_LU	CONS_PRAC	URB_LU	URB_RO	OVN	TILEDRAIN	SEPTIC	FSTRIP	GRASSWW	BMPUSER
forestmixed	null	frst_mixed	null	wood_f	up_down_slope	null	null	fallow_nores	null	null	null	null	null
pasture	null	pasture	null	pasth	up_down_slope	null	null	fallow_nores	null	null	null	null	null
agriculture	null	corn_soybean	csoy_ai_nt	rc_strowres_p	up_down_slope	null	null	fallow_nores	null	null	null	null	null
urban	null	urban_residential	null	urban	up_down_slope	residen_low_den	buildup_washoff	fallow_nores	null	null	null	null	null
fpbench	null	canary_grass	canary_nomgt	pasth	up_down_slope	null	null	fallow_nores	null	null	null	null	null

Variable name	Definition
TITLE	The first line of the landuse.lum file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
HEADER	Headings for landuse.lum variables
NAME	Name of land use treatments/practice/conditions
CAL_GRP	Calibration group
PLANT_COV	Plant cover from plants.plt
MGT_OPS	Management operation

CN_LU Landuse curve number identifier (from table)

Table 19d-1: Runoff Curve Numbers for Cultivated Agricultural Lands

	COVER	
CN_LU	LANDUSE	TREATMENT/PRACTICE
1	Fallow	Bare soil
2	"	Crop residue cover*
3	"	
4	Row crops Straight row	
5	"	
6	"	Straight row w/residue
7	"	
8	"	Contoured
9	"	
10	"	Contoured w/residue
11	"	
12	"	Contoured & Terraced
13	"	
14	"	Contoured & Terraced w/residue
15	"	
15	Small grains	Straight Row
16	"	
17	"	Straight Row w/residue
18	"	
19	"	Contoured
20	"	
21	"	Contoured w/residue
22	"	
23	"	Contoured & Terraced
24	"	
25	"	Contoured & Terraced w/residue
26	"	

Runoff Curve Numbers for Other Agricultural Lands

	COVER			Hydrologic Soil Group
CN_LU	COVER TYPE	HYDROLOGIC COND	AVERAGE % IMPERVIOUS AREA	

27	Pasture, grassland or range continuous forage for grazing[1]
28	“”
29	“”
30	Meadow-continuous grass, protected from grazing and general mowed for hay
31	Brush—brush-weed-grass mixture with brush the major element[2]
32	“”
33	“”
34	Woods-grass combination (orchard or tree farm)
35	“”
36	“”
37	Woods[3]
38	“”
39	“”
40	Farmsteads-building, lanes, driveways and surrounding lots

* Crop residue cover applies only if residue is on at least 5% of the surface thr
[1] *Poor:* < 50% ground cover or heavily grazed with no mulch; *Fair:* 50 to 75
ground cover and lightly or only occasionally grazed
[1] *Poor:* < 50% ground cover; *Fair:* 50 to 75% ground cover; Good: > 75%
[1] *Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or r
burned, and some forest litter covers the soil; *Good:* Woods are protected fro
soil.

CONS_PRAC	USLE equation support practice (P) factor
URB_LU	Urban land use
URB_RO	Urban simulation runoff code: USGS_REG - simulate using USGS regression equations Build up/wash off – simulate using build up washoff algorithm Most large watersheds and river basins contain areas of urban land use. Estimates of the quantity and quality of runoff in urban areas are required for comprehensive management analysis. SWAT calculates runoff from urban areas with the SCS curve number method or the Green & Ampt equation. Loadings of sediment and nutrients are determined using one of two options. The first is a set of linear regression equations developed by the USGS (Driver and Tasker, 1988) for estimating storm runoff volumes and constituent loads. The other option is to simulate the buildup and washoff mechanisms, similar to SWMM – Storm Water Management Model (Huber and Dickinson, 1988).
OVN	Manning's "n" value for overland flow (points to ovn_table.lum)
TILEDRAIN	Tile drain (points to tiledrain.str)
SEPTIC	Septic tank (points to septic.str)
FSTRIP	Filter strip file (points to filterstrip.str)
GRASSWW	Grassed waterways (points to grassww.str)
BMPUSER	Best management practices (points to bmpuser.str)

MANAGEMENT.SCH

The inputs management operations are found in the MANAGEMENT.SCH file. A sample MANAGEMENT.SCH file is listed below:

management.sch										
NAME	NUM_OPS	OP	MON	DAY	HUSC	OP_DATA	_METHOD	OP_OVER		
csoy_ai_nt	7	1								
		autoirr_str.8								
fert			0	0	0.14	anh-nh3	inject	200		FERTILIZER
plnt			0	0	0.15	corn	null	0		PLANT CORN BEGIN
hvkl			10	30	1.2	corn	grain	0		HARVKILL
skip			0	0	0	null	null	0		SKIP_YEAR
plnt			0	0	0.15	soyb	null	0		PLANT SOYBEANS
hvkl			10	30	1.2	soyb	grain	0		HARVKILL
skip			0	0	0	null	null	0		SKIP_YEAR
canary_nomgt			0	0						

SWAT will simulate different types of management operations. The variables for the different operations will be defined in separate sections. The type of operation simulated is identified by the code given for the variable MGT_OP.

The different codes for MGT_OP are:

PCO	**plant community:** this operation initializes the plant community in the HRU
PLNT	**planting/beginning of growing season:** this operation initializes the growth of a specific land cover/plant type in the HRU
HARV	**harvest only operation:** this operation harvests the portion of the plant designated as yield and removes the yield from the HRU, but allows the plant to continue growing. This operation is used for hay cuttings.
HVKL	**harvest and kill operation:** this operation harvests the portion of the plant designated as yield, removes the yield from the HRU and converts the remaining plant biomass to residue on the soil surface.
TILL	**tillage operation:** this operation mixes the upper soil layers and redistributes the nutrients/chemicals/etc. within those layers
IRRM	**irrigation operation:** this operation applies water to the HRU on the specified day. (IRROPS.DAT)
FERT	**fertilizer application:** this operation adds nutrients to the soil in the HRU on the specified day (FERTOPS.DAT)
PEST	**pesticide application:** this operation applies a pesticide to the plant and/or soil in the HRU on the specified day
GRAZ	**grazing operation:** this operation removes plant biomass at a specified rate and allows simultaneous application of manure.
BURN	**burn operation:** the burn operation records the biomass, residue and phosphorus that is burned.
SWEP	**street sweeping operation:** this operation removes sediment and nutrient build-up on impervious areas in the HRU. This operation can only be used when the urban build up/wash off routines are activated for the HRU (see IURBAN).
SKIP	**skip operation:** this operation skips to the end of the year.

For each year of management operations provided, the operations must be listed in chronological order starting in January.

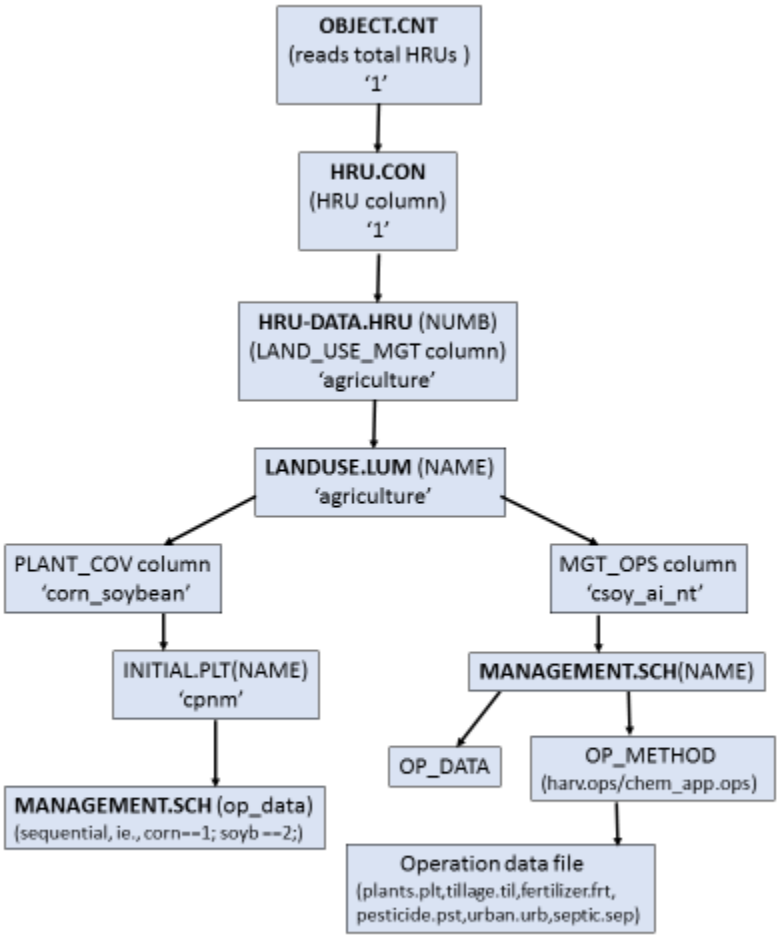
For simulations where a certain amount of crop yield and biomass is required, the user can force the model to meet this amount by setting a harvest index target and a biomass target. These targets are effective only if a harvest and kill operation is used to harvest the crop. Variables are listed below.

Variable name	Definition
TITLE	Title for the management.sch file. Optional (may be blank)
HEADER	Header for the management.sch variables
NAME	Name of the operations
NUM_OPS	Number of operations following
NUM_AUTOS	Number of auto schedule
OP	Management operation name: **pcom** = plant community **plnt** = beginning of growing season **harv** = harvests the portion of the plant designated as yield and removes the yield from the HRU, but allows the plant to continue to grow. **hvkl** = harvests the portion of the plant designated as yield, removes the yield from the HRU and converts the remaining plant biomass to residue on the soil surface. **till** = mixed the upper soil layers and redistributes the nutrients/chemicals, etc within thos layers **irrm** = applies water to the HRU on the specified day **fert** = adds nutrients to the soil in the specified day **pest** = applies a pesticide to the plant and/or soil in the HRU on a specified day **graz** = removes plant biomass at a specified rate and allows simultaneous application of manure **burn** = burning **swep** = removes sediment and nutrient build up on impervious areas in the HRU. This operation can only be used when the urban build up/wash off routines are activated for the HRU (see IURBAN) **skip**
MON	Month operation takes place. Either MONTH/DAY or HUSC is required.
DAY	Day operation takes place. Either MONTH/DAY or HUSC is required.
HUSC	Fraction of total base zero heat units at which operation takes place. Heat unit scheduling is explained in Chapter 5:1 of the Theoretical Documentation. If MONTH and DAY are not provided, HUSC must be set to a value. Either MONTH/DAY or HUSC is required.

OP_CHAR	Operation type character
OP_PLANT	Plant name in community
OP3	Harvest index override

Further explanation of management.sch file:

management.sch					
OP	**OP_DATA from file --->**			**OP_METHOD from file ---->**	
plnt	cots	initial.plt		null	
harv	corn	initial.plt		grain	harv.ops
kill					
hvkl	soyb	initial.plt		grain	harv.ops
till	riprsubs	tillage.til			till.ops
irrm				drip	irr.ops
fert	anh-nh3	fertlizer.frt		broadcast	chem_app.ops
pest	aatrex	pesticide.pst		inject	chem_app.ops
graz					graze.ops
burn					fire.ops
swep					sweep.ops
skip					
mons					
dwm					



OBJECT.CNT FILE

object.cnt: Spatial object counts – (2-stage)

OBJ	HRU	LTE	SUB	MODFL	AQU	CHA	RES	REC	EXCO	DR	CANAL	PUMP	OUT	CHDEG	2DAQU
4	1	0	0	0	0	0	0	1	0	0	0	0	1	1	0

HRU.CON FILE

hru.con (2-stage)

NUMB	NAME	AREA	LAT	LONG	ELEV	**HRU**	WST	CON_TYP	OVERFLOW	RULESET	OUT_TOT
1	bench	0.480	0.000	0.000	0.000	**1**	wea1	0	0	0	0

HRU-DATA.HRU

hru-data.hru: HRU properties – (2-stage)

NUM	NAM	TOPO	HYD	SOIL	**LU_MGT**	SOLN_INI	SURF_STOR	SNOW	FLD	SCH_UPD
1	hru0010104	hru00101	hru0010104	IN025	**agriculture**	IN025	null	snow01	null	null

LANDUSE_LUM: General land use properties (2-stage - partial file)

NAME	CAL_GRP	**PLNT_COV**	**MGT_OPS**	CN_LU	CONS_PRAC
forestmixed	null	frst_mixed	null	wood_f	up_down_slope
pasture	null	pasture	null	pasth	up_down_slope
agriculture	null	**corn_soybean**	**csoy_ai_nt**	rc_strowres_p	up_down_slope
urban	null	urban_residential	null	urban	up_down_slope
fpbench	null	canary_grass	canary_nomgt	pasth	up_down_slope

MANAGEMENT.SCH: Management schedules – (2-stage)

NAME	NUM_OPS	OP	MON	DAY	HUSC	**OP_DATA**	**OP_METHOD**	OP_OVER	
csoy_ai_nt	7	1							
	autoirr_str.8								
		fert	0	0	0.140	anh-nh3	inject	200.	FERTILIZER
		plnt	0	0	0.150	corn	null	0.0	PLNT CORN
		hvkl	10	30	1.200	corn	grain	0.0	HARVKILL
		skip	0	0	0.000	null	null	0.0	SKIP_YEAR
		plnt	0	0	0.150	soyb	null	0.0	PLNT SOYB
		hvkl	10	30	1.200	soyb	grain	0.0	HARVKILL
		skip	0	0	0.000	null	null	0.0	SKIP_YEAR
canary_nomgt	0	0							

CNTABLE.LUM

The SCS curve number is a function of the soil's permeability, land use and antecedent soil water conditions. Typical curve numbers for moisture condition II are listed in the following tables for various land covers and soil types (SCS Engineering Division, 1986). These values are appropriate for a 5% slope.

The curve number may be updated in plant, tillage, and harvest/ kill operations. If CNOP is never defined for these operations, the value set for CN2 will be used throughout the simulation. If CNOP is defined for an operation, the value for CN2 is used until the time of the operation containing the first CNOP value. From that point on, the model only uses operation CNOP values to define the curve number for moisture condition II. Values for CN2 and CNOP should be entered for pervious conditions. In HRUs with urban areas, the model will adjust the curve number to reflect the impact of the impervious areas.

Below is the CNTABLE.LUM FILE:

cntable.lum							
LANDUSE	CN_A	CN_B	CN_C	CN_D	LANDUSE_DESCRIPTION	TREATMENT	CONDITIO
fal_bare	77	86	91	94	Fallow	Bare_soil	----
fal_res_p	76	85	90	93	Fallow	Crop_residue_cover	Poor
fal_res_g	74	83	88	90	Fallow	Crop_residue_cover	Good
rc_strow_p	72	81	88	91	Row_crops	Straight_row	Poor
rc_strow_g	67	78	85	89	Row_crops	Straight_row	Good
rc_strowres_p	71	80	87	90	Row_crops	Straight_row_w_residue	Poor
rc_strowres_g	64	75	82	85	Row_crops	Straight_row_w_residue	Good
rc_cont_p	70	79	84	88	Row_crops	Contoured	Poor
rc_cont_g	65	75	82	86	Row_crops	Contoured	Good
rc_contres_p	69	78	83	87	Row_crops	Contoured_w_residue	Poor
rc_contres_g	64	74	81	85	Row_crops	Contoured_w_residue	Good
rc_contter_p	66	74	80	82	Row_crops	Contoured_&_terraced	Poor
rc_contter_g	62	71	78	81	Row_crops	Contoured_&_terraced	Good
rc_conterres_p	65	73	79	81	Row_crops	Contoured_&_terraced_w_residue	Poor
rc_conterres_g	61	70	77	80	Row_crops	Contoured_&_terraced_w_residue	Good
sg_strow_p	65	76	84	88	Small_grains	Straight_row	Poor
sg_strow_g	63	75	83	87	Small_grains	Straight_row	Good
sg_strowres_p	64	75	83	86	Small_grains	Straight_row_w_residue	Poor
sg_strowres_g	60	72	80	84	Small_grains	Straight_row_w_residue	Good
sg_cont_p	63	74	82	85	Small_grains	Contoured	Poor
sg_cont_g	61	73	81	84	Small_grains	Contoured	Good
sg_contres_p	62	73	81	84	Small_grains	Contoured_w_residue	Poor
sg_contres_g	60	72	80	83	Small_grains	Contoured_w_residue	Good
sg_contter_p	61	72	79	82	Small_grains	Contoured_&_terraced	Poor
sg_contter_g	59	70	78	81	Small_grains	Contoured_&_terraced	Good
sg_conterres_p	60	71	78	81	Small_grains	Contoured_&_terraced_w_residue	Poor
sg_conterres_g	58	69	77	80	Small_grains	Contoured_&_terraced_w_residue	Good
legr_strow_p	66	77	85	89	Close-seeded_or_broadcast_legumes_or_rotation	Straight_row	Poor
legr_strow_g	58	72	81	85	Close-seeded_or_broadcast_legumes_or_rotation	Straight_row	Good
legr_cont_p	64	75	83	85	Close-seeded_or_broadcast_legumes_or_rotation	Contoured	Poor
legr_cont_g	55	69	78	83	Close-seeded_or_broadcast_legumes_or_rotation	Contoured	Good
legr_contter_p	63	73	80	83	Close-seeded_or_broadcast_legumes_or_rotation	Contoured_&_terraced	Poor
legr_contter_g	51	67	76	80	Close-seeded_or_broadcast_legumes_or_rotation	Contoured_&_terraced	Good
pastg_p	68	79	86	89	Pasture_grassland_or_range-continuous_forage_for_grazing	----	Poor
pastg_f	49	69	79	84	Pasture_grassland_or_range-continuous_forage_for_grazing	----	Fair
pastg_g	39	61	74	80	Pasture_grassland_or_range-continuous_forage_for_grazing	----	Good
pasth	30	58	71	78	Meadow-continuous_grass_protected_from_grazing_mowed_for_hay	----	----
brush_p	48	67	77	83	Brush-brush-weed-grass_mixture_with_brush_the_major_element	----	Poor
brush_f	35	56	70	77	Brush-brush-weed-grass_mixture_with_brush_the_major_element	----	Fair
brush_g	30	48	65	73	Brush-brush-weed-grass_mixture_with_brush_the_major_element	----	Good
woodgr_p	57	73	82	86	Woods-grass_combination_(orchard_or_tree_farm)	----	Poor
woodgr_f	43	65	76	82	Woods-grass_combination_(orchard_or_tree_farm)	----	Fair
woodgr_g	32	58	72	79	Woods-grass_combination_(orchard_or_tree_farm)	----	Good
wood_p	45	66	77	83	Woods	----	Poor
wood_f	36	60	73	79	Woods	----	Fair
wood_g	30	55	70	77	Woods	----	Good
farm	59	74	82	86	Farmsteads-buildings_lanes_driveways_and_surrounding_lots	----	----
open_p	68	79	86	89	Open_spaces_(lawns_parks_golfcourses_cemeteries_etc.)	----	Poor
urban	98	98	98	98	Paved_parking_lots_roofs_driveways_etc_(excl_right-of-way)	----	----
paveroad	83	89	92	93	Paved_streets_and_roads;_open_ditches_(incl._right-of-way)	----	----
gravroad	76	85	89	91	Gravel_streets_and_roads_(including_right-of-way)	----	----
dirtroad	72	82	87	89	Dirt_streets_and_roads_(including_right-of-way)	----	----

Variable name	Definition
TITLE	The first line of the cntable.lum file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
HEADER	Headings for cntable.lum variables
NAME	Name of land use treatments/practice/conditions
CNA	Land use curve number A
CNB	Land use curve number B
CNC	Land use curve number C
CND	Land use curve number D
	Land use description follows (not read by model)

CONS_PRACTICE.LUM

Below is a sample CONS_PRACTICE.LUM FILE:

cons_practice.lum				
NAME	P_FACTOR	OPE_LEN_MAX		DESCRIPTION
up_down_slope	1	121		Up_and_down_slope
cross_slope	0.75	121		Cross_slope_tillage
contour_farming	0.5	121		Contour_tillage
strip_cros_slope	0.37	121		Strip_cropping_cross_slope
strip_contour	0.25	121		Strip_cropping_contour
contour_1-2	0.3	121		Contour_tillage_1-2%_slopes
contour_3-5	0.5	91		Contour_tillage_3-5%_slopes
contour_6-8	0.5	61		Contour_tillage_6-8%_slopes
contour_9-12	0.6	36		Contour_tillage_9-12%_slopes
contour_13-16	0.7	24		Contour_tillage_13-16%_slopes
contour_17-20	0.8	18		Contour_tillage_17-20%_slopes
contour_21-25	0.9	15		Contour_tillage_21-25%_slopes
strip_1-2_past	0.3	244		Strip_cropping_1-2%_slopes_with-pasture
strip_1-2_row	0.6	244		Strip_cropping_1-2$_slopes_with-rowcrops
strip_3-5_past	0.25	183		Strip_cropping_3-5%_slopes_with-pasture
strip_3-5_row	0.5	183		Strip_cropping_3-5%_slopes_with-rowcrops
strip_6-8_past	0.25	122		Strip_cropping_6-8%_slopes_with-pasture
strip_6-8_row	0.5	122		Strip_cropping_6-8%_slopes_with-rowcrops
strip_9-12_past	0.3	73		Strip_cropping_9-12%_slopes_with-pasture
strip_9-12_row	0.6	73		Strip_cropping_9-12%_slopes_with-rowcrops
strip_13-16_past	0.35	49		Strip_cropping_13-16%_slopes_with-pasture
strip_13-16_row	0.7	49		Strip_cropping_13-16%_slopes_with-rowcrops
strip17-20_past	0.4	36		Strip_cropping_17-20%_slopes_with-pasture
strip_17-20_row	0.8	36		Strip_cropping_17-20%_slopes_with-rowcrops
strip_21-25_past	0.45	30		Strip_cropping_21-25%_slopes_with-pasture
strip_21-25_row	0.9	30		Strip_cropping_21-25%_slopes_with-rowcrops
ter_1-2_sodout	0.12	121		terraces_1-2%_slopes_sod-outlet
ter_1-2_undout	0.05	121		terraces_1-2%_slopes_underflow-outlet
ter_3-8_sodout	0.5	76		terraces_3-8%_slopes_sod-outlet
ter_3-8_undout	0.25	76		terraces_3-8%_slopes_underflow--outlet
ter_9-12_sodout	0.6	61		terraces_9-12%_slopes_sod-outlet
ter_9-12_undout	0.3	61		terraces_9-12%_slopes_underflow--outlet
ter_13-16_sodout	0.7	45		terraces_13-16%_slopes_sod-outlet
ter_13-16_undout	0.35	45		terraces_13-16%_slopes_underflow--outlet
ter_17-20_sodout	0.8	45		terraces_17-20%_slopes_sod-outlet
ter_17-20_undout	0.4	45		terraces_17-20%_slopes_underflow--outlet
ter_21-25_sodout	0.9	30		terraces_21-25%_slopes_sod-outlet
ter_21-25_undout	0.45	30		terraces_21-25%_slopes_underflow--outlet

Variable name	Definition
TITLE	The first line of the cons_practice.lum file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
HEADER	Headings for cons_practice.lum variables
NAME	Name of conservation practice
PFAC	Usle P factor
SL_LEN_MX	Maximum slope length (m)

OVN_TABLE.LUM

Below is a sample OVN_TABLE.LUM FILE:

ovn_table.lum:					
OVN_ID	MANN_N	MIN	MAX		DESCRIPTION
fallow_nores	0.01	0.008	0.012		Fallow_no_residue
convtill_nores	0.09	0.06	0.12		Conventional_tillage_no_residue
convtill_res	0.19	0.16	0.22		Conventional_tillage_residue
chisplow_nores	0.09	0.06	0.12		Chisel_plow_no_residue
chisplow_res	0.13	0.1	0.16		Chisel_plow_residue
falldisk_res	0.4	0.3	0.5		Fall_disking_residue
notill_nores	0.07	0.04	0.1		No_till_no_residue
notill_0.5-1res	0.12	0.07	0.17		No_till_0.5-1_t/ha_residue
notill_2-9res	0.3	0.17	0.47		No_till_2-9_t/ha_residue
range_sparse	0.13	0.13	0.13		Rangeland_sparse_cover
range_20cover	0.6	0.6	0.6		Rangeland_20%_cover
shortgrass	0.15	0.1	0.2		Short_grass_prairie
densegrass	0.24	0.17	0.3		Dense_grass
bermudagrass	0.41	0.3	0.48		Bermudagrass
forest_light	0.4	0.3	0.5		Forest_light_fair
forest_med	0.6	0.5	0.7		Forest_medimum_good
forest_heavy	0.8	0.7	0.9		Forest_heavy
urban_asphalt	0.11	0.11	0.11		Urban_asphalt
urban_concrete	0.012	0.012	0.012		Urban_concrete
urban_rubble	0.024	0.024	0.024		Urban_rubble

Variable name	Definition
TITLE	The first line of the ovn_table.lum file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
HEADER	Headings for ovn_table.lum variables
NAME	Name of conservation practice
OVN	Overland flow mannings n – mean
OVN_MIN	Overland flow mannings n – min
OVN_MAX	Overland flow mannings n - max

CHG – The change section includes the files for soft calibration simulation runs in SWAT+.

CODES.CAL

The CODES.CAL file contains the input variables for the characteristics of the calibration update properties. Below is a sample CODES.CAL file:

codes.cal							
HYD_HRU	HYD_HRULTE	PLT	SED	NUT	CHSED	CHNUT	RES
y	n	n	n	n	n	n	n

Variable name	Definition
TITLE	The first line of the codes.cal file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
HEADER	Headings for codes.cal variables
HYD_HRU	if y, calibrate hydrologic balance for hru by land use in each region
HYD_HRU1	if y, calibrate hydrologic balance for hru_lte by land use in each region
PLT	if y, calibrate plant growth by land use (by plant) in each region
SED	if y, calibrate sediment yield by land use in each region
NUT	if y, calibrate nutrient balance by land use in each region
CHSED	if y, calibrate channel widening and bank accretion by stream order
CHNUT	if y, calibrate channel nutrient balance by stream order
RES	if y, calibrate reservoir budgets by reservoir

CAL_PARMS.CAL

The CAL_PARMS.CAL file contains the input variables for the characteristics of the calibration update properties. Below is a sample CAL_PARMS.CAL file:

cal_parms.upd				
187				
NAME	OBJ_TYP	ABSMIN	ABSMAX	UNITS
cn2	hru	25	98	null
usle_p	hru	0	1	null
ovn	hru	0.01	30	null
elev	hru	0	5000	m
slope	hru	0	1	m/m
slope_len	hru	10	150	m
lat_ttime	hru	0	180	days
lat_sed	hru	0	5000	g/L
lat_len	hru	0	150	m

Variable name	Definition
TITLE	The first line of the cal_parms.cal file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
MCHG_PAR	Maximum number of calibration parm changes
HEADER	Headings for cal_parms.cal variables
NAME	cn2, esco, awc, etc.
OB_TYP	object type the parameter is associated with (hru, chan, res, basin, etc)
ABSMIN	minimum range for variable
ABSMAX	maximum change for variable
UNITS	units used for each parameter

CALIBRATION.CAL

The CALIBRATION.CAL file contains the input variables for the characteristics of the calibration update properties. Below is a sample CALIBRATION.CAL file:

calibratio												
8												
NAME	CHG_TYPE	VAL	CONDS	LYR1	LYR2	YEAR1	YEAR2	DAY1	DAY2	NUM_TOT		
k	pctchg	25	0	1	1	0	0	0	0	0		
k	pctchg	20	0	1	2	0	0	0	0	0		
k	pctchg	20	0	4	6	0	0	0	0	0		
k	pctchg	27	0	0	0	0	0	0	0	0		
k	pctchg	25	1	1	2	0	0	0	0	0		
hsg	=	0	D									
k	pctchg	25	1	1	1	0	0	0	0	0		
texture	=	0	fsl									
k	pctchg	25	2	1	1	0	0	0	0	0		
texture	=	0	fsl									
landuse	=	0	past									
k	pctchg	25	2	1	1	0	0	0	0	6	1 -3 4 -8 12 -18	
texture	=	0	FSL									
landuse	=	0	past									

Variable name	Definition
TITLE	The first line of the calibration.cal file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
MCAL	Total number of calibration updates in the file
NAME	Name of SWAT+ variable (NAME column from cal_parms.upd file)
CHG_TYPE	Type of change (‘absval’, ‘abschg’, ‘pctchg’)
VAL	Value of change
CONDS	Number of conditions in following lines
LYR1	First layer in range for soil variables (input == 0 assumes all layers)
LYR2	Last layer in range for soil variables
YEAR1	First year of update (for precip and temp)
YEAR2	Last year of update (for precip and temp)
DAY1	First day in range (for precip and temp)
DAY2	Last day in range (for precip and temp)
NUM_TOT	Total number of objects to follow
ELEM_CNT1	Number of elements modified

LS_PARMS.CAL

The LS_PARMS.CAL file contains the input variables for the characteristics of the calibration parameter properties. Below is a sample LS_PARMS.CAL file:

ls_parms.cal					
10					
NAME	CHG_TYP	NEG	POS	LO	UP
cn2	abschg	-8	8	0	0
esco	absval	0	1	0	0
k	pctchg	-30	30	0	0
k_lo	pctchg	-99	30	0	0
slope	pctchg	-25	25	0	0
tconc	pctchg	-30	30	0	0
etco	absval	0.8	1.2	0	0
perco	absval	-0.99	10	0	0
revapc	absval	0	0.4	0	0
cn3_swf	abschg	0	1	0	0

Variable name	Definition
TITLE	The first line of the ls_parms.cal file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
MLSP	Total number of parameter updates in the file
NAME	Name of SWAT+ variable (NAME column from cal_parms.upd file)
CHG_TYPE	Type of change (‘absval’, ‘abschg’, ‘pctchg’)
NEG	Negative limit of change
POS	Positive limit of change
LO	Lower limit of parameter
UP	Upper limit of parameter

LS_REGIONS.CAL

The LS_REGIONS.CAL file contains the input variables for the characteristics of land use regions parameter properties for HRUs. Below is a sample LS_REGIONS.CAL file:

ls_regions.cal								
1								
NAME	LUM_NUM	NPSU	ELEM_CNT					
region_1	15	0						
NAME	SRR	ETR	TFR	SED	ORGN	ORGP	NO3	SOLP
landuse001	0.1	0.7	0	3	0	0	0	0
landuse002	0.1	0.7	0	3	0	0	0	0
landuse003	0.1	0.7	0	3	0	0	0	0
landuse004	0.1	0.7	0	3	0	0	0	0
landuse005	0.1	0.7	0	3	0	0	0	0
landuse006	0.1	0.7	0	3	0	0	0	0
corn_noprac	0.15	0.7	0	3	0	0	0	0
corn_conprac	0.15	0.7	0	3	0	0	0	0
oats_noprac	0.15	0.7	0	3	0	0	0	0
oats_conprac	0.1	0.7	0	3	0	0	0	0
past_noprac	0.1	0.7	0	3	0	0	0	0
past_conprac	0.1	0.7	0	3	0	0	0	0
forest_graze	0.1	0.7	0	3	0	0	0	0
forest_congraze	0.1	0.7	0	3	0	0	0	0
farmstead	0.15	0.7	0	3	0	0	0	0

Variable name	Definition
TITLE	The first line of the ls_regions.cal file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
MLSCAL	Total number of regions updates in the file
NAME	Regions calibration name
LUM_NUM	Total number of land use regions in following lines
NUM_REG	The number of elements in following lines
REG	Elements count
NAME2	Name of the land use management regions
SRR	Surface runoff ratio – surface runoff/precip
LFR	Lateral flow ratio – soil lat flow/precip
PCR	Percolation ratio – perc/precip
ETR	ET ratio – ET/precip
TFR	Tile flow ratio – tile flow/total runoff
SED	Sediment yield (t/ha or t)
ORGN	Organic N yield (kg/ha or kg)
ORGP	Organic P yield (kg/ha or kg)
NO3	Nitrate yield (kg/ha or kg)
SOLP	Soluble P yield (kg/ha or kg)

CH_ORDERS.CAL

The CH_ORDERS.CAL file contains the input variables for the characteristics of channel orders parameter properties for
SWAT HRUs. Below is a sample CH_ORDERS.CAL file:

chan_orders.cal				
1				
NAME	ORD_NUM	NPSU	ELEM_CNT	
region_1	8	0		
	ORDER	CHW	CHD	FPD
	gully	100	100	0.0
	tributary	25	10	0.0
	main_upper_c	10	10	0.0
	main_lower_c	5	5	0.0
	gully_c	0	0	0.0
	tributary_c	1	1	0.0
	main_upper_c	1	1	0.0
	main_lower_c	0.58	0	0.0

Variable name	Definition
TITLE	The first line of the chn_orders.cal file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
MREG	Total number of stream order updates in the file
NAME	Regions calibration name
ORD_NUM	Total number of stream orders in following lines
NSPU	The number of elements in following lines
ELEM_CNT	
NAME2	Order name
CHW	Channel widening (mm/yr)
CHD	Channel down cutting or accretion (mm/yr)
HC	Head Cut advance (m/yr)
FPD	Flood plain accretion (mm/yr)

CH_PARMS.CAL

The CH_PARMS.CAL file contains the input variables for the characteristics of land use parameter properties for SWAT HRUs. Below is a sample CH_PARMS.CAL file:

Variable name	Definition
TITLE	The first line of the chan_parms.cal file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
MCHP	Total number of stream order updates in the file
HEADER	Heading
NAME	Regions calibration name
CH_TYP	Type of change (‘absval’, ‘abschg’, ‘pctchg’)
NEG	Negative limit of change
POS	Positive limit of change
LO	Lower limit of parameter
UP	Upper limit of parameter

INIT – The initial files includes initialization data for pesticide and plants.

PLANT.INI

The PLANT.INI file contains the input variables for the characteristics of the plant community properties. Below is a sample PLANT.INI file:

plant.ini									
NAME	LANTS_COM	CPNM	IGRO	LAI	BIOMS	PHUACC	POP	YRMAT	RSDIN
frst_mixed	1								
		frst	y	0	0	0	0	0	10000
pasture	1	1							
		past	n	0	0	0	0	0	3000
agriculture_land_gen	1	1							
		agrl	n	0	0	0	0	0	1000
urban_residential	1	1							
		berm	n	0	0	0	0	0	3000
corn_soybean	2	2							
		corn	n	0	0	0	0	0	2000
		soyb	n	0	0	0	0	0	2000
ryegrass	1	1							
		ryeg	y	0	500	0	0	0	2000
canary_grass	1	1							
		cana	y	0	500	0	0	0	2000

Variable name	Definition
TITLE	The first line of the file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
HEADER	Headings for the variables
NAME	Name of plant community
NUMB	Number of plants in this community
NAME2	Name of plant in this community
PLANTS_COM	Number of plants in the community
CPNM	Plant name (from plants.plt database file) A four character code to represent the land cover/plant name. The 4-letter codes in the plant growth and urban databases are used by the GIS interfaces to link land use/land cover maps to SWAT plant types. This code is printed to the output files. When adding a new plant species or land cover category, the four letter code for the new plant must be unique. Required.
GRO	Land cover status code (character) This code informs the model whether or not a land cover is growing at the beginning of the simulation. 'n' = no land cover growing 'y' = land cover growing Required.

LAI	Initial leaf area index. If a land cover is growing at the beginning of the simulation (IGRO = 1), the leaf area index of the land cover must be defined. Required if IGRO = 1.
BIOMS	Initial dry weight biomass (kg/ha). If a land cover is growing at the beginning of the simulation (IGRO = 1), the initial biomass must be defined. Required if IGRO = 1.
PHUACC	Total number of heat units or growing degree days needed to bring plant to maturity. This value is needed only if a land cover is growing at the beginning of the simulation (IGRO = 1). Calculation of PHU_PLT is reviewed in Chapter 5:1 of the Theoretical Documentation. Required if IGRO = 1.
POP	Plant population
YRMAT	Years to maturity
RSDIN	Initial residue cover (kg/ha)

SOIL_PLANT.INI

The SOIL_PLANT.INI file contains the input variables for the characteristics of the pesticide properties. Below is a sample SOIL_PLANT.INI file:

soil_plant.ini						
NAME	SW_FRAC	NUTRIENT	PESTICIDES	PATHOGENS	HEAVY_METALS	SALTS
no_init	0.2	in25	no_ini	no_ini	null	null
low_init	0.7	in25	low_ini	low_ini	null	null

PEST_SOIL.INI (NEED ADDRESSING)

The PEST_SOIL.INI file contains the input variables for the characteristics of the pesticide properties. Below is a sample PEST_SOIL.INI file:

TITLE	The first line of the initial.pst file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
HEADER	Heading of file
NAME	Name of pesticide in community
NUM	Number of pesticides in community
EXCO_DF	Name of export coefficient file for pesticide community
DR_DF	Name of delivery ratio file for pesticide community
NAME2	Name in pesticide community
PLT	Amount of pesticide on plant at start of simulation (kg/ha)
SOIL	Amount of pesticide in soil at start of simulation (kg/ha)
ENR	Pesticide enrichment ratio

PEST_WATER.INI

Variable name	Definition
TITLE	The first line of the file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
HEADER	Headings for the variables

PATH_SOIL.INI (NEEDS UPDATING)

Variable name	Definition
TITLE	The first line is reserved for user comments. This line is not processed by the model and may be left blank. Optional.
MBAC_DB	
HEADER	Headings for the initial.bac file
NUM	Total number of initial bacteria in file
NUM_DB	Number of bacteria to follow
PLT	Bacteria on plants at beginning of simulation (#cfu/m^2)
SOL	Soluble bacteria in soil at beginning of simulation (#cfu/m^2)
SOR	Sorbed bacteria in soil at beginning of simulation (#cfu/m^2)

PATH_WATER.INI

Variable name	Definition
TITLE	The first line of the file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
HEADER	Headings for the variables

HMET_SOIL.INI

Variable name	Definition
TITLE	The first line of the file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
HEADER	Headings for the variables

SALT_SOIL.INI

Variable name	Definition
TITLE	The first line of the file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
HEADER	Headings for the variables

SALT_WATER.INI

Variable name	Definition
TITLE	The first line of the file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
HEADER	Headings for the variables

SOILS – The soils data used by SWAT+ can be divided into two groups, physical characteristics and chemical characteristics. The physical properties of the soil govern the movement of water and air through the profile and have a major impact on the cycling of water within the HRU. Inputs for chemical characteristics are used to set initial levels of the different chemicals in the soil. While the physical properties are required, information on chemical properties is optional. The soil input (.sol) file defines the physical properties for all layers in the soil.

SOILS.SOL

The SOILS.SOL file contains the input variables for the characteristics of the soil properties. Below is a partial sample SOILS.SOL file (four layer soil):

soils.sol																				
SNAM	NLY	HYD_GRP	ZMX	ANION_EX	CRK	TEXTURE	DEPTH	BD	AWC	K	CBN	CLAY	SILT	SAND	ROCK	ALB	USLE_K	EC	CAL	PH
IN025	4	B	1524	0.5	0.5	sandy-loam														
							355.6	1.6	0.13	83	1.74	15	19.09	65.91	1.52	0.01	0.2	0	0	0
							812.8	1.7	0.1	65	0.35	12.5	19.65	67.85	1.62	0.12	0.2	0	0	0
							1219.2	1.8	0.07	180	0.15	7.5	9.02	83.48	1.71	0.17	0.15	0	0	0
							1524	1.8	0.04	300	0.05	6	1.88	92.11	1.71	0.21	0.15	0	0	0

TITLE	The first line of the .sol file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
HEADER	
SNAM	Soil name
NLY	Number of layers in the soil
HYDGRP	Soil hydrologic group (A, B, C, or D). Required only for the SWAT ArcView interface. The U.S. Natural Resource Conservation Service (NRCS) classifies soils into four hydrologic groups based on infiltration characteristics of the soils. NRCS Soil Survey Staff (1996) defines a hydrologic group as a group of soils having similar runoff potential under similar storm and cover conditions. Soil properties that influence runoff potential are those that impact the minimum rate of infiltration for a bare soil after prolonged wetting and when not frozen. These properties are depth to seasonally high water table, saturated hydraulic conductivity, and depth to a very slowly permeable layer. The definitions for the different classes are: A Soils having high infiltration rates even when thoroughly wetted, consisting chiefly of sands or gravel that are deep and well to excessively drained. These soils have a high rate of water transmission (low runoff potential). B Soils having moderate infiltration rates when thoroughly wetted, chiefly moderately deep to deep, moderately well to well drained, with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

Variable name	Definition
HYDGRP, cont.	C Soils having slow infiltration rates when thoroughly wetted, chiefly with a layer that impedes the downward movement of water or of moderately fine to fine texture and a slow infiltration rate. These soils have a slow rate of water transmission (high runoff potential).
	D Soils having very slow infiltration rates when thoroughly wetted, chiefly clay soils with a high swelling potential; soils with a high permanent water table; soils with a clay pan or clay layer at or near the surface; and shallow soils over nearly impervious materials. These soils have a very slow rate of water transmission.

Guidelines used by USDA Soil Survey to categorize soils into Hydrologic Groups are summarized in Table 22-1.

Table 22-1: Hydrologic Group Rating Criteria

	Hydrologic Soil Groups			
Criteria*	**A**	**B**	**C**	**D**
Final constant infiltration rate (mm/hr)	7.6-11.4	3.8-7.6	1.3-3.8	0-1.3
Mean permeability: surface layer (mm/hr)	> 254.0	84.0-254.0	8.4-84.0	< 8.4
Mean permeability: most restrictive layer below the surface layer to a depth of 1.0 m (mm/hr)	> 254.0	84.0-254.0	8.4-84.0	< 8.4
Shrink-swell potential: most restrictive layer**	Low	Low	Moderate	High, Very High
Depth to bedrock or cemented pan (mm)	> 1016	> 508	> 508	< 508
DUAL HYDROLOGIC GROUPS	**A/D**	**B/D**	**C/D**	
Mean depth to water table (m)	< 0.61	< 0.61	< 0.61	

* These criteria are guidelines only. They are based on the theory that the minimum permeability occurs within the uppermost 50 cm. If the minimum permeability occurs between a depth of 50 to 100 cm, then the Hydrologic Soil Group is increased one group. For example, C to B. If the minimum permeability occurs below a depth of 100 cm, the Hydrologic Soil Group is based on the permeability above 100 cm, using the rules previously given.

** Shrink-swell potential is assigned to a profile using the following guidelines:

Low: All soils with sand, loamy sand, sandy loam, loam or silt loam horizons that are at least 50 cm thick from the surface without a clay horizon within 100 cm of the surface.

Medium: All soils with clay loam horizons within 50 cm of the surface or soils with clay horizons from 50 to 100 cm beneath the surface.

High: All soils with clay horizons within 50 cm of the surface. Lower the shrink-swell potential one class when kaolinite clay is dominant.

Variable name	Definition
ZMX	Maximum rooting depth of soil profile (mm). If no depth is specified, the model assumes the roots can develop throughout the entire depth of the soil profile.
ANION_EXCL	Fraction of porosity (void space) from which anions are excluded. Most soil minerals are negatively charged at normal pH and the net interaction with anions such as nitrate is a repulsion from particle surfaces. This repulsion is termed negative adsorption or anion exclusion. Anions are excluded from the area immediately adjacent to mineral surfaces due to preferential attraction of cations to these sites. This process has a direct impact on the transport of anions through the soil for it effectively excludes anions from the slowest moving portion of the soil water volume found closest to the charged particle surfaces (Jury et al, 1991). In effect, the net pathway of the anion through the soil is shorter than it would be if all the soil water had to be used (Thomas and McMahon, 1972). If no value for ANION_EXCL is entered, the model will set ANION_EXCL = 0.50.

CRK	Potential or maximum crack volume of the soil profile expressed as a fraction of the total soil volume. To accurately predict surface runoff and infiltration in areas dominated by Vertisols, the temporal change in soil volume must be quantified. Bronswijk (1989, 1990) outlines methods used to determine the maximum crack volume.
TEXTURE	Texture of soil layer (string): sand; loamy_sand; loam; silt_loam; silt; silty_clay; clay_loam; sandy_clay_loam; sandy_clay This data is not processed by the model and the line may be left blank.
Z(layer #)	Depth from soil surface to bottom of layer (mm).
BD(layer #)	Moist bulk density (Mg/m^3 or g/cm^3). The soil bulk density expresses the ratio of the mass of solid particles to the total volume of the soil, $\rho_b = M_S / V_T$. In moist bulk density determinations, the mass of the soil is the oven dry weight and the total volume of the soil is determined when the soil is at or near field capacity. Bulk density values should fall between 1.1 and 1.9 Mg/m^3.
AWC(layer #)	Available water capacity of the soil layer (mm H_2O/mm soil). The plant available water, also referred to as the available water capacity, is calculated by subtracting the fraction of water present at permanent wilting point from that present at field capacity, $AWC = FC - WP$ where AWC is the plant available water content, FC is the water content at field capacity, and WP is the water content at permanent wilting point. Available water capacity is estimated by determining the amount of water released between in situ field capacity (the soil water content at soil matric potential of -0.033 MPa) and the permanent wilting point (the soil water content at soil matric potential of -1.5 MPa).
K(layer #)	Saturated hydraulic conductivity (mm/hr). The saturated hydraulic conductivity, K_{sat}, relates soil water flow rate (flux density) to the hydraulic gradient and is a measure of the ease of water movement through the soil. K_{sat} is the reciprocal of the resistance of the soil matrix to water flow.
CBN(layer #)	Organic carbon content (% soil weight). When defining by soil weight, the soil is the portion of the sample that passes through a 2 mm sieve.

CLAY(layer #)	Clay content (% soil weight). The percent of soil particles which are < 0.002 mm in equivalent diameter.
SILT(layer #)	Silt content (% soil weight). The percentage of soil particles which have an equivalent diameter between 0.05 and 0.002 mm.
SAND(layer #)	Sand content (% soil weight). The percentage of soil particles which have a diameter between 2.0 and 0.05 mm.
ROCK(layer #)	Rock fragment content (% total weight). The percent of the sample which has a particle diameter > 2 mm, i.e. the percent of the sample which does not pass through a 2 mm sieve.
ALB(top layer)	Moist soil albedo. The ratio of the amount of solar radiation reflected by a body to the amount incident upon it, expressed as a fraction. The value for albedo should be reported when the soil is at or near field capacity.
USLE_K(top layer)	USLE equation soil erodibility (K) factor (units: 0.013 (metric ton m2 hr)/(m3-metric ton cm)). Some soils erode more easily than others even when all other factors are the same. This difference is termed soil erodibility and is caused by the properties of the soil itself. Wischmeier and Smith (1978) define the soil erodibility factor as the soil loss rate per erosion index unit for a specified soil as measured on a unit plot. A unit plot is 22.1-m (72.6-ft) long, with a uniform length-wise slope of

Variable name	Definition
USLE_K, cont.	9-percent, in continuous fallow, tilled up and down the slope. Continuous fallow is defined as land that has been tilled and kept free of vegetation for more than 2 years. The units for the USLE soil erodibility factor in MUSLE are numerically equivalent to the traditional English units of 0.01 (ton acre hr)/(acre ft-ton inch). Wischmeier and Smith (1978) noted that a soil type usually becomes less erodible with decrease in silt fraction, regardless of whether the corresponding increase is in the sand fraction or clay fraction. Direct measurement of the erodibility factor is time consuming and costly. Wischmeier et al. (1971) developed a general equation to calculate the soil erodibility factor when the silt and very fine sand content makes up less than 70% of the soil particle size distribution. $$K_{USLE} = \frac{0.00021 \cdot M^{1.14} \cdot (12 - OM) + 3.25 \cdot (c_{soilstr} - 2) + 2.5 \cdot (c_{perm} - 3)}{100}$$ where KUSLE is the soil erodibility factor, M is the particle-size parameter, OM is the percent organic matter (%), csoilstr is the soil structure code used in soil classification, and cperm is the profile permeability class. The particle-size parameter, M, is calculated $$M = (m_{silt} + m_{vfs}) \cdot (100 - m_c)$$ where msilt is the percent silt content (0.002-0.05 mm diameter particles), mvfs is the percent very fine sand content (0.05-0.10 mm diameter particles), and mc is the percent clay content (< 0.002 mm diameter particles). The percent organic matter content, OM, of a layer can be calculated: $$OM = 1.72 \cdot orgC$$ where orgC is the percent organic carbon content of the layer (%).

Variable name	Definition
USLE_K, cont.	Soil structure refers to the aggregation of primary soil particles into compound particles which are separated from adjoining aggregates by surfaces of weakness. An individual natural soil aggregate is called a ped. Field description of soil structure notes the shape and arrangement of peds, the size of peds, and the distinctness and durability of visible peds. USDA Soil Survey terminology for structure consists of separate sets of terms defining each of these three qualities. Shape and arrangement of peds are designated as type of soil structure; size of peds as class; and degree of distinctness as grade. Angular Blocky: bounded by planes intersecting at relatively sharp angles Subangular Blocky: having mixed rounded and plane faces with vertices mostly rounded The soil-structure codes for the equation are defined by the type and class of soil structure present in the layer. There are four primary types of structure, several of which are further broken down into subtypes: -Platy, with particles arranged around a plane, generally horizontal -Prismlike, with particles arranged around a verticle line and bounded by relatively flat vertical surfaces Prismatic: without rounded upper ends Columnar: with rounded caps -Blocklike or polyhedral, with particles arranged around a point and bounded by flat or rounded surfaces which are casts of the molds formed by the faces of surrounding peds -Spheroidal or polyhedral, with particles arranged around a point and bounded by curved or very irregular surfaces that are not accomodated to the adjoining aggregates Granular: relatively non-porous Crumb: very porous The size criteria for the class will vary by type of structure and are summarized in Table 22-2.

Variable name	Definition
USLE_K, cont.	

Table 22-2: Size classes of soil structure

	Shape of structure			
Size Classes	**Platy**	**Prismatic and Columnar**	**Blocky**	**Granular**
Very fine	< 1 mm	< 10 mm	< 5 mm	< 1 mm
Fine	1-2 mm	10-20 mm	5-10 mm	1-2 mm
Medium	2-5 mm	20-50 mm	10-20 mm	2-5 mm
Coarse	5-10 mm	50-100 mm	20-50 mm	5-10 mm
Very coarse	> 10 mm	> 100 mm	> 50 mm	> 10 mm

The codes assigned to $c_{soilstr}$ are:

5 very fine granular
6 fine granular
7 medium or coarse granular
8 blocky, platy, prismlike or massive

Permeability is defined as the capacity of the soil to transmit water and air through the most restricted horizon (layer) when moist. The profile permeability classes are based on the lowest saturated hydraulic conductivity in the profile. The codes assigned to c_{perm} are:

7 rapid (> 150 mm/hr)
8 moderate to rapid (50-150 mm/hr)
9 moderate (15-50 mm/hr)
10 slow to moderate (5-15 mm/hr)
11 slow (1-5 mm/hr)
12 very slow (< 1 mm/hr)

Williams (1995) proposed an alternative equation:

$$K_{USLE} = f_{csand} \cdot f_{cl-si} \cdot f_{orgc} \cdot f_{hisand}$$

where f_{csand} is a factor that gives low soil erodibility factors for soils with high coarse-sand contents and high values for soils with little sand, $f_{cl\text{-}si}$ is a factor that gives low soil erodibility factors for soils with high clay to silt ratios, f_{orgc} is a factor that reduces soil erodibility for soils with high organic carbon content, and f_{hisand} is a factor that reduces soil erodibility for soils with extremely high sand contents. The factors are calculated:

$$f_{csand} = \left(0.2 + 0.3 \cdot \exp\left[-0.256 \cdot m_s \cdot \left(1 - \frac{m_{silt}}{100}\right)\right]\right)$$

Variable name	Definition
USLE_K, cont.	$$f_{cl-si} = \left(\frac{m_{silt}}{m_c + m_{silt}} \right)^{0.3}$$ $$f_{orgc} = \left(1 - \frac{0.0256 \cdot orgC}{orgC + \exp\left[3.72 - 2.95 \cdot orgC\right]} \right)$$ $$f_{hisand} = \left(1 - \frac{0.7 \cdot \left(1 - \frac{m_s}{100}\right)}{\left(1 - \frac{m_s}{100}\right) + \exp\left[-5.51 + 22.9 \cdot \left(1 - \frac{m_s}{100}\right)\right]} \right)$$ where m_s is the percent sand content (0.05-2.00 mm diameter particles), m_{silt} is the percent silt content (0.002-0.05 mm diameter particles), m_c is the percent clay content (< 0.002 mm diameter particles), and $orgC$ is the percent organic carbon content of the layer (%).
EC(layer #)	Electrical conductivity (dS/m).
CAL(layer #)	Soil CaCo3 (%). (0 – 50%)
PH(layer #)	Soil Ph (3-10)

NUTRIENTS.SOL

The NUTRIENTS.SOL file Soil nutrient parameters.
Below is a sample NUTRIENTS.SOL file:

nutrients.sol:											
NAME	EXP_CO	TOTALN	INORGN	ORGN	TOTALP	INORGP	ORGP	WATERSOL_P	H3A_P	MEHLICH_P	BRAY_STRONG
lrew01	0.001	13	6.85	3.34	3.22	3.66	0.39	0.16	0.26	1.22	0.85
lrew02	0.001	13	6.85	3.34	3.22	3.66	0.39	0.16	0.26	1.22	0.85
lrew03	0.001	13	6.85	3.34	3.22	3.66	0.39	0.16	0.26	1.22	0.85
lrew04	0.001	13	6.85	3.34	3.22	3.66	0.39	0.16	0.26	1.22	0.85
lrew05	0.001	13	6.85	3.34	3.22	3.66	0.39	0.16	0.26	1.22	0.85
lrew06	0.001	13	6.85	3.34	3.22	3.66	0.39	0.16	0.26	1.22	0.85
lrew07	0.001	13	6.85	3.34	3.22	3.66	0.39	0.16	0.26	1.22	0.85
lrew08	0.001	13	6.85	3.34	3.22	3.66	0.39	0.16	0.26	1.22	0.85
lrew09	0.001	13	6.85	3.34	3.22	3.66	0.39	0.16	0.26	1.22	0.85
lrew10	0.001	13	6.85	3.34	3.22	3.66	0.39	0.16	0.26	1.22	0.85
lrew11	0.001	13	6.85	3.34	3.22	3.66	0.39	0.16	0.26	1.22	0.85
lrew12	0.001	13	6.85	3.34	3.22	3.66	0.39	0.16	0.26	1.22	0.85

TITLE	The first line of the nutrients.sol file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
HEADER	
NAME	Nutrient name
EXP_CO	Depth coefficient to adjust concentrations for depth
TOTALN	Total N in soil (ppm)
INORGN	Inorganic N in soil surface (ppm)
ORGN	Organic N in soil surface (ppm)
TOTALP	Total P in soil surface (ppm)
INORGP	Inorganic P in soil surface (ppm)
ORGP	Organic P in soil surface (ppm)
WATERSOL_P	Water soluble P in soil surface (ppm)
H3A_P	H3a P in soil surface (ppm)
MEHLICH_P	Mehlich P in soil surface (ppm)
BRAY_STRONG_P	Bray P in soil surface (ppm)

D_TABLE – Decision tables are a precise yet compact way to model complex rule sets and their corresponding actions.

Decision tables, like flowcharts and if-then-else and switch-case statements, associate conditions with actions to perform, but in many cases do so in a more elegant way (see Wikipedia – 'Decision table')

STRUCTURE OF DECISION TABLES

I. Conditions
II. Condition alternatives
III. Actions
IV. Action entries

Each decision corresponds to a variable, relation or predicate whose possible values are listed among the condition alternatives. Each action is a procedure or operation to perform, and the entries specify whether (or in what order) the action is to be performed for the set of condition alternatives the entry corresponds to. Many decision tables include in their condition alternatives the 'don't care' symbol, a hyphen. Using 'don't cares' can simply decision tables, especially when a given condition has little influence on the actions to be performed. In some cases, entire conditions thought to be important initially are found to be irrelevant when none of the conditions influence which actions are performed.

Decision tables, especially when coupled with the use of a domain-specific language, allow developers and policy experts to work from the same information, the decision tables themselves.

Tools to render nested if statements from traditional programming languages into decision tables can also be used as a debugging tool.

Decision tables have proven to be easier to understand and review than code, and have been used extensively and successfully to produce specifications for complex systems.

Quadrant I. Number of conditions, alternatives and actions

1. Conditional variables
2. Limit variables (each conditional variable has predefined limit variables

CHAR NAME	TYPE	DESCRIPTION	UNITS	LIMIT VAR
soil_water	soil			wp, fc, ul
w_stress	plant			
month	time			
jday	time			
hu	plant			
n_stress	plant			
soil_n	soil			
soil_p	soil			
n_applied	mgt			
plant	plant			
rot_yr	mgt			
biomass	plant			
cover	plant/soil			
lai				
stir_tillage	mgt			
vol	res			pvol, evol
flow	chan			

Quadrant II. Condition alternatives

1. Condition rules – all alternatives met (<, >, =, -)

Quadrant III. Actions

ACTION	OPTIONS
irrigate	amt, file → irr.ops
release	rate,day,weir
plant	name from plants.plt
harvest	file→ harv.ops
tillage	file→ till.ops
fire	file→ fire.ops
(structures)	
(herd)	
(water-rights)	

Quadrant IV. Action Entries

1. ‘y’ (yes)
2. ‘n’ (no)

D_TABLE.DTL

The D_TABLE.DTL file contains the input variables for the nutrient characteristics of the soil properties. Below is a sample D_TABLE.DTL file:

d_table.dtl									
2									
NAME	CONDS	ALTS	ACTS						
pl_grow_sum	2	2	1						
	VAR	OBJ	OB_NUM	LIM_VAR	LIM_OP	LIM_CONST	ALT1	ALT2	
phu_base0	hlt	0	null	-	0.15	>	<		
phu_base0	hlt	0	null	-	0.2	<	-		
	ACT_TYP	NAME	TYPE	CONST	APPLICATION	OUTCOME			
grow_init	hlt	0	start_growth	file	0	null	y	n	
NAME	CONDS	ALTS	ACTS						
pl_end_sum	2	3	1						
	VAR	OBJ	OB_NUM	LIM_VAR	LIM_OP	LIM_CONST	ALT1	ALT2	ALT3
phu_base0	hlt	0	null	-	0.5	>	<	-	
jday	hlt	0	null	-	330	-	-	=	
	ACT_TYP	NAME	TYPE	CONST	APPLICATION	OUTCOME			
grow_end	hlt	0	end_growth	file	0	null	y	n	y

Variable name	Definition
TITLE	The first line of the file is reserved for user comments. The comments may take up to 80 spaces. The title line is not processed by the model and may be left blank.
MDTBL	Total number of decision tables in the file
HEADER	Header
NAME	Name of decision table
CONDS	Number of conditions
ALTS	Number of alternatives
ACTS	Number of actions
VAR	Condition variable (vol, sw, time, etc)
OB	Object variable (res, hru, canal, etc)
OB_NUM	Object number
LIM_VAR	Limit variable (evol, pvol, fc, ul, etc)
LIM_OP	Limit operator (*,+,-)
LIM_CONST	Limit constant
ALT	Condition alternatives
TYP	Type of action (reservoir, irrigate, fertilizer, etc)
NAME	Name of action
OPTION	Action option-specific to type of action (ie for reservoir, option to input rate, days of drawdown, weir equation pointer, etc)
CONST	Constant used for rate, days, etc
FILE_POINTER	Pointer for option (ie weir equation pointer)
ACT_OUTCOMES CONST	Action outcomes ('y' to perform action; 'n' to not perform action

REGIONS–

LS_UNIT.ELE

The LS_UNIT.ELE file contains the input variables
Below is a sample LS_UNIT.ELE:

ls_unit.ele:						
NUMB	NAME	OBTYP	OBTYPNO	BSN_FRAC	LSU_FRAC	REG_FRAC
1	hru1	hru	1	0.00026108	0.0817	0
2	hru2	hru	2	1.67E-05	0.0052	0
3	hru3	hru	3	0.00153037	0.4791	0
4	hru4	hru	4	8.33E-06	0.0026	0
5	hru5	hru	5	5.00E-05	0.0157	0
6	hru6	hru	6	3.61E-05	0.0113	0
7	hru7	hru	7	5.55E-06	0.0017	0
8	hru8	hru	8	0.00012221	0.0383	0
9	hru9	hru	9	7.50E-05	0.0235	0
10	hru10	hru	10	0.00012221	0.0383	0
11	hru11	hru	11	9.44E-05	0.0296	0
12	hru12	hru	12	0.00027497	0.0861	0
13	hru13	hru	13	0.00016665	0.0522	0
14	hru14	hru	14	0.0001472	0.0461	0

Variable name	Definition
TITLE	Description of the LS_UNIT.ELE file
HEADER	Headings for file
NUMB	The sequential number of the LS_UNIT.ELE
NAME	Name
OB_TYP	Type of object to print (cha, res, etc)
OBTYPNO	Object type number
BSN_FRAC	fraction of element in basin (expansion factor)
LSU_FRAC	fraction of element in landscape unit (expansion factor)
REG_FRAC	fraction of element in region (expansion factor)

LS_UNIT.DEF

The LS_UNIT.DEF file contains the input variables. Below is a sample LS_UNIT.DEF:

ls_unit.def					
LSU_NUMB	LSU_NAME	LSU_AREA	ELEM_TOT	ELEM1	ELEM2
1	lcu1	103.5	2	1	-21
2	lcu2	6.21	2	22	-28
3	lcu3	61.92	2	29	-39
4	lcu4	3.06	2	40	-42
5	lcu5	73.8	2	43	-62
6	lcu6	2.07	2	63	-67
7	lcu7	63.36	2	68	-87
8	lcu8	3.42	2	88	-92
9	lcu9	78.57	2	93	-111
10	lcu10	3.33	2	112	-118
11	lcu11	66.51	2	119	-139
12	lcu12	0.72	2	140	-143
13	lcu13	83.25	2	144	-164
14	lcu14	5.04	2	165	-174

Variable name	Definition
TITLE	Description of the LS_UNIT.DEF file
MLSU	Number of regions
HEADER	
NUMB	The sequential number of the LS_UNIT.DEF
NAME	
AREA	Surface area
NSPU	Total number of elements to follow
ELEM_CNT	Element counts

LS_REG.DEF (NEEDS UPDATING)

The LS_REG.DEF file contains the input variables

Below is a sample LS_REG.DEF

ls_reg.def	Subbasin				
2					
NUMB	NAME	AREA_HA	NSPU	ELEM1	ELEM2
1	lcu1	493.38	1	1	2

Variable name	Definition

TITLE	Description of the LS_REG.DEF file
MREG	Number of regions
MLUG	Number of landuse groups
HEADER	
NUMB	The sequential number of the LS_REG.DEF
NAME	
AREA_HA	Surface area
NSPU	
ELEM_CNT	

CH_CATUNIT.DEF

The CH_CATUNIT.DEF file contains the input variables
Below is a sample CH_CATUNIT.DEF

Ch_catunit.def Subbasin
2

NUMB	NAME	AREA_HA	NSPU	ELEM1	ELEM2
1	lcu1	493.38	1	1	2

Variable name	Definition
TITLE	Description of the CH_CATUNIT.DEF file
MREG	Number of regions
HEADER	
NUMB	The sequential number of the CH_CATUNIT.DEF
NAME	
AREA_HA	Surface area
NSPU	
ELEM_CNT	

CH_REG.DEF

The CH_REG.DEF file contains the input variables
Below is a sample CH_REG.DEF

TITLE	Description of the CH_REG.DEF file
MREG	Number of regions
HEADER	
NUMB	The sequential number of the CH_REG.DEF
NAME	
AREA_HA	Surface area

NSPU	
ELEM_CNT	

AQU_CATUNIT.ELE

The AQU_CATUNIT.ELE file contains the input variables

Below is a sample AQU_CATTUNIT.ELE

Aqu_catunit.ele

NUMB	NAME	OBTYP	OBTYPNO	BSN_FRAC	SUB_FRAC	REG_FRAC
1	hru1	hru	1	0.500	0.5	0
2	hru2	hru	2	0.500	0.5	0

Variable name	Definition
TITLE	Description of the AQU_CATUNIT.ELE file
HEADER	
NUMB	The sequential number of the AQU_CATUNIT.ELE
NAME	
OBTYP	Type of object to print (cha, res, etc)
OBTYPNO	Object type number
BSN_FRAC	fraction of element in basin (expansion factor)
SUB_FRAC	fraction of element in sub (expansion factor)
REG_FRAC	fraction of element in calibration region (expansion factor)

AQU_CATUNIT.DEF

The AQU_CATUNIT.DEF file contains the input variables

Below is a sample AQU_CATUNIT.DEF

Aqu_catunit.def Subbasin

2

NUMB	NAME	AREA_HA	NSPU	ELEM1	ELEM2
1	lcu1	493.38	1	1	2

Variable name	Definition
TITLE	Description of the AQU_CATUNIT.DEF file
MREG	Number of regions
HEADER	
NUMB	The sequential number of the AQU_CATUNIT.DEF
NAME	
AREA_HA	Surface area
NSPU	

ELEM_CNT	

AQU_REG.DEF

The AQU_REG.DEF file contains the input variables

Below is a sample AQU_REG.DEF

aqu_reg.def Subbasin

2

NUMB	NAME	AREA_HA	NSPU	ELEM1	ELEM2
1	lcu1	493.38	1	1	2

Variable name	Definition
TITLE	Description of the AQU_REG.DEF file
MREG	Number of regions
HEADER	
NUMB	The sequential number of the AQU_REG.DEF
NAME	
AREA_HA	Surface area
NSPU	
ELEM_CNT	

RES_CATUNIT.ELE

The RES_CATUNIT.ELE file contains the input variables

Below is a sample RES_CATTUNIT.ELE

res_catunit.ele

NUMB	NAME	OBTYP	OBTYPNO	BSN_FRAC	SUB_FRAC	REG_FRAC
1	hru1	hru	1	0.500	0.5	0
2	hru2	hru	2	0.500	0.5	0

Variable name	Definition
TITLE	Description of the RES_CATUNIT.ELE file
HEADER	
NUMB	The sequential number of the RES_CATUNIT.ELE
NAME	
OBTYP	Type of object to print (cha, res, etc)
OBTYPNO	Object type number
BSN_FRAC	fraction of element in basin (expansion factor)
SUB_FRAC	fraction of element in sub (expansion factor)
REG_FRAC	fraction of element in calibration region (expansion factor)

RES_REG.DEF

The RES_REG.DEF file contains the input variables

Below is a sample RES_REG.DEF

res_reg.def Subbasin
2

NUMB	NAME	AREA_HA	NSPU	ELEM1	ELEM2
1	lcu1	493.38	1	1	2

Variable name	Definition
TITLE	Description of the RES_REG.DEF file
MREG	Number of regions
HEADER	
NUMB	The sequential number of the RES_REG.DEF
NAME	
AREA_HA	Surface area
NSPU	
ELEM_CNT	

RES_CATUNIT.DEF

The RES_CATUNIT.DEF file contains the input variables

Below is a sample RES_CATUNIT.DEF

res_catunit.def Subbasin
2

NUMB	NAME	AREA_HA	NSPU	ELEM1	ELEM2
1	lcu1	493.38	1	1	2

Variable name	Definition
TITLE	Description of the RES_CATUNIT.DEF file
MREG	Number of regions
HEADER	
NUMB	The sequential number of the RES_CATUNIT.DEF
NAME	
AREA_HA	Surface area
NSPU	
ELEM_CNT	

REC_CATUNIT.ELE

The REC_CATUNIT.ELE file contains the input variables

Below is a sample REC_CATTUNIT.ELE

rec_catunit.ele

NUMB	NAME	OBTYP	OBTYPNO	BSN_FRAC	SUB_FRAC	REG_FRAC
1	hru1	hru	1	0.500	0.5	0

2	hru2	hru	2	0.500	0.5	0

Variable name	Definition
TITLE	Description of the REC_CATUNIT.ELE file
HEADER	
NUMB	The sequential number of the REC_CATUNIT.ELE
NAME	
OBTYP	Type of object to print (cha, res, etc)
OBTYPNO	Object type number
BSN_FRAC	fraction of element in basin (expansion factor)
SUB_FRAC	fraction of element in sub (expansion factor)
REG_FRAC	fraction of element in calibration region (expansion factor)

REC_CATUNIT.DEF

The REC_CATUNIT.DEF file contains the input variables

Below is a sample REC_CATUNIT.DEF

rec_catunit.def Subbasin

2

NUMB	NAME	AREA_HA	NSPU	ELEM1	ELEM2
1	lcu1	493.38	1	1	2

Variable name	Definition
TITLE	Description of the REC_CATUNIT.DEF file
MREG	Number of regions
HEADER	
NUMB	The sequential number of the REC_CATUNIT.DEF
NAME	
AREA_HA	Surface area
NSPU	
ELEM_CNT	

REC_REG.DEF

The REC_REG.DEF file contains the input variables

Below is a sample REC_REG.DEF

rec_reg.def Subbasin

2

NUMB	NAME	AREA_HA	NSPU	ELEM1	ELEM2
1	lcu1	493.38	1	1	2

Variable name	Definition
TITLE	Description of the REC_REG.DEF file
MREG	Number of regions
HEADER	
NUMB	The sequential number of the REC_REG.DEF
NAME	
AREA_HA	Surface area
NSPU	
ELEM_CNT	

PATH_PCP/PATH_TMP/PATH_SLR/PATH_HMD/PATH_WND

The PATH weather files contain the daily values for the simulation run. The data files can be present in the same directory as the other input data OR in a separate sub-directory. If they are copied to a sub-directory, the following should be input so the model will read from the files during runtime.

In the following example, the data directory is: c:\LREW and the weather will be read from c:\LREW\weather.

Example:

CLIMATE_PCP	weather\\
CLIMATE_TMP	weather\\
CLIMATE_SLR	weather\\
CLIMATE_HMD	weather\\
CLIMATE_WND	weather\\