CHAPTER 27

SWAT INPUT DATA: .SWQ

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. The data used by SWAT for in-stream water quality processes is contained in two files: the stream water quality input file (.swq) for specific reaches and the general water quality input file (.wwq) for processes modeled uniformly over the entire watershed.

Following is a brief description of the variables in the stream water quality input file. The variables are listed in the order they appear within the file.

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.
NUTRIENT TITLE	The second line is reserved for the nutrient section title. This line is not processed by the model and may be left blank. Optional.
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 $O_2/(m^2 \cdot day)$). If routing is performed on an hourly time step (see IEVENT in .bsn file), the units of RK4 are converted to (mg $O_2/(m^2 \cdot hr)$) by the model. If no value for RK4 is entered, the model sets RK4 = 2.0 mg $O_2/(m^2 \cdot day)$. 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.

Variable name	Definition
PESTICIDE TITLE	This line is reserved for the pesticide section title. This line is not processed by the model and may be left blank.
CHPST_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.
CHPST_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
CHPST_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: $K_l = \sqrt{r_l \cdot D_l}$ $\quad$ $K_g = \sqrt{r_g \cdot D_g}$ 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.
CHPST_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 ($\text{mg m}^{-3}_{\text{octanol}} \left(\text{mg m}^{-3}_{\text{water}}\right)^{-1}$).

Variable name	Definition
CHPST_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.
CHPST_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.
CHPST_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.

Variable name	Definition
CHPST_MIX	Mixing velocity (diffusion/dispersion) for pesticide in reach (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. 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.
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.

Variable name	Definition
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_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.

The stream water quality file is a free format file. The variables may be placed in any position the user wishes on the line. Values for variables classified as integers *should not* include a decimal while values for variables classified as reals *must* contain a decimal. A blank space denotes the end of an input value and the beginning of the next value if there is another on the line. The format of the stream water quality input file is:

Variable name	Line #	Format	F90 Format
TITLE	1	character	a80
NUTRIENT TITLE	2	character	a80
RS1	3	real	free
RS2	4	real	free
RS3	5	real	free
RS4	6	real	free
RS5	7	real	free
RS6	8	real	free
RS7	9	real	free
RK1	10	real	free
RK2	11	real	free
RK3	12	real	free
RK4	13	real	free
RK5	14	real	free
RK6	15	real	free
BC1	16	real	free
BC2	17	real	free
BC3	18	real	free
BC4	19	real	free

Variable name	Line #	Format	F90 Format
PESTICIDE TITLE	20	character	a80
CHPST_REA	21	real	free
CHPST_VOL	22	real	free
CHPST_KOC	23	real	free
CHPST_STL	24	real	free
CHPST_RSP	25	real	free
CHPST_MIX	26	real	free
SEDPST_CONC	27	real	free
SEDPST_REA	28	real	free
SEDPST_BRY	29	real	free
SEDPST_ACT	30	real	free

REFERENCES

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