CHAPTER 26

SWAT INPUT DATA: .WWQ

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 general 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.
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 ($\text{m}^{-1}\cdot(\mu\text{g chla/L})^{-1}$). 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 ($\text{m}^{-1}\cdot(\mu\text{g chla/L})^{-2/3}$). 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.
CHLA-SUBCO	Regional adjustment on sub chla_a loading

The watershed 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 general water quality input file is:

Variable name	Line #	Format	F90 Format
TITLE	1	character	a80
LAO	2	integer	free
IGROPT	3	integer	free
AI0	4	real	free
AI1	5	real	free
AI2	6	real	free
AI3	7	real	free
AI4	8	real	free
AI5	9	real	free
AI6	10	real	free
MUMAX	11	real	free
RHOQ	12	real	free
TFACT	13	real	free
K_L	14	real	free
K_N	15	real	free
K_P	16	real	free
LAMBDA0	17	real	free
LAMBDA1	18	real	free
LAMBDA2	19	real	free
P_N	20	real	free
CHLA_SUBCO	21	real	free

REFERENCES

Bowie, G.L. W.B. Mills, D.B. Porcella, C.L. Campbell, J.R. Pagenkopt, G.L. Rupp, K.M. Johnson, P.W.H. Chan, and S.A. Gherini. 1985. Rates, constants, and kinetic formulations in surface water quality modeling, 2nd ed. EPA/600/3-85/040, U.S. Environmental Protection Agency, Athens, GA.