

Raisin Soil and Water Assessment Tool (SWAT) Calibration and Validation Report

Calibration methods:

Calibration of the Raisin SWAT model was carried out using the prescribed procedures outlined in important publications from the team of model developers (Arnold et al. 2000; Santhi et al. 2002, Neitsch et al. 2002) and through personal correspondence with developers. These procedures included initially calibrating hydrology at 3 sites in the watershed (Manchester, Adrian, and Monroe) as well as subsequent sediment and nutrient (total nitrogen and total phosphorus) calibration at Monroe. The time period for calibration was 1998-2001. This allowed data from 1995-1997 to be used for model spin-up and thus discarded, and the remaining data from 2002-2005 to be used for model validation. Detailed lists of all parameter changes made during calibration and notes on each change can be found in appendices A, B, and C.

Model hydrology was calibrated using average annual discharge measurements made at 3 USGS gaging stations along the main stem of the Raisin River (Manchester-04175600, Adrian-04176000, Monroe-04176500). Hydrologic calibration was first completed for Manchester site since it was furthest upstream. After annual average hydrology was acceptable for this site, the next downstream site at Adrian was completed to the same level of detail. Finally, the Monroe site was calibrated most intensively. A baseflow filter program was used to determine relative proportions of annual flow at each gage station that was due to surface runoff or baseflow contributions. This information was then used in order to get SWAT to correctly reflect basic observed water balance at these 3 sites in the watershed. After average annual discharge rates were acceptable, SWAT-predicted monthly and daily hydrographs at the 3 sites were compared to observed USGS data for further calibration. Two statistical measures, r-squared and Nash-Sutcliffe efficiency were used in addition to this visual comparison to evaluate model performance.

Sediment calibration was conducted using observed near-daily water chemistry measurements near Monroe provided by the National Center for Water Quality Research at Heidelberg College. The suspended sediment (SS) concentration measurements were compiled with USGS water discharge data into the USGS Estimator program to estimate annual sediment loads at the sampling site. Observed average annual load estimates were then compared to SWAT predicted average annual loads at the same site for calibration.

Nutrients calibration was conducted similar to sediments using observed near-daily water chemistry measurements near Monroe provided by the National Center for Water Quality Research at Heidelberg College. The total nitrogen (TN) and total phosphorus (TP) concentration measurements were compiled with USGS water discharge data into the USGS Estimator program to estimate annual TN and TP loads at the sampling site. Observed average annual load estimates were then compared to SWAT predicted average annual loads at the same site for calibration.

Calibration results:

Intensive hydrologic calibration yielded strong SWAT predictive power at the monthly temporal scale near the base of the watershed (Figure 1) when compared to USGS gage station data. Monthly statistics showed values of 0.71 and 0.70 for r-squared and Nash-Sutcliffe efficiency respectively. The Nash-Sutcliffe efficiency is a statistical measure that is more stringent than r-squared because it compares 2 variables assuming a 1:1 relationship rather than measuring deviation from the best fit line as with r-squared measures. Efficiency values greater than or equal to 0.50 are thus considered adequate for SWAT model applications (Santhi et al. 2001).

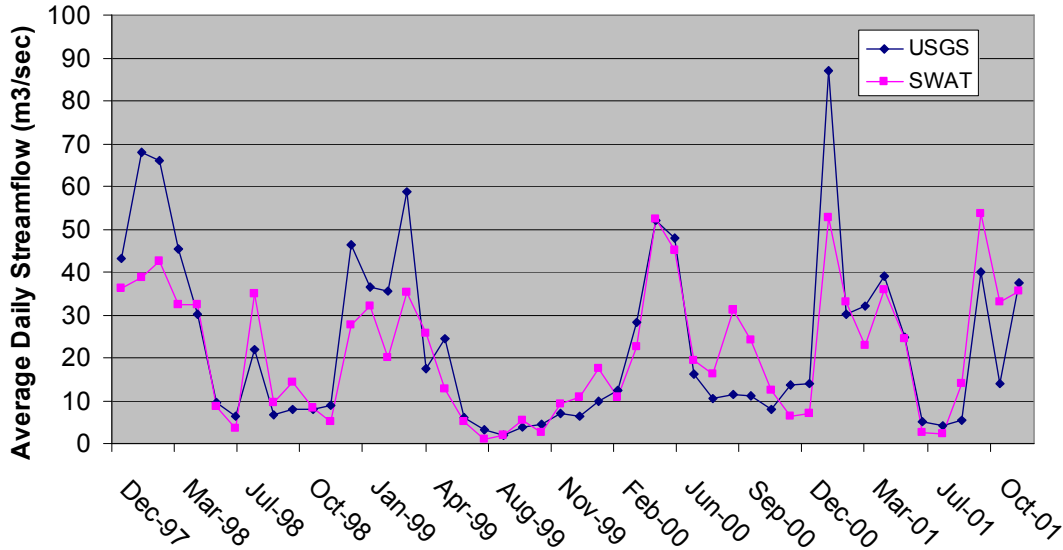


Figure 1: Plot showing observed (USGS) and predicted (SWAT) average daily stream discharges near Monroe for each month of the calibration period (1998-2001).

Less intensive calibration of sediments and nutrients allowed strong SWAT predictions when comparing predicted average annual loads to loads from observed Heidelberg data (Table 1).

Table 1: Table showing comparison of observed (Heidelberg) and predicted (SWAT) average annual loads near Monroe for calibration time period (1998-2001).

Parameter	Average Annual Loads (metric tons)	
	Observed (Heidelberg)	Predicted (SWAT)
Suspended Sediments	127669	126363
Total Nitrogen	4864	4816
Total Phosphorus	170	175

Validation results:

SWAT retained strong hydrologic predictive power at the monthly temporal scale near the base of the watershed (Figure 2) when compared to USGS gage station data during the validation period (2002-2005). Monthly statistics showed values of 0.70 and 0.69 for r-squared and Nash-Sutcliffe efficiency respectively.

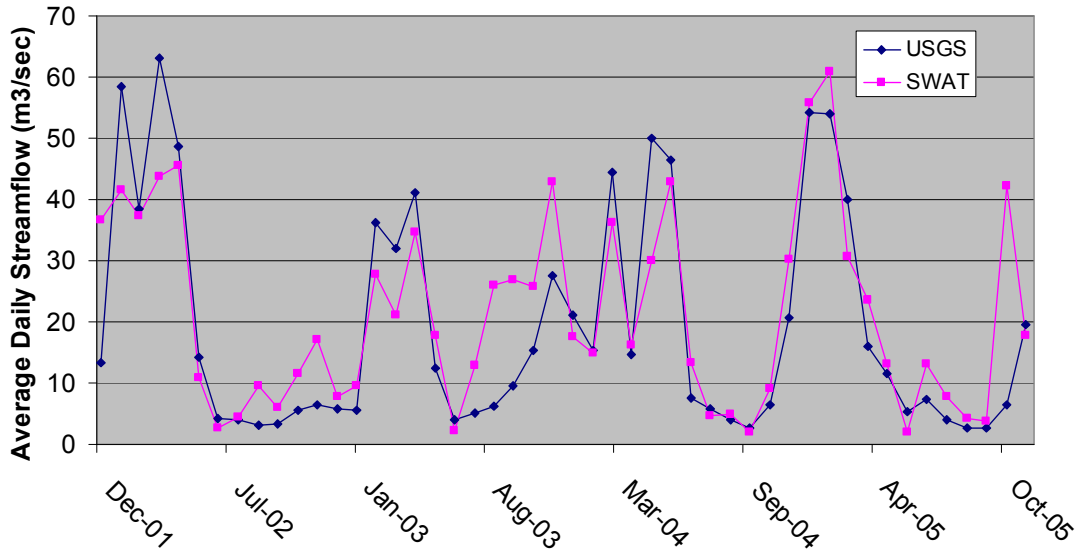


Figure 2: Plot showing observed (USGS) and predicted (SWAT) average daily stream discharges near Monroe for each month of the validation period (2002-2005).

SWAT water quality predictions were weaker when compared to the Heidelberg data (Table 2) for the validation time period. An average annual over-prediction of SS and TP loads is evident. This average over-prediction is caused by high annual SWAT loads for years 2003 and 2005 and corresponds to monthly over-predictions in stream discharge during the same years.

Table 2: Table showing comparison of observed (Heidelberg) and predicted (SWAT) average annual loads near Monroe for validation time period (2002-2005).

Parameter	Average Annual Loads (metric tons)	
	Observed (Heidelberg)	Predicted (SWAT)
Suspended Sediments	85983	127157
Total Nitrogen	4839	4539
Total Phosphorus	133	242

References:

- Arnold, J.G., Muttiah, R.S., Srinivansan, R., and P.M. Allen. 2000. Regional estimation of base flow and groundwater recharge in the Upper Mississippi River basin. *Journal of Hydrology*. 227:21-40.
- Neitsch, S.L., Arnold, J.G., Kiniry, J.R. Williams, and K.W. King. 2002. *Soil and Water Assessment Tool Theoretical Documentation—Version 2000*. TWRI Report TR-191. Texas Water Resources Institute, College Station, Texas. Available at (<http://www.brc.tamus.edu/swat/downloads/doc/swat2000theory.pdf>.)
- Santhi, C., Arnold, J.G., Williams, J.R., Dugas, W.A. and L. Hauck. 2002. Application of a watershed model to evaluate management effects on point and nonpoint source pollution. *Transactions of the ASAE* 44:1559-1570.
- Santhi, S., Arnold, J.G., Williams, J.R., Dugas, W.A., Srinivasan, R., and L.M. Hauck. 2001. Validation of SWAT model on a large river basin with point and nonpoint sources. *Journal of the American Water Resources Association* 37:1169-1188.