Figure 9.25 depicts the conceptualization of the basin hydrologic balance adopted by Sophocleous et al. (1999). The important water balances (see also Figure 9.26) are as follows:

- Surface runoff (SRO) becomes lateral inflow to a stream or pond.
- Recharge (R) to the relatively shallow aquifer occurs from infiltration (INF) that percolates downward beyond the root zone (PERC), along with pond seepage (POND SEEP), channel transmission losses (TL), and subsurface lateral flow (SLF) that does not flow into ponds.
- Groundwater pumped from the aquifer (Q) is applied as irrigation at the surface (IRR).
- Water in ponds evaporates (E), and water in the soil zone within reach of plant roots is removed by evapotranspiration (ET).
- The stream and aquifer interact via leakage driven by hydraulic gradients across the streambed (q).

Percolation below the root zone was distributed over the aquifer without explicitly accounting for the time lag and attenuation that would be associated with the unsaturated subsurface flow, given the long-term simulation horizon, the relatively high infiltration rates, low available water capacity of the basin soils, and the relatively shallow depth to water table over most of the basin. The authors combined MODFLOW (McDonald and Harbaugh 1988) and the watershed model SWAT (Arnold et al. 1993) to create SWATMOD, a comprehensive surface- and ground-water
modeling tool for evaluating options for water-resources management.

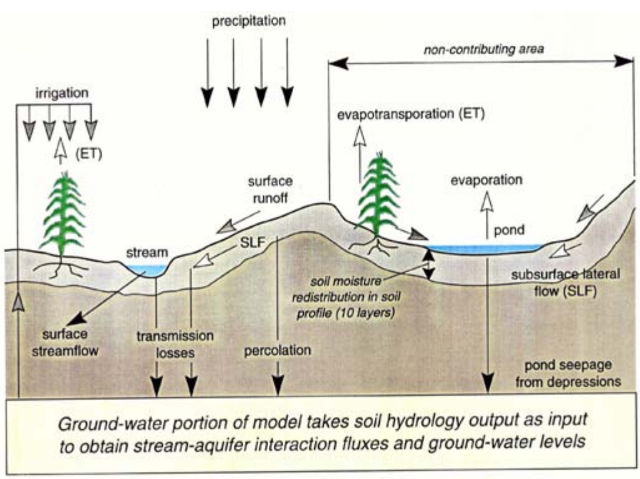

Figure 9.25: Conceptualization of noncontributing ponds and their interaction with underlying aquifer for the Rattlesnake Creek basin.

Both SWAT and MODFLOW were modified to implement the linkages shown in Figure 9.26. Specifically, two subroutines were developed by the authors: HYDBAL, to be called by SWAT, and MODSWB, to be called by MODFLOW. HYDBAL's functions are called at the end of each simulated aquifer time step to pass data back and forth between SWAT and MODFLOW, and to write SWAT's results to a "hydrologic balance" data file for each aquifer time step. MODSWB associates the geographic domain of the subbasins represented by SWAT with the aquifer grid domain and stream network defined in MODFLOW, and converts the hydrologic fluxes calculated by SWAT for each time step into flow rates for recharge, tributary flow, and both surface and groundwater diversions. In this manner, SWAT and MODFLOW were externally coupled by the authors. A time step of one day was implemented for the SWAT model, whereas a monthly time step was utilized for MODFLOW simulations to deal with the computational constraints and also because of the difference in the flow rates in the surface and subsurface systems. Readers are referred to Sophocleous et al. (1999) for more details and for evaluating the capabilities of the SWATMOD model. The authors show examples highlighting the important role of stream-aquifer interaction in a watershed-scale setting.

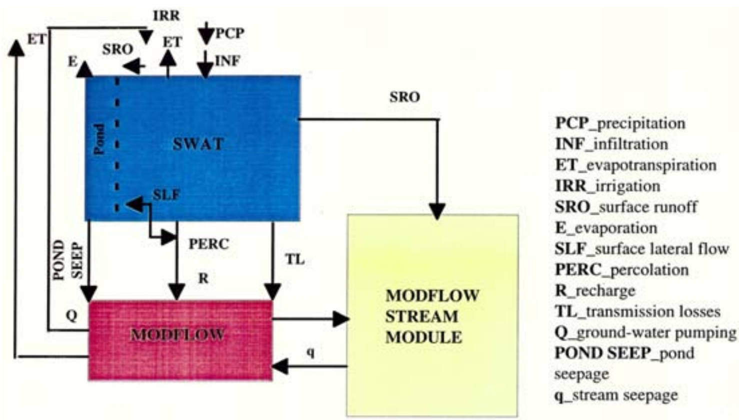

Figure 9.26: Water balance components and connections between the MODFLOW and SWAT models. From Sophocleous et al. (1999), used with permission of Elsevier.

9.5 References

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