

Transient Water Balance Methodology

The methodology presented here is based on that described in Streetly (2008)¹. This approach uses daily rainfall and potential evapotranspiration (PE) data as inputs to a Penman style soil moisture balance calculation implemented in an Excel spreadsheet (see Illustration 3.2 for a flow chart of the main processes). This methodology does not set out the theory and detail behind the hydrological processes simulated – references in the original paper or standard hydrological text books would be a good starting place for that.

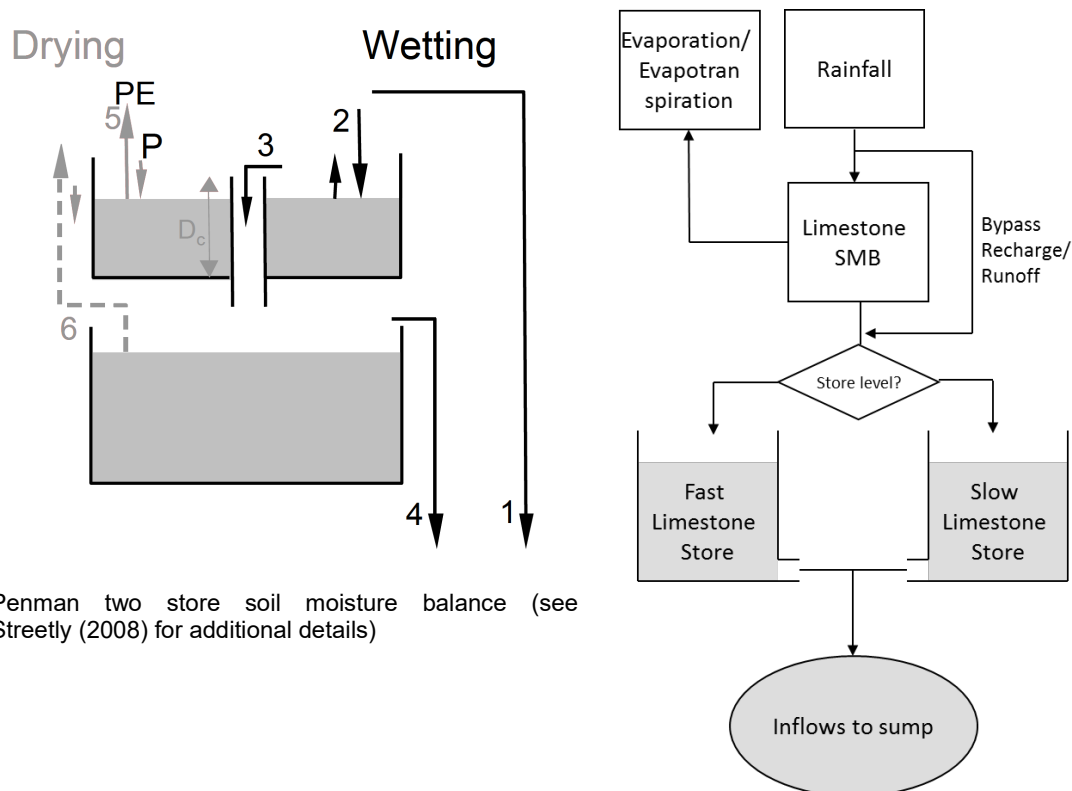


Illustration 1.1 Flow charts of key processes in transient water balances

NB See Streetly, 2008 for definition of numbered processes on left hand figure

The key advantage of this methodology over an annual check is that this allows processes within a year to be examined and thus periods of problematic data to be identified. In addition, the transient water balance methodology avoids the issues associated with the assumption in the annual water balance that storage conditions are the same at the start and end of the year.

The transient water balance operates in two main stages:

1. The **soil moisture balance** calculation apportions the rainfall into components comprising evapotranspiration, change in soil moisture, runoff and recharge (including bypass recharge) depending on factors such as the soil and crop type, the rainfall rate, the antecedent soil conditions and the potential evapotranspiration rate for that day.
2. The 'outflows' from the soil moisture balance (recharge and runoff) are then processed via a series of '**stores**' to generate a time series of total catchment flow (e.g. at a spring or quarry sump) which can be compared directly with measured data by multiplication by the effective catchment area.

¹ Streetly M. J., 2008 Transient water balances to support the conceptual understanding of flows in limestone aquifers. Quarterly Journal of Engineering Geology and Hydrogeology, 41, 21–33.

This methodology is based on ESI's (now Stantec) in-house R&D developments that were subsequently applied at Torcoed Quarry as described in Streetly (2008).

This 'lumped' approach to modelling flows is commonly applied in hydrology and is particularly appropriate for karstic systems, which in many ways resemble surface water systems more closely than groundwater systems. Inevitably, the simplifications involved in this style of modelling mean that there is a move away from explicit physical representation of the systems being modelled towards a more empirical approach. The simpler lumped approaches can also lead to a degree of model equivalence. This can still be acceptable as long as the period being modelled is reasonably representative and caution is applied when attempting to apply results outside of the calibration range.

Parameterisation

There are a limited number of parameters used to calibrate the transient water balances to the measured data. The parameters applied for simulating the sump discharge flows at Torcoed (Table 1.1) in Streetly (2008) are given as an example of typical values.

Table 1.1 Parameters used for transient water balance

Parameter	Streetly (2008) (sump calcs)
Drying constant (mm)	25
Runoff/ direct percolation/ (%)	25
Drying curve slope	0.3
Slow store decay constant (days)	250
Fast store decay constant (days)	10
% to slow store	0