Baseflow in the Lockyer Creek

James C. Galletly
M Agr Sc, University of Queensland

A thesis submitted for the degree of Doctor of Philosophy

School of Land, Crop and Food Sciences
and
School of Natural and Rural Systems Management
University of Queensland, Gatton, Australia
2007

Abstract

The basic question which this thesis seeks to answer is: 'Was the baseflow which flowed continuously in Lockyer Creek prior to 1980 outflow from adjacent alluvial aquifers, or was it outflow from basalt aquifers on the Main Range?' This question was not obvious at the start of the project when information from 'official sources' suggested that Lockyer Creek was ephemeral, and there was no baseflow.

To answer this question, it was necessary to define baseflow (as outflow from aquifers) and to devise a means of separating it from overland flow, because the existing methods separate 'quick flow' from 'prolonged flow'; not overland flow from baseflow. The existence of baseflow presumes the existence of aquifers in the catchment, so geology of the catchment was examined to identify its aquifers.

Streamflow records at four sites: three upstream and one downstream, were analysed to establish that baseflow was a significant component (25%) of streamflow over the period 1910–2000, and that average baseflow over this period was close to the estimated long-term safe yield of the Lockyer alluvium. The process of aquifer recharge was analysed and it was concluded that the alluvial aquifers are recharged by infiltration of water mainly through the bed of creeks and saturated flow in the aquifer below the water table, followed by unsaturated flow across a saturated/unsaturated boundary at the wetting front.

Saturated flow is driven by the hydraulic gradient on the water table (which was shown in 1949 to slope away from creeks), while unsaturated flow is driven by the matric potential across the wet and dry sides of the wetting front. Unsaturated flow is orders of magnitude slower than saturated flow, but takes place over a much greater area than saturated flow. Because it is such a slow process, long duration flows are required to achieve significant aquifer recharge.

Chemical analyses of water from basalt aquifers, baseflow and alluvial aquifers confirmed that the 'ionic signature' of the three waters was similar, which would be expected if baseflow was outflow from basalt aquifers, which in turn recharged alluvial aquifers. The ionic signature of water in the adjacent sandstones is quite different from that of these three waters. Ions present in water in the alluvium, including the sodium ions, are therefore consistent with the idea of the basalt water being concentrated by evaporation and/or evapotranspiration. It was concluded that water use by phreatophytes (historically) and irrigation (recently) was largely responsible for the slope on the water table in aquifers (towards aquifer margins).

Since the commencement of irrigation, flow duration in Lockyer Creek has progressively decreased, and the depth of water in alluvial aquifers has also declined, indicating that, in many years since 1937, the rate of water use for irrigation has exceeded the rate at which water was supplied by the catchment.

The water in alluvial aquifers is derived from baseflow which, in the Lockyer Valley, is outflow from basalt aquifers in the Main Range, not from adjacent alluvial aquifers. The water is not infiltration from rainfall, bank flow or cross-formational flow from adjacent sandstones as is often reported in the literature. This new understanding should be useful in devising a strategy for managing irrigation water use in the Valley as part of an integrated catchment-management strategy.