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Modelling monthly runoff generation processes following land use changes: groundwater–surface runoff interactions

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Abstract. A conceptual water balance model is presented to represent changes in monthly water balance following land use changes. Monthly rainfall–runoff, groundwater and soil moisture data from four experimental catchments in Western Australia have been analysed. Two of these catchments, "Ernies" (control, fully forested) and "Lemon" (54% cleared) are in a zone of mean annual rainfall of 725 mm, while "Salmon" (control, fully forested) and "Wights" (100% cleared) are in a zone with mean annual rainfall of 1125 mm. At the Salmon forested control catchment, streamflow comprises surface runoff, base flow and interflow components. In the Wights catchment, cleared of native forest for pasture development, all three components increased, groundwater levels rose significantly and stream zone saturated area increased from 1% to 15% of the catchment area. It took seven years after clearing for the rainfall–runoff generation process to stabilise in 1984. At the Ernies forested control catchment, the permanent groundwater system is 20 m below the stream bed and so does not contribute to streamflow. Following partial clearing of forest in the Lemon catchment, groundwater rose steadily and reached the stream bed by 1987. The streamflow increased in two phases: (i) immediately after clearing due to reduced evapotranspiration, and (ii) through an increase in the groundwater-induced stream zone saturated area after 1987. After analysing all the data available, a conceptual monthly model was created, comprising four inter-connecting stores: (i) an upper zone unsaturated store, (ii) a transient stream zone store, (ii) a lower zone unsaturated store and (iv) a saturated groundwater store. Data such as rooting depth, Leaf Area Index, soil porosity, profile thickness, depth to groundwater, stream length and surface slope were incorporated into the model as *a priori* defined attributes. The catchment average values for different stores were determined through matching observed and predicted monthly hydrographs. The observed and predicted monthly runoff for all catchments matched well with coefficients of determination (R^2) ranging from 0.68 to 0.87. Predictions were relatively poor for: (i) the Ernies catchment (lowest rainfall, forested), and (ii) months with very high flows. Overall, the predicted mean annual streamflow was within ±8% of the observed

values.

Keywords: monthly streamflow, land use change, conceptual model, data-based approach, groundwater

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