Residence times and flow paths of pipe and stream flow were studied during low flow in the Nant Gerig and Gwy experimental catchments at Plynlimon in mid-Wales, UK, using a two-month time series of natural deuterium and electrical conductivity data from perennial and ephemeral pipe flow, stream flow, groundwater and rainfall. Low flow in both the perennial pipe and the stream was maintained by 'old' groundwater discharge. This groundwater was at least 40 days old. Flow in the ephemeral pipe was dominated by old groundwater and was only slightly affected by direct inputs of new water. Although direct rainfall inputs contributed minimally to runoff in the perennial pipe and the stream, rainfall influenced the isotopic and chemical character of the groundwater. Rainfall also affected the water-table elevation, which determined the flashiness of the perennial pipe flow and whether the ephemeral pipe flowed. The isotope and electrical conductivity data suggest that storm runoff in both the main pipe and the stream is overwhelmingly old water. A sensitivity analysis suggests that the old water is supplied both from near-stream groundwater and upslope groundwater delivered by the ephemeral pipes.