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Estimating flood event hydrographs and the influence of storm seasonality on hydrograph shape: an example from Great Britain

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The estimation of flood hydrographs and associated peak discharge rates and discharge volumes for an assigned return period are the foundation of flood risk management. At the scale of the development site, these estimates are crucial for informing engineering solutions to manage and mitigate storm runoff from roofs and other impervious surfaces. At the catchment scale, the correct estimation of flood hydrographs is a critical step in hydraulic modelling of inundation depths and design of the conveyance capacity of bridges, reservoir spillways and flood risk management works.

In the UK, the Flood Estimation Handbook (FEH) provides a rainfall-runoff method to estimate a design hydrograph; an estimated rainfall depth for a given duration and frequency is translated into an estimated flood hydrograph of equivalent frequency using a generalised rainfall-runoff model, the ReFH2 model. Historically, rainfall-runoff methods have focussed on the estimation of peak runoff rates with less attention given to the correct estimation of hydrograph shape. With the now common application of sophisticated 2D hydrodynamic models and the regulatory requirement to control event runoff generation at source in new urban developments, there is renewed interest in the shape of modelled hydrographs. The modelled flood hydrograph is a function of the parameterisation and estimation of initial soil moisture and baseflow conditions and the storm duration and profile selected for the event. The model initial conditions, parameters and storm duration are estimated through multiple regression models based on a set of morpho-climatic indices of the basin. The profile of the storm is a binary choice based on whether the storm of a given frequency is assumed to be a more peaked summer (convective) or winter (associated with Atlantic cyclones). Current practice is to assume that extreme events are associated with winter storms in rural catchments and summer storms in urbanised catchments which have significant extents of impervious surface and anthropogenic drainage paths of comparatively short residence time. The seasonal assumptions have been tested through an analysis of the seasonality of annual peak flow maxima across 644 catchments including 153 catchments of less than 40 km2 using a dimensioned form of circular statistics. This analysis has shown that the seasonality patterns are more complex than a simple binary winter/summer choice and summer storms only generally dominate in very heavily urbanised catchments or urbanised catchments within permeable (groundwater-dominated) catchments. Building on this analysis, the hydrograph shapes predicted by ReFH2 have been evaluated within a cross-section of small catchments by reference to shapes derived through a direct, empirical analysis of observed storm events. This analysis has demonstrated that the design hydrograph shapes are consistent with observed events.

Finally, the paper reviews the consequences of the choice of storm seasonality for the estimation of event hydrographs in urbanised catchments and make recommendations for operational practice.