Determination of Instantaneous Unit Hydrographs for Small Watersheds in Texas Using Digital Elevation Data and Quadratic Flux Law Particle Tracking

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ABSTRACT

This research is conducted as part of a four-institution team (Texas Tech University, Lamar University, University of Houston, and the U.S. Geological Survey) to develop regionalized methods for use in watersheds with limited stream gage data for use by the Texas Department of Transportation.

This research is examining a technique for estimating unit hydrographs, and their related timing parameters, based on a particle-tracking implementation of the time-area method and a Rayleigh probability density function. The method in this report is currently similar to Clark's method, and other methods already employed in Geographical Information Systems (GIS). The method employed in produces estimates of Qp, Tp, and Tc, that have their conventional meaning, but are extracted from the Rayleigh model hydrograph distribution.

U.S.G.S. digital elevation maps (DEMs) for the 90 stations at 30-meter resolution form the topographic database for estimating the overland and concentrated flow behavior using a simplified flow model. Watershed boundaries were manually delineated on paper-based maps and used to extract an elevation grid of the watershed inside these boundaries.

A particle-tracking algorithm generates S-curve type hydrographs then a curvilinear probability density function (PDF) is fitted to this S-curve hydrograph. The curvilinear fit produces three parameters, a residence time T-bar (roughly analogous to Tp in the NRCS dimensionless hydrograph), a peak discharge rate Qp (analogous to Qp in the NRCS dimensionless hydrograph), and a reservoir number, N, (analogous to shape coefficients in most methods, i.e. R in Clark's method, K or N in NRCS methods). The Tc is determined by numerical integration of the PDF until 98% of the area is accumulated. The Tp is determined from the first-derivative of the PDF.

Paired rainfall and runoff data for over 80 stations form the database used to evaluate the performance of the method. The performance evaluation used the historical precipitation data, and a simple loss model, (calibrated by trial-and-error for one watershed -- then applied unchanged to all the stations) to generate runoff hydrographs using the PDFs generated from the particle-tracking model. Plots of model and observed runoff hydrographs are made for qualitative comparisons. Quantitative comparisons are made using a set of acceptance criteria to evaluate the performance for over 1600 storms.