STOCHASTIC FLOW DURATION CURVES FOR EVALUATION OF FLOW REGIMES IN RIVERS

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Made in United States of America
Reprinted from JOURNAL OF THE AMERICAN WATER RESOURCES ASSOCIATION
Vol. 39, No. 1, February 2003

JOURNAL OF THE AMERICAN WATER RESOURCES ASSOCIATION
FEBRUARY AMERICAN WATER RESOURCES ASSOCIATION 2003

STOCHASTIC FLOW DURATION CURVES FOR EVALUATION OF FLOW REGIMES IN RIVERS[1]

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ABSTRACT: A stochastic estimation of low flow in the upper reaches of streams is needed for the planning, development, and management of water resources and/or water use systems. In this paper, the definition and development procedure for the stochastic flow duration curve is presented and applied to five catchments located in eastern Japan and to two catchments in western Thailand. The probability distribution of N-year daily discharge data is extracted at various percentages of time for which specified discharges are equaled or exceeded in a water year. Such a distribution is usually represented with a straight line on log-normal probability paper. However, some of the probability plots for the annual minimum daily discharge are best represented with a straight line on Weibull probability paper. The effectiveness of the stochastic flow duration curve defined for the evaluation of flow regime is illustrated through its application. The ten year probability for the discharge exceeded 97 percent of the time may be recognized as an index of low flow. The recession shape of the lower part of the flow duration curve is dependent on the strength of low flow persistence.
(KEY TERMS: surface hydrology; stochastic flow duration curve; flow regime; low flow index; Weibull plotting formula; log-normal distribution; Weibull distribution.)

Sugiyama, Hironobu, Varawoot Vudhivanich, Andrew C. Whitaker, and Kosit Lorsirirat, 2003. Stochastic Flow Duration Curves for Evaluation of Flow Regimes in Rivers. J. of the American Water Resources Association (JAWRA) 39(1):47-58.

INTRODUCTION

The flow duration curve (FDC) is an informative method that shows characteristics of the flow regime for a river basin. It has been a useful tool for various water resources problems, irrigation, and/or hydroelectric power planning since the end of 19th century. However, the flow duration curve has rarely been applied to the evaluation of flow regime in the upper reaches of streams. Rather than an improvement of the flow duration curve, many hydrologists and/or engineers have been interested in the construction of the flow duration curve at ungaged sites, namely, the synthesis of flow duration curves (e.g., Singh, 1971: Dingman, 1978: Quimpo *et al.,* 1983: Mimikou and Kaemaki, 1985; Fennessey and Vogel, 1990). Because the effects of climate, topography, and geology are integrally represented in the flow duration curve, the curve is useful in comparing runoff characteristics of different land use areas (Takimoto *et al.,* 1994). A method that enables confidence intervals and return periods to be associated with the flow duration curve, proposed by Vogel and Fennessey (1994), is novel and convenient for the evaluation of the flow fluctuation in rivers.

The flow duration curve of daily flows is drawn with serially correlated data. However, such a curve is not appropriate for extracting stochastic hydrologic information for water resources problems. If the flow duration curve can be drawn by using an arbitrary flow return period at various percentages of time, it is possible to extract stochastic hydrologic information to evaluate the severity of high, ordinary, and low flow regimes. Such an approach is more convenient for sustainable planning and/or management of water resources in the upper reaches of streams. Smakhtin (2001) emphasized in a review of low flow hydrology, "Although the recent years have seen the increased interest to FDC in hydrology, water resources, and river ecology, its application potential is not yet fully explored."

[1]Paper No. 01147 of the *Journal of the American Water Resources Association.* **Discussions are open until August 1, 2003.**
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