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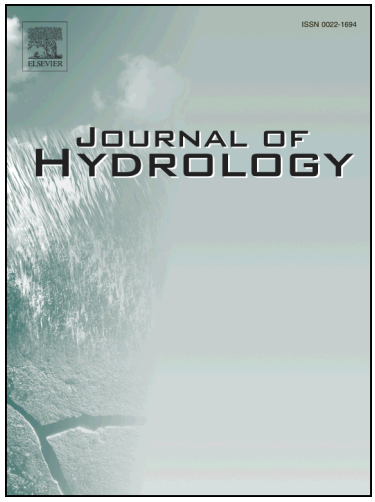

Research papers

Effect of Uncertainties on Probabilistic-based Design Capacity of Hydrosystems

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Effect of Uncertainties on Probabilistic-based Design Capacity of Hydrosystems

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ABSTRACT

Hydrosystems engineering designs involve analysis of hydrometric data (e.g., rainfall, floods) and use of hydrologic/hydraulic models, all of which contribute various degrees of uncertainty to the design process. Uncertainties in hydrosystem designs can be generally categorized into aleatory and epistemic types. The former arises from the natural randomness of hydrologic processes whereas the latter are due to knowledge deficiency in model formulation and model parameter specification. This study shows that the presence of epistemic uncertainties induces uncertainty in determining the design capacity. Hence, the designer needs to quantify the uncertainty features of design capacity to determine the capacity with a stipulated performance reliability under the design condition. Using detention basin design as an example, the study illustrates a methodological framework by considering aleatory uncertainty from rainfall and epistemic uncertainties from the runoff coefficient, curve number, and sampling error in design rainfall magnitude. The effects of including different items of uncertainty and performance reliability on the design detention capacity are examined. A numerical example shows that the mean value of the design capacity of the detention basin increases with the design return period and this relation is found to be practically the same regardless of the uncertainty types considered. The standard deviation associated with the design capacity, when subject to epistemic uncertainty, increases with both design frequency and items of epistemic uncertainty involved. It is found that the epistemic uncertainty due to sampling error in rainfall quantiles should not be ignored. Even with a sample size of 80 (relatively large for a hydrologic application) the inclusion of sampling error in rainfall quantiles resulted in a standard deviation about 2.5 times higher than that considering only the uncertainty of the runoff coefficient and curve number. Furthermore, the presence of epistemic uncertainties in the design would result in under-estimation of the annual failure probability of the hydrosystem and has a discounting effect on the anticipated design return period.

Keywords: Probabilistic design, hydrosystems engineering, uncertainty analysis, aleatory and epistemic uncertainty, detention basin design.

1. INTRODUCTION

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