ENGINEERING

Chairman: Milton E. Harr
Purdue University, West Lafayette, Indiana 47907

Chairman-Elect: Ramachandra A. Rao
Purdue University, West Lafayette, Indiana 47907

A Statistical and Stochastic Analysis of Synthetically Generated Storm Drainage Quantity and Quality Data. J. W. Delleur and G. Padmanabhan, Purdue University, West Lafayette, Indiana 47907.——For detailed planning and design of urban drainage systems the design storm concept is usually inadequate and it is necessary to simulate the watershed response using extensive historical rainfall data. The purpose of this paper is to illustrate the statistical information that can be obtained from a continuous simulation using the planning model STORM. Making use of the model STORM calibrated for runoff quantity and quality on the Upper Ross-Ade watershed in West Lafayette, Indiana, and using a 21-year time series of recorded hourly rainfalls near the watershed, simulated series of hourly runoff, BOD, and suspended solids were obtained for the same 21-year period (1954-1974), for the assumption of no storage and no treatment. A detailed statistical analysis was performed on these 1826 storm events. Significant regression equations were obtained between rainfall and suspended solids, and rainfall and BOD, the rainfalls being classified according to their durations from 1 to 6 hours in steps of one hour. Extreme value and partial duration analyses were performed for rainfall, runoff, suspended solids and BOD. For estimating the suspended solids and BOD for a given return period it is suggested to use the rainfall frequency curves, based on observed rainfalls, and the regression equation to obtain the corresponding expected suspended solids and BOD. A mixed autoregressive model of order one and a moving average model of order one were fitted to the cyclicly standardized series of monthly rainfall, runoff, suspended solids and BOD. These models can be used to generate synthetic series for each of these four variables which have the same statistical properties as the historical series for the rainfall and as the STORM generated series for the other variables.

Automatic Calibration of Urban Runoff Models. Ji Han and A. R. Rao, School of Civil Engineering, Purdue University, West Lafayette, Indiana 47907.——To assign values to the parameters of the urban runoff models is both time consuming and subjective as it is usually done by trial-and-error procedures. It is unlikely that the urban runoff models will be used up to their full potential unless the calibration procedure is reliable and objective. A good optimization technique can assist the user in determining the "best" set of input parameter values to be used with the model.

Two widely used and better documented models, the "ILLUDAS" developed at the Illinois State Water Survey and the Runoff Block of

"SWMM" developed by EPA, were coupled with the modified version of Rosenbrock's optimization technique to form the self-calibrating models, OPTIL and OPTSWMM respectively. The basic concept is to get the best match between the generated and observed hydrographs according to a predefined objective function.

The technique was tested by using data from upper Ross-Ade watershed, located in West Lafayette, Indiana. The results were consistently good and reduced the bias inherent in subjective methods. Although there is a limit to the size and complexity of a model which can be optimized using an objective best fit criteria, the parameter optimization in urban runoff models can be achieved scientifically and economically.

A Daily Flow Forecasting Model for the Green River Basin in Kentucky. H. YAZICIGIL, G. H. TOEBES, and A. R. RAO, School of Civil Engineering, Purdue University, West Lafayette, Indiana 47907.——In operating flood control resevoirs it is desirable to forecast river flows at selected locations in the downstream of the reservoirs in the immediate future. The development and testing of a stochastic model (GRBSYS2) for forecasting daily flows at system control points downstream of four reservoirs in Green River Basin, Kentucky is described. The GRBSYS2 model; comprises nine multi-input linear routing sub-models (MILRM) each representing selected river reaches. These MILRM models accept reach inflow, gaged tributary flows, and rainfall as inputs. Their single outputs are the reach outflows.

The parameters of each MILRM were estimated by using a constrained linear systems (CLS) estimation technique developed by Natale and Todini (1977). The estimated parameters of the model which satisfy the continuity and non-negativity restrictions were then used to forecast flows up to five days ahead. The analysis of forecast errors showed a bias in forecasts with an over-prediction in dry seasons and under-prediction in wet seasons. There upon the residual series of each MILRM were analyzed. They were found to be correlated. Consequently, models of the residual series were developed and incorporated into the original models to obtain one day ahead forecasts. The results indicated that the bias as well as the forecast errors were significantly reduced by this approach.

An interactive GRBSYS2 simulation algorithm was written that may be employed by the Green River Basin reservoir managers (i.e., Corps of Engineers) that may facilitate their daily operations work. Its utility is currently the subject of field office tests.

"A Chance Constrained Stochastic LP Model to Include Risk Explicity in Optimal Reservoir Planning. HASAN YAZICIGIL and MARK H. HOUCK, Purdue University, West Lafayette, Indiana 47907.——A chance constrained linear programming model, which utilizes multiple linear decision rules and is useful for river basin planning and management, is used to evaluate the effects of risk and reliability on optimal reservoir design. Streamflow forecasts or predictions can be explicitly included in the linear program. The risk associated with the predictions is included in the model through the use of a cumulative distribution functions (CDF) of streamflows which are conditioned on the predictions.

The present study deals with the construction and solution of this model for the Gunpowder River in Maryland. The conditioned CDFs were obtained by: fitting an ARMA (p,q) model to a portion of the historical streamflow record; using the ARMA model as a forecasting tool; and comparing the forecasted and actual streamflows from the remaining portion of the historical record. For this site, a single dam is considered for construction, and will be used to control streamflows to enhance the local water supply and to mitigate flooding damages.

In order to provide the decision makers with complete and useful information, trade-off curves relating minimum reservoir capacity (a surrogate for dam costs), water supply and flood control targets, and the reliability of achieving the targets are developed. The trade-off curves are presented to the decision maker to allow the selection of the best dam capacity considering technological and financial constraints as well as the trade-offs between targets, risks, and costs.

Lowering of Well Water Temperature by Natural Heat Equalization. ROBERT H. L. HOWE, West Lafayette, Indiana 47906.——The significant lowering of well water temperature by the natural heat capacity equalization in certain areas is explained. The principle of this technique for energy saving is advanced.

Move Away, Moody Diagram! ALDO GIORGINI, A. R. RAO, School of Civil Engineering, Purdue University, West Lafayette, Indiana 47907.——Using graphically presented information hinders efficient use of computers and calculators. For example, if the widely used friction factor-Reynolds Number-Relative Roughness information presented in the Moody Diagram is to be used in a computer program, it may be stored and interpolated, which takes considerable computer storage and time. Alternatively mathematical relationships may be developed and used, and this is more efficient.

In this paper, some of the previously proposed mathematical representations of the friction factor-Reynolds Number relationships are reviewed. A new representation for the information in the Moody diagram is presented. This new representation is shown to be more accurate than some of the previous ones. Extensions of this representation to friction factor-Reynolds number-roughness variations in open *channel flows* are also discussed.

A New Look at the K_{La} Temperature Relationship in Oxygenation Processes Below 100 Degrees. R. H. L. HOWE, West Lafayette, Indiana 47906.——A new formulation $K_La_{(T_2)} = K_La_{(T_1)}/\Theta T2\text{–}T1$, where $T2 > T1$, for the oxygenation of water (and other biological fluids) is introduced and explained. This new formulation, now called Howe-Howland-Li-Dehye equation is in agreement with all gas laws. It is different from the old formulation and has significant impacts on stream water oxygenation, food and other aerobic fermentation engineering processes.