Near Real-Time Flood-Simulation System for Salt Creek in Du Page County, Illinois

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Abstract

A near real-time flood-simulation system is being developed by the U.S. Geological Survey (USGS), in cooperation with the Du Page County Department of Environmental Concerns, for a 15-mile reach of Salt Creek in Du Page County, Illinois. The system will be used to estimate the downstream effects of diverting streamflow during flood conditions into the Elmhurst Quarry Flood Control Facility, an off-line stormwater diversion reservoir containing about 8,300 acre-feet of storage.

The continuous-simulation model, Hydrologic Simulation Program-Fortran (HSPF), is used to simulate the rainfall-runoff and snowmelt relations. The runoff time series resulting from the HSPF simulation is routed using the one-dimensional unsteady-flow model, Full Equations (FEQ). Climatologic data are acquired and relayed to the County offices from a radio-telemetered precipitation-gage network and other sources in near real time. Preprocessor routines are used for data quality assurance/quality control and for filling missing records. The interactive computer program Generation and Analysis of Model Simulation Scenarios (GENSCN) is the interface to the HSPF and FEQ models and aids in data-base management.

Introduction

The Salt Creek watershed is in northeastern Illinois (fig. 1), primarily in Du Page and Cook Counties. The drainage area is 115 square miles to the U.S. Geological Survey streamflow-gaging station (05531500). This gaging station is at the downsteam boundary of the simulated reach. The Elmhurst Quarry Flood Control Facility, adjacent to Salt Creek at a point 12 river miles (drainage area is approximately 90 square miles) from the downstream boundary, is an off-line stormwater diversion reservoir containing 8,300 acre-feet of storage volume.

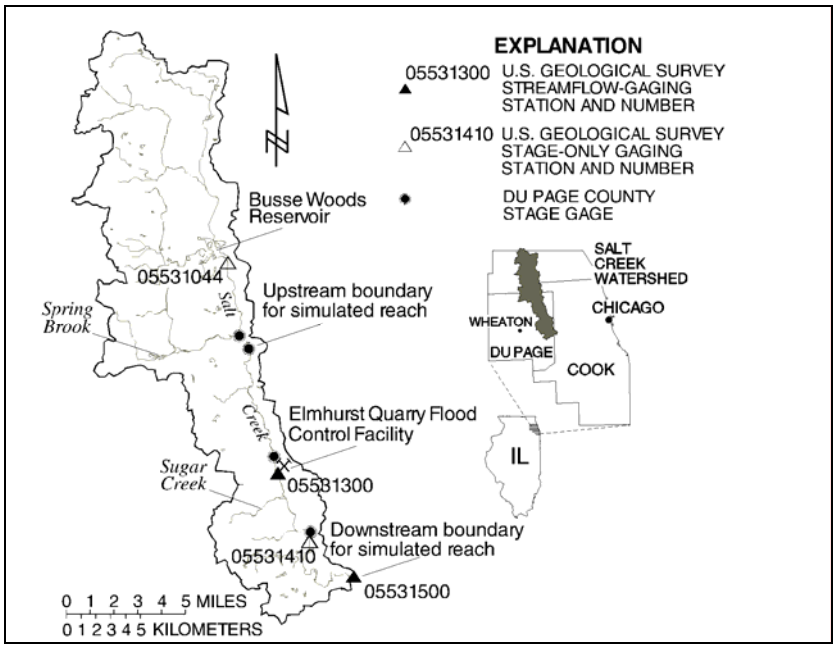

Figure 1. Salt Creek watershed in northeastern Illinois.

Hydrologic and hydraulic model simulations of Salt Creek have indicated that the timing of the flood wave in the lower watershed is highly sensitive to the temporal and spatial distribution of rainfall (Ishii and others, 1998). During short duration, high-intensity precipitation events, local runoff can produce the peak creek stages in the lower watershed. These peaks can occur before the flood wave from the upper watershed arrives. During long duration or multiple precipitation events, the local runoff can combine with the flood wave from the upper watershed, producing peak creek stages in the lower watershed. The capability to simulate the watershed response to precipitation events in near real time is a useful tool used by Du Page County to help evaluate and make effective decisions about diversion operations to reduce flood damages.

Salt Creek Flood-Simulation System Development

Du Page County uses continuous rainfall-runoff simulation and unsteady-flow routing for watershed planning, hydraulic design and analysis, and flood-plain delineation. The continuous-simulation rainfall-runoff model, Hydrologic Simulation Program Fortran, HSPF (Bicknell and others, 1997), and the unsteady-flow hydraulic routing model, Full Equations, FEQ (Franz and Melching, 1997), are used by the County. The HSPF model, as calibrated and verified by Price (1994), is used to determine the unit runoffs. The FEQ models of the Salt Creek Basin and tributaries developed by Du Page County for use in planning, design, and flood-plain studies were unified and streamlined for use in the flood-simulation system.

Modifications were made to the HSPF and FEQ model codes to improve their utility for the unique requirements of near real-time simulation. HSPF was enhanced to save the state variables to a file at the end of a simulation. Subsequent model simulations

read the state variable file to obtain the initial conditions, thereby eliminating manual entry. An option to output a binary time-series file of unit runoffs suitable for direct input as lateral inflows to FEQ also was added. FEQ was modified to include additional output options for GENSCN post-processing.

The graphical user interface GENeration and analysis of model simulation SCeNarios, GENSCN (Kittle and others, 1998), is an interactive software tool for plotting, listing, producing statistics, and animating the results of HSPF and FEQ model simulations. The program runs on Microsoft Windows 9x/NT and functions as a model builder for HSPF, runs HSPF 12.0, and can be used to view and animate input data as well as HSPF and FEQ model-simulation outputs. The GENSCN interface, along with HSPF and FEQ, form the basis of the flood-simulation system. The GENSCN interface main window, as applied to Salt Creek, is shown in figure 2.

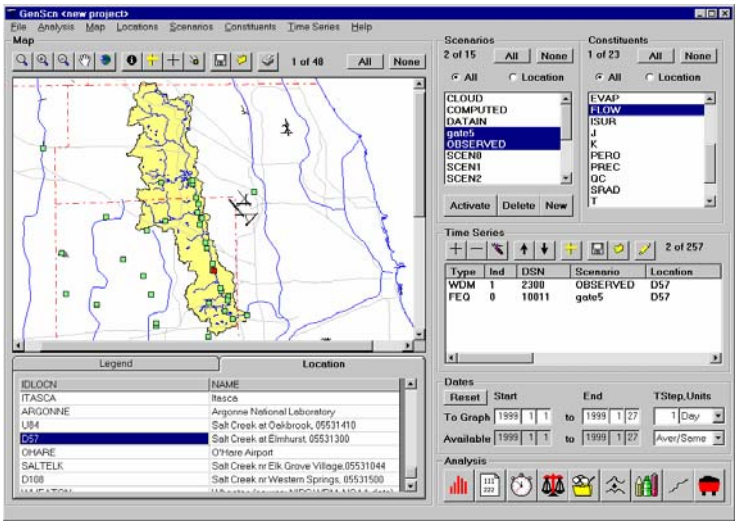

Figure 2. Salt Creek application of the GENSCN interface main window .

Application of the Salt Creek Flood-Simulation System

The flood-simulation system will be operated by the Du Page County staff to assist in the evaluation of alternative diversion structure operations. The major function of the system is to simulate the Salt Creek mainstem stages resulting from real-time or forecasted rainfall and snowmelt data, alternative operating strategies for the sluice gate at Elmhurst Quarry, and the timing of return flows pumped from the quarry. The diversion works for the Elmhurst Quarry Flood Control Facility consist of a 140-foot fixed-crest weir, an 80-foot variable-height weir, and a 7-foot by 7-foot sluice gate. Return flows are accomplished by pumping to a cascading aerating structure. The hydraulic features of these structures are simulated in the FEQ model.

Climatological data (air and dewpoint temperature, wind velocity, and solar radiation) needed to simulate rainfall-runoff and snowmelt are obtained by Internet access or from instruments at the Du Page County emergency management offices. The primary source of precipitation data is the radio-telemetered precipitation network

consisting of 28 gages located throughout the County and surrounding area. After the data are retrieved, they are checked for errors or missing values and reformatted for input to the data base by a preprocessor program. Errors and missing data reports are reviewed and the automatic data revisions are either accepted or exchanged for data from other sources or estimates. The GENSCN interface is used to write the data to the data base and run the hydrologic model (HSPF) input that produces the runoff time series to be routed. The unsteady-flow hydraulic routing model (FEQ) input uses data from the radio-telemetered stage gage as the upstream boundary condition for the simulated reach and the measured stage-discharge relation at the USGS gaging station (05531500) (fig. 1) as the downstream boundary condition. The hydraulic model is run, and the routed results are reviewed for discharge, stage, and storage at critical locations. Additional forecast precipitation scenarios or structure operation scenarios then may be applied and the process repeated. The quicker visualization and analysis of each scenario generated with the flood simulation system permits better interpretation of the watershed hydraulics simulated with the complex HSPF and FEQ models, which will result in improved response by the County during precipitation events.

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CITE THIS PAPER AS FOLLOWS:

Vonnahme, C.C., Ortel, T.W., Ishii, A.L., and Charlton, A.J., 1999, Near Real-Time Flood-Simulation System for Salt Creek in Du Page County, Illinois, (paper) in Planning Ahead: Flood-Loss Reduction for the 21st Century, Association of State Floodplain Managers, Portland, Oregon, 6 p.