SUPPLEMENT TO TECHNICAL NOTE 1

PSEUDO-CALIBRATION OF A RUNOFF MODEL

BY ADJUSTING BASIN INFILTRATION PARAMETERS

INTRODUCTION

This supplement to the Montana Dam Safety Program's *Technical Note 1, Determination of the Inflow Design Flood for High Hazard Dams in Montana*, provides short, practical guidance for conducting a pseudo-calibration of a rainfall-runoff model by adjusting the basin infiltration parameters. Pseudo-calibration refers to the adjustment of a rainfall-runoff model to create a synthetic runoff hydrograph that reasonably matches the characteristics or peak flow of a hydrograph "obtained independently from the rainfall-runoff model, such as the 100- and 500-year flood magnitudes. For example, adjusting model parameters based on comparing model results with the 100-year and 500-year flood magnitude estimates computed using the USGS regional regression equations" (Technical Note 1). This supplement assumes the user is familiar with common hydrologic terminology and has some experience in conducting hydrologic analyses for dam safety purposes in Montana.

DESCRIPTION

The basin infiltration parameters that can be adjusted in a rainfall-runoff model (in this case we will use an example of a model developed by *HEC-HMS (Hydrologic Model System – US Army Corps of Engineers)* are the " "percent impervious area", "initial abstractions", and the loss rate (typically the curve number or ultimate infiltration rate)" (Technical Note 1). These parameters are typically estimated using the hydrologic soil groups identified in the USDA Natural Resources Conservation Service (NRCS) *Web Soil Survey*, a web-based system that provides soil identification and properties for most of the United States. The system allows a drainage basin to be delineated and areas of different soils are determined within a basin.

The following examples provide ways in which infiltration parameters (percent impervious area, initial abstractions, and loss rate) are adjusted. No other basin characteristics, such as unit hydrograph parameters, were modified in the examples.

EXAMPLES FOR ADJUSTING INFILTRATION PARAMETERS

To demonstrate the effects of adjusting infiltration parameters, an example will be used with a HEC-HMS model for an unnamed drainage basin in south-central Montana. The basin characteristics are shown in Table 1. The soil loss rate is estimated by the curve number (CN) method. The unit hydrograph method used was the Clark Method. The goal of the analysis is to pseudo-calibrate the model to obtain a peak discharge for a 500-year runoff event close to 389 cubic feet per second (cfs), which was the average peak discharge for the 500-year flood obtained using the USGS StreamStats® analysis tool and USGS regression equations for ungaged basins in this region. (Note that this does not follow the recommended pseudo-calibration process in Technical Note 1, which suggests that a peak discharge value for a basin used for dam safety purposes should be higher than the upper envelope value for peak flow values in this region. The values in this example are for demonstration purposes only.) The rainfall depth for this event was developed using methods for a 500-year return period storm from *USGS Water-Resources Investigations Report (WRIR) 97-4004, Regional Analysis of Annual Precipitation Maxima in Montana*. The storm hyetograph was developed using methods in *USGS Water-Resources Investigations Report (WRIR) 98-4100, Characteristics of Extreme Storms in Montana and Methods for Constructing Synthetic Storm Hyetographs*.

TABLE 1. EXAMPLE INITIAL BASIN CHARACTERISTICS.

Parameter	Initial Value	Parameter	Initial Value
Drainage Area	5.1 square miles	Clark's T_c[3]	0.86 hours
Average CN[1]	54.3	Clark's R[3]	4.81 hours
Initial Abstration[2]	1.681 inches	Constant Baseflow[4]	0.1 cfs
Impervious area[1]	0.8% of total basin		

Notes:

1. The Natural Resources Conservation Service (NRCS) Curve Number (CN) was initially determined by a weighted-average calculation of CN over the basin based on hydrologic soil groups identified in the *USDA NRCS Web Soil Survey*. The same web program estimated the percentage of impervious area in the basin. Curve numbers are estimated using *Chapter 9, Hydrologic Soil-Cover Complexes, of the NRCS National Engineering Handbook, Part 630, Hydrology*.
2. Initial abstraction (I_a) is the amount of rainfall infiltration at the beginning of the rainfall event and is determined by the NRCS equation $I_a = 0.2(1000/CN – 10)$.
3. Clark unit hydrograph parameters T_c and R were calculated using methods in *WSP 2420*.
4. Baseflow was estimated. No stream gage data was available for this basin. The estimated baseflow has little to no effect on the storm runoff determined by the model.

Adjusting % Impervious Area

The resultant peak flow from the basin using the initial basin parameters, the initial trial of Table 2, was 283.4 cfs, significantly lower than the target 389 cfs. The peak of 283.4 cfs occurred 35 hours after the start of the storm and produced 473.1 acre-feet of direct runoff volume. In Trial 1 of Table 2, only the percentage of impervious basin area is adjusted while all other parameters remain unchanged from the initial trial. When the percentage of impervious area is increased from 0.8% to 12.4%, the resulting peak discharge is 389.4 cfs, which is very close to the target 389 cfs. However, the volume of direct runoff, 624.9 acre-feet, is significantly more than the 473.1 acre-feet of the initial trial.

TABLE 2. RESULTS OF EXAMPLE HEC-HMS ROUTINGS WITH ADJUSTED PERCENTAGE OF IMPERVIOUS AREA.

Trial	Area (sq mi)	% Impervious Area	Initial Abstraction (in)	Curve Number	Q_{peak} (cfs)	Time of Peak (hr)	Runoff Volume (ac-ft)
Initial	5.1	0.80	1.68	54.3	283.4	35	473.1
1	5.1	12.4	1.68	54.3	389.4	33	624.9

Adjusting CN and Initial Abstraction

The other two infiltration parameters, CN and initial abstraction, are inherently linked if the strict definition of initial abstraction is maintained as defined by the NRCS (I_a = 0.2(1000/CN – 10)). A change in CN would automatically change initial abstraction. Also, as CN increases, soil loss rate and initial abstraction decrease, resulting in higher direct runoff. Table 3 shows the results of changing CN and initial abstraction while keeping the percentage of impervious area the same. Trial 1 of Table 3 shows that when CN is changed to 59, initial abstraction becomes 1.39 inches, and peak discharge increases to 395.9 cfs (close and slightly higher than the target of 389 cfs). The volume of direct runoff also increases to 585.5 acre-feet.

TABLE 3. RESULTS OF EXAMPLE HEC-HMS ROUTINGS WITH ADJUSTED CN AND INITIAL ABSTRACTION.

Trial	Area (sq mi)	% Impervious Area	Initial Abstraction (in)	Curve Number	Q_{peak} (cfs)	Time of Peak (hr)	Runoff Volume (ac-ft)
Initial	5.1	0.80	1.68	54.3	283.4	35	473.1
1	5.1	0.80	1.39	59	395.9	33	585.5

CONSIDERATIONS AND CAUTIONS

Adjusting the drainage basin infiltration parameters is relatively easy and is a quick way to pseudo-calibrate a rainfall-runoff model. Adjusting the percentage of impervious area in the basin is the easiest parameter to change, but it has a profound effect on both the peak discharge and direct runoff volume from a basin. It may result in a proportionally larger runoff volume-to-peak discharge ratio than when other parameters are adjusted. In the example where CN and initial abstraction were adjusted, it was decided to maintain the dependence of initial abstraction on CN. The two parameters can be adjusted independently of each other, but the user should be aware that the two soil properties are linked physically and, in general, will change proportionally to one another.

Parameters can be adjusted in a rainfall-runoff model in many ways. The examples for this supplement were intended to show how each parameter by itself (or together with other parameters if they are linked physically) may affect a model, but the user should conduct a pseudo-calibration, as indicated in Technical Note 1, "… with various combinations of basin infiltration parameters during the process of verification."