SUPPLEMENT TO TECHNICAL NOTE 1

DETERMINING BASEFLOW FOR INFLOW DESIGN FLOODS

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 determining baseflow in a *HEC-HMS (Hydrologic Model System – US Army Corps of Engineers)* model for an inflow design flood (IDF). In most cases, baseflow is probably the most neglected parameter in IDF flood analyses. But in some cases it may have an impact on the volume of inflow entering a dam's reservoir, and perhaps even affect the peak discharge of the flood hydrograph. The purpose of this supplement is to provide information about the baseflow function in HEC-HMS and to help determine how to best use baseflow in an IDF evaluation.

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. For this type of evaluation, it is expected the engineer has enough dam safety experience to judge adequacy of the analysis and to make modifications appropriate for the public's safety and the dam owner's protection.

DESCRIPTION

Baseflow is a parameter used in HEC-HMS models, so the following discussion is based solely on how to use the baseflow function in HEC-HMS. From the *HEC-HMS User's Manual*, there are five different options to model baseflow:

- Bounded Recession;
- Constant Monthly;
- Linear Reservoir;
- Nonlinear Boussinesq; and
- Recession.

All of the options, except for Constant Monthly baseflow, include parameters intended to, as accurately as possible, model the recession of baseflow after a storm event or between storm events. While these options also provide baseflow before and during a storm event, their real value is to replicate as closely as possible the flow recession for the basin being modeled. For dam safety evaluations, IDF models produce direct runoff hydrographs in which the magnitude and timing of the peak discharge plus the volume of runoff of the storm event are the important features in conducting spillway and dam height analyses. While the recession of baseflow may impact the volume of storm runoff, it likely will not impact it to an extent that affects dam safety

decisions. So the Bounded Recession, Linear Reservoir, Nonlinear Boussinesq, and Recession baseflow options would be unnecessarily complicated to include in most single event IDF models, unless long term modeling is required. The Constant Monthly method seems best suited for most IDF models.

CONSTANT MONTHLY BASEFLOW OPTIONS

While the Constant Monthly method seems to be the simplest form of incorporating baseflow in an IDF, there are decisions the user needs to make for monthly flows and regarding the basin being considered. With a few exceptions, baseflow will make up a very small portion of the peak flow from an IDF runoff hydrograph. The following are options users can try in developing baseflows for HEC-HMS analyses.

Average Monthly Flow

Estimating the average monthly flow for a stream may not be straight-forward unless the stream is gaged and data have been compiled. You will need USGS help on this. Here is the general way to get to average monthly stream flow data:

1. Go to the website for USGS Surface-Water Data for Montana (https://waterdata.usgs.gov/mt/nwis/sw).
2. Scroll down to a blue box labeled “Statistics” and click on the “Monthly” blue box under it.
3. On the screen that appears, scroll down to “Choose Site Selection Criteria”. Here you can select options under “Site Location,” “Site Identifier,” “Site Attribute,” or Data Attribute.” Click Submit.
4. Another webpage will appear where you can select the criteria for searching for your site.
    a. The two common criteria you will need are “Site Type” (select “Stream”) and “Available Parameters” (select “Streamflow, ft^3/s (under “Water Level/Flow Parameters”).
5. On the same page, scroll down to “Choose Output Format” and select what type of output you prefer.
    a. The option “Show sites on a map” is convenient for showing nearby sites to the possibly ungaged site you are targeting. If your targeted site is on a gaged stream, you may be able to estimate average monthly flows by transposing flow values according to ratios of ungaged basin area to gaged basin area (there are suggested methods for doing this according to USGS criteria, such as that for transposing peak flow values found in *Scientific Investigations Report 2015–5019–F, Methods for Estimating Peak-Flow Frequencies at Ungaged Sites in Montana Based on Data through Water Year 2011, Chapter F of Montana StreamStats*). If your targeted site is on a separate ungaged basin, transposing data from a nearby gaged basin could help in producing rough estimates of monthly average streamflows

for the purpose of using as baseflow information in a HEC-HMS IDF analysis, but this is not an acceptable hydrologic method of transposing gaged data.

b. A handy option that will help in narrowing your selections is to scroll to the bottom of the page, but still within the "Choose Output Format" section, and select "List of sites with links available for Monthly Statistics" under "Retrieve USGS Surface-Water Monthly Statistics for Selected Sites." This will produce a list of sites with general information regarding the stream and periods of record from which the user can choose the appropriate basin for their site.

Bankfull Stream Flows

In stream geomorphological terminology, "bankfull" discharge is considered the most effective flow for moving sediment and forming the shape and gradient of stream channels. It is generally accepted that bankfull discharge has a return period of 1 to 2 years, and on average is considered to be the 1½ year return period. It may be appropriate to use bankfull discharge as baseflow for a stream in a HEC-HMS IDF analysis during months that historically have high flow occurrences related to spring runoff (for Montana, typically May or June). Another justification for using bankfull flow is to simulate high flows from rainfall prior to an IDF event, in which case can be during any spring, summer or fall month in Montana or possibly chinook-caused runoff in late winter in central and eastern Montana.

Bankfull discharge (1½ year return flow) can be estimated using StreamStats®, a USGS web system for determining peak discharges for various return periods (https://streamstats.usgs.gov/ss/). A detailed description on how to use StreamStats is found in the *Supplement to Technical Note 1, Evaluating Spillway Capacity for Small Dams for a 500-Year Storm*.

User Discretion on Selecting Constant Monthly Baseflows

If it is the user's decision that baseflow will be an insignificant contribution to the IDF peak discharge and runoff volume, dummy values of monthly constant flows can be used. It would be reasonably appropriate to estimate monthly flows based on the basin size and stream characteristics.

CONSIDERATIONS AND CAUTIONS

Input for Constant Monthly Baseflow is very subjective is typically based on engineering judgement. For most drainage basins, baseflow will account for an insignificant portion of the IDF hydrograph. In some cases where baseflow could affect the peak discharge and volume of direct runoff to a reservoir, care should be taken to obtain baseflow values from verified sources and methods.

A sensitivity analysis can be appropriate in understanding the effects of baseflow on the peak discharge and runoff volume for an IDF. Trial runs using various values as baseflow can clarify baseflow effects.