Chapter 9

HEC-1 Model Development

Introduction

Overview	This chapter provides an overview of the key input data required and general considerations in developing a HEC-1 model according to the Sacramento Method.
Examples	More specific examples of HEC-1 models are given in Chapter 10.

Basin Parameters

Subbasin Delineation

The size of the subbasins should reflect the purpose and the level of analysis to be performed. Some of the key factors which should be considered in delineating subbasins include:

- locations of points of hydrologic interest in the basin such as; road crossings, detention ponds, and flood prone areas
- tributary confluence locations
- major storm sewer outlet locations
- changes in land use
- changes in channel routing

For planning level studies basin, the recommended subbasin size ranges from 100 acres to 2 square miles (FEMA guidelines set the maximum subbasin size at 3 square miles) with lag times ranging from 20 minutes to 2 hours.

Hydrologic Parameters

Once the drainage area has been subdivided, runoff parameters for each subbasin should be determined and summarized to facilitate input into SACPRE. The following parameters are required to calculate precipitation and precipitation losses.

- area
- rainfall zone
- average elevation
- impervious percent or land use
- soil type

Lag Parameters

The lag time of each basin is required to calculate runoff hydrographs. The information needed to determine the lag time is dependent on the method used (basin "n" or travel time component). The required information for each method is listed below. Chapter 7 includes more detailed information on these methods.

Continued on next page...

Basin Parameters (continued)

Lag Parameters, (cont.)

Basin "n" Method:

- slope of the main channel
- length of the main channel
- length to the centroid
- basin "n" value or land use and main channel condition

Travel Time Component Method:

- land use and slope of overland flow
- length, slope, and size of the various conveyance structures along the main flow path such as gutters, pipes, channels, and ditches

Routing Parameters

Information pertaining to the main reaches through which hydrographs will be routed is also required. This information is dependent on the routing method used (Modified Puls, Muskingum or Muskingum-Cunge). Chapter 8 outlines the specific information required for each method. For all methods however, it is important to know the following parameters.

- reach length
- slope
- channel shape
- Manning's roughness coefficient.

Sources of Data

Sources of information which are helpful in determining hydrologic, lag, and routing parameters are listed below.

Sources of Data		
Hydrologic Parameters	**Lag Parameters**	**Routing Parameters**
USGS topographic maps*	USGS topographic maps*	existing HEC-2 models
SCS soils maps*	grading and drainage plans	field survey of channel
land use maps*	field investigations	
aerial photos		

* included in this volume

Future and Ultimate Development

Future Development

An increase in development can effect the runoff volume and peak flow from a basin. The impact of future development in a basin on downstream hydraulic structures or conveyance systems should always be evaluated. Future development is defined as the land use described by the most recent City and County General Plans. The General Plans usually have a planning horizon of approximately 20 years, and are updated approximately every 5 years. In analyzing the affect of future development in a basin three factors should be evaluated:

- increases in the percent of impervious area
- decreases in basin lag time due to drainage improvements within the subbasin
- decreases in hydrograph routing time due to channel improvements

Ultimate Development

Ultimate development is the land use beyond the General Plan time horizon which assumes build-out condition. Current Sacramento County drainage master plans assume that most agricultural open space and agricultural/ residential lands within the Urban Services Boundary delineated on the General Plan will be developed to low density residential land use (50% impervious) in the ultimate condition. In many developed areas, the future and ultimate conditions are the same. Most drainage facilities are designed for the ultimate condition.

Basin Models

Many drainage studies require that existing and ultimate HEC-1 models be developed and that the corresponding modeling parameters be documented. Typically a baseline hydrologic model is developed using existing land use and existing channelization. An ultimate model is then developed using the appropriate land uses, together with the existing channel condition. This model is referred to as the "without-project" model. Channel improvements, bridge or culvert projects, detention basins, etc. are then provided as "with-project" alternatives .

Design Storm Selection

Frequency

The frequency of the storm used in an analysis is dictated by the structure or system to be designed or analyzed. The design frequency criteria for various drainage facilities are given in the Sacramento County Improvement Standards. The required design frequencies for the most common drainage facilities are given below.

Facility	Design Frequency*	Comments
open channel	100 year	some channels may require a lower design frequency to avoid increasing downstream flows.
detention basins for flood control	100 year	may also include other frequencies depending on downstream conditions.
bridges	100 year	lowest structural member
	50 year	two feet of freeboard
culverts	100 year	no objectionable backwater elevation.
	10 year	soffit elevation
design of storm and street drainage	2 to 10 year	refer to Chapter 2 for applications

* Flows are typically based on ultimate conditions. Design frequency and development condition may vary at the discretion of the City or County.

Continued on next page...

Design Storm Selection (continued)

Duration

These Hydrology Standards include design storms having durations of 6-, 12-, and 24-hours (short-duration), and 36-hours, 5- and 10- days (long- duration). The duration selected should produce the worst case design condition, i.e. the critical flow or volume for the facility being considered.

The short-duration storms can be used for applications concerned with peak discharges or runoff volume. The 6-hour storm is most applicable to drainage design within subdivisions. The 12- and 24-hour storm durations are appropriate for larger basins and basin master planning. The particular short-duration storm used should be greater than the lag time of the entire basin.

The long-duration storms, the 36-hour, 5- and 10- day events are used when volume of runoff, rather than peak discharge, is important. This occurs when designing pumping stations, delineating flooded areas behind levees, or when quantifying increases in runoff volume due to development where long-duration storms have downstream impacts.

SACPRE Design Storms

Design storms of varying frequencies and durations are easily created and changed in SACPRE so that the critical duration (the duration that gives the highest peak flow or detention volume) can be identified. The preprocessor can generate design storms with the following frequencies and durations.

- Frequency: 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-years
- Duration: 6-, 12-, and 24-hours (short-duration), and 36-hour, 5- and 10-day (long-duration).

Computation Time Interval

Computation Interval Selection

HEC-1 requires the length of the computation interval, in minutes, and the number of intervals for all hydrograph calculations. The computation interval is the time increment between each runoff hydrograph calculation. That is, the unit hydrograph ordinates will be read from the input file and the runoff hydrograph ordinates will be calculated as output for each time interval.

The computation interval is dictated primarily by the lag times of the subbasins. Typical subbasin sizes range from 100 acres to 2 square miles with typical lag times ranging from 20 minutes to 2 hours. The computation interval should be approximately one-fifth of the shortest subbasin lag in the model. This assures that the unit hydrograph is adequately defined near the peak for all subbasins.

The number of computation intervals is dependent on the duration of the storm, the total lag time of the drainage basin and the version of HEC-1. The number of time increments should be at least the duration of the storm plus the lag of the basin divided by the length of the computation interval as summarized in the following equation.

$$\text{Number of Computation Intervals} \leq \frac{\text{Storm Duration + Basin Lag}}{\text{Computation Interval}}$$

Continued on next page...

Computation Time Interval (continued)

Using SACPRE

SACPRE automatically determines the computation interval and number of intervals based on the storm duration selected and the constraints of the users version of HEC-1. When these values are set, the minimum and maximum values of lag time are also established. Should the user input a lag time which is incompatible with the default time increment or number of time increments a warning message will appear on the screen indicating the lag time may be too short or too long for the selected time interval. Table 9-1 summarizes the computation intervals set by SACPRE.

The default computation intervals may be changed by editing the SACPRE intermediate file as discussed in Chapter 13. If the intermediate file is edited, the results should be verified to ensure that the entire runoff hydrograph is included and that the unit hydrograph volumes equal approximately one inch.

Table 9-1. HEC-1 Computation Time Interval

	HEC-1 Ver. 4.0				HEC-1 Ver. 4.01e			
Storm Duration	**Computation Interval**	**Number of Intervals**	**Min Basin Lag**	**Max Basin Lag**	**Computation Interval**	**Number of Intervals**	**Min Basin Lag**	**Max Basin Lag**
6 hrs	2 min	300	10 min	1.5 hrs	1 min	500	5 min	1.5 hrs
12 hrs	3 min	300	15 min	2 hrs	2 min	500	10 min	3 hrs
24 hrs	5 min	300	30 min	3 hrs	2 min	1000	10 min	3 hrs
36 hrs	10 min	300	1.0 hr	7 hrs	2 min	1500	10 min	3 hrs
5 days	30 min	300	2.5 hr	20 hrs	5 min	1750	30 min	7 hrs
10 days	---	---	---	---	10 min	1750	1 hr	14 hrs

Notes:
- HEC-1 version 4.0 is limited to 150 unit hydrograph points and 300 computational points.
- HEC-1 version 4.01e is limited to 300 unit hydrograph points and 2000 computational points.
- The user should select subbasin sizes such that the resulting lag times are generally between the minimum and maximum range.
- A minimum lag time of 5 minutes is used by SACPRE.