Preparation of a Hydrology Manual for Imperial County, California

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INTRODUCTION

The hydrology manual prepared for the Imperial Irrigation District (IID), in southern Imperial County, California (see Figure 1), provides guidelines for the determination of storm runoff for the design of flood management facilities, floodplain analysis, and drainage system design. The manual has been written specifically as part of a drainage master plan for IID (see Knell et al., 1996). However, since the master plan area encompasses a major portion of Imperial County, discussions with the county for adoption of the manual as the county hydrology manual are ongoing, with the expectation that the county will adopt the manual.

The hydrology manual provides procedures for computing runoff from rainfall for specific frequencies and duration. Appropriate loss rate procedures are based on land use and soil types. Runoff for small subbasins is computed using the Rational Method. For areas above one square mile in area, unit hydrograph calculations are used to compute runoff. Stream flow routing procedures are defined for routing of flows between subbasin node points.

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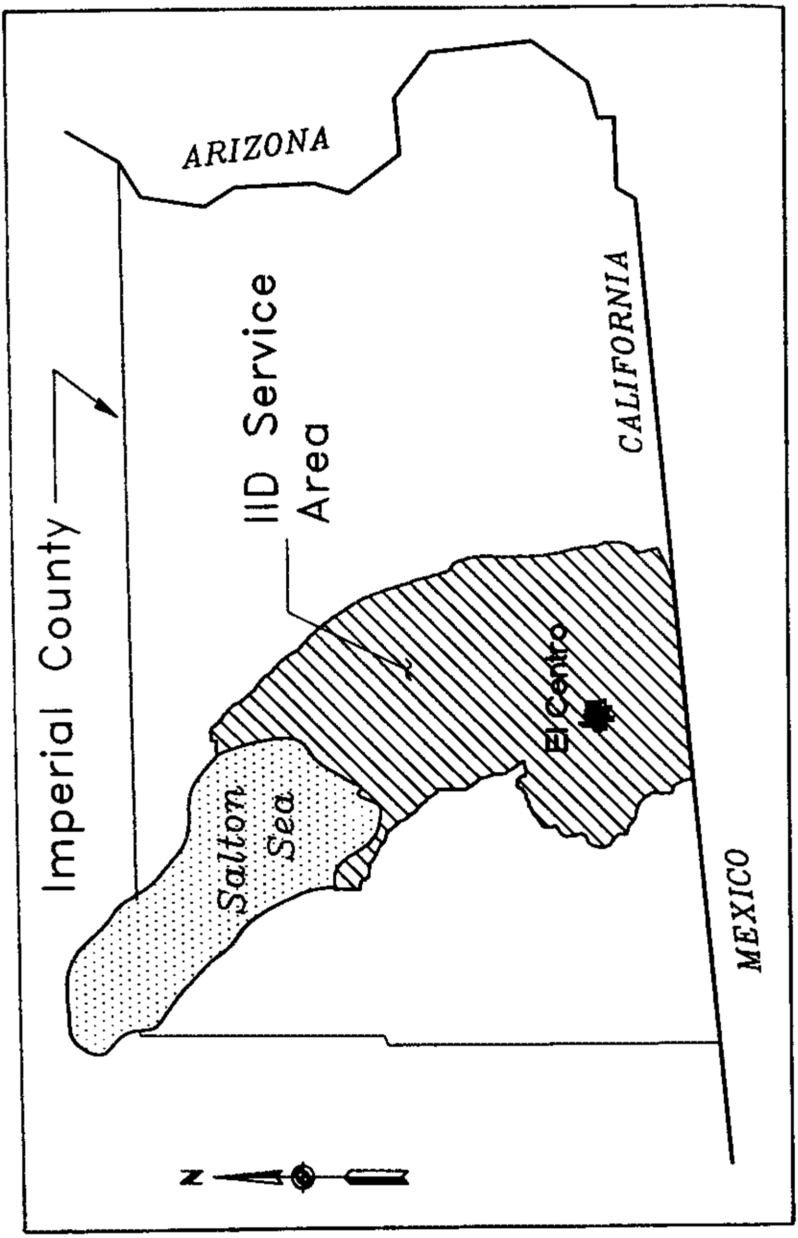

Figure 1. Vicinity map.

HYDROLOGY MANUAL DEVELOPMENT APPROACH

The major focus of the hydrology manual is to provide policy standards and guidelines for stormwater management. The results from application of the manual procedures should be consistent and fair, scientifically defensible and dependable, reliable and reproducible when applied by different users, and fairly easy to use. The procedures should also provide a reasonable "standard of care" (see for example, Nestlinger, 1990).

Due to the uncertainty in establishing an accurate value for the peak discharge associated with a specified frequency of a flood, the parameters in the manual were chosen to provide an 85% confidence level for the flood discharges. This allows uncertainty in estimating peak discharge to be accounted for since on a regional basis only 15% of the design discharges will be "too small" in contrast to the 50% that would result from using the expected value of the peak discharge.

RAINFALL

Annual rainfall throughout Imperial County is very low, and intense short-duration rainfall events are responsible for most floods. A large portion of the county is below sea level (Imperial Valley and Salton Sea), but these areas are surrounded by mountains. A significant flood hazard is posed by streams originating in the mountains and draining into the valley areas.

Two forms of rainfall data were developed for the manual. For hydrograph applications, a design storm is used. The defining parameters are storm duration, point rainfall depth, areal depth adjustment, storm intensity, and time distribution of the rainfall. For the Rational Method calculations, rainfall intensity-duration-frequency curves were developed.

A design rainfall procedure similar to that used for other counties (see, for example, San Joaquin County, 1996), was initially proposed to be used for this manual. The development of design storm procedures of this type is described by DeVries and Hromadka (1994). A review of the available rainfall data indicated that only one gage in the Imperial Valley (at El Centro, see Figure 1) had data for durations of less than 24 hours. Although this gage had incremental rainfall values for durations as short as 5 minutes, it was not sufficient for defining design storms. Fortunately, regional data were available from the newly extended database for the publication that will replace National Oceanic and Atmospheric Administration (NOAA) Atlas 2 for the southwestern United States. The design storm concept was therefore used in this manual to develop hypothetical design storms of various durations and frequencies for calculating runoff based on the recently published rainfall maps (NOAA, 1995).

For a given storm frequency, rainfall values are determined for specific durations (5-minute, 10-minute, 15-minute, etc.). These data are used to compute incremental rainfall amounts (say for each 5-minute interval), which are then arranged into a pattern to form a design storm for hydrograph calculations. The design storm pattern is based on a single synthetic 24-hour critical storm pattern that includes peak rainfall intensities from 5 minutes up to 24 hours. For small watersheds (usually under 5 square miles), only the peak 3-hour period of the storm is needed.

LOSS RATE COMPUTATIONS

The two watershed loss components of initial abstraction and infiltration are related to the hydrologic soil groups in the subarea being analyzed, soil cover and condition, and extent of watershed development. The major factor affecting loss rates is the nature of the soil itself, including surface characteristics, ability to convey water to subsurface layers, and storage capacity. Soils classified into the commonly used four hydrologic soil groups as defined by the U.S. Soil Conservation Service are Group A (low runoff potential), B (soil with moderate infiltration rates), C (soil having slow infiltration rates), and D (high runoff potential). Detailed soil survey information from the Soil Conservation Service was used to prepare maps of hydrologic soil groups. Specific vegetation types and the condition of the cover (poor, fair, or good) are also used to calculate loss rate, initial abstraction, and storm runoff yield.

RUNOFF ANALYSIS METHODS

Relatively simple procedures have been found to give accurate estimation of discharges for design of project components for flood management projects. For small areas (less than one square mile) the well-known Rational Method has been found to provide a good estimation of the peak discharge. For larger areas, unit hydrograph procedures provide accurate determination of the runoff hydrograph. Effective rainfall is determined by calculating time-dependent losses and subtracting the losses from the gross rainfall. The two watershed loss components of initial abstraction and infiltration are incorporated in procedures of this manual.

Rational Method Calculations

For this method, the rainfall is defined by an intensity-duration-frequency (IDF) relationship (as an equation or in tabular form), and the runoff coefficient C is based on vegetation, cover density, infiltration capacity of the soil, and slope of the drainage area.

The manual gives a confluence analysis procedure for estimating the peak flow by the Rational Method at the junction of two or more stream channels. In this procedure, the Rational Method is used to estimate peak flow by adjusting the catchment area to give a more realistic estimate of the *contributing* catchment area based on the critical duration of rainfall.

Unit Hydrograph Calculations

Unit hydrographs are determined from dimensionless S-graphs representative of the type of watershed being analyzed (Hromadka et al., 1993). Individual S-graphs are used for valley, foothill, or mountain watersheds. S-graphs also may reflect urbanization, so that the watershed may be represented by a "valley-developed" S-graph or by a "valley-undeveloped" S-graph. Combinations of S-graph types can also be used.

Base flows seldom occur in Imperial County streams, and any subsurface flow components of the runoff hydrograph that may occur are incorporated in the unit hydrograph response. Stream flow routing is used where routing may affect the runoff hydrograph. Reservoir routing is used to analyze the effects of detention basins on reducing peak discharges.

The dimensionless distribution graph (or dimensionless S-graph) is a form of a unit hydrograph whose ordinates are expressed in terms of percentage of ultimate discharge and the time at which these discharges occur are fractions of the "basin lag." "Lag" for a watershed is the time (in hours) from the beginning of a continuous series of unit period effective rainfall to the instant when the rate of the watershed runoff equals 50% of the ultimate rate of the resulting runoff. The lag relates e relationships of the hydrograph to physical characteristics of the rshed. Lag times determined from calibration in other California counties have shown that lag is related to the time of concentration (T_c) used in Rational Method analyses. Here, the relationship between lag and time of concentration is: lag = 0.8 T_c. Because the time of concentration is also an important parameter for unit hydrograph analysis determination, the hydrology manual provides procedures for calculation of T_c that also take into account the return frequency of the event being modeled.

When lags determined from summation hydrographs for several gaged watersheds are correlated to the hydrologic characteristics of other watersheds, an empirical relationship can be determined. This relationship can then be used to determine the lag for drainage areas for which the hydrologic characteristics can be determined, but for which distribution graphs are not available because of inadequate hydrologic data. Given the absence of more extensive site-specific data for Imperial Valley, this is the approach that is used for the hydrology manual.

CONCLUSIONS

In the preparation of the new hydrology for Imperial Valley, the new NOAA rainfall maps were judged to be the best source of design storm data. To account for uncertainty in establishing an accurate value for the peak discharge associated with a specified flood frequency, the rainfall and loss rate parameters in the manual were chosen to provide an 85% confidence level for the flood discharges. This philosophy, which is similar to that used in Orange County and other Southern California county hydrology manuals, provides the necessary "standard of care" for hydrologic analyses based on the procedures described in this manual.

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