

PHYSICAL WATERSHED PARAMETERS AND DERIVED UNIT
HYDROGRAPHS FROM DENVER METROPOLITAN WATERSHEDS

A Status Report

by

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Submitted to

Hydrologic Engineering Center
Corps of Engineers
Department of the ARmy
Davis, California 95616

under contract
DACW05-73-C-0029

May 1973

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The purpose of this report is to summarize the activities on the research project:

"Urban Watershed Response Time"
Contract DACW05-73-C-0029
CSU Number 31-1372-2342
Report Period 1 January 1973 to 1 April 1973.

INTRODUCTION

The activities on this project during this quarterly period were directed to 1) obtaining a complete set of data on the hydraulic characteristics of the storm drainage network in the Denver Urban Watershed, 2) punching data cards for the hyetographs and hydrographs of the events recorded from the Denver Urban Network, 3) deriving unit hydrographs from the recorded events and 4) making a preliminary survey of the flood data that might be available from the Texas watersheds.

WATERSHED CHARACTERISTICS

The purpose of the project was to relate various properties of the unit hydrograph with physical characteristics of the urban watershed. As urban subdivisions are planned, the new unit hydrograph from the urban region can be predicted on the basis of the physical characteristics of the urban region. Eagleson (1962), Espey et al. (1969), Schulz (1971) and others have shown these physical parameters to be important in quantifying urbanization as far as hydrologic

properties are concerned:

- 1) Impervious parts of the watershed,
- 2) Length of storm sewer in the watershed,
- 3) Effective channel roughness of the floodways,
- 4) Length of paved streets in the watershed,
- 5) Length of paved, curbed and guttered streets in the watershed.

Impervious Area: - The percent of the watershed which is impervious has a great influence on the hydrology of the watershed. The paved area prevents the infiltration of rainfall into the watershed. During periods between rainfall, the paved parts of the watershed eliminates the normal evapotranspirational losses from the watershed. These two generally result in an increase in annual runoff volume from the watershed.

As a general rule the paved surfaces are also more efficient conveyors of the surface detention storage. Hence the decrease in watershed response time shown by Espey et al. (1969).

The impervious areas in the watershed can be measured from aerial photographs made in the watershed. Research in more efficient methods for measuring the impervious parts of the watershed are being carried out in the Department of Watershed Sciences at Colorado State University. One method is based on using a non photographic multispectral mapper to scan an aerial photograph.

The spectral density of the reflected image for selected wave lengths is examined for a large number of spots on the photograph by this scanner. The common surfaces encountered in an urban region are: 1) Concrete, 2) Asphalt, 3) Roof tops, 4) Gravel surfaces, 5) Lawns, 6) Fields or pasture, 7) Agricultural lands, 8) Trees,

9) Exposed soil and 10) Water.

Root and Miller (1971) have measured the reflectance signatures for some of these surfaces based on a technique developed earlier by Oliver and Miller (1971). The reflectance signatures for impervious materials are summed up for the watershed (or aerial photograph) and number expressing the impervious areas can be automatically obtained from the computer linked to the spectral scanner.

As an example of the application of the method, Root and Miller (1971) reported the impervious area for 13 of the USGS Denver Urban Watersheds. There is hope that this technique will provide an adequate means for measuring the percent of impervious watershed area.

Length of Storm Sewer: - The data regarding the amount and capacity of the storm sewers installed in the urban watershed must be obtained from engineering drawings. There are two variables which are important- 1) the density of the storm drainage network and 2) the relative carrying capacity. The first variable can be assessed by measuring the total length of the storm drains. Eagleson (1962) measured only the length of sewers larger than 36 inches in diameter. The second variable must assess the flow carrying capacity in relation to discharge likely to appear in the drainage system. The actual variables would be diameter (or size) of the sewer, the slope of the line, the material of construction (or measure of its roughness) and the flood flow of some given recurrence interval.

The information of this type can only be obtained from engineering drawings of the storm drainage system. This type of information should be a matter of public record in the City Engineer's Office. The

information for the Denver Urban Watersheds has been assembled. There is doubt, however, regarding the accuracy of some of the data.

This arises because of changes made in the drainage system because of unforeseen difficulties encountered during construction.

The usual pattern of construction follows this general arrangement:

- 1) Project presented to City Engineer for approval including Engineering Drawings,
- 2) Project approved or disapproved,
- 3) Project construction started,
- 4) Project may encounter construction difficulties,
- 5) Project plans revised to solve construction problem,
- 6) Revised project completed, but the official drawings may not be an accurate representation of the installed storm drain,
- 7) Unauthorized changes, extensions and improvements may be made to the storm drainage system after the construction. These may not appear on any kind of drawings.

The storm drain parameter thus is a parameter which may not be easily measured or known with great accuracy. Aside from possible difficulties in obtaining all of the drawings, careful field check must be made to verify all of the details of the system.

Length of Paved Streets: - The total length of paved streets and the length of curbed and guttered streets can be obtained from aerial photographs. There must be some checking on the ground to verify the existence of the curbed and guttered streets.

The curbed and guttered street is an important link in the hydraulics of the storm drainage. The curbs hold the runoff from the street in relatively deep and straight channels. This is a more efficient drainage system than the simple drainage of the sheet of surface detention.

If the paved street does not have a curb, the runoff drains to a pervious surface. Often time the edge of the road is a grassed surface which is more permeable than the native pristine surface which may exist a short distance away. This type of situation exists along many freeways and newer type of urban expressways.

The native vegetation was destroyed during the highway construction. After highway construction, the shoulders of the roadway and median strip were seeded with a suitable grass to control erosion and provide a pleasing appearance. At the immediate edge of the roadway, the water supply to the vegetated surface is enhanced by the additional runoff harvested from the impervious roadway surface. In many climates this additional water supply is a benefit to the grassed surface. The benefit may be partly off set by the adverse effect of some of the other constituents of the micro climate of the highway such as lead, nitrous oxides, rubber and asbestos dust, carbon monoxide resulting from the traffic.

The hydrologic function of a paved street without curbs and a paved street with curbs and gutters are likely to be quite different. Hopefully we may be able to add some data to the knowledge about this process.

Effectiveness of Drainage Ways: - Some of the natural drainage ways are preserved in an urban setting. Sometimes these are grassed and improved to make green belts, narrow parks, bicycle paths or bridle paths. Channels are straightened. Many times the banks are shaped to confine the flow or stabilize the banks. This results in improved hydraulic efficiency of the channel. When this takes place the response time of the urban watershed is reduced because of the higher stream velocities.

The higher stream velocities causes a higher shear force on the bed and results in bed scour which is then controlled by installation of drop structures, weirs and other types of slope control devices. These structures in turn tend to increase the response time of the watershed.

These drainage ways tend to accumulate trash and rubbish.

In fact many times they become illicit dumping grounds for individuals who do not dispose of their trash in an approved way. The accumulation of trash and rubbish in a flood drainageway has an adverse effect on the hydrologic performance of the waterway. While it might be argued that banks and bed might be protected against erosion, the benefit thus obtained is offset by other detrimental effects.

The detrimental effects are the unsightly appearance, the reduction in flow crosssection, and the fact that the trash is a source of all types of buoyant objects which float downstream and become lodged in various control points downstream. The presence of this debris has often caused the failure of an otherwise adequate structure.

The length and overall adequacy of the drainageway can be assessed from aerial photographs but the detailed appraisal of its hydraulic properties requires on-the-ground inspection. The existence of buoyant objects in the floodway is one of the very dynamic features of an urban watershed. Hopefully the current interest in the improvement of the environment might be mobilized to eliminate some of these hydrologic hazards.

Assembly of Urbanization Data: - The assembly of the data for assessing the urbanization parameters is about 80% completed. Recent aerial photographs of the watersheds have been obtained. The watersheds have been

outlined on 7½ minute USGS quadrangle maps. Drawings of the storm sewer systems have been obtained. Some photographs of critical points have been obtained.

UNIT HYDROGRAPHS

Unit hydrographs have been obtained from all events having good rainfall hyetographs and runoff hydrographs. These unit hydrographs have been derived using a matrix inversion method developed by a graduate student at CSU, Kavvas (1972).

The unit hydrographs are also being derived by the HEC method which is in the HEC 1 computer program package. The HEC program has not obtained a logical unit hydrograph in all instances. The reason for this failure is now being investigated.

PLANS FOR THE NEXT QUARTER

The derivation of the unit hydrographs by the HEC procedure will be completed during the next period. Correlations between the unit hydrograph parameters and the physical urban watersheds will be developed. Discrepancies in the data and correlations will be checked. Preparation of the thesis and final report will be started.

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