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Methods for Estimating the Effective Impervious Area of Urban Watersheds

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One of the most difficult and important parameters that must be estimated for accurate hydrologic analyses is the effective impervious area (EIA) of a watershed or basin of interest. EIA is the portion of the total impervious area (TIA) within a basin that is directly connected to the drainage collection system. EIA includes street surfaces, paved driveways connecting to the street, sidewalks adjacent to curbed streets, rooftops which are hydraulically connected to the curb or storm sewer system, and parking lots.

EIA is usually reported as a percentage of total basin or subbasin area. In traditional urban runoff modeling or hydrologic analysis, the EIA for a given basin is usually less than the TIA. However, in highly urbanized basins, EIA values can approach and equal TIA values.

The EIA of a basin is an important parameter in the rainfall/runoff process because it directly affects the volume of runoff. Many hydrological models assume all the precipitation that falls on impervious areas becomes direct runoff. In actuality, the precipitation falling on impervious areas which are not hydraulically connected to the drainage collection system does not always result in direct runoff. Impervious area that does not contribute directly to runoff should be subtracted from the total impervious area to obtain the *effective* impervious area, in order to get a more accurate estimate of runoff volumes.

Determination of Effective Impervious Area

The methodology for determining EIA has been refined through three levels:

1. Direct measurement in the field

The direct measurement of EIA is a tedious exercise which is rarely undertaken since most consultants cannot afford its excessive labor cost. To actually measure the EIA of a basin, it is necessary to catalog and evaluate the effectiveness of the hydraulic connection between *each* of the impervious areas and the major collector systems. This extremely time consuming exercise is impractical for most drainage planning and design related activities.

2. Derivation from models run on gauging data

If a basin is gauged, the effective impervious area can be estimated by employing a rainfall-to-runoff model like HEC-1 or SWMM to calibrate the EIA parameter. This calibration is performed by fixing reasonable estimates of the precipitation loss components for the pervious portions of the basin and impervious areas, then adjusting the value of EIA to correlate computed and observed runoff volumes. The calibration process should be undertaken for several observed rainfall events, with the final estimate of EIA representing the weighted average of those values calibrated for each individual storm.

3. Empirical equations derived from whole-basin or subbasin parameters

Empirical equations can be developed to compute realistic values of EIA based on physical basin parameters that are easy to estimate. For example, the United States geological Survey (USGS) developed estimates of EIA for over 40 watersheds throughout the metropolitan areas of Portland and Salem, Oregon (Laenen, 1980 and 1983). Working with this database, the USGS also developed an empirical equation to estimate EIA as a function of total impervious area.

It should be noted that the modeling technique used by the USGS lumped all of the precipitation excess into a single optimized percentage of the basin area that was assumed to be contributing runoff. This optimized value was defined as the effective impervious area. Working with these optimized values, the USGS (Laenen, 1983) developed the following equation:

$$EIA = 3.6 + 0.43\,(TIA) \qquad (1)$$

Equation (1) has been found to work well for TIA values greater than 10% and less than 50% but provides unrealistic EIA values for TIA values outside of this range (i.e., more urbanized areas). In surface water management master planning, one commonly deals with *small subbasins* (i.e. 20 to 70 acres) in which the ultimate mapped impervious area can routinely exceed 50%, and may be as high as 90%.

Therefore, there is a need to develop a better relationship between TIA and EIA and several alternative equations based upon the USGS data have recently been developed to satisfy this need, known as the Sutherland Equations.