Hydro13A Users Guide

**Runoff Methods**. The rational method is used to compute rainfall and runoff for up to 200 acres for both urban and rural areas. USGS regression equations are used to compute runoff for drainage areas larger than 200 acres. The flow chart shows the process and spreadsheets to use to calculate rainfall and runoff.

**RATIONAL METHOD**

**Basis for intensities**. The rainfall intensities for Hydro13A are based upon the NWS NOAA Atlas 14 Volume 9, Version 2, Point Precipitation Frequency Estimates: AL which was published in 2013 for 174 weather stations in Alabama. Intensities at 5, 10, 15, 30 and 60-minute rainfall durations with frequencies of 2, 5,10, 25, 50, 100 and 200 years can be read directly from Atlas 14 Volume 9 at: <http://www.nws.noaa.gov/ohd/hdsc/>.

The NOAA Atlas 14 rainfall data replaces the NWS Hydro 35 data which was published in 1977. The old Winhydro program intensities are based on Hydro 35 and are outdated. The Atlas 14 estimates spatially are single point estimates for the 174 weather stations but are not directly applicable to a large area. A 90 percent confidence interval is shown for each intensity which has a fairly wide range. Atlas 14 Intensities are shown at average recurrence intervals and time durations. The average recurrence interval is the average period between years in which a given precipitation magnitude is exceeded at least once. It is also called the return period or frequency. The annual exceedance probability (percent) or risk is the reciprocal of the recurrence interval multiplied by100 percent. Risk is the probability that an event of a given magnitude will be equaled or exceeded within a specific time period.

Atlas 14 does not have intensity equations to calculate intensities between the durations shown at 5, 10, 15, 30 and 60 minutes. However, Hydro13A has 23 geographically diverse Alabama weather stations (selected out of the 174) each of which have seven intensity-duration equations for frequencies of 2, 5, 10, 25, 50, 100 and 200 years developed from Atlas 14 data.

For locations close to a station, the equations for that station can be used, or for locations midrange between two stations, conservatively the station with the higher intensity should be used. The most intense rainfall occurs across the southwest part of the state, and the least at the northeast part. The intensity gradient is greatest across the southern counties of the state. The Point Intensities sheet shows the Atlas 14 10-year, 5-minute intensities, and the 50-year, 15-minute intensities at these 23 stations as a guide to rainfall variation.

The Flow Chart sheet shows the steps to get the decimal fraction of runoff (the runoff coefficient C), and the longest flow time from any point on the periphery of the drainage area to the outlet (the time of concentration or tc).

**Composite C value**

The Impervious Area, IA, spreadsheet is provided for the computation of impervious area, IA, (acres) for the rational method runoff coefficient C computation. The impervious area is simply the sum of buildings, roads, sidewalks or even rock outcrops which can be field measured or scaled off photographs. The impervious area should be converted to percent to compute the lagtime for the urban regression equations,

The spreadsheet for composite C values first estimates the composite soil C value with the use of the USDA Soil Data server data for the drainage area (area of interest or AOI), and Table 4-2 of runoff coefficients from the hydraulic manual. Then it subtracts the IA (acres) from the overall watershed area which facilitates the computation of a composite C value. The IA (acres) typically has a high runoff coefficient such as 0.85 or 0.90. This provides an orderly method for computation of composite coefficients and provides documentation to prove due diligence.

**Kirpich time of concentration, tc**

A Kirpich time of concentration, tc, calculation spreadsheet is provided to account for the different types of overland and channel flows based upon the Kirpich formula with appropriate modification factors. There are computational blocks for up to four flow paths from the periphery of the drainage area to the basin outlet. Each block has columns for up to five different flow path segments if necessary. Each segment flow time is calculated on a vertical column. The Kirpich formula flow time is computed for each segment, and then is multiplied by a modification factor. The modified flow times are summed on the bottom line to get the total time of concentration. Overland flow is considered to last a maximum of 300 feet unless the surface is paved or cannot erode. The longest flow time is the time of concentration for the entire drainage area.

**Rational method worksheets**

Each of the 23 stations has a separate rational method spreadsheet with three unique coefficients for each of the seven intensity equations. The reference rainfall station data and intensity equations for that gage are already entered. The worksheet should be identified with the project data and date. This is important data because without this data the sheet will be worthless several months hence. To obtain the runoff the drainage area, A, runoff coefficient, C, and time of concentration, tc, are entered directly on the selected rainfall station sheet.

**REGRESSION EQUATIONS**

Regression equations spreadsheets are provided to compute runoff for drainage areas too large to use the rational method. Separate spreadsheets have equations to compute runoff from three classifications of streams (actually drainage areas); large rural streams, small rural streams, and urban streams

**Large Rural Regression Equations.**  For large rural streams the equations from *Magnitude* *and Frequency of Floods in Alabama*, 2003: USGS Scientific Investigations Report 2007-5204, are used. This report divides the state into four flood regions, and each region has its own equations and area range with recurrence intervals of 1.5, 2, 5, 10, 25, 50, 100, 200 and 500 years. The lower limit of each region is set at 5 square miles so as not to overlap the small rural streams equations. These flood regions are shown on Figure 2 of the Flood Regions sheet. The DA as sq mi is the only parameter needed to compute flows for a region. These equations should not be used where dams, detention or channelization have a significant effect on peak discharges. The percent developed (P.D.) must be less than 20 per cent.

To use the spreadsheet the project data is entered which is similar to the rational method spreadsheets. The region is determined, and the drainage area as square miles is entered on the upper part of the sheet. The peak flow column for the applicable region then shows the flows for seven recurrence intervals from 2 to 200 years. The flows shown for the other three regions are not applicable for a particular region.

The fall line is shown on Figure 1 of the Flood Regions sheet. The location north or south of the fall line is necessary only for lagtime computations and hydrograph generation but is shown for information on the top part of the sheet. At the bottom of the sheet the USGS estimated volume which is indirectly generalized from a family of hydrographs is shown for each return period.

**Small Rural Regression Equations.** The report*Magnitude and Frequency of Floods on Small Rural Streams in Alabama,* 2004: USGS Scientific Investigations Report 2004-5135,is used to compute runoff for rural drainage areas up to 15 square miles statewide. About 5 to 7 square miles is where the larger streams’ regression equations become more applicable. The DA as sq mi is the only parameter needed to compute flows. The preferred range for the small rural streams equations is from 0.31 (200 acres) to 5 square miles. A single set of statewide equations with recurrence intervals of 2, 5, 10, 25, 50, 200, and 500 years applies for the small rural streams regardless of the region. A small rural area has a percent developed (P.D.) of less than 20 percent, and the P.D. may need to be computed to make sure the small rural equations apply.Channelization and backwater must not significantly affect the site for the small rural regression equations to apply.

To use the spreadsheet the project data is entered which is similar to the rational method spreadsheets. The P.D. is checked or estimated to see if the urban regression equations could apply. Drainage area as square miles is entered on the upper part of the sheet. The peak flow column then shows the flows for the seven recurrence intervals.

The location north or south of the fall line is necessary only for lagtime computations and hydrograph generation but is shown for information on the top part of the sheet. At the bottom of the sheet the USGS estimated volume is shown for each return period.

**Urban regression Equations.**

Regression equations are used to compute runoff for urban drainage areas from 1 to 43 sq mi from *Magnitude and Frequency of Floods for Urban Streams in Alabama,* 2007: USGS Scientific Investigations Report 2010-5012. For practical use this lower limit is extrapolated down to 0.31 sq mi to the upper limit of the rational equation for want of a more precise method. This report divides the state into the same four flood regions as for the larger rural streams. A single set of equations for Regions 1, 2, and 4 are used with recurrence intervals of 2, 5, 10, 25, 50, 100, and 200 years. Flood Region 3 (the blackbelt region of the coastal plain) has soils that effectively seal over when thoroughly wet, and has no urban equations because the small and large rural equations for that region give better estimates of runoff.

To compute urban flood flow, the DA as sq mi is needed, and also the percent developed (P.D.) as percent, which is the percentage of the drainage area covered by any kind of development. This includes yards, roofs, pavement, etc. covered by subdivisions, downtown areas, industrial areas, etc. A P.D. of at least 20 percent is required for an area to be considered urban. The sum of the developed areas is divided by the total area and multiplied by 100% to get the P.D. The Percent Developed, P.D. spreadsheet has space to make and document the P.D. computations, or the user can make his own spreadsheet. The DA must not significantly be affected by dams, detention storage, hurricane storm surges or substantial tidal fluctuations. Regression techniques used by the U.S. Geological Survey generalized from a family of hydrographs indicate that the P.D, correlates to roughly 3.75 times IA (%).

To use the spreadsheet the project data and date are entered which is similar to the rational method spreadsheets. Drainage area as square miles and the P.D. are entered on the upper part of the sheet. The peak flow column then shows the flows for seven recurrence intervals for the three applicable regions.

The lagtime computation is at the bottom of the sheet. The IA as a percent is necessary to compute urban regression equations lagtime. The location north or south of the fall line is not necessary for urban hydrograph generation. The generalized USGS estimated volume is also shown for each return period,

**Alabama hydrograph.** A spreadsheet is provided for a statewide average dimensionless Alabama hydrograph based on *Estimating Flood Hydrographs and Volumes for Alabama Streams,* 1988: USGS Water Resources Investigations Report 88-4041.

Lagtime, LT, is needed to compute the time coordinates of the dimensionless hydrograph. The hydrograph is used with the computed lag time for the regression equations, or with the time of concentration for the rational method. Lagtime for the regression equations is the time, in hours, from the centroid of the rainfall excess to the centroid of the resultant runoff hydrograph.

The 10- 85 percent channel slope is used to compute the regression equations lagtime. The slope of the channel, expressed as feet/mile, is measured between points 10 and 85 percent of the distance from the outlet along the flow path that has the longest flow time from the basin divide to the outlet. The 10-85 % Slope sheet is provided as an aid for the computation of that slope.

The regression lagtime equations all depend upon area (sq mi) and the10-85 % channel slope S (ft/mile). The rural lagtime equations are different north and south of the fall line. The fall line separates the coastal plain from the other four physiographic provinces of the state. The fall line is approximately the southern and western boundary of flood region 1 but is shown specifically on Figure 1 of the Flood Regions spreadsheet. The urban lagtime equations lag time additionally depends upon the percent imperviousness IA (%).

On the Runoff Volume sheet, the total depth of flow (inches) which includes base flow is estimated from the LT (hrs), peak discharge (cfs), and drainage area (square miles) from the USGS Water Resources Investigations Report 88-4041 but has a standard error of estimate of plus or minus 23.2 %.

The total volume of flow (cubic feet) under the hydrograph is also calculated on the Runoff Volume sheet by the trapezoidal rule. Direct rainfall runoff is the volume of runoff which results from the design storm. The base flow is subtracted off the calculated total volume to obtain the direct rainfall runoff.

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