CHAPTER 2

HYDROLOGY

2.9 U.S. Geological Survey Peak Flow And Hydrograph Method

2.9.1 Introduction

For the past 20 years the U.S. Geological Survey has been collecting rain and stream flow data at various sites within the Atlanta Metropolitan Area and throughout the State of Georgia. The data from these efforts have been used to calibrate a U.S. Geological Survey rainfall-runoff model for use within the Atlanta Area. The U.S. Geological Survey Model was then used to develop peak discharge regression equations for the 2-, 5-,10-, 25-, 50- and 100-year floods. In addition, the USGS used the statewide data base to develop a dimensionless hydrograph which can be used to simulate flood hydrographs from rural and urban streams within the City of Lawrenceville.

2.9.2 Peak Discharge Equations

USGS Regression Equations for Gwinnett County – City of Lawrenceville

Frequency	Equation	
	Region 1	Region 2
2-year	$Q_2 = 167A^{0.73}\ TIA^{0.31}$	$Q_2 = 145A^{0.70}\ TIA^{0.31}$
5-year	$Q_5 = 301A^{0.71}\ TIA^{0.26}$	$Q_5 = 258A^{0.69}\ TIA^{0.26}$
10-year	$Q_{10} = 405A^{0.70}\ TIA^{0.21}$	$Q_{10} = 351A^{0.70}\ TIA^{0.21}$
25-year	$Q_{25} = 527A^{0.70}\ TIA^{0.20}$	$Q_{25} = 452A^{0.70}\ TIA^{0.20}$
50-year	$Q_{50} = 643A^{0.60}\ TIA^{0.18}$	$Q_{50} = 548A^{0.70}TIA^{0.18}$
100-year	$Q_{100} = 762A^{0.69}\ TIA^{0.17}$	$Q_{100} = 644A^{0.70}\ TIA^{0.17}$
200-year	$Q_{200} = 892A^{0.68}\ TIA^{0.16}$	$Q_{200} = 747A^{0.70}\ TIA^{0.16}$
500-year	$Q_{500} = 1063A^{0.68}\ TIA^{0.14}$	$Q_{500} = 888A^{0.70}\ TIA^{0.14}$

For these equations: A = drainage area, mi^2 TIA = total impervious area, %

For a complete description of the USGS regression equations presented above, consult the USGS publication "Flood-Frequency Relations For Urban Streams In Georgia – 1994 Update, Water-Resources Investigation Report 95-4017. The above USGS regression equations are for use in the City of Lawrenceville. Note that drainage areas in Region 1 flow to the Chattahoochee River while areas in Region 2 flow to the south away from the Chattahoochee River.

2.9.3 Limitations

Following are the limitations of the variables within the peak discharge equations. These equations should not be used on drainage areas which have physical characteristics outside the limits listed below.

Physical Characteristics	Minimum	Maximum	Units
A – Drainage Area	0.04	19.1	mi^2
TIA – Total Impervious Area	1.00	62	percent

2.9.4 Hydrographs

The USGS has developed a dimensionless hydrograph for Georgia streams having drainage areas of less than 500 mi^2. This dimensionless hydrograph can be used to simulate flood hydrographs for rural and urban streams within the City of Lawrenceville. For a complete description of the USGS dimensionless hydrograph consult the USGS publication "Lag time Relationship for Urban Streams in Georgia", Water-Resources Investigation Report 00-4049 (Inman, 2000). Table 2.9.4-1 shows the time and discharge ratios for the dimensionless hydrograph for the City of Lawrenceville.

The lag time equation that should be used in the City of Lawrenceville use the dimensionless hydrograph is:

$$T_L = 7.86 A^{0.35} S^{0.31} IA^{-0.22} \qquad \textbf{(Eq 2.9.4-1)}$$

Where: T_L = lag time (hours)
A = drainage area (mi^2)
S = main channel slope (ft/mi)
IA = total impervious area (percent)

Using this lag time equation and the dimensionless hydrograph, a runoff hydrograph can be determined after the peak discharge is calculated.

Table 2.9.4-1

Discharge ratios for the Dimensionless Hydrographs for the City of Lawrenceville

Time Ratio (t/T_t)	Discharge Ratio (Q/Q_p)	Time Ratio (t/T_t)	Discharge Ratio (Q/Q_p)
0.25	0.12	1.35	0.62
0.30	0.16	1.40	0.56
0.35	0.21	1.45	0.51
0.40	0.26	1.50	0.47
0.45	0.33	1.55	0.43
0.50	0.40	1.60	0.39
0.55	0.49	1.65	0.36
0.60	0.58	1.70	0.33
0.65	0.67	1.75	0.30
0.70	0.76	1.80	0.28
0.75	0.84	1.85	0.26
0.80	0.90	1.90	0.24
0.85	0.95	1.95	0.22
0.90	0.98	2.00	0.20
0.95	1.00	2.05	0.19
1.00	0.99	2.10	0.17
1.05	0.96	2.15	0.16
1.10	0.92	2.20	0.15
1.15	0.86	2.25	0.14
1.20	0.80	2.30	0.13
1.25	0.74	2.35	0.12
1.30	0.68	2.40	0.11

2.9.5 Limitations

Following are the limitations of the variables within the lagtime equation (2.9.4-1). The lagtime equation should not be used for drainage areas which have physical characteristics outside the limits listed below.

Physical Characteristics	Minimum	Maximum	Units
A – Drainage Area	0.04	19.1	mi^2
S – Main Channel Slope	9.4	772	feet per mile
A – Total Impervious Area	1.0	61.6	percent

2.9.6 Rural Basins

The USGS has recently revised the equation for estimating peak discharge for rural basins. For a complete discussion of the development of these

equations consult the USGS publication "Techniques for Estimating Magnitude And Frequency of Floods in Rural Basins of Georgia", Water-Resources Investigations Report 93-4016.

For these rural equations, the USGS has two regions (Region 1 and 2) that will affect the use of the equations within the City of Lawrenceville. Region 1 includes all those drainage areas that eventually flow into the Chattahoochee River. Table 2.9.6-1 shows the equations used to calculate peak discharges for rural basins in the City of Lawrenceville.

Table 2.9.6-1

Peak Discharges for Rural Basins in the City of Lawrenceville

Frequency	Equations Region 1	Equations Region 2
Q^{2}	$207A^{.654}$	$182A^{.622}$
Q^{5}	$357A^{.632}$	$311A^{.616}$
Q^{10}	$482A^{.619}$	$411A^{.613}$
Q^{25}	$666A^{.605}$	$552A^{.610}$
Q^{50}	$827A^{.595}$	$669A^{.607}$
Q^{100}	$1010A^{.584}$	$794A^{.605}$
Q^{200}	$1220A^{.575}$	$931A^{.603}$
Q^{500}	$1530A^{.563}$	$1130A^{.601}$

A – Drainage Area in mi^2

2.9.7 Limitations

Following are the limitations associated with the rural basin equations given above.

Physical Characteristics	Minimum	Maximum	Units
Region 1			
A – Drainage Area	0.17	730	mi^2
Region 2			
A – Drainage Area	0.10	3,000	mi^2

2.9.8 Example Problem

For the 100-year flood, calculate the peak discharge for rural and developed conditions for the following drainage area location in Region 1.

Drainage Area = 175 acres = 0.273 mi^2
Total Impervious Area (TIA) = 32%

<u>100-year Rural Peak Discharge</u>

$$Q_{100} = 1010A^{.584} = 1010(.273)^{.584} = 473\,cfs$$

<u>100-year Developed Peak Flow</u>

$$Q_{100} = 762A^{.69}TIA^{.17}$$
$$Q_{100} = 762(.273)^{.69}(32)^{.17} = 561\,cfs$$

END OF SECTION 2.9