SECTION 11

STORMWATER HYDROLOGY

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11.1 General

The City and City Engineer shall issue final approval for the design of all storm sewer facilities.

11.2 Methodology for Determination of Runoff Rates

Runoff rates shall be computed for the area of the parcel under development plus the area of the watershed flowing into the parcel under development. The rate of runoff which is generated as the result of a given rainfall intensity may be calculated as follows:

A. Development Sites Less than or Equal to five (5) Acres in Size, With a Contributing Drainage Area Less than or Equal to fifty (50) Acres and No Depressional Storage

The Rational Method may be used. A computer model, such as TR-55 (NRCS), TR-20 (NRCS), HEC-HMS (COE), and HEC-1 (COE), that can generate hydrographs based on the NRCS TR-55 time of concentration and curve number calculation methodologies may also be used along with a twenty-four (24) hour duration NRCS Type 2 storm. In the Rational Method, the peak rate of runoff, Q, in cubic feet per second (cfs) is computed as:

$$Q = CIA$$

Where:

C = Runoff coefficient, representing the characteristics of the drainage area and defined as the ratio of runoff to rainfall.

I = Average intensity of rainfall in inches per hour for a duration equal to the time of concentration (tc) for a selected rainfall frequency.

A = Tributary drainage area in acres.

Values for the runoff coefficient "C" are provided in **Tables 11-1** and **11-2**, which show values for different types of surfaces and local soil characteristics. The composite "C" value used for a given drainage area with various surface types shall be the weighted average value for the total area calculated from a breakdown of individual areas having different surface types. **Table 11-3** provides runoff coefficients and inlet times for different land use classifications. Rainfall intensity shall be determined from the rainfall frequency data shown in **Table 11-4**.

In general, the time of concentration (tc) methodology to be used for all stormwater management projects within City of Monticello shall be as outlined in the U.S. Department of Agriculture (USDA) - NRCS TR-55 Manual. In urban or developed areas, the methodology to be used shall be the sum of the inlet time and flow time in the stormwater facility from the most remote part of the drainage area to the

point under consideration. The flow time in the storm sewers may be estimated by the distance in feet divided by velocity of flow in feet per second. The velocity shall be determined by the Manning's Equation (see **Section 15**). Inlet time is the combined time required for the runoff to reach the inlet of the storm sewer. It includes overland flow time and flow time through established surface drainage channels such as swales, ditches, and sheet flow across such areas as lawns, fields, and other graded surfaces.

Table 11-1
Urban Runoff Coefficients

Type of Surface	Runoff Coefficient "C"
Hard Surfaces	
Asphalt	0.82
Concrete	0.85
Roof	0.85
Lawns (Sandy)	
Flat (0-2% Slope)	0.07
Rolling (2-7% Slope)	0.12
Steep (> than 7% Slope)	0.17
Lawns (Clay)	
Flat (0-2% Slope)	0.16
Rolling (2-7% Slope)	0.21
Steep (> than 7% Slope)	0.30

Source: HERPICC Stormwater Drainage Manual, July 1995.

Table 11-2
Rural Runoff Coefficients

Type of Surface	Runoff Coefficient "C"
Woodland (Sandy)	
Flat (0-5% Slope)	0.10
Rolling (5-10% Slope)	0.25
Steep (Greater than 10% Slope)	0.30
Woodland (Clay)	
Flat (0-5% Slope)	0.30
Rolling (5-10% Slope)	0.35
Steep (Greater than 10% Slope)	0.50
Pasture (Sandy)	
Flat (0-5% Slope)	0.10
Rolling (5-10% Slope)	0.16
Steep (Greater than 10% Slope)	0.22
Pasture (Clay)	
Flat (0-5% Slope)	0.30
Rolling (5-10% Slope)	0.36
Steep (Greater than 10% Slope)	0.42
Cultivated (Sandy)	
Flat (0-5% Slope)	0.30
Rolling (5-10% Slope)	0.40
Steep (Greater than 10% Slope)	0.52
Cultivated (Clay)	
Flat (0-5% Slope)	0.50
Rolling (5-10% Slope)	0.60
Steep (Greater than 10% Slope)	0.72

Source: HERPICC Stormwater Drainage Manual, July 1995.

Table 11-3
Runoff Coefficients "C"
by Land Use and Typical Inlet Times

Land Use	Runoff Coefficients			Inlet Times (Minutes)[1]
	Flat[2]	Rolling[3]	Steep[4]	
Commercial (CBD)	0.75	0.83	0.91	5
Commercial (Neighborhood)	0.54	0.60	0.66	5-10
Industrial	0.63	0.70	0.77	5-10
Garden Apartments	0.54	0.60	0.66	5-10
Churches	0.54	0.60	0.66	5-10
Schools	0.31	0.35	0.39	10-15
Semi Detached Residential	0.45	0.50	0.55	10-15
Detached Residential	0.40	0.45	0.50	10-15
Quarter Acre Lots	0.36	0.40	0.44	10-15
Half Acre Lots	0.31	0.35	0.39	10-15
Parkland	0.18	0.20	0.22	To be Computed

Source: HERPICC Stormwater Drainage Manual, July 1995

B. Development Sites Greater Than 5 Acres in Size or Contributing Drainage Area Greater than 50 Acres or With Significant Depressional Storage

The runoff rate for these development sites and contributing drainage areas shall be determined by a computer model that can generate hydrographs based on the NRCS TR-55 time of concentration and curve number calculation methodologies and the twenty-four (24) hour NRCS Type 2 Rainfall Distribution. Twenty-four (24) hour Rainfall depth for various frequencies shall be taken from **Table 11-5**. The NRCS Type 2 distribution ordinates are found in **Table 11-6**. Examples of computer models that can generate such hydrographs include TR-55 (NRCS), TR-20 (NRCS), HEC- HMS (COE), and HEC-1 (COE). These programs may be downloaded free of charge from the associated agencies' web sites. Other models may be acceptable and should be accepted by the City of Monticello City Engineer prior to their utilization.

[1] Interpolation, extrapolation and adjustment for local conditions shall be based on engineering experience and judgment.

[2] Flat terrain involves slopes of 0-2%.

[3] Rolling terrain involves slopes of 2-7%.

[4] Steep terrain involves slopes greater than 7%.

Table 11-4
Rainfall Intensities for Various Return Periods and Storm Durations

Intensity (Inches/Hour)						
Duration	Return Period (Years)					
	2	5	10	25	50	100
5 Min.	5.04	8.24	7.08	8.16	9.00	9.84
10 Min.	3.84	4.74	5.46	6.24	6.90	7.50
15 Min.	3.20	3.96	4.52	5.16	5.72	6.20
20 Min.	2.85	3.51	4.02	4.59	5.10	5.55
30 Min.	2.22	2.74	3.12	3.58	3.96	4.32
40 Min.	1.85	2.28	2.61	2.99	3.30	3.60
50 Min.	1.60	1.97	2.24	2.57	2.83	3.10
1 Hr.	1.40	1.73	1.97	2.25	2.49	2.72
1.5 Hrs.	1.13	1.39	1.59	1.82	2.02	2.20
2 Hrs.	0.86	1.06	1.21	1.38	1.53	1.67
3 Hrs.	0.61	0.76	0.87	0.99	1.10	1.20
4 Hrs.	0.52	0.64	0.73	0.83	0.92	1.00
5 Hrs.	0.43	0.53	0.61	0.70	0.77	0.84
6 Hrs.	0.37	0.46	0.52	0.60	0.66	0.72
7 Hrs.	0.33	0.41	0.47	0.53	0.59	0.64
8 Hrs.	0.29	0.36	0.42	0.47	0.53	0.57
9 Hrs.	0.27	0.33	0.38	0.43	0.48	0.52
10 Hrs.	0.25	0.31	0.35	0.40	0.44	0.48
12 Hrs.	0.22	0.27	0.30	0.35	0.38	0.42
14 Hrs.	0.19	0.24	0.27	0.31	0.34	0.37
16 Hrs.	0.17	0.21	0.24	0.28	0.31	0.34
18 Hrs.	0.16	0.19	0.22	0.25	0.28	0.31
20 Hrs.	0.14	0.18	0.20	0.23	0.26	0.28
24 Hrs.	0.13	0.15	0.18	0.20	0.22	0.24

Table 11-5
Rainfall Depths for Various Return Periods

Depth (Inches)						
Duration	Return Period (Years)					
	2	5	10	25	50	100
24 Hrs.	3.00	3.70	4.23	4.83	5.35	5.83

Table 11-6
NRCS Type II Rainfall Distribution Ordinates

Cumulative Percent of Storm Time	Cumulative Percent of Storm Depth
0	0
5	1
10	3
15	4
20	6
25	8
30	10
35	13
40	17
45	22
50	64
55	78
60	84
65	87
70	90
75	92
80	94
85	96
90	98
95	99
100	100