Stormwater Drainage Design

In addition to providing safe and efficient ingress and egress for vehicles, an engineer/architect should design parking lots in a way to prevent flooding and erosion damage to surrounding landscaping.

- Stormwater conveyance system includes:
  - storm sewers,
  - Ditches,
  - channels,
  - pumps, etc.

Stormwater Drainage Design

Both MINOR and MAJOR storm events must be considered and conveyed!

MINOR SYSTEM

Minor storms (typically 2-year) are "frequent" events that are conveyed through:

- Ditches
- Curb / gutters
- Catchbasins / manholes
- Storm sewers
- Water quality control features

We need to quickly convey minor storm events efficiently to the storm sewer or open channels to minimize the impact on vehicle and pedestrian traffic, and to prevent water from reaching the subgrade leading to cracking and shortening the life of the pavement.

MAJOR SYSTEM

Major storms (typically 100-year) are "infrequent" events that are conveyed through:

- Land Surfaces
- Streets / roadways
- Streams / creeks / rivers / lakes
- Wetlands
- Think OFR (Overland Flow Release)

Stormwater Drainage Design

- Parking lot drainage requires consideration of surface drainage, gutter flow, inlet capacity, and inlet locations. The design of these elements is dependent on storm frequency and rainfall intensity.

Considerations:

- Gutter flow;
- Inlet capacity;
- Inlet locations;

Stormwater Drainage Design

<u>WHAT HAPPENS WHEN RAIN FALLS?</u>

- Infiltration (small)
- Evaporation (small)
- Runoff (most)

The MAJORTIY of the rainfall volume flows naturally to the lowest points as a result of gravity.

- The runoff water forms sheet flow - a thin film of water that increases in thickness as it flows to the edge of the pavement.
- Factors which influence the depth of water on the pavement are the length of flow path, surface texture, surface slope, and rainfall intensity.
- Surface drainage for a parking lot consists of slopes, gutters and inlets. Desirable gutter grades should not be less than 0.5%

Rational Method

Q = CIA / 360 (metric units) or Q = CIA (English units)

where:

- Q = Peak flow, m3/s (ft3/s)
- C = Runoff Coefficient
- I = Rainfall Intensity, mm/hr (in/hr)
- A = Drainage area, hectares (acres)

Runoff Coefficient, C

The runoff coefficient (C), also called the "coefficient of imperviousness," is the ratio of runoff to rainfall. Factors that contribute to C include:

- Shape of the drainage area.
- Slope of the watershed
- Land use (percentage of impervious surface and surface type).
- Character of the soil.
- Basin storage potential (potholes, roof storage, etc.).
- Previous (antecedent) moisture conditions.
- Interception by vegetation or animal life (e.g. a beaver dam).
- Rainfall duration.
- Rainfall intensity.
- Recurrence interval (rainfall frequency).

- Runoff coefficient values can vary for 2-year, 5-year, 100-year (etc.) and are determined by agency (City, MTO, etc.)
- May require interpolation

MTO Runoff Coefficients

Design Chart 1.07: Runoff Coefficients

- Urban for 5 to 10-Year Storms

Land Use		Runoff Coefficient Min.	Runoff Coefficient Max.	
Pavement	- asphalt or concrete	0.80	0.95	Use 0.90
	- brick	0.70	0.85	
Gravel roads and shoulders		0.40	0.60	
Roofs		0.70	0.95	Use 0.90
Business	- downtown	0.70	0.95	
	- neighbourhood	0.50	0.70	
	- light	0.50	0.80	
	- heavy	0.60	0.90	
Residential	- single family urban	0.30	0.50	
	- multiple, detached	0.40	0.60	
	- multiple, attached	0.60	0.75	
	- suburban	0.25	0.40	
Industrial	- light	0.50	0.80	
	- heavy	0.60	0.90	
Apartments		0.50	0.70	
Parks, cemeteries		0.10	0.25	
Playgrounds (unpaved)		0.20	0.35	
Railroad yards		0.20	0.35	
Unimproved areas		0.10	0.30	
Lawns	- Sandy soil			
	- flat, to 2%	0.05	0.10	
	- average, 2 to 7%	0.10	0.15	
	- steep, over 7%	0.15	0.20	
	- Clayey soil			
	- flat, to 2%	0.13	0.17	
	- average, 2 to 7%	0.18	0.22	
	- steep, over 7%	0.25	0.35	Use 0.25

For flat or permeable surfaces, use the lower values. For steeper or more impervious surfaces, use the higher values. For return period of more than 10 years, increase above values as 25-year - add 10%, 50-year - add 20%, 100-year - add 25%.

The coefficients listed above are for unfrozen ground.

Rainfall Intensity (I)

- Rainfall intensity (I) is the average rate of rainfall given in in/hr (mm/hr) that occurs over the duration of a storm.
  - To calculate I, the designer must first select a recurrence interval (TR)..... 2-year, 5-year, etc.
  - Next the designer calculates the time of concentration (Tc).
  - Often, Tc falls between the values in the tables, so it needs to be interpolated.
- Rainfall intensity does not account for a rainfall's variable intensity over time or across a basin, or for how much rainfall fell prior to the period in question. Designers should keep these factors in mind, especially for areas prone to flash flooding.

Time of Concentration

Time of concentration (Tc) is the time required for water falling on the hydraulically most remote point in a drainage area to flow to the point of interest. Remoteness relates to time rather than distance. Factors affecting Tc include:

- Surface roughness. Rough terrain, such as undeveloped areas, impedes flow of runoff more than smooth surfaces such as pavement. This increases Tc.
- Channel shape and flow patterns. Channels typically convey runoff more efficiently than flat terrain. This reduces Tc.
- Slope. The velocity of runoff increases with increase **in slope. This reduces Tc.**

Water traveling a short distance across rough, flat terrain may require more time to reach a point of interest than water traveling a longer distance across smooth, steep terrain. Thus, the most hydraulically distant point in a drainage area may not be the point located furthest from the point of interest.

Total Tc may consist of several factors but typically a minimum Tc is set by governing agency.

Min. Tc is usually 10 minutes

Other Considerations

To prevent stormwater from becoming a hazard to the public and causing damage to the surrounding properties, a designer should also consider the following aspects:

- Drainage Connections and Path (see below)
- Maximum Depth of Standing Water (typ. 150mm max.)
- Any ponding areas should be away from main entryways (vehicular / pedestrian)
- Slopes between 2.0% and 5.0%

Dry Pond

Connection

Island

Time of Concentration (TORONTO)

Equation of IDF curves [5] is:

$$I = AT^C$$

Where:

I = Rainfall Intensity (mm/hr)
T = Time of Concentration (hour) - use 10 minutes inlet time (or initial time of concentration)

Parameters of A and C are shown as follows:

Return Period (Year)	A	C
2	21.8	-0.78
5	32	-0.79
10	38.7	-0.80
25	45.2	-0.80
50	53.5	-0.80
100	59.7	-0.80

2-Year IDF Curve (Toronto) = $I = \frac{21.8}{(T)^{0.780}}$

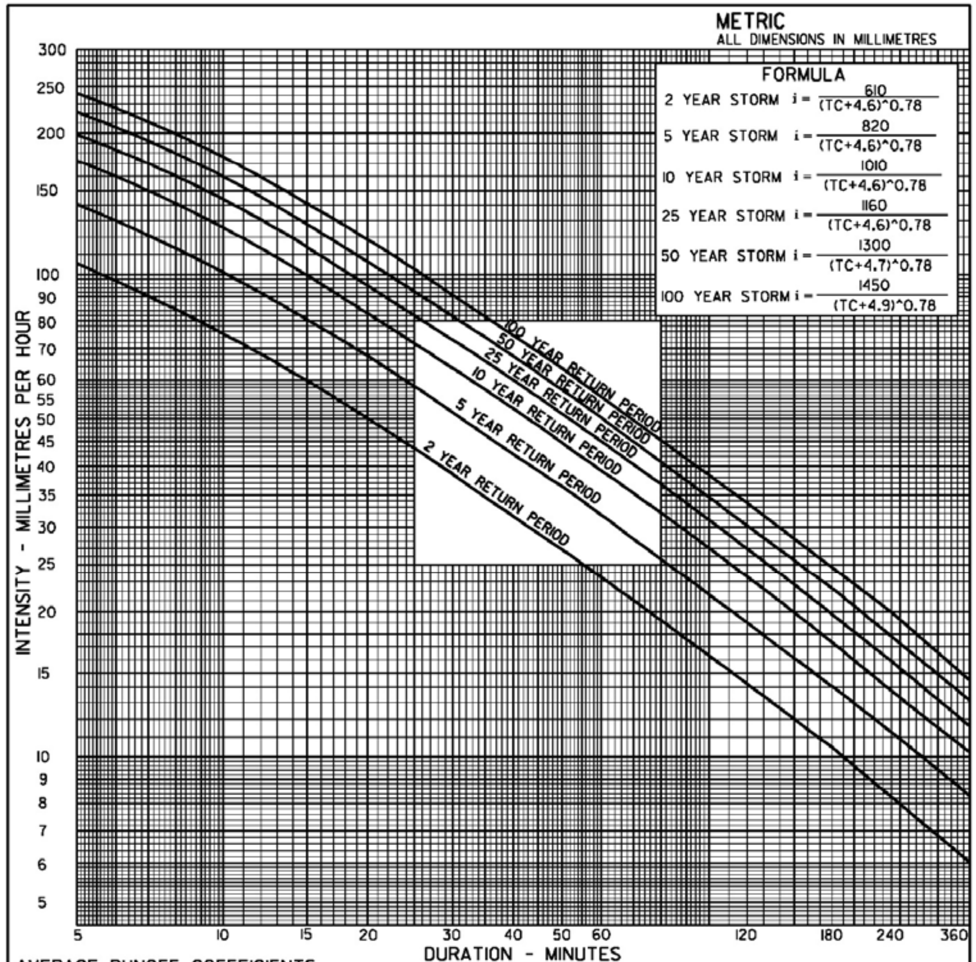
100-Year IDF Curve (Toronto) = $I = \frac{59.7}{(T)^{0.80}}$

- Assuming an initial Tc of 10 minutes, calculate the 2 and 100 year Rainfall Intensities
- DON'T FORGET TO CONVERT FROM MINUTES TO HOURS AS RAINFALL INTENSITY IS mm/hr!

2-Year IDF = 88.19 mm/hr

100-Year IDF = 250.32 mm/hr

Time of Concentration (MISSISSAUGA)



AVERAGE RUNOFF COEFFICIENTS

DESCRIPTION OF AREA	COEFFICIENT
SINGLE FAMILY AND SEMI-DETACHED	0.45
COMPACT OR DENSE HOUSING AREA (INCLUDING APARTMENT DWELLING AREA)	0.60
PARKS AND CEMETERIES	0.25
PLAYGROUNDS	0.30
INDUSTRIAL AND COMMERCIAL	0.75
COMPOSITE RUNOFF COEFFICIENTS (TO BE USED WHERE SURFACE AREAS KNOWN)	
LAWNS AND GARDENS	0.25
ALL OTHER SURFACES	0.90

NOTES

1. ALL CALCULATIONS TO BE DONE ASSUMING FULL DEVELOPMENT AS SHOWN ON CITY OF MISSISSAUGA ZONING MAPS.
2. TO BE USED WITH RATIONAL FORMULA:

$$Q = \frac{CIA}{360}$$

Q=QUANTITY OF RUNOFF (M^3/S)
C=RUNOFF COEFFICIENT
A=AREA (ha)
I=RAINFALL INTENSITY (mm/hr)

MISSISSAUGA Transportation and Works

STANDARD INTENSITY-DURATION-FREQUENCY RAINFALL CURVES

EFF. DATE	2002-01-01	SCALE	N.T.S
REV.		STANDARD No.	2111.010

Sample Drainage Area Map