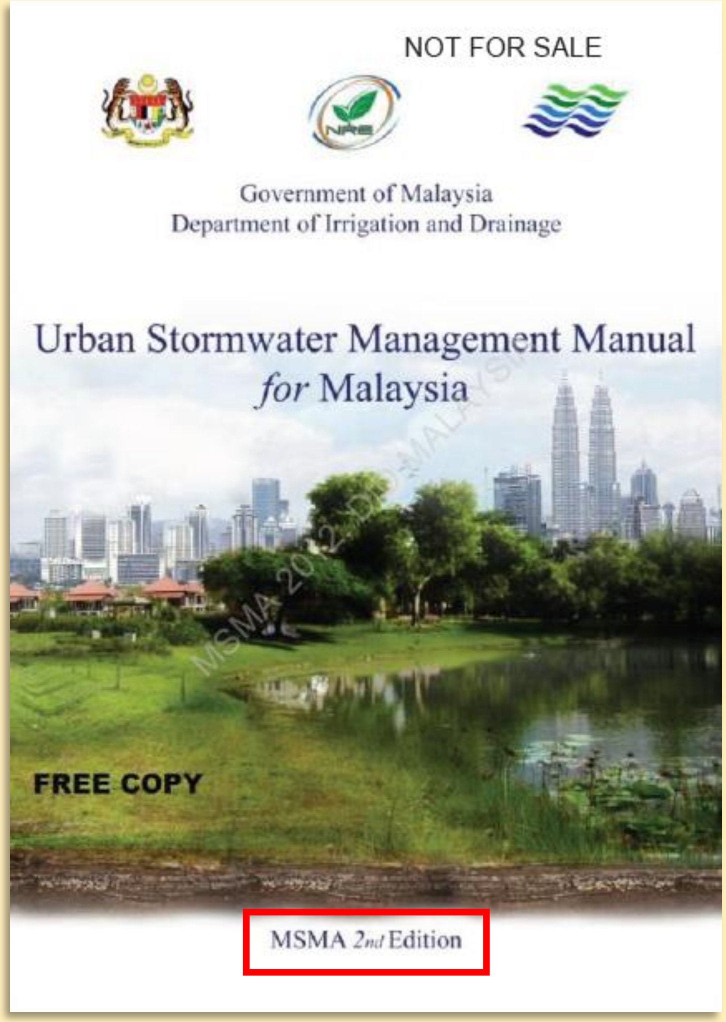
HANDS-ON
PEAK FLOW ESTIMATION



OVERVIEW

- Estimation of Peak Flow using Rational Method
  - Drainage area A
  - Runoff coefficient C
  - Estimation of Rainfall Intensity I
    - Empirical IDF relationship
      - Average recurrence interval (ARI) T
      - Time of concentration t_c

RATIONAL METHOD

Rational Method

$$Q = CIA$$

where,

Q = peak flow (m^3/s)

C = runoff coefficient

I = average rainfall intensity (m/s)

A = drainage area (m^2)

In MSMAM:

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

where,

Q =

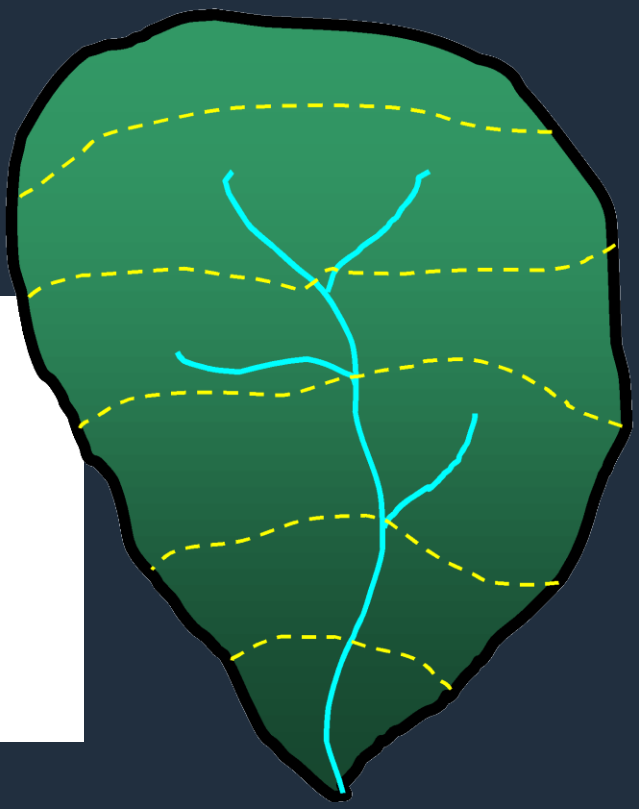
C =

I =

A =

RATIONAL METHOD

Rational Method $Q = CIA$



Rational Method	Drainage area	Runoff coefficient	Rainfall Intensity

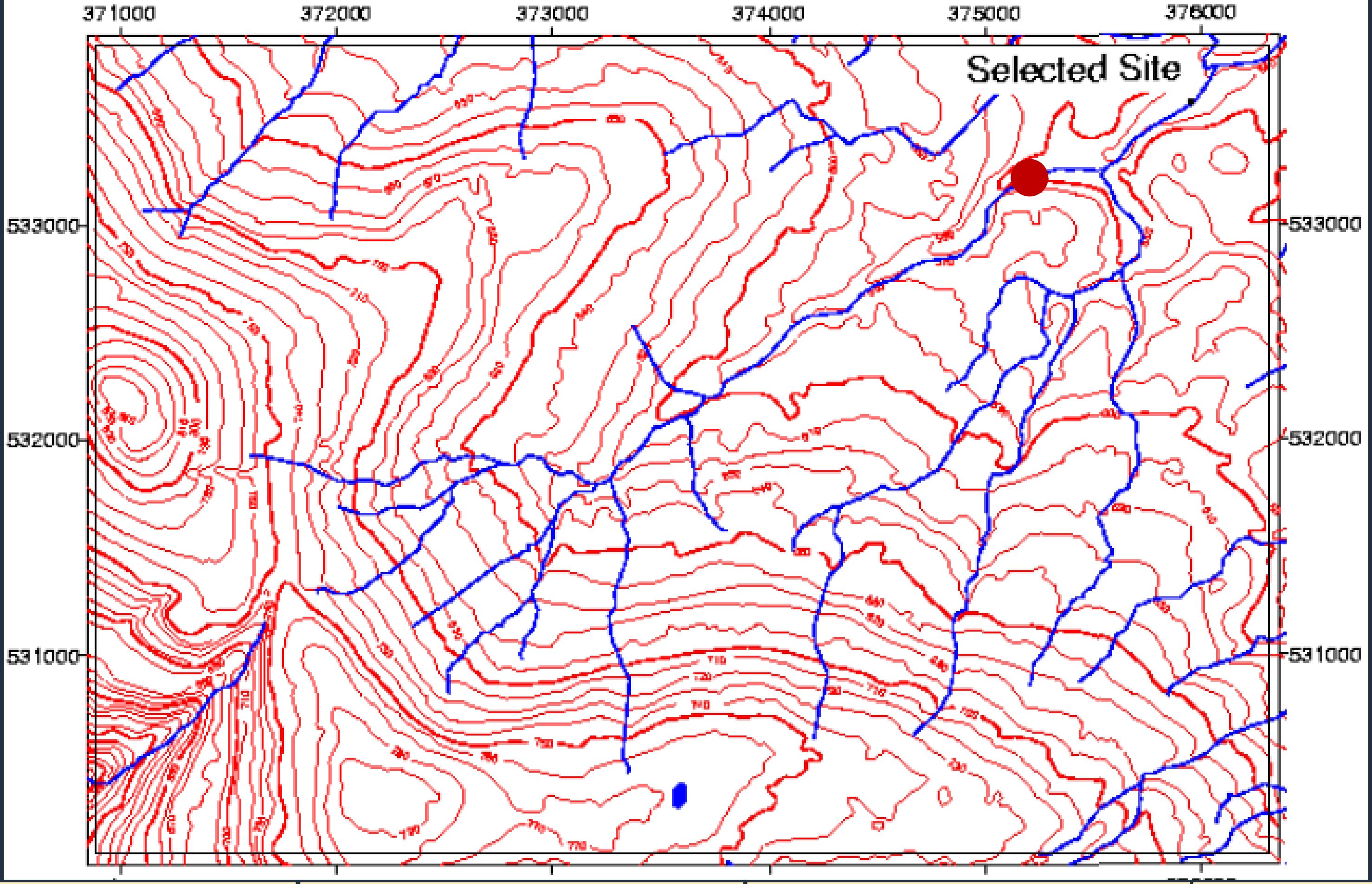
Activity 1.

Justify the conversion factor 360 used in the Rational method equation recommended in MSMA 2nd edition (as Equation 2.3).

Drainage Area *A*

Activity 2.

Draw the boundary of catchment area based on the contour shown in Figure 1.



Rational Method	Drainage area	Runoff coefficient	Rainfall Intensity

Runoff Coefficient C of $Q = CIA$

Table 2.5: Recommended runoff coefficient for various landuses (DID, 2012)

Landuse	Minor System (≤ 10 yr ARI)	Major System (> 10 yr ARI)
Residential		
Bungalow	0.65	0.70
Semi-Detached Bungalow	0.70	0.75
Link and Terrace House	0.80	0.90
Flat and Apartment	0.80	0.85
Condominium	0.75	0.80
Commercial and Business Centres	0.90	0.95
Industrial	0.90	0.95
Sport Fields, Park and Agriculture	0.30	0.40
Open Spaces		
Bare Soil (No Cover)	0.50	0.60
Grass Cover	0.40	0.50
Bush Cover	0.35	0.45
Forest Cover	0.30	0.40
Roads and Highways	0.95	0.95
Water Body (Pond)		
Detention Pond (with outlet)	0.95	0.95
Retention Pond (no outlet)	0.00	0.00

Runoff Coefficient C

Runoff coefficient for mixed landuse

$$C_{avg} = \frac{\sum_{i=1}^{n} C_i A_i}{\sum_{i=1}^{n} A_i}$$

where,

i = index for n number of segments of different landuse

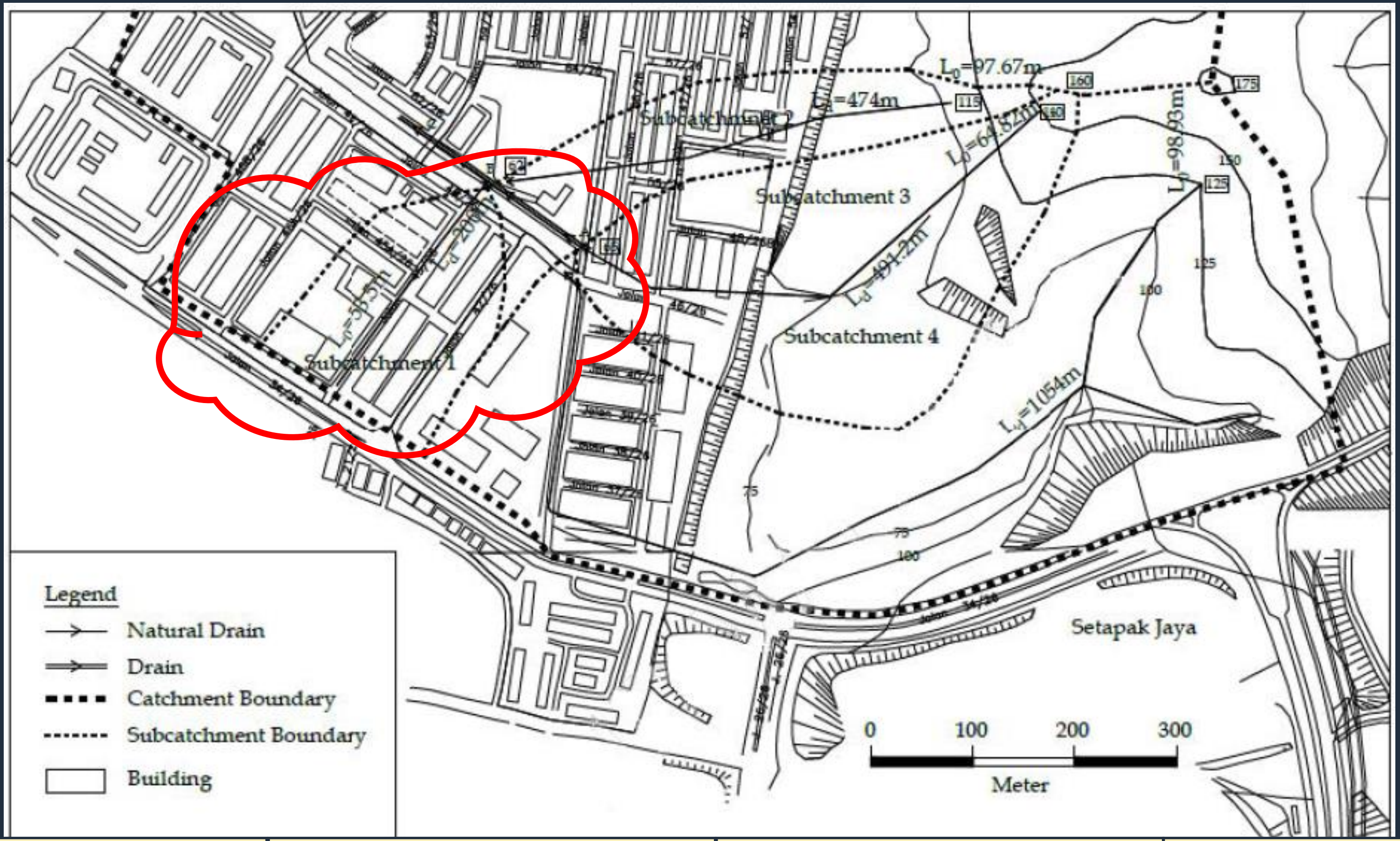
n = total number of segments of different landuse

A_i = area of segment i

C_i = runoff coefficient of segment i

Activity 3.

Subcatchment 1 has an area of 3.87 ha consisting of 94% flat & apartment area and 6% open grass spaces. Determine the runoff coefficient for subcatchment 1 considering 50-year ARI.



Rational Method | Drainage area | Runoff coefficient | Rainfall Intensity

RAINFALL INTENSITY I of $Q = CIA$

It is the amount of rainfall during a period of time, usually expressed in mm/hr.

It can be estimated using an intensity-duration-frequency relationship (IDF) curve or the fitted mathematical equation at desired frequency (or average recurrence interval ARI) and time of concentration t_c.

MSMA (DID, 2012) provides IDF curve and constants for fitted mathematical equation for 135 rainfall stations within all states in Peninsular Malaysia.

RAINFALL INTENSITY *I*

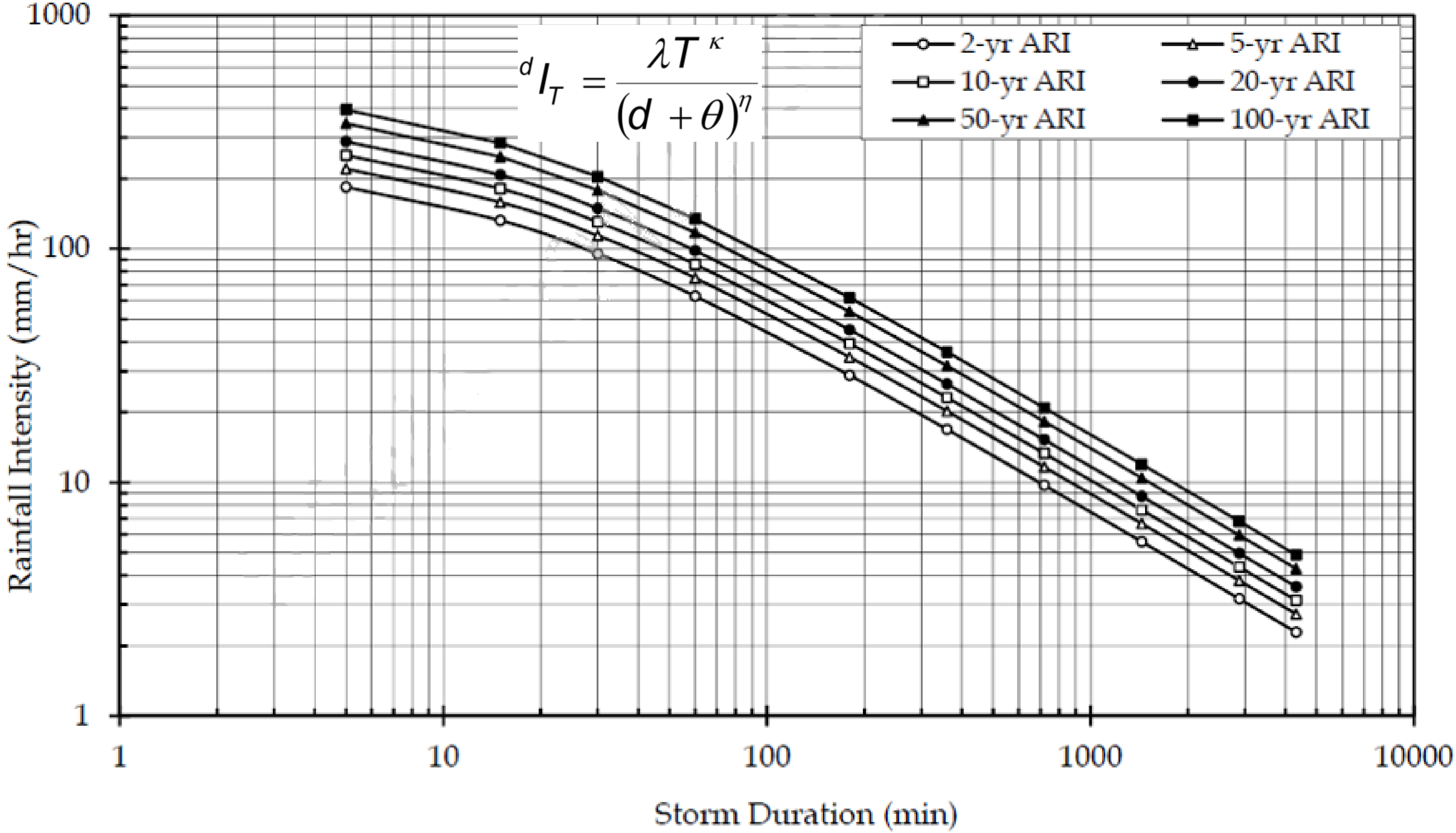
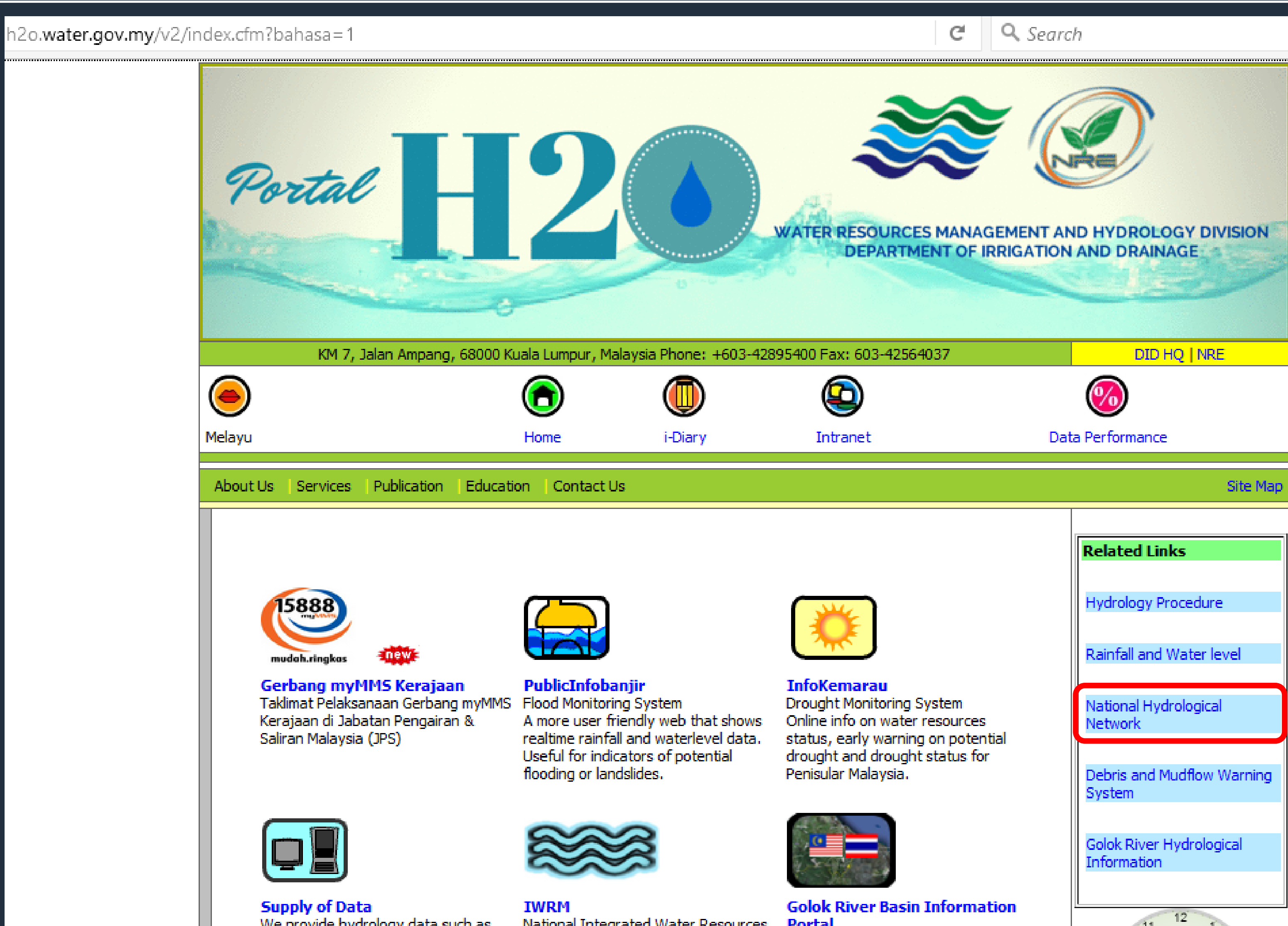


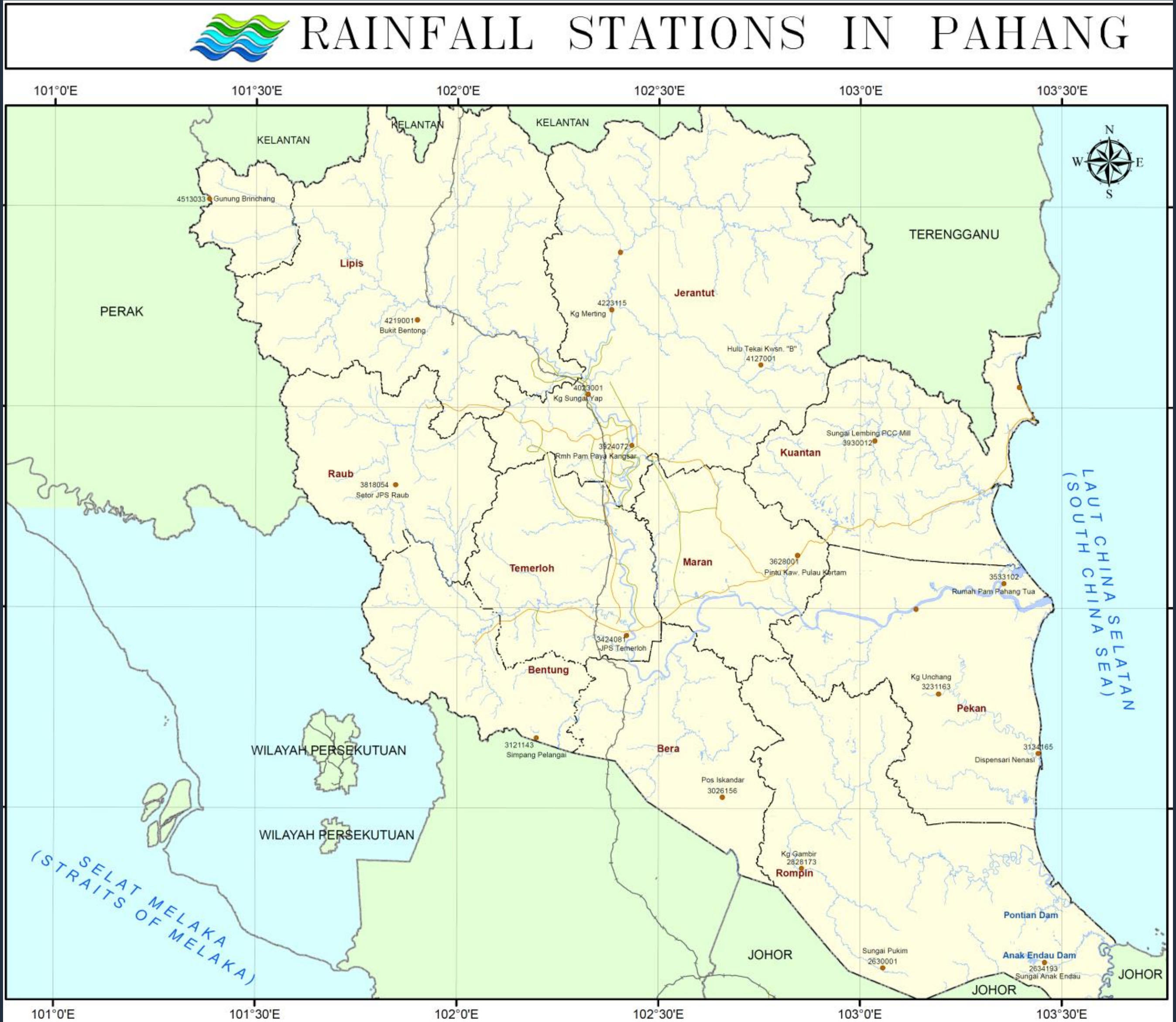
Figure AX3.7.14: Rainfall Station at Kg Sungai Yap - 4023001

RAINFALL INTENSITY I



Rational Method	Drainage area	Runoff coefficient	Rainfall Intensity

RAINFALL INTENSITY I



RAINFALL INTENSITY *I*

Empirical IDF

$$^{d}I_T = \frac{\lambda T^{\kappa}}{(d+\theta)^{\eta}}$$

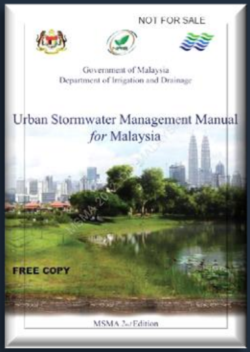
where,

I = average rainfall intensity (mm/hr)

T = average recurrence interval (ARI) ($0.5 \leq T \leq 12$ month and $2 \leq T \leq 100$ year)

d = storm duration (hr) ($0.08333 \leq d \leq 72$)

$\lambda, \kappa, \theta, \eta$ = fitting constants dependent on location of rain gauge



Average Recurrence Interval (ARI) *T*

It is the average length of time between rain events that exceeds the same magnitude.

Annual maximum discharges of the Guadalupe River

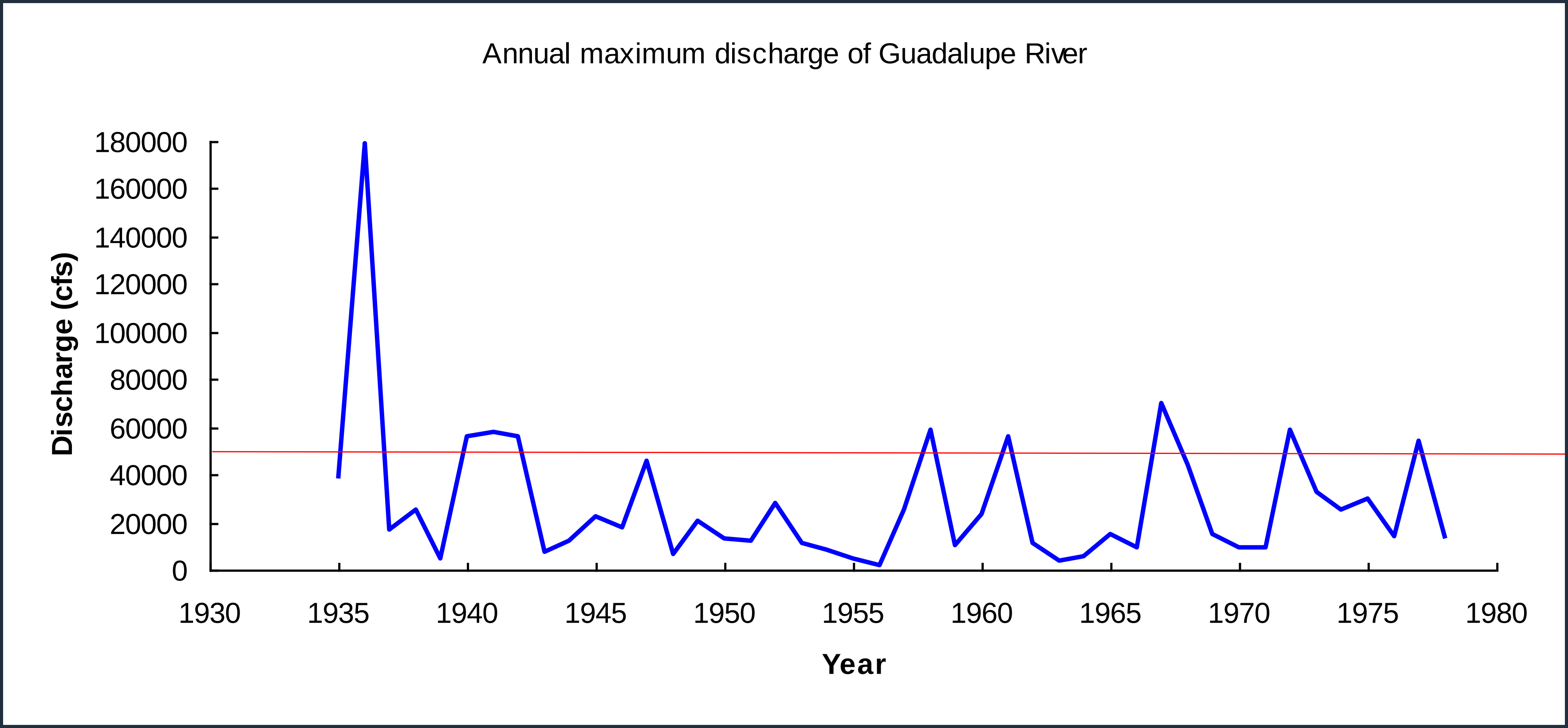
Year	1930	1940	1950	1960	1970
0		55,900	13,300	23,700	9,190
1		58,000	12,300	55,800	9,740
2		56,000	28,400	10,800	58,500
3		7,710	11,600	4,100	33,100
4		12,300	8,560	5,720	25,200
5	38,500	22,000	4,950	15,000	30,200
6	179,000	17,900	1,730	9,790	14,100
7	17,200	46,000	25,300	70,000	54,500
8	25,400	6,970	58,300	44,300	12,700
9	4,940	20,600	10,100	15,200	

There are 8 recurrence intervals covering a total period of 41 years between the first and last exceedences of 50,000 cfs

Return period $\bar{\tau} = \frac{41}{8} = 5.1\,\text{years}$

Thus, the return period of an event of a given magnitude may be defined as average recurrence interval between events equalling or exceeding a specified magnitude.

Average Recurrence Interval (ARI) *T*



Average Recurrence Interval (ARI) *T*

Table 1.1: Quantity design storm ARIs (Minimum year ARI) (DID, 2012)

Type of Development	Minor System (≤ 10 yr ARI)	Major System (> 10 yr ARI)
Residential		
Bungalow and semi-detached dwellings	5	50
Link house/apartment	10	100
Commercial and business Centre	10	100
Industrial	10	100
Sport field, park and agriculture land	2	20
Infrastructure/utility	5	100
Institutional building/complex	10	100

Time of Concentration t_c

It is the time required for surface runoff to travel from the most remote part of the catchment to its outlet.

$$t_c = t_o + t_g + t_d$$

where,

t_o = time of overland flow
t_g = time of curb gutter flow
t_d = time of drain flow

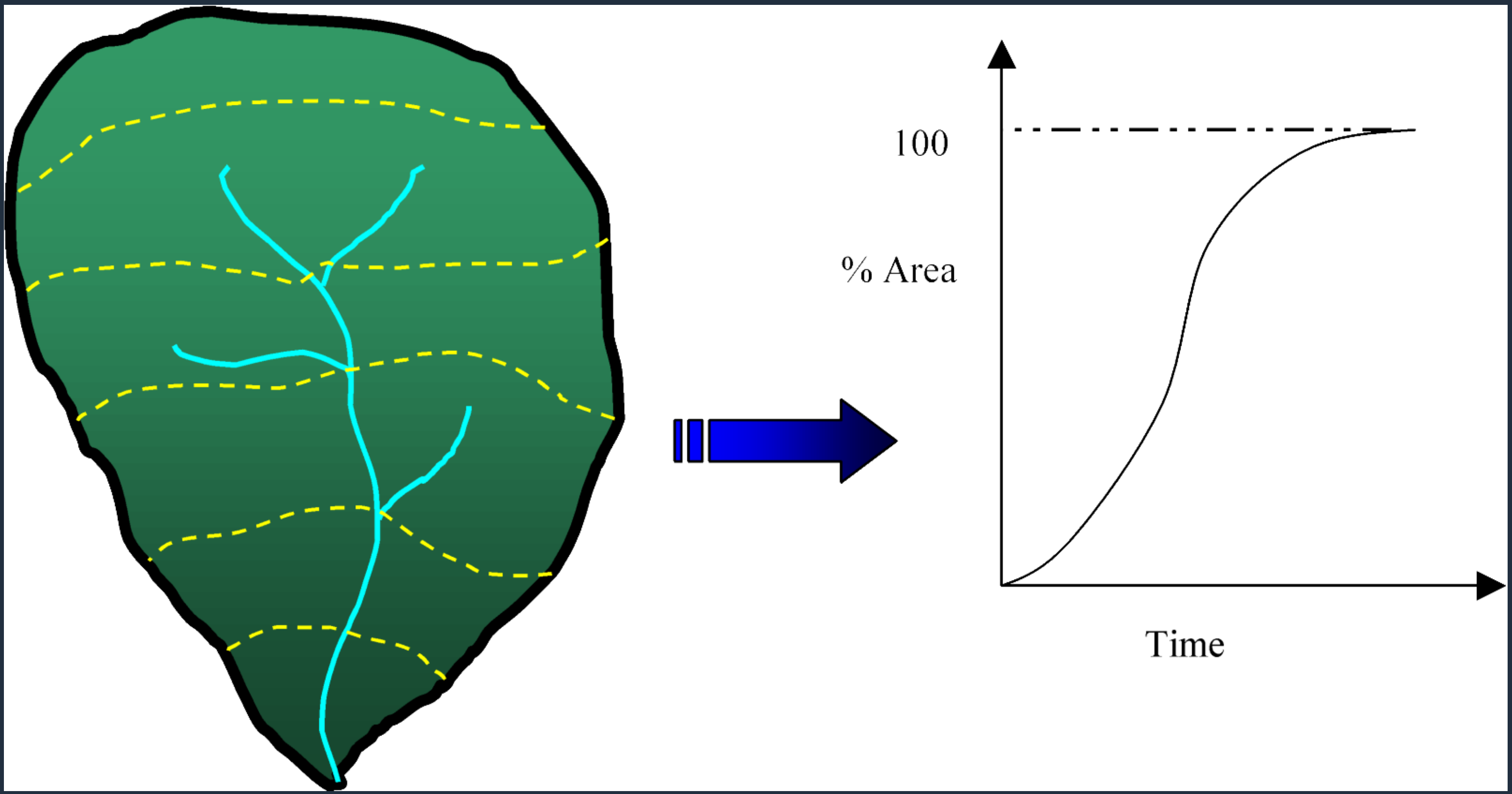
In rational method, $d = t_c$.

Time of Concentration t_c

Table 2.1: Equations to Estimate Time of Concentration (QUDM, 2007)

Travel Path	Travel Time	Remark
Overland Flow	$t_o = \frac{107.n^{*}.L^{1/3}}{S^{1/5}}$	t_o = Overland sheet flow travel time (minutes) L = Overland sheet flow path length (m) *for Steep Slope (>10%), L ≤ 50 m* *for Moderate Slope (<5%), L ≤ 100 m* *for Mild Slope (<1%), L ≤ 200 m* n^{*} = Horton's roughness value for the surface (Table 2.2) S = Slope of overland surface (%)
Curb Gutter Flow	$t_g = \frac{L}{40\sqrt{S}}$	t_g = Curb gutter flow time (minutes) L = Length of curb gutter flow (m) S = Longitudinal slope of the curb gutter (%)
Drain Flow	$t_d = \frac{n.L}{60R^{2/3}S^{1/2}}$	n = Manning's roughness coefficient (Table 2.3) R = Hydraulic radius (m) S = Friction slope (m/m) L = Length of reach (m) t_d = Travel time in the drain (minutes)

Time of Concentration t_c



It is the time required for surface runoff to travel from the most remote part of the catchment to its outlet.

$$t_c = t_o + t_g + t_d$$

Time of Concentration t_c

Table 2.2: Values of Horton's roughness n^* (DID, 2012)

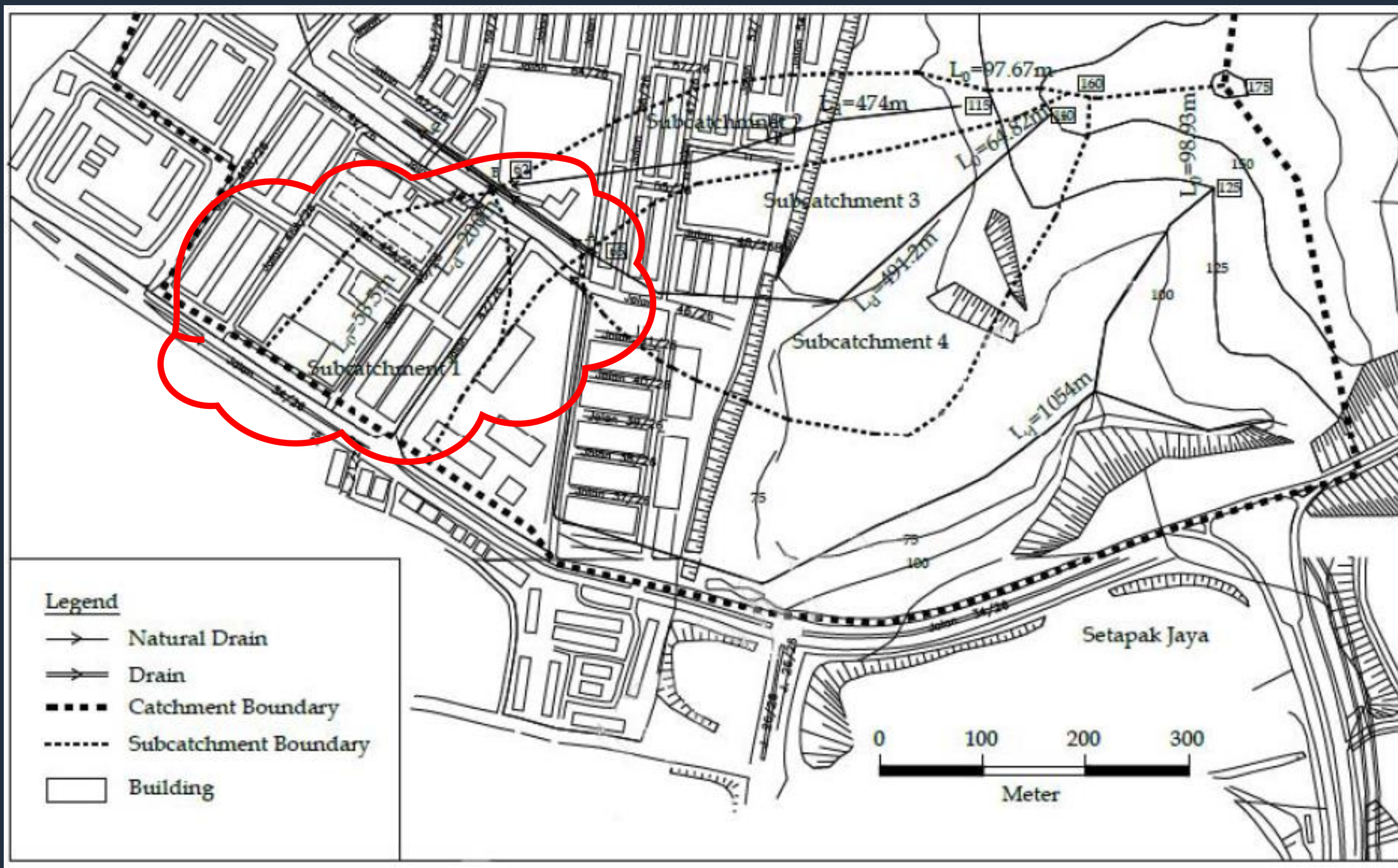
Land Surface	Horton's roughness n^*
Paved	0.015
Bare Soil	0.0275
Poorly Grassed	0.035
Average Grassed	0.045
Densely Grassed	0.060

Table 2.3: Values of Manning's roughness coefficient *n* for open drains and pipes (DID, 2012)

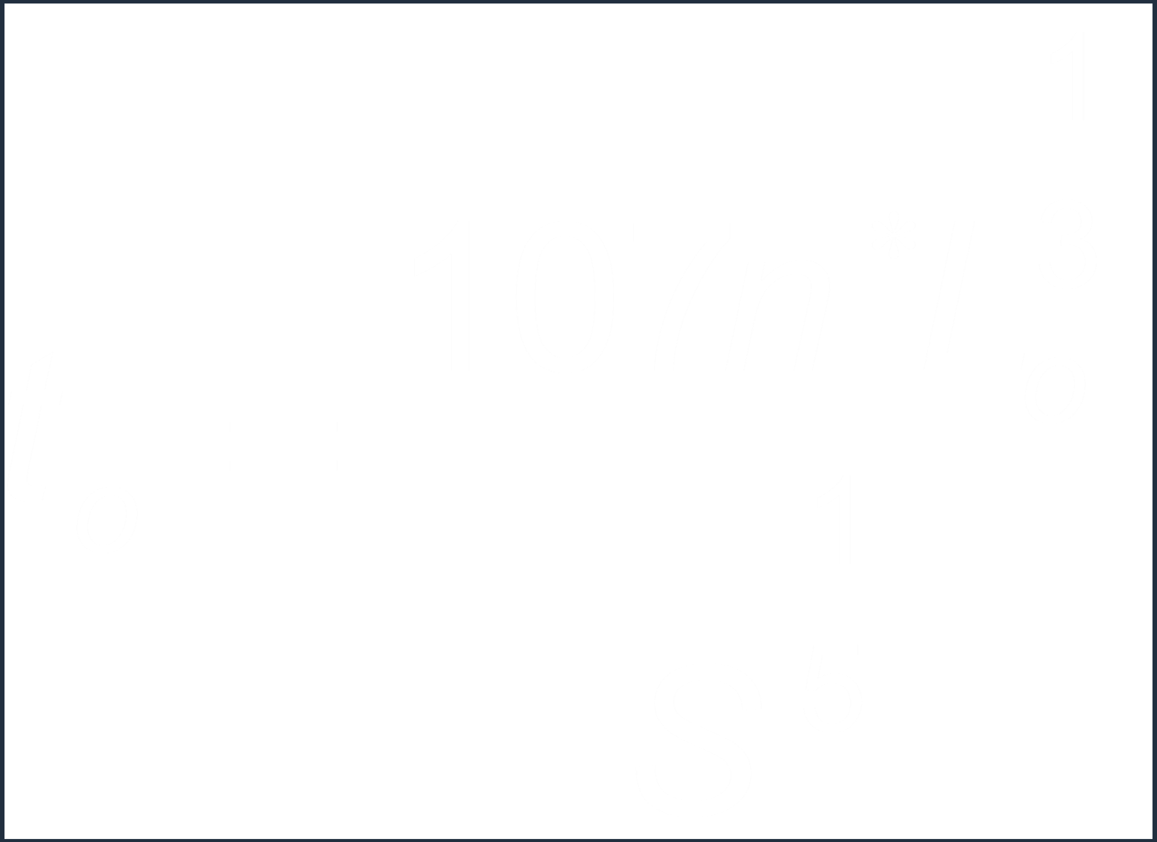
Drain/pipe	Manning roughness *n*
Grassed drain	
Short grass cover (< 150 mm)	0.035
Tall grass cover (≥ 150 mm)	0.050
Lined drain	
Concrete	
Smooth finish	0.015
Rough finish	0.018
Stone pitching	
Dressed stone in mortar	0.017
Random stones in mortar or rubble masonry	0.035
Rock riprap	0.030
Brickwork	0.020
Pipe material	
Vitrified clay	0.012
Spun precast concrete	0.013
Fibre reinforced cement	0.013
UPVC	0.011

Activity 4.

If the slope of overland paved surface in Subcatchment 1 is 3.74%, find the time of overland flow.



Given S = 3.74%, paved surface n^* = 0.015,



Activity 5.

If the time in drain flow is 1.4 min, estimate the peak flow of subcatchment 1 (in Wangsa Maju, Kuala Lumpur) based on Rational method considering 50-year ARI.

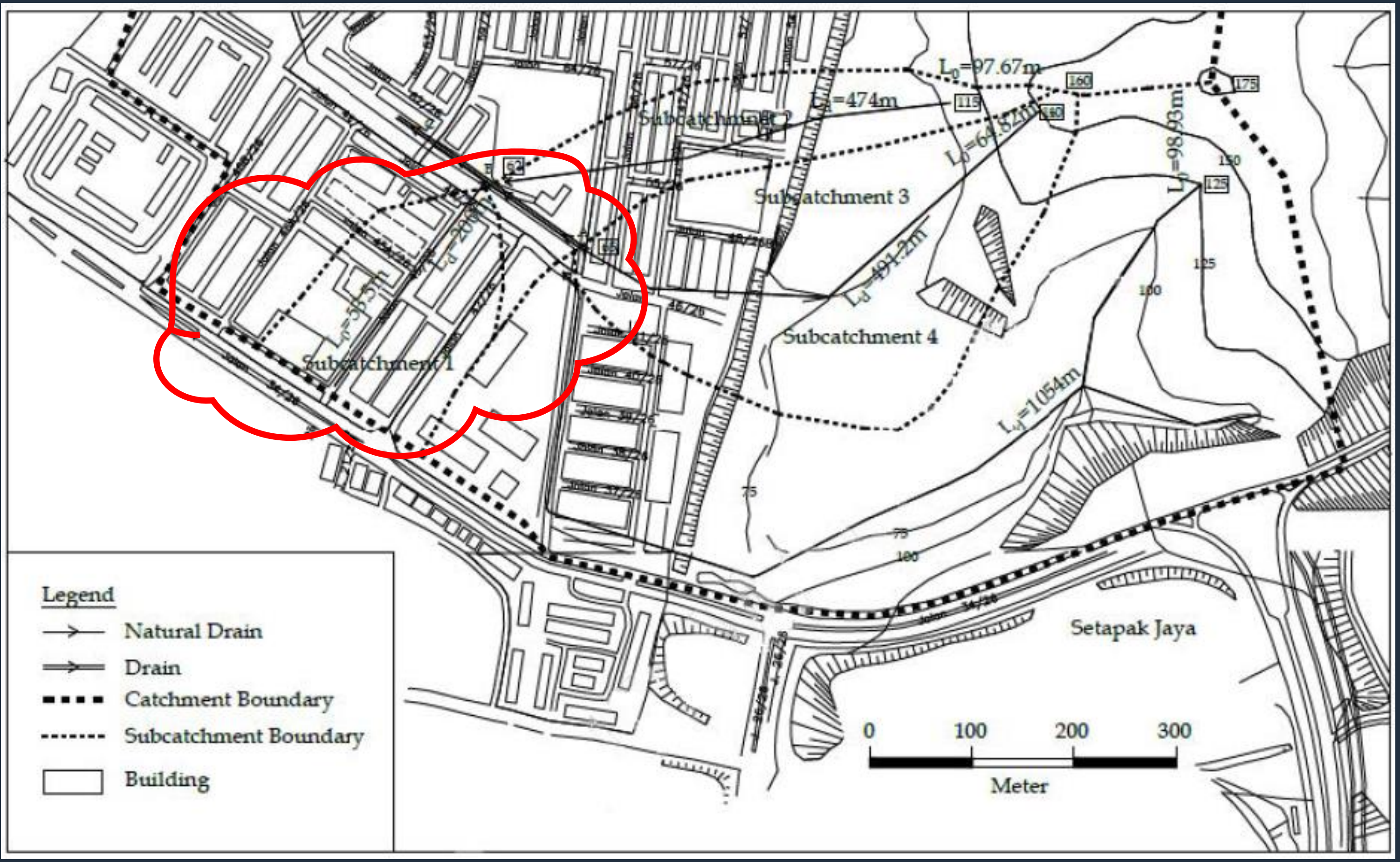


Table 2.B1: Fitting constants for IDF empirical equation for 2 to 100-year ARI and storm duration of 5 mins to 72 hours (DID, 2012)

State	No.	Station ID	Station name	Constants			
				λ	κ	θ	η

$$^{d}I_{T} = \frac{\lambda T^{\kappa}}{(d + \theta)^{\eta}}$$

where,

I = average rainfall intensity (mm/hr)

T = average recurrence interval (ARI) ($0.5 \leq T \leq 12$ month and $2 \leq T \leq 100$ year)

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