Quilty Training
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Engineering Fundamentals Stormwater

The Rational Method

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Simplify Rainfall with Design Storms

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Simplifying Rainfall

Rainfall is complex

Need to simplify

Easier to calculate and analyse

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Design Storms

Hypothetical rainfall events

Simulate natural rainfall events

Based on historical rainfall data

Design storm classified by:

- Storm burst duration
- Storm frequency

Example:

- 1% AEP storm with 10 minute burst duration; or
- Q_{100} event with storm burst of 10 minutes

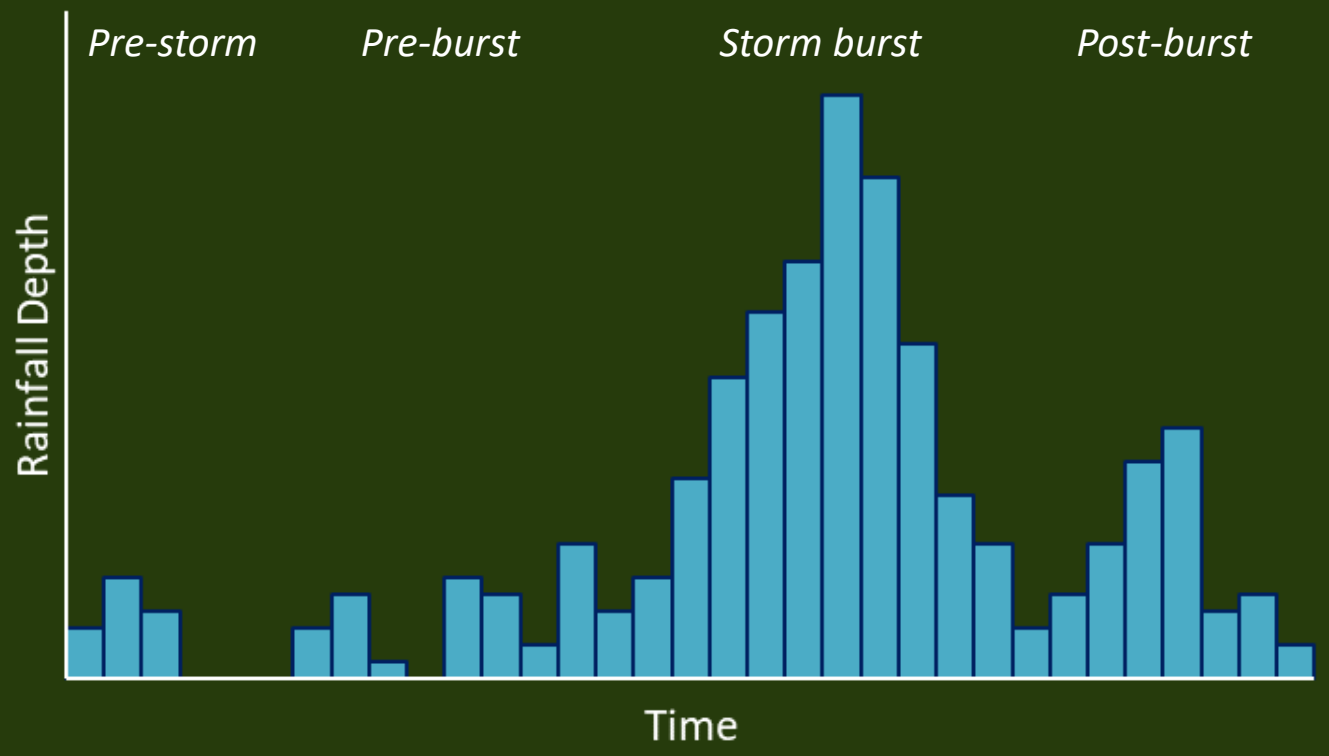
Anatomy of a Storm

Pre-storm rainfall

Pre-burst rainfall

Storm burst rainfall

Post-burst rainfall



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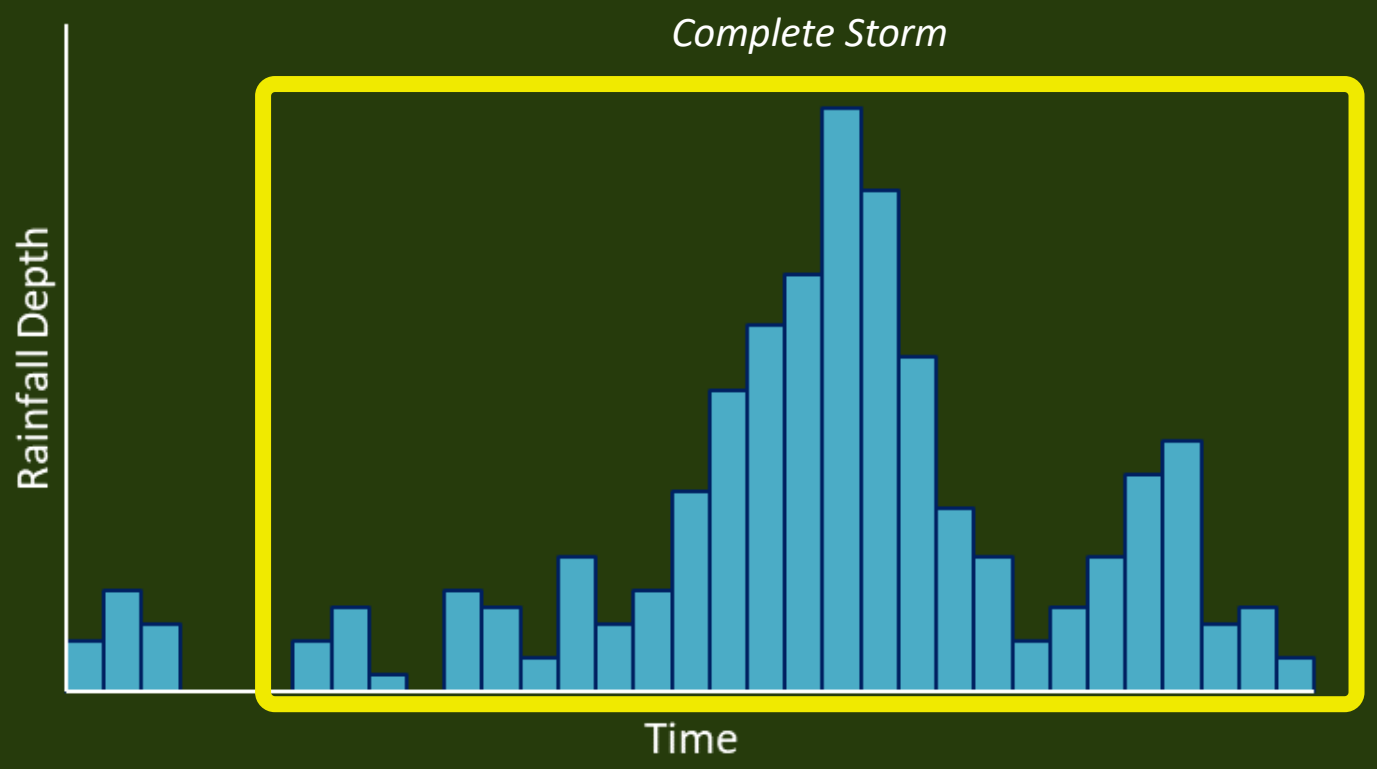
Complete Storm

Entirety of a rainfall event

Includes:

- Build-up
- Peak
- Decline



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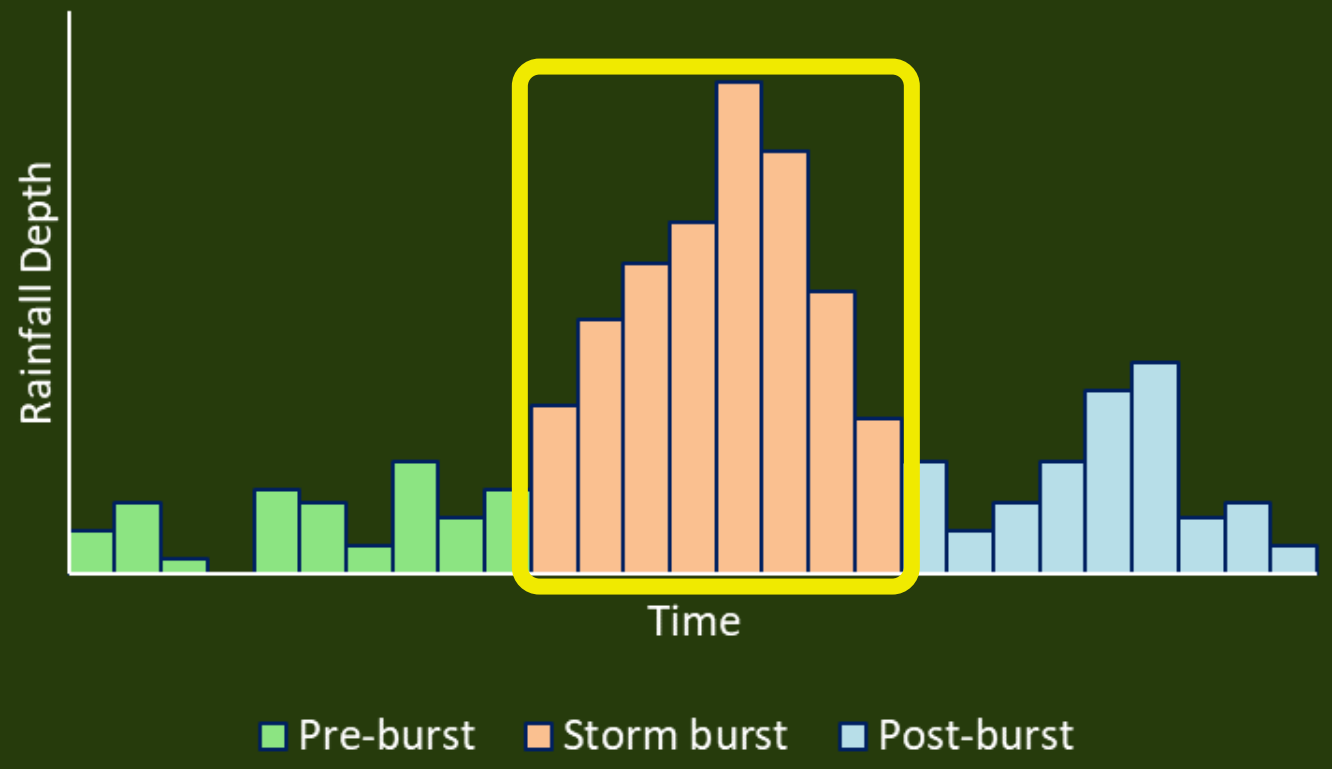
Storm Burst

Rational Method based on analysing the storm burst.



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Very frequent Storms

Light rainfall intensity

Likely to occur multiple times a year

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Frequent Storms

Light to moderate rainfall

63% to 18% chance of occurring in any given year

Q_1 to Q_5 event

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Infrequent Storms

Heavy rainfall intensity

10% to 1% chance of occurring in any given year

Q_{10} to Q_{100} event

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Rare Storms

Very heavy rainfall

0.5% to 0.1% chance of occurring in any given year

Q_{200} to Q_{1000} event

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Extremely Rare Storms

Extreme rainfall

0.05% to 0.02% chance of occurring in any given year

Q_{2000} to Q_{5000} event

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Storm Frequency

Storms broadly grouped as:

- Very frequent
- Frequent
- Infrequent
- Rare
- Extremely Rare
- Extreme

Frequency Descriptor	EY	AEP (%)	AEP (1 in X)	ARI (Years)
Very frequent	12			
	6	99.75	1.002	0.17
	4	98.17	1.02	0.25
	3	95.02	1.05	0.33
	2	86.47	1.16	0.50
Frequent	1	63.20	1.58	1.00
	0.69	50.00	2	1.44
	0.50	39.35	2.54	2.00
	0.22	20.00	5	4.48
	0.20	18.13	5.52	5.00
Infrequent	0.11	10.00	10	9.49
	0.05	5.00	20	20
	0.02	2.00	50	50
	0.01	1.00	100	100
Rare	0.005	0.50	200	200
	0.002	0.20	500	500
	0.001	0.10	1000	1000
Extremely Rare	0.0005	0.05	2000	2000
	0.0002	0.02	5000	5000
Extreme			PMP	

Storm Frequency

Frequency measured in:

- Exceedances per year (EY)
- Annual Exceedance Probability (AEP)
- Average Recurrence Interval (ARI)

Frequency Descriptor	EY	AEP (%)	AEP (1 in X)	ARI (Years)
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	0.001	0.10	1000	1000
Extremely Rare	0.0005	0.05	2000	2000
	0.0002	0.02	5000	5000
Extreme			PMP	

Storm Frequency

For civil engineering design:

- Common frequencies shown
- ARI not used anymore
- AEP preferred terminology

Frequency Descriptor	EY	AEP (%)	Q_y	Typical Use Case
Very frequent	4	98.17	Q_{3month}	Stormwater quality (WSUD)
Frequent	1	63.20	Q_1	Stormwater longitudinal (pit and pipe), culvert design
	0.50	39.35	Q_2	
	0.20	18.13	Q_5	
Infrequent	0.11	10.00	Q_{10}	
	0.05	5.00	Q_{20}	Roofwater design (eaves gutters)
	0.02	2.00	Q_{50}	Floodplain management, waterway design, major storm event analysis
	0.01	1.00	Q_{100}	

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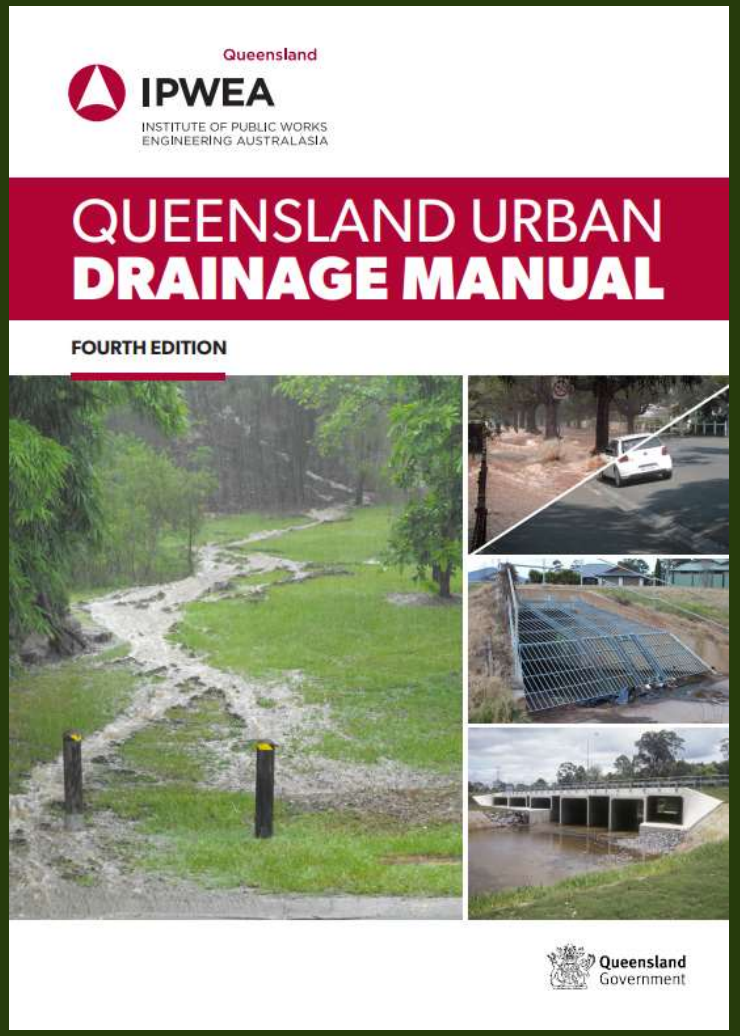
Local Standards and Guidelines

Queensland Urban Drainage Manual (QUDM):

- Widely adopted throughout Queensland.
- QUDM's Time of Concentration processes are used across Australia, not just Queensland.



Source: Institute of Public Works Engineering Australasia, Queensland 2017

What is the Rational Method?

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What is the Rational Method?

Allows us to calculate how much stormwater will runoff at any given location.

Source: Google 2023

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What is the Rational Method?

Hydrological method

Estimates peak discharge from rainfall runoff

Used for over 150 years

Based on

- Rainfall intensity
- Catchment area
- Catchment response to runoff

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

What is the Rational Method?

Relies on the following assumptions:

- A storm burst of duration equal to the time of concentration will yield the maximum or peak discharge rate.
- Entire watershed receives uniform rainfall during this time of concentration.

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

What is Time of Concentration?

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The Rational Method Equation

$$Q_y = \frac{C_y \, {}^{t}I_y A}{360}$$

Q_y	Peak flow rate (m^3/s) for AEP of 1 in 'y' years
C_y	Coefficient of runoff (discharge) for AEP of 1 in 'y' years
A	Catchment area (ha)
${}^{t}I_y$	Average rainfall intensity (mm/h) for a design duration of 't' hours and AEP of 1 in 'y' years
t	Nominal design storm duration defined by time of concentration, t (min)

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$$t = time\ of\ concentration$$

The time it takes for stormwater runoff to travel from the farthest point of the catchment to the outlet.

'Farthest point' refers to <u>time not length</u>.

Time of Concentration Components

- Various components relating to catchment conditions.
- Some components may not be applicable in certain catchments.
- Single or combination of components make up the ‘flow path’.

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Roof to Main System Connection

Kerb Flow

Pipe Flow

Channel Flow

Overland Sheet Flow

Concentrated Overland Flow

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Roof to Main System Connection

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Roof to Main System Connection

- Rainfall runs off roof, through downpipes into a pipe connection.

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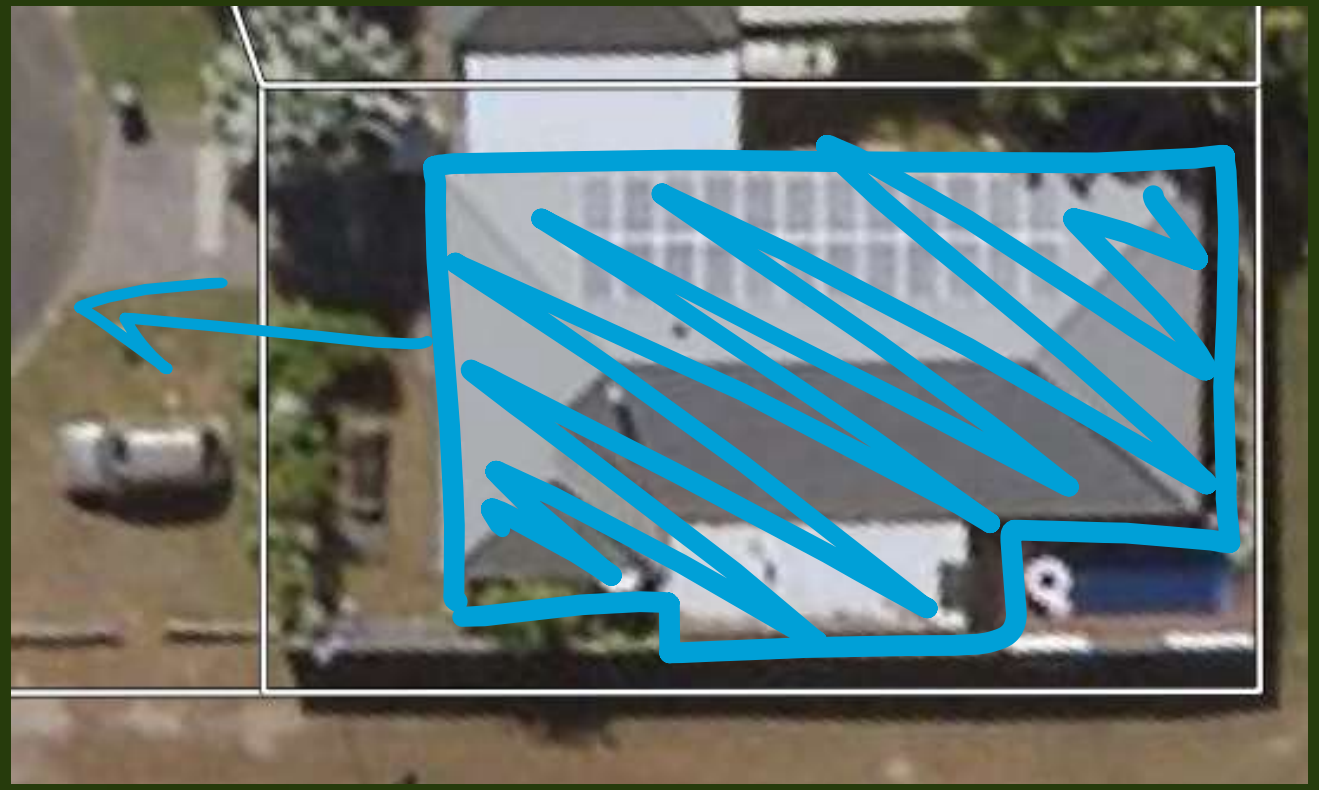
Roof to Main System Connection

- Time taken for rainfall to runoff from roof to street.



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Roof to Main System Connection

$$t = 5\ minutes$$

Roof to Main System Connection

Kerb Flow

Pipe Flow

Channel Flow

Overland Sheet Flow

Concentrated Overland Flow

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Kerb Flow

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Kerb Flow

- Movement of stormwater over the road surface.
- Stormwater accumulates on the road and flows downhill due to gravity.

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Kerb Flow

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Kerb Flow

$$t = \frac{0.025L}{S^{0.5}}$$

t	Time of gutter flow (min)
L	Length of gutter flow (m)
S	Slope of gutter (%)

Roof to Main System Connection

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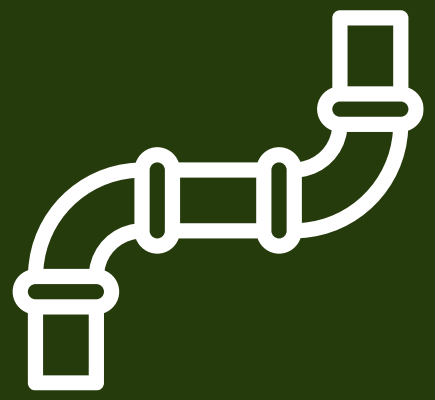

Pipe Flow

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Pipe Flow

Movement of stormwater through a pipe or conduit.

Common occurrence in urban environments.

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Pipe Flow

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Pipe Flow

$$t = \frac{L}{60V}$$

t	Pipe flow (min)
L	Pipeline length (m)
V	Pipe velocity (m/s)

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Roof to Main System Connection

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Channel Flow

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Channel Flow

Refers to engineered channels.

e.g. table drains, swales.

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Channel Flow

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Manning's Equation

$$V = \frac{1}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$$

V	Average velocity (m/s)
n	Manning's roughness coefficient
R	Hydraulic radius (m)
S	Friction slope (m/m)

Manning's Equation – Rearranged to Solve for Time

$$t = \frac{L}{60V} = \frac{nL}{60R^{\frac{2}{3}}S^{\frac{1}{2}}}$$

V	Average velocity (m/s)
n	Manning's roughness coefficient
R	Hydraulic radius (m)
S	Friction slope (m/m)
L	Length of reach (m)
t	Travel time (min)

Roof to Main System Connection

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Overland Sheet Flow

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Overland Sheet Flow

Overland Sheet Flow Time

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Overland Sheet Flow

Overland Sheet Flow Time

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Overland Sheet Flow – Friend's Equation

$$t = \frac{107nL^{0.333}}{S^{0.2}}$$

t Overland sheet flow travel time (min)

n Horton's surface roughness factor

L Overland sheet flow path length (m)

S Slope of surface (%)

Table 4.6.4 – Recommended maximum length of overland sheet flow

Surface condition	Assumed maximum flow length (m)
Steep (say >10%) grassland (Horton's n = 0.045)	20
Steep (say >10%) bushland (Horton's n = 0.035)	50
Medium gradient (approx. 5%) bushland or grassland	100
Flat (0–1%) bushland or grassland	200

Surface Condition	Horton's n
Paved surface	0.015
Bare soil surface	0.0275
Poorly grassed surface	0.035
Average grassed surface	0.045
Densely grassed surface	0.060

Overland Sheet Flow – Kinematic Wave Equation

$$t = \frac{6.94(Ln^*)^{0.6}}{I^{0.4}S^{0.3}}$$

t	Overland travel time (min)
L	Overland sheet flow path length (m)
n^*	Surface roughness coefficient
I	Rainfall intensity (mm/h)
S	Slope of surface (m/m)

Table 4.6.4 – Recommended maximum length of overland sheet flow

Surface condition	Assumed maximum flow length (m)
Steep (say >10%) grassland (Horton's n = 0.045)	20
Steep (say >10%) bushland (Horton's n = 0.035)	50
Medium gradient (approx. 5%) bushland or grassland	100
Flat (0–1%) bushland or grassland	200

Surface Type	Horton's Roughness Coefficient n*
Concrete or asphalt	0.010 - 0.013
Bare sand	0.010 - 0.016
Gravelled surface	0.012 - 0.030
Bare clay-loam soil (eroded)	0.012 - 0.033
Sparse vegetation	0.053 - 0.130
Short grass paddock	0.100 - 0.200
Lawns	0.170 - 0.480

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Roof to Main System Connection

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Channel Flow

Overland Sheet Flow

Concentrated Overland Flow

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Concentrated Overland Flow

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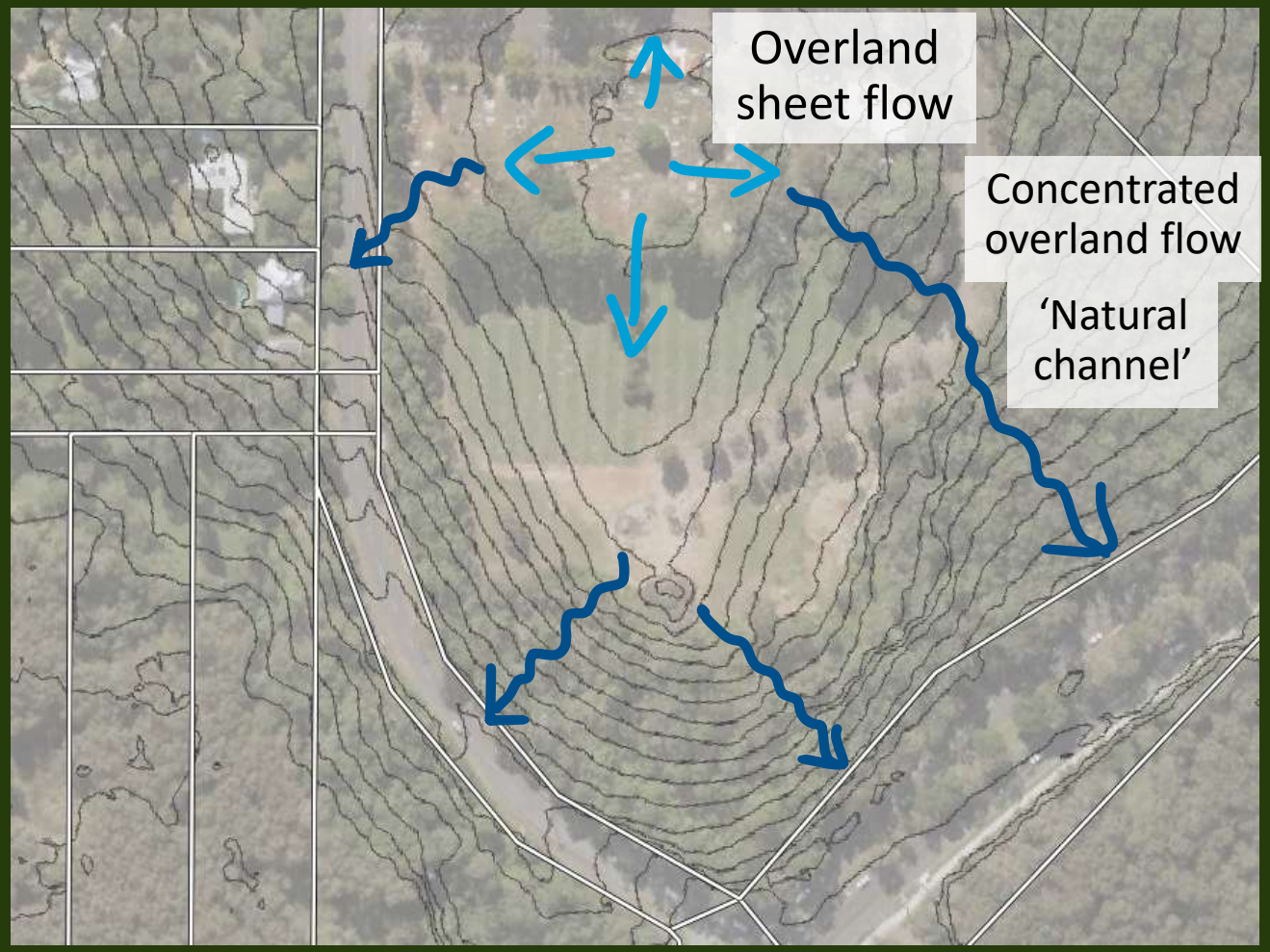
Concentrated Overland Flow (Natural Channel)

Overland sheet flow starts at top of catchment.

After sheet flow reaches limit, flows turn into concentrated channel flow.



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Concentrated Overland Flow (Natural Channel)

QUDM Figure 4.5 estimates flow time in channels.

Measure flow distance (length of natural channel) and fall of channel.

Obtain flow time from Figure 4.5.

Multipliers used depending on channel type.

Multiplier	Flow path
1	Kerb and gutter channels
1	Stormwater pipes
1	Open channels
2	Blade-cut earth drains
3	Natural channels
4	Grassed swales

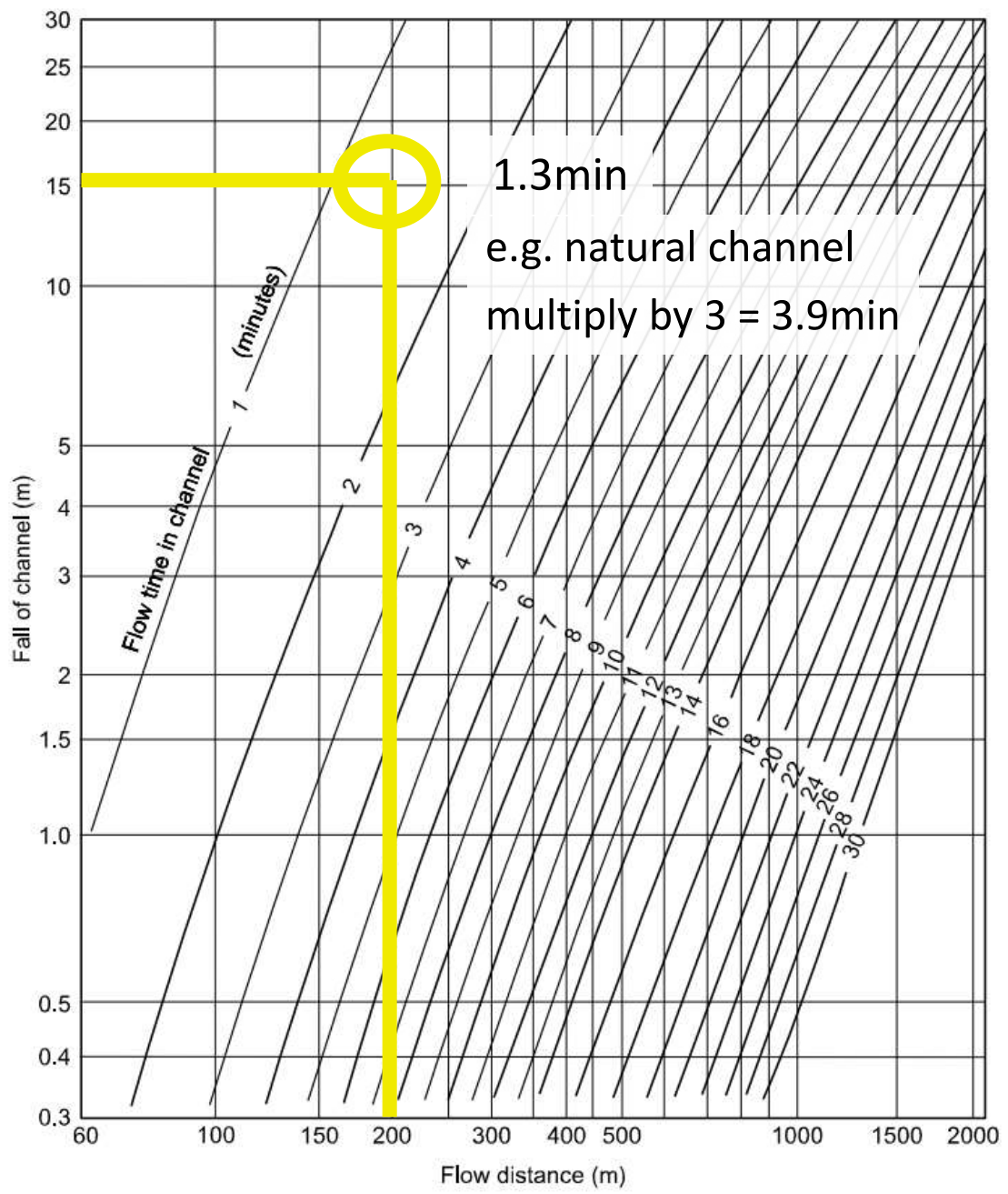

Figure 4.5 – Flow travel time in pipes and channels (Source: Argue, 1986)

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$$Q = \frac{C\ I\ A}{360}$$

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C

Coefficient of Runoff

or

Coefficient of Discharge (QUDM)

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Coefficient of Runoff

Ratio of total runoff to total rainfall.

Accounts for catchment infiltration and other runoff losses.

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Coefficient of Runoff

Low C values tend to reflect pervious areas.

If C = 0.5, 50% of rainfall results in runoff.

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Coefficient of Runoff

High C values tend to reflect impervious areas.

If C = 1.0, 100% of rainfall results in runoff.

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$$Q = \frac{C\ I\ A}{360}$$

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I

Rainfall Intensity

Rainfall Intensity

Rate of precipitation (rain) falling over a certain period of time.

Expressed as a rate (mm/h) or as a depth (mm).

To obtain Rainfall Intensity, we need:

- Time of concentration
- Storm frequency
- IFD Table

Intensity Frequency Duration (IFD)

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Intensity Frequency and Duration (IFD)

Obtain rainfall intensity from IFD table.

Council may provide IFD or you can download from BOM.

BOM IFD website:

bom.gov.au/water/designRainfalls/revised-ifd/

Duration	Annual Exceedance Probability (AEP)						
	63.20%	50%	20%	10%	5%	2%	1%
1 min	161.0	182.0	246.0	289.0	331.0	386.0	427.0
2 min	136.0	153.0	208.0	245.0	283.0	334.0	374.0
3 min	127.0	143.0	194.0	229.0	264.0	311.0	347.0
4 min	121.0	136.0	185.0	218.0	250.0	293.0	327.0
5 min	116.0	130.0	176.0	207.0	238.0	278.0	309.0
8 min	102.0	115.0	155.0	182.0	208.0	243.0	269.0
10 min	94.5	107.0	144.0	169.0	193.0	224.0	248.0
15 min	80.2	90.4	122.0	143.0	163.0	190.0	210.0
20 min	69.9	78.7	106.0	125.0	143.0	166.0	183.0
25 min	62.1	70.0	94.5	111.0	127.0	148.0	164.0
30 min	56.0	63.1	85.3	100.0	115.0	134.0	149.0
45 min	43.8	49.3	66.8	78.8	90.5	106.0	118.0
1 hour	36.3	40.9	55.6	65.7	75.7	89.1	99.6
1.5 hour	27.6	31.1	42.5	50.4	58.3	69.1	77.5

Intensity Frequency and Duration (IFD)

Trends in data:

- Rainfall intensity will increase as the storm frequency decreases.

Duration	Annual Exceedance Probability (AEP)						
	63.20%	50%	20%	10%	5%	2%	1%
1 min	161.0	182.0	246.0	289.0	331.0	386.0	427.0
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Intensity Frequency and Duration (IFD)

Trends in data:

- Rainfall intensity will decrease as the storm duration increases.

Duration	Annual Exceedance Probability (AEP)						
	63.20%	50%	20%	10%	5%	2%	1%
1 min	161.0	182.0	246.0	289.0	331.0	386.0	427.0
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1.5 hour	27.6	31.1	42.5	50.4	58.3	69.1	77.5

Intensity Frequency and Duration (IFD)

Intensity:

- Rate of rainfall (mm/h or mm)

Frequency:

- Probability storm may occur in given year at specific location

Duration:

- Length of time storm burst persists

Duration	Annual Exceedance Probability (AEP)						
	63.20%	50%	20%	10%	5%	2%	1%
1 min	161.0	182.0	246.0	289.0	331.0	386.0	427.0
2 min	136.0	153.0	208.0	245.0	283.0	334.0	374.0
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30 min	56.0	63.1	85.3	100.0	115.0	134.0	149.0
45 min	43.8	49.3	66.8	78.8	90.5	106.0	118.0
1 hour	36.3	40.9	55.6	65.7	75.7	89.1	99.6
1.5 hour	27.6	31.1	42.5	50.4	58.3	69.1	77.5

$$Q = \frac{C\ I\ A}{360}$$

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A

Catchment Area

Catchment Area

Determined by:

- Contour maps
- Council records
- Aerial imagery
- Site inspections

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Catchment Area

To identify a catchment, need a point of interest.

We can calculate peak discharge rate at any location:

- Gully pit
- Bottom of a hill
- Along a property boundary
- End of a drainage channel

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$$Q = \frac{C\ I\ A}{360}$$

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Q

Peak Discharge

Peak Discharge

Maximum rate of stormwater runoff at a specific location during a rainfall event.

When we know the maximum flow rate expected, we can calculate:

- Runoff for catchments
- Inlets and pipe systems
- Drainage channels
- Road capacity
- Flooded widths, depths
- Freeboard to buildings

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The Rational Method Equation

$$Q_y = \frac{C_y {}^{t}I_y A}{360}$$

Q_y	Peak flow rate (m^3/s) for AEP of 1 in ‘y’ years
C_y	Coefficient of runoff (discharge) for AEP of 1 in ‘y’ years
A	Catchment area (ha)
${}^{t}I_y$	Average rainfall intensity (mm/h) for a design duration of ‘t’ hours and AEP of 1 in ‘y’ years
t	Nominal design storm duration defined by time of concentration, t (min)

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Time for some calculations

CHEAT SHEET!

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Rational Method

Catchment

1. Identify point of discharge / interest
2. Draw catchment contributing to runoff at point of interest
3. Measure catchment area
4. Measure fraction impervious

Time of Concentration

1. Identify all time of concentration components
2. Choose a flow path (or multiple paths if unsure of longest travel time)
3. Calculate each time component
4. Add all components to obtain time of concentration for catchment

Intensity Frequency Duration (IFD) Table

1. Obtain catchment location (latitude longitude)
2. BOM IFD website bom.gov.au/water/designRainfalls/revised-ifd/
3. Set units to 'mm/h'

Rainfall Intensity (IFD Table)

1. Identify storm frequency needed e.g. 1% AEP
2. Identify time of concentration
3. Obtain rainfall intensity for your specific design storm (storm frequency and burst duration) ${}^{t}I_{y}$ mm/h

Coefficient of Runoff

1. Fraction impervious f_i
2. Rainfall intensity for 1 hour 10% AEP ${}^{1}I_{10}$ (mm/h)
3. Obtain C_{10} value based on f_i and ${}^{1}I_{10}$
   QUDM or Council will provide this table.
4. Frequency factor for design storm F_y
5. Calculate C_y for design storm

$$C_y = F_y C_{10}$$

Rational Method Peak Discharge

1. Calculate Peak Discharge

$$Q = CIA/360$$

Example 1:
Gully Pit

Calculating peak discharge at a stormwater gully pit.

Design storm:

- Storm duration = time of concentration
- Storm frequency = 39% AEP or 0.5EY or 2 year ARI or Q_2

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Catchment

1. Identify point of discharge / interest
2. Draw catchment contributing to runoff at point of interest
3. Measure catchment area
4. Measure fraction impervious

Catchment area, A = 0.6317ha

Fraction impervious, f_i = 3790m^2 / 6317m^2 = 0.60

Time of Concentration

Draw flow path that would result in the longest time.

Roof to main system connection

t = 5 minutes

Kerb flow

L = 125m S = 4%

$$t = \frac{0.025L}{S^{0.5}}$$

t = (0.025*125)/4$^{0.5}$ = 1.6min

Total time of concentration for catchment is:

Roof to main connection time + kerb flow time

t = 5 + 1.6 = 6.6 = 7 min

Rational Method needs to adopt a storm burst of 7 minutes.

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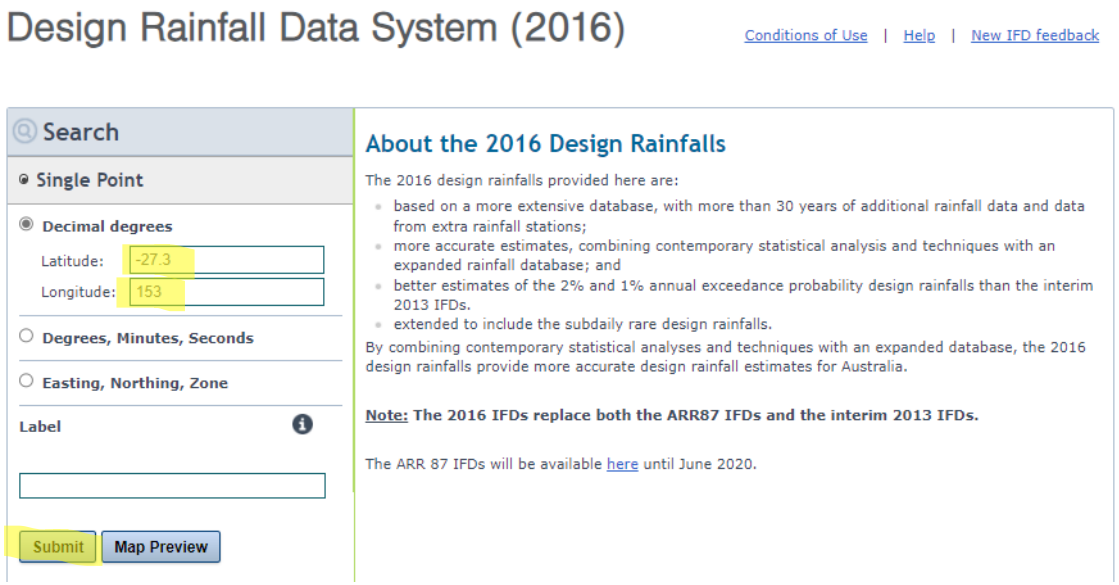
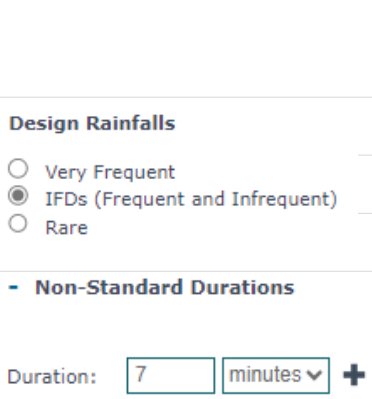
Intensity Frequency Duration (IFD) Table

1. Obtain catchment location (latitude longitude)
2. BOM IFD website bom.gov.au/water/designRainfalls/revised-ifd/
3. Set units to 'mm/h'



Select Design Rainfalls needed e.g. IFD values.



Add non-standard duration if required e.g. 7 min. duration

We will need two values: ${}^{1}I_{10}$ (for Coefficient of Runoff) and ${}^{7}I_{2}$ (for Q_2 Peak Discharge)

Table | Chart — Unit: mm/h

	Exceedance per Year (EY)							
Duration	12EY	6EY	4EY	3EY	2EY	1EY	0.5EY#	0.2EY*
1 min	65.2	76.1	94.9	108	127	161	202	251
2 min	58.2	67.2	82.2	93.0	108	136	170	212
3 min	54.0	62.5	76.8	87.0	102	127	159	198
4 min	50.6	58.7	72.6	82.5	96.5	121	151	188
5 min	47.6	55.5	68.9	78.5	92.1	116	145	180
7 min	42.7	50.1	62.7	71.7	84.3	106	133	165

Rainfall intensity ${}^{7}I_{2}$ = 133mm/h

Table | Chart — Unit: mm/h

	Annual Exceedance Probability (AEP)						
Duration	63.2%	50%#	20%*	10%	5%	2%	1%
1 hour	36.3	40.9	55.6	65.7	75.7	89.1	99.6

Rainfall intensity ${}^{1}I_{10}$ = 65.7mm/h

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Coefficient of Runoff

Now we can obtain C_{10} based on f_i and $^1I_{10}$

$f_i = 0.60$ $^1I_{10} = 65.7mm/h$

Intensity (mm/hr) $^1 1_{10}$	Fraction impervious f_i					
	0.20	0.40	0.60	0.80	0.90	1.00
39-44	0.44	0.55	0.67	0.78	0.84	0.90
45-49	0.49	0.60	0.70	0.80	0.85	0.90
50-54	0.55	0.64	0.72	0.81	0.86	0.90
55-59	0.60	0.68	0.75	0.83	0.86	0.90
60-64	0.65	0.72	0.78	0.84	0.87	0.90
65-69	0.71	0.76	0.80	0.85	0.88	0.90
70-90	0.74	0.78	0.82	0.86	0.88	0.90

$C_{10} = 0.80$

Then we multiply this by our Frequency Factor to calculate our C_2 value.

AEP (%)	ARI (years)	Frequency factor (F_y)
63%	1.00	0.80
39%	2.00	0.85
18%	5.00	0.95
10%	10.00	1.00
5%	20.00	1.05
2%	50.00	1.15
1%	100.00	1.20

$$C_y = F_y C_{10}$$

$C_2 = 0.85 \times 0.80 = 0.68$

Now we have all our variables needed.

Rational Method Peak Discharge

$$Q_y = \frac{C_y {}^t I_y A}{360}$$

Peak discharge $Q = CIA/360$ (m^3/s)

$Q_2 = (C_2 \, {}^7I_2 \, A)/360$

$Q_2 = (0.68*133*0.6317)/360$

$Q_2 = 0.159m^3/s$

Example 2: Inter-allotment Drainage

Calculating peak discharge at the outlet of a stormwater piped network.

Design storm:

- Storm duration = time of concentration
- Storm frequency = 39% AEP or 0.5EY or 2 year ARI or Q_2

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Catchment

1. Identify point of discharge / interest
2. Draw catchment contributing to runoff at point of interest
3. Measure catchment area
4. Measure fraction impervious

Catchment area, A = 0.1870ha

Fraction impervious, f_i = 1122m^2 / 1870m^2 = 0.60

Time of Concentration

Draw flow path that would result in the longest time.

Roof to main system connection

t = 5 minutes

Pipe flow

We haven't modelled the stormwater flows through the piped system, so we don't know the actual pipe velocity. QUDM suggests:

Low gradient pipes, pipe velocity = 2m/s

Medium to steep gradient pipes, pipe velocity = 3m/s

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Pipe flow (cont'd)

Assume low (flatter) pipe grade, so pipe velocity = 2m/s

$$t = \frac{L}{60V}$$

L = 90m (assume we measured from GIS, survey etc.)

t = 90/(60*2) = 0.75min

Total time of concentration for this catchment is:

Roof to main connection time + pipe flow time

t = 5 + 0.75 = 5.75 = 6 min

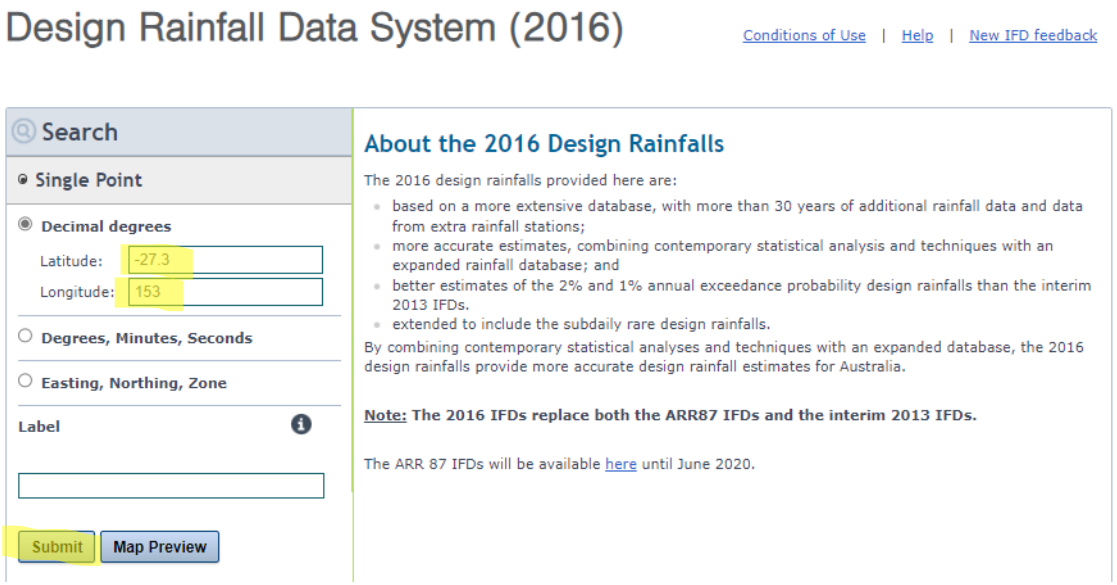
Time of concentration = 6 min.

Note: Some guidelines may require a fixed time of concentration of 5 minutes for specific inter-allotment drainage systems.

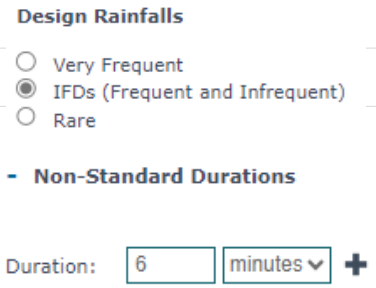
If we continue with Rational Method, the storm burst needs to be 6 minutes.

Intensity Frequency Duration (IFD) Table

1. Obtain catchment location (latitude longitude)
2. BOM IFD website bom.gov.au/water/designRainfalls/revised-ifd/
3. Set units to 'mm/h'



Select Design Rainfalls needed e.g. IFD values.



Add non-standard duration if required e.g. 6 min. duration

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We will need two values: ${}^{1}I_{10}$ (for Coefficient of Runoff) and ${}^{6}I_{2}$ (for Q_2 Peak Discharge)

Table | Chart Unit: mm/h

	Exceedance per Year (EY)							
Duration	12EY	6EY	4EY	3EY	2EY	1EY	0.5EY#	0.2EY*
1 min	65.2	76.1	94.9	108	127	161	202	251
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3 min	54.0	62.5	76.8	87.0	102	127	159	198
4 min	50.6	58.7	72.6	82.5	96.5	121	151	188
5 min	47.6	55.5	68.9	78.5	92.1	116	145	180
6 min	45.0	52.6	65.7	74.9	88.0	111	138	172

Rainfall intensity ${}^{6}I_{2}$ = 138mm/h

Table | Chart Unit: mm/h

	Annual Exceedance Probability (AEP)						
Duration	63.2%	50%#	20%*	10%	5%	2%	1%
1 hour	36.3	40.9	55.6	65.7	75.7	89.1	99.6

Rainfall intensity ${}^{1}I_{10}$ = 65.7mm/h

Coefficient of Runoff

Now we can obtain C_{10} based on f_i and ${}^{1}I_{10}$

$f_i = 0.60$ ${}^{1}I_{10} = 65.7$mm/h

Intensity (mm/hr) ${}^{1}1_{10}$	Fraction impervious f_i					
	0.20	0.40	0.60	0.80	0.90	1.00
39-44	0.44	0.55	0.67	0.78	0.84	0.90
45-49	0.49	0.60	0.70	0.80	0.85	0.90
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65-69	0.71	0.76	0.80	0.85	0.88	0.90
70-90	0.74	0.78	0.82	0.86	0.88	0.90

$C_{10} = 0.80$

Then we multiply this by our Frequency Factor to calculate our C_2 value.

AEP (%)	ARI (years)	Frequency factor (F_y)
63%	1.00	0.80
39%	2.00	0.85
18%	5.00	0.95
10%	10.00	1.00
5%	20.00	1.05
2%	50.00	1.15
1%	100.00	1.20

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$$C_y = F_y C_{10}$$

$C_2 = 0.85 \times 0.80 = 0.68$

Now we have all our variables needed.

Rational Method Peak Discharge

$$Q_y = \frac{C_y{}^t I_y A}{360}$$

Peak discharge $Q = CIA/360$ (m^3/s)

$Q_2 = (C_2\ {}^6I_2\ A)/360$

$Q_2 = (0.68*138*0.1870)/360$

$Q_2 = 0.049 m^3/s$

Here are common problems we encounter in the industry:

- Pre-developed & post-developed analysis
- External catchments
- Sensitivity analysis
- Partial area effect
- Limitations of the Rational Method
- What to do when Rational Method is not suitable

If these sound familiar but you're not 100% confident in calculating, get in touch and we can teach you.

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Want to learn more?

We can help with:

- Free consultations
- Online self-paced learning
- Coaching
- Face-to-face workshops
- In-house training delivery

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