1. **Drainage Proposal**

1.1 Site Particulars

1.1.1 The application site is abutting a local vehicular access leading to Kong Nga Po Road. possesses an area of approximately 2,118m^2.

1.1.2 There is an existing drainage system directly to the west of the application site extending north to an open stream to the northwest of the site, and an underground drainage to the east of the application site which leads to an open watercourse to the northeast.

1.2 Level and gradient of the subject site & proposed surface channel

1.2.1 The application site is mostly paved, an area of approximately 2,118m^2. The paved area will have a gradient sloping from southeast to northwest from about +29.7mPD to +29.5mPD.

1.2.2 In order to follow the topography of the application site, the proposed surface channel will be constructed following the gradient of the site. As demonstrated in the calculations in Paragraph 3 and 4 hereunder, a 300mm surface U-channel will be capable to drain the surface runoff accrued at the subject site and a 375mm surface U-channel will be capable to drain the surface runoff from the external catchment that may potentially flow overland to the site.

1.3 Catchment area of the proposed drainage provision at the subject site.

1.3.1 For the internal catchment, with an area of approximately 2,118m^2, a 300mm surface U-Channel along the site peripheral is proposed to intercept the run-off of the site.

1.3.2 The intercepted stormwater from the site will then be discharged to the existing drainage facilities and eventually to the open streamcourse to the Northwest of the Site via a proposed 300mm surface U-channel.

1.3.3 It is noted that the land to the East and South of the application site commands a higher level whereas the land to the north and west command a lower level. The external catchment area is estimated to be approximately 2,425m^2

1.3.4 The Internal and External Catchment Areas are shown in Figure 1.

1.3.5 A proposed peripheral 375mm surface U-channel outside of the boundary of the application site is proposed to intercept the external catchment run-off from the East and South of the site, and to be discharged into an existing catchpit as indicated in the drainage plan.

1.3.6 The existing drainage system to the west of the application site currently intercepts the run-off from an existing catchment, an area of approximately 16,931m^2, to the south and west of the application site.

2 Runoff Estimation and Proposed Drainage Facilities

2.1 Proposed Drainage Facilities

2.1.1 Subject to the below calculations, it is determined that 300mm surface U-channel which is made of concrete along the site periphery is adequate to intercept storm water generated at the application site, and a 375mm surface U-channel which is made of concreate along the outer peripheral site boundary is adequate to intercept potential overland flow to the site from the external catchment.

2.1.2 The intercepted stormwater from the site will then be discharged to the existing drainage to the northwest of the application site as shown in Figure 3, and eventually discharges into an natural watercourse to the north. The intercepted stormwater from the external catchment will be discharged into an existing catchpit to the Southwest of the site.

2.1.3 The flow capacities of the proposed U-channel are calculated using the Chart for the Rapid Design of Channels. Runoff from corresponding Site Catchments (calculated based on a return period of 50 years), the capacity estimation are included below.

2.1.4 The first set of calculations below shows that the proposed 300mm U-channel has adequate capacity to cater for the surface runoff generated at the application site.

2.1.5 The second set of calculations below shows that the proposed 375mm U-channel has adequate capacity to cater for the surface runoff generated at the external catchments of the application site.

2.1.6 A final set of calculations checks and confirms that the downstream drainage and subsequent watercourse has the capacity for the surface runoff generated at the application site and external catchment. The calculations can be broken down into the following sections

- Calculations 4: Capacity of the first section of one 0.7m Drainage Pipe
- Calculations 5: Capacity of the second section of two 0.7m Drainage Pipes
- Calculations 6: Capacity of the Existing Drainage Channel
- Calculations 7: Capacity of the Natural Stream

2.1.7 All the proposed drainage facilities, including the section of surface channel proposed in between the subject site to the streamcourse will be provided and maintained at the applicant's own expense. Also, surface U-channel will be cleaned at regular interval to avoid the accumulation of rubbish/debris which would affect the dissipation of storm water.

2.1.8 Prior to the commencement of drainage works, the applicant will seek the consent of the District Lands Office/North District and the registered land owner for any drainage works outside the application site or outside the jurisdiction of the applicant.

2.1.9 The provision of the proposed surface U-channel will follow the gradient of the application site. All the proposed drainage facilities will be constructed and maintained at the expense of the applicant.

3 Calculation 1: Drainage Calculation for the proposed Provision of Drainage Facilities at the Application Site

3.1 Runoff Estimation

3.1.1 Rational method is adopted for estimating the designed run-off

$$Q=0.278\ C \times I \times A$$

Table 1: Runoff Coefficients

Surface Characteristics	Runoff Coefficient
Asphalt	0.70-0.95
Concrete	0.80-0.95
Brick	0.70-0.85
Grassland (Heavy Soil)	
Flat	0.13-0.25
Steep	0.25-0.35
Grassland (Sandy Soil)	
Flat	0.05-0.15
Steep	0.15-0.2

Assuming that:

I. The total catchment area from the application site is about 2,118 m^2;

II. Approximately 2,118 m^2 is hard paved, and therefore the value of run-off co-efficient (k) is taken as 0.95.

Difference in Land Datum	=	29.7m –29.5m = 0.2m
L	=	71.6m
Average fall	=	0.28m in 100m

According to the Brandsby-Williams Equation adopted from the “Stormwater Drainage Manual – Planning, Design and management” published by the Drainage Services Department (DSD),

Time of Concentration (t_c)	=	$0.14465[L/(H^{0.2} \times A^{0.1})]$
t_c	=	$0.14465[71.6/(0.28^{0.2} \times 2{,}118^{0.1})]$
t_c	=	6.22 minutes

The rainfall intensity *i* is determined by using the Gumbel Solution:

$$i = \frac{a}{(td + b)^c}$$

Where *I* = Extreme mean intensity in mm/hr
td = Duration in minutes (td≤240)
a, b, c = Storm constants given in the table below

Table 2: Storm Constants for Different Return Periods of North District Area

Return Period T(years)	2	5	10	20	50
a	1004.5	1112.2	1157.7	1178.6	1167.6
b	17.24	18.86	19.04	18.49	16.76
c	0.644	0.614	0.597	0.582	0.561

i	=	$1167.6/[6.22+16.76]^{0.561}$
i	=	201.2mm/hr

By Rational Method, Q	=	0.95× 201.2mm/hr × 2,118/3600
Q	=	112l/s = 0.112m^3/s = 6,747 l/min

In accordance with the Chart of the Rapid Design of Channels in “Geotechnical Manual for Slopes”, 300mm surface U-channel in 1:100 gradient is considered adequate to dissipate all the stormwater accrued by the application site, as shown in Figure 4. The intercepted stormwater will then be discharged to the existing natural stream to the north of the application site as shown in Figure 3.

4 Calculation 2: Drainage Calculation for the Proposed Peripheral Channel for the External Catchment to the South

4.1 Runoff Estimation

4.1.1 Rational method is adopted for estimating the designed run-off

$$Q=0.278\ C \times I \times A$$

Table 1: Runoff Coefficients

Surface Characteristics	Runoff Coefficient
Asphalt	0.70-0.95
Concrete	0.80-0.95
Brick	0.70-0.85
Grassland (Heavy Soil)	
Flat	0.13-0.25
Steep	0.25-0.35
Grassland (Sandy Soil)	
Flat	0.05-0.15
Steep	0.15-0.2

Assuming that:

I. The total external catchment area is about 2,425 m^2;
II. Approximately 2,261 m^2 is hard paved, and therefore the value of run-off co-efficient (k) is taken as 0.95, and approximately 164m^2 is steep grassland, and therefore the value of run-off co-efficient (k) is take as 0.25.

Difference in Land Datum = 40m –29.5m = 10.5m
L = 107.8m
Average fall = 9.74m in 100m

According to the Brandsby-Williams Equation adopted from the "Stormwater Drainage Manual – Planning, Design and management" published by the Drainage Services Department (DSD),

Time of Concentration (t_c) = $0.14465[L/(H^{0.2}\times A^{0.1})]$
t_c = $0.14465[107.8/(9.74^{0.2}\times 2{,}425^{0.1})]$
t_c = 4.54 minutes

The rainfall intensity *i* is determined by using the Gumbel Solution:

$$i = \frac{a}{(td + b)^c}$$

Where *I* = Extreme mean intensity in mm/hr
td = Duration in minutes (td≤240)
a, b, c = Storm constants given in the table below

Table 2: Storm Constants for Different Return Periods of North District Area

Return Period T(years)	2	5	10	20	50
a	1004.5	1112.2	1157.7	1178.6	1167.6
b	17.24	18.86	19.04	18.49	16.76
c	0.644	0.614	0.597	0.582	0.561

i = $1167.6/[4.54+16.76]^{0.561}$
i = 209.9mm/hr

By Rational Method, Q = 0.95× 209.9mm/hr × 2,261/3600 +0.2× 209.9mm/hr × 164/3600

Q = 127l/s = 0.127m^3/s = 7,631 l/min

In accordance with the Chart of the Rapid Design of Channels in "Geotechnical Manual for Slopes", 375mm surface U-channel in 1:100 gradient is considered adequate to dissipate all the stormwater accrued by the external catchment, as shown in Figure 5. The intercepted stormwater will then be discharged to the existing catchpit to the West of the external catchment area as shown in Figure 3.

5 Calculations 3: Runoff Calculation of Existing Catchment

5.1 Runoff Estimation

5.1.1 Rational method is adopted for estimating the designed run-off

$$Q=0.278\ C \times I \times A$$

Table 1: Runoff Coefficients

Surface Characteristics	Runoff Coefficient
Asphalt	0.70-0.95
Concrete	0.80-0.95
Brick	0.70-0.85
Grassland (Heavy Soil)	
Flat	0.13-0.25
Steep	0.25-0.35
Grassland (Sandy Soil)	
Flat	0.05-0.15
Steep	0.15-0.2

Assuming that:

III. The total existing catchment area is about 16,931m^2;

IV. Approximately 4,9191 m^2 is hard paved, and therefore the value of run-off co-efficient (k) is taken as 0.95, and approximately 12,012m^2 is steep grassland, and therefore the value of run-off co-efficient (k) is take as 0.25.

Difference in Land Datum = 71.2m –29.1m = 42.1m
L = 179.7m
Average fall = 23.4m in 100m

According to the Brandsby-Williams Equation adopted from the "Stormwater Drainage Manual – Planning, Design and management" published by the Drainage Services Department (DSD),

Time of Concentration (t_c) = $0.14465[L/(H^{0.2}\times A^{0.1})]$
t_c = $0.14465[179.7/(23.4^{0.2}\times 16{,}931^{0.1})]$
t_c = 5.23 minutes

The rainfall intensity i is determined by using the Gumbel Solution:

$$i = \frac{a}{(td + b)^c}$$

Where I = Extreme mean intensity in mm/hr
td = Duration in minutes (td≤240)
a, b, c = Storm constants given in the table below

Table 2: Storm Constants for Different Return Periods of North District Area

Return Period T(years)	2	5	10	20	50
a	1004.5	1112.2	1157.7	1178.6	1167.6
b	17.24	18.86	19.04	18.49	16.76
c	0.644	0.614	0.597	0.582	0.561

i = $1167.6/[5.23+16.76]^{0.561}$
i = 206.2mm/hr

By Rational Method, Q = 0.25× 206.2mm/hr × 12,012/3600 + 0.95× 206.2mm/hr × 4,919/3600
Q = 440l/s = 0.440m^3/s = 26,385 l/min

6 Calculations 4: Capacity of the first section of one 0.7m Drainage Pipe

Manning Equation

$$V = \frac{HMD^{\frac{2}{3}} \times S_f^{0.5}}{n}$$

Hydraulic Mean Depth (HMD) = 0.291 × D
HMD = 0.291 × 0.7
HMD = 0.204
n = 0.013 s/$m^{1/3}$
for good uncoated cast iron pipe
(Table 13 of Stormwater Drainage Manual)
V = $[0.204^{2/3}]\times[0.01^{0.5}]/0.013$
V = 2.67m/sec

Maximum Capacity Q_{Max} = V × A

A = πR^2
A = $\pi 0.35^2$
A = 0.385m^2
Q_{Max} = 2.67m/sec × 0.385m^2
Q_{Max} = 1.03m^3/sec
1.03m^3/sec > Runoff from Existing + External Catchment
1.03m^3/sec > (0.440+0.127)m^3/sec
1.03m^3/sec > 0.567m^3/sec
Q_{Max} > Q

The runoff estimation is only a small fraction of the first section of the existing drainage pipe's capacity

7 Calculations 5: Capacity of the second section of two 0.7m Drainage Pipes

Manning Equation

$$V = \frac{HMD^{\frac{2}{3}} \times S_f^{0.5}}{n}$$

Hydraulic Mean Depth (HMD)	=	0.291 × D
HMD	=	0.291 × 0.7
HMD	=	0.204
n	=	0.013 $s/m^{1/3}$
		for good uncoated cast iron pipe
		(Table 13 of Stormwater Drainage Manual)
V	=	$[0.204^{2/3}] \times [0.01^{0.5}]/0.013$
V	=	2.67m/sec

Maximum Capacity $Q_{Max} = V \times A$

A	=	$2 \times \pi R^2$
A	=	$2 \times \pi 0.35^2$
A	=	$0.769m^2$
Q_{Max}	=	$2.67m/sec \times 0.769m^2$
Q_{Max}	=	$2.05m^3/sec$
$2.05m^3/sec$	>	Total Runoff from all catchments
$2.05m^3/sec$	>	$(0.112+0.440+0.127)m^3/sec$
$2.05m^3/sec$	>	$0.679m^3/sec$
Q_{Max}	>	Q

The runoff estimation is only a small fraction of the second section of the existing drainage pipes' capacity

8 Calculations 6: Capacity of the Existing Drainage Channel

Manning Equation

$$V = \frac{R^{\frac{2}{3}} \times S_f^{0.5}}{n}$$

$$R = \frac{L \times D}{2D+L}$$

L	=	1.9m
D	=	1.6m
R	=	[1.9×1.6]/[2×1.6+1.9]
R	=	0.596m
n	=	0.014 $s/m^{1/3}$ for concrete lined channels
		(Table 13 of Stormwater Drainage Manual)
V	=	$[0.596^{2/3}] \times [0.01^{0.5}]/0.014$
V	=	5.06m/sec

Maximum Capacity $Q_{Max} = V \times A$

A	=	L × D
A	=	1.9 × 1.6
A	=	$3.04m^2$
Q_{Max}	=	$5.06m/sec \times 3.04m^2$
Q_{Max}	=	$15.4m^3/sec$
$15.4m^3/sec$	>	Total Runoff from all catchments
$15.4m^3/sec$	>	$(0.112+0.440+0.127)m^3/sec$
$15.4m^3/sec$	>	$0.679m^3/sec$
Q_{Max}	>	Q

The runoff estimation is only a small fraction of the existing drainage channel's capacity

9 Calculations 7: Capacity of the Natural Watercourse

Manning Equation

$$V = \frac{R^{\frac{2}{3}} \times S_f^{0.5}}{n}$$

$$R = \frac{L \times D}{2D + L}$$

L	=	2.5m
D	=	1.6m
R	=	[2.5×1.6]/[2×1.6+2.5]
R	=	0.702m
n	=	0.04 $s/m^{1/3}$ for canal with rough stony beds, weed on earth banks in bad condition (Table 13 of Stormwater Drainage Manual)
V	=	$[0.702^{2/3}]\times[0.01^{0.5}]/0.04$
V	=	1.97m/sec

Maximum Capacity Q_{Max} = V × A

A	=	L × D
A	=	2.5 × 1.6
A	=	$4m^2$
Q_{Max}	=	1.97m/sec × $4m^2$
Q_{Max}	=	$7.90m^3/sec$
$7.90m^3/sec$	>	Total Runoff from all catchments
$7.90m^3/sec$	>	$(0.112++0.440+0.127)m^3/sec$
$7.90m^3/sec$	>	$0.679m^3/sec$
Q_{Max}	>	Q

The runoff estimation is only a small fraction of the existing natural watercourse's capacity

10 Conclusion

10.1 The applicant will be responsible for the construction and ongoing maintenance of the drainage facilities.

10.2 Potential drainage impacts that may arise from the Site after construction of the Proposed Development have been assessed. Thus, existing stormwater system will have sufficient capacity to receive stormwater runoff from the Proposed Development and surrounding catchments.

10.3 Adequate measures are provided at the resources of the applicant to prevent the site from being eroded and flooded

10.4 External catchments is taken into account such that flooding susceptibility of the adjoining areas would not be adversely affected by the proposed development.

Figure 1 Catchment Areas and Flowpath

Figure 2

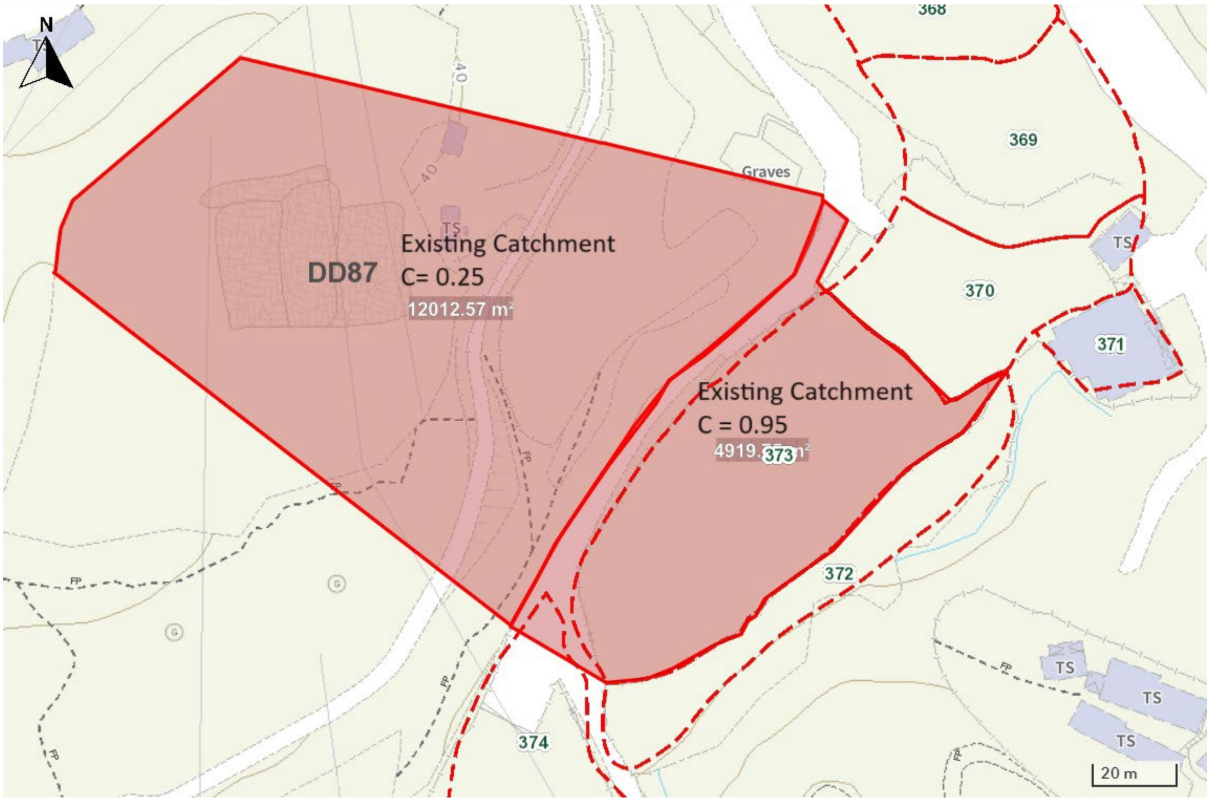

Figure 3 Drainage Plan

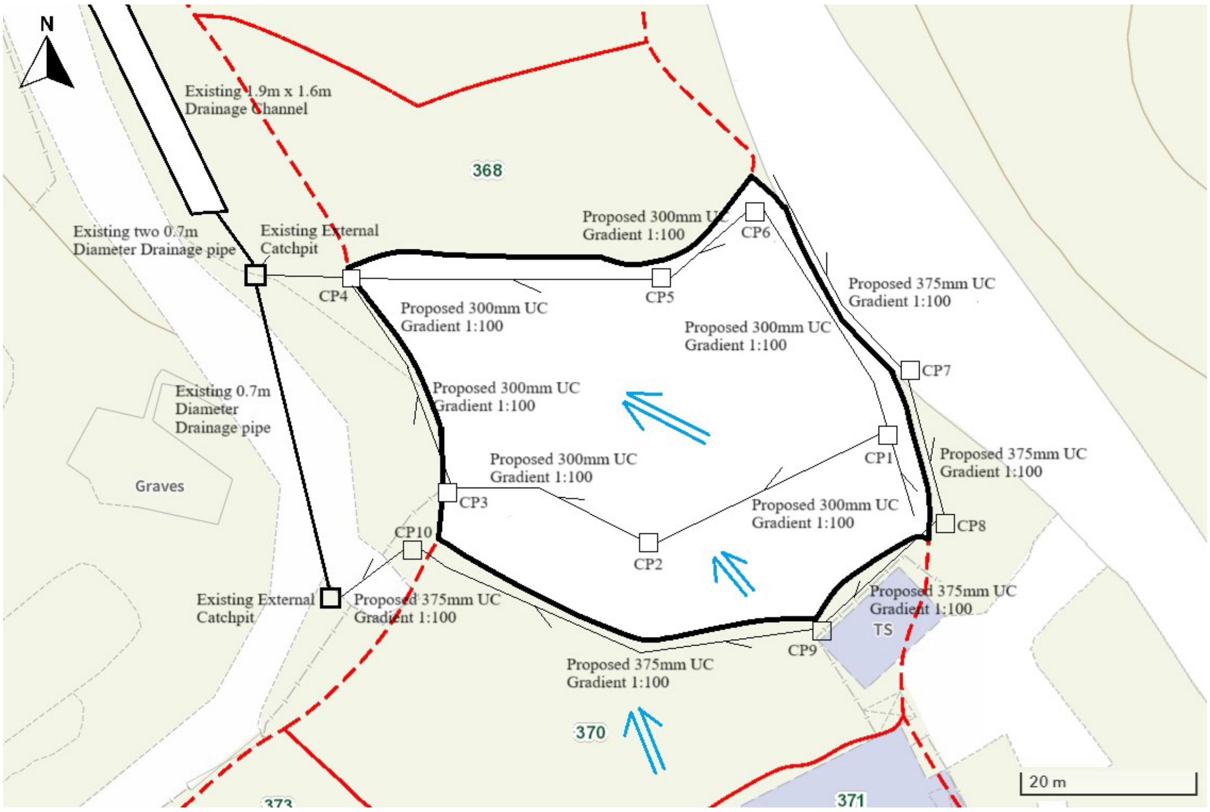

Figure 4 Chart for the Rapid Designs of Channels (Application Site)

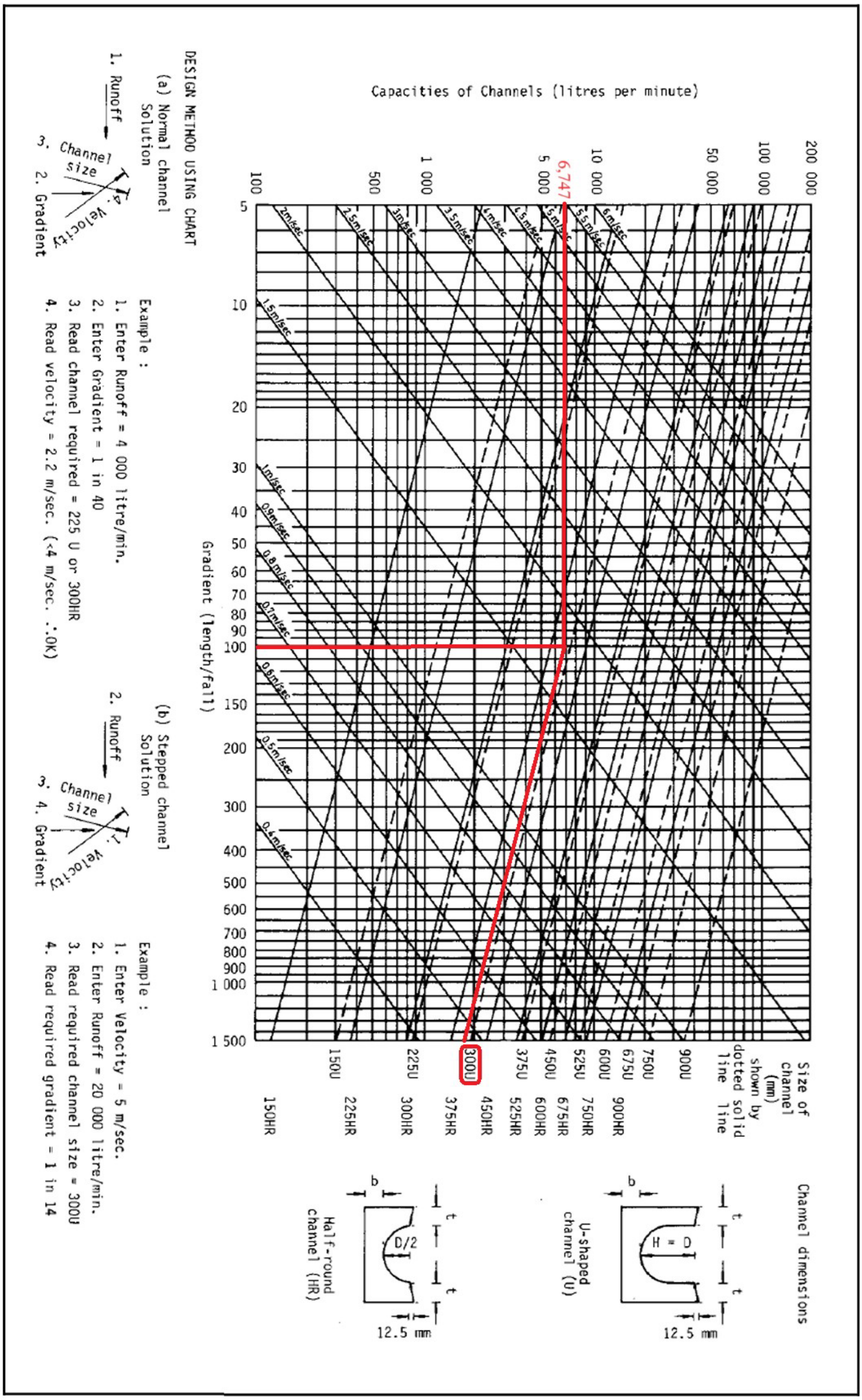

Chart for the Rapid Design of Channels in the Geotechnical Manual for Slopes (Second Edition) (GCO, 1984)

Figure 5 Chart for the Rapid Designs of Channels (External Catchment)

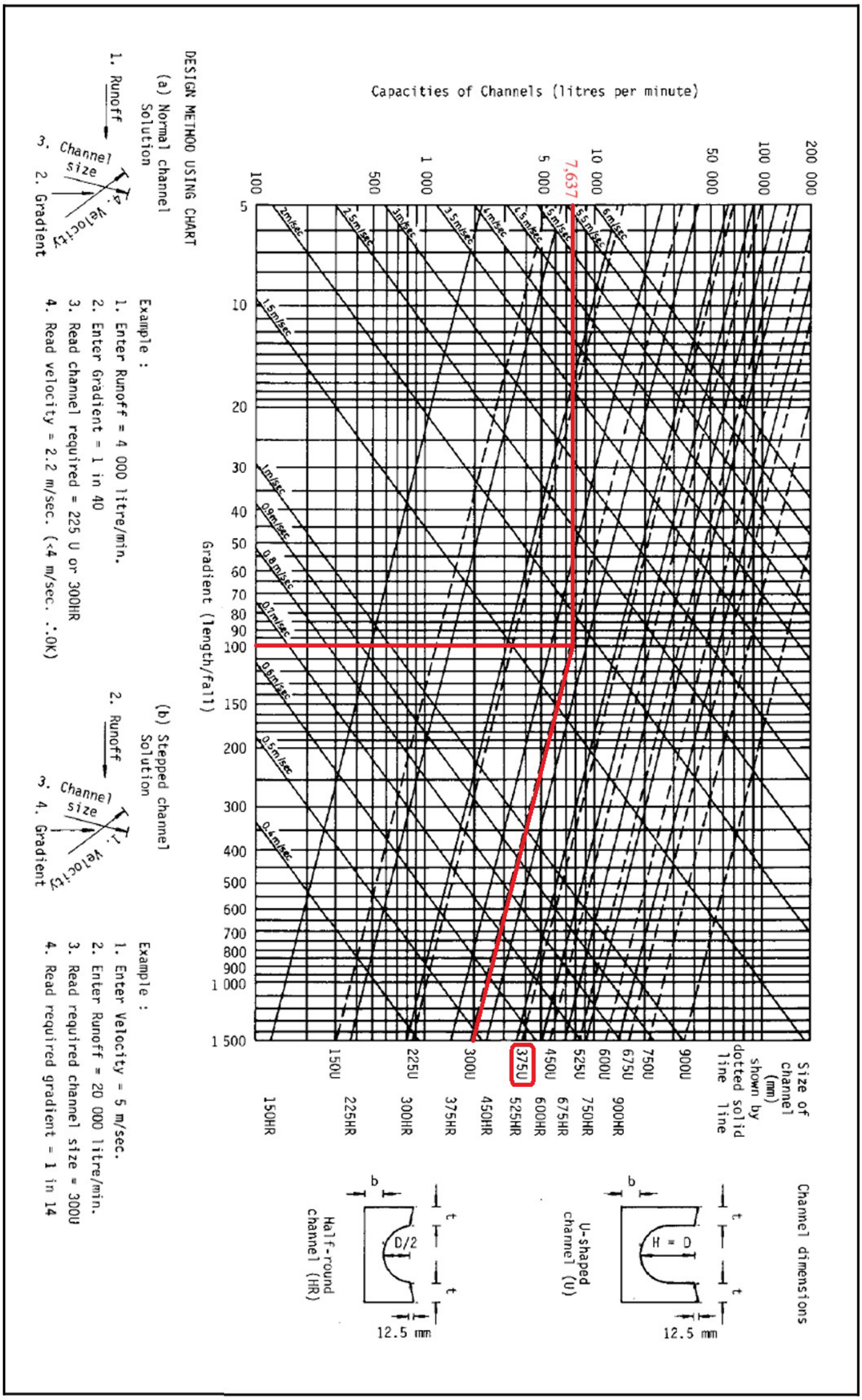

Chart for the Rapid Design of Channels in the Geotechnical Manual for Slopes (Second Edition) (GCO, 1984)