Attachment 3

Revised Drainage Impact Assessment

Prepared by

Ramboll Hong Kong Limited

PROPOSED SCHOOL AT VARIOUS LOTS IN D.D. 94, 98 & 100 AND ADJOINING GOVERNMENT LAND, KWU TUNG SOUTH, NEW TERRITORIES

DRAINAGE IMPACT ASSESSMENT

Date	**December 2025**
Prepared by	**Sunny Yeung** **Assistant Engineer**
Signed	
Approved by	**Tony Cheng** **Senior Manager**
Signed	
Project Reference	**HENKTSISEI00**
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CHAPTERS

FIGURES

APPENDICES

1. INTRODUCTION

1.1 Project Background

1.1.1 Ramboll Hong Kong Limited in associated with Binnies Hong Kong Limited (Binnies) has been commissioned to carry out drainage impact assessment (DIA) for the Proposed International School in Kwu Tung South. (Application Site).

1.1.2 The Application Site is divided into eastern and western parts by the River Beas, with a few local village houses. Access to the Application Site is provided via Hang Tau Road and village track roads (**Figure F1**).

1.1.3 The Application Site covers an area of approximately 127,000 m^2.

1.1.4 The Proposed Development consists of kindergartens, primary schools, middle & high schools and ancillary facilities, with a total plot ratio of 1.35. There are two phases for this development. The scheduled year of completion of 2036. A summary of key information of the Proposed Development is shown below in **Table 1-1**

Table 1-1 Development Schedule (Final Phase)

Development Parameter	Proposed Development
Site Area	About 127,000 m^2
Plot Ratio	About 1.35
Total Gross Floor Area (GFA)	About 171,000 m^2
Anticipated Population	
Kindergarten	About 600
Grades 1-5	About 1,000
Grades 6-12	About 1,400

1.1.5 This DIA is prepared based on available information and requirement under Drainage Services Department (DSD) Advice Note No. 1 – Application to Drainage Impact Assessment Process to Private Sector Projects.

2. EXISTING DRAINAGE NETWORK

2.1 The Application Site

2.1.1 The Application Site is currently occupied by a number of temporary structures. The land use of the Application Site will be changed to approximately 70% paved after the Proposed Development.

2.2 Existing Catchment Drainage

2.2.1 The Application Site lies in the middle reach of River Beas. River Beas runs from the south to the north and discharges into River Indus, which further discharges into Shenzhen River to the north. Shenzhen River flows to the west and eventually discharges into Deep Bay.

2.2.2 River Beas locates within the Indus Basin forming one of the tributaries of River Indus and serves the southwest part of the Indus Basin.

2.3 Site Drainage and Sub-catchments

2.3.1 The identified relevant sub-catchments for and in vicinity of the Application Site are shown on **Figure F2**. The existing drainage system in vicinity of the Application Site is shown on **Figure F3**.

2.3.2 Runoff from all sub-catchments (Catchments 1 to 5) drains to the River Beas. Runoff from these area passes through the Application Site and discharge to the River Beas.

2.4 Ground Levels

2.4.1 The western part of the Application Site slopes downward from the south and west in general, and dipped gently towards River Beas.

2.4.2 The existing ground level of the western part falls gently from +10.0 mPD to +20.5 mPD (south to north). The existing ground level of the eastern part falls gently from +13.0 mPD to +10 mPD (north to south).

3. METHODOLOGY AND DESIGN PARAMETERS

3.1.1 The assessment criteria for the Application Site is based on the standards as set out in DSD's 5th edition of Stormwater Drainage Manual (SDM) published in January 2018 and the updates pursuant to Corrigendum No. 1/2022 and No.1/2024 promulgated. Table 10 of the SDM provides the recommended design return periods based on flood levels for the various drainage systems depending on the land use.

3.1.2 According to the SDM, 50-year design return period is recommended for the design of drainage system.

3.1.3 The Rational Method is adopted for evaluating the runoff for the drainage design.

3.1.4 According to the rainfall zone as shown in Figure 3 of SDM, the Application Site is located in an area that adopts rainfall statistics of North District Area. Hence, the design storm constants are adopted in accordance with Table 3a of the SDM corrigendum No.1/2024. The storm constants are shown in **Table 3.1** below.

Table 3-1 Storm Constants with 50-year Return Period

Parameter	Value
A	474.6
B	2.9
C	0.371

3.1.5 The runoff coefficient (C) values for the Rational Method were adopted in accordance with Clause 7.5.2 of the SDM. A table of runoff coefficient is shown in **Table 3.2** below.

Table 3-2 Runoff Coefficient

Land Use	Runoff Coefficient (C) Value
Unpaved (e.g. existing tree groups)	0.35
Paved (e.g. concrete)	0.95

3.1.6 The effects of climate change are considered in accordance with Clause 6.8, Table 28 and Table 29 of the SDM corrigendum No.1/2022. A summary of increased rainfall due to climate change is shown in **Table 3.3** below.

Table 3-3 Rainfall Increase due to Climate Change

Classification	Rainfall Increase (%)	Sea Level Rise (m)
End of 21st Century (2081-2100)	16.0	0.47

3.1.7 Design allowance in the End-21st Century is considered in the calculation as well and summarized in **Table 3–4**.

Table 3-4 Design Allowance in End of 21st Century

Rainfall Increase	Sea Level Rise (m)
12.1%	0.23

3.1.8 The roughness values of pipes were adopted in accordance with Table 13 and 14 of the SDM. As a conservation approach, 10% (of flow area) sedimentation is adopted for the proposed drainage system in design checking. A summary of roughness coefficients is shown in **Table 3-5** below.

Table 3-5 Roughness Coefficient

Classification	Roughness Coefficient	Remarks
Poor Precast Concrete Pipes	Colebrook-White k_s = 0.6mm	Concrete Pipe
Rectangular Channel	Mannings'n = 0.015	Peripheral drains

4. POTENTIAL DRAINAGE IMPACT OF PROPOSED DEVELOPMENT

4.1.1 The Application Site will be developed into an international school. The Master Layout Plan of the Proposed Development is shown in **Annex 1**.

4.2 Changes to Drainage Characteristics

4.2.1 The Proposed Development will induce changes to the land use of the Application Site. The percentage of paved area comprising building blocks, concrete structures, roads and other paved facilities will be increased. As a result, there will be an increase in surface runoff generated from the Application Site.

4.3 Volume of Runoff and Peak Runoff Rate

4.3.1 The increase in the peak runoff rates due to the Proposed Development at the Application Site against various rainstorm return periods are shown in **Tables 4-1** below.

4.3.2 The relevant calculations are included in **Annex 2**.

Table 4-1 Estimated Peak Runoff Rate

Return Period	Peak Runoff Rate (m^3/s)		
	Before Development (1)	After Development (2)	Increase in Runoff (2) – (1)
50 years	5.21	7.56	2.35
200 years	5.89	8.56	2.67

5. PROPOSED DRAINAGE IMPACT MITIGATION MEASURES

5.1.1 To intercept existing overland flow blocked by the Proposed Development, surface channels will be provided along the site boundaries of the Proposed Development. The catchment of the flow intercepted and the proposed drainage system are shown on **Figure F4**.

5.1.2 The flow will be discharged to River Beas through the proposed 1000 mm to 1650 mm diameter drains along the public road inside the Application Site.

5.1.3 Details of the hydraulic calculations and results of hydraulic check of the proposed drainage system along the public road inside the Application Site are contained in **Annex 3**.

5.1.4 The sensitivity checking of River Beas is included in **Annex 4**.

5.1.5 The runoff from the Proposed Development and its adjacent catchment as shown in **Figure F4**.

6. MAINTENANCE AND CONSTRUCTION CONSIDERATIONS

6.1 Maintenance Considerations

6.1.1 The parties responsible for managing and maintaining the completed proposed drainage works are listed in **Table 6-1**.

Table 6-1 Preliminary Management and Maintenance Matrix

Description of Proposed Drainage Works	Management and Maintenance Party
Stormwater Storage facilities, box culverts, drainage pipes and associated manholes on public roads or outside boundaries	Drainage Services Department
U-channels and associated catchpits which received the surface water inside the Development sites	The Applicant
Stormwater drainage facilities exclusively used for public roads (I.e. carriageway and footpaths.)	Highways Department

6.2 Construction Considerations

6.2.1 The contractor for the Proposed Development will be responsible for the maintenance of the existing drainage conditions in the vicinity of the Proposed Development during the construction stage. The contract documents will specify that the contractor must put in place appropriate temporary drainage measures to ensure that the flooding conditions during the construction period must not be worse than those under existing conditions.

6.2.2 The contractor’s attention shall be drawn to the diversion of the existing U-channel along the boundary of the Proposed Development. Such measures must be submitted to the Authorised Person or his representative for approval before construction activities commence.

6.2.3 A settling basin will be installed to intercept runoff from the construction Application Site before discharge into the River Beas.

7. CONCLUSION

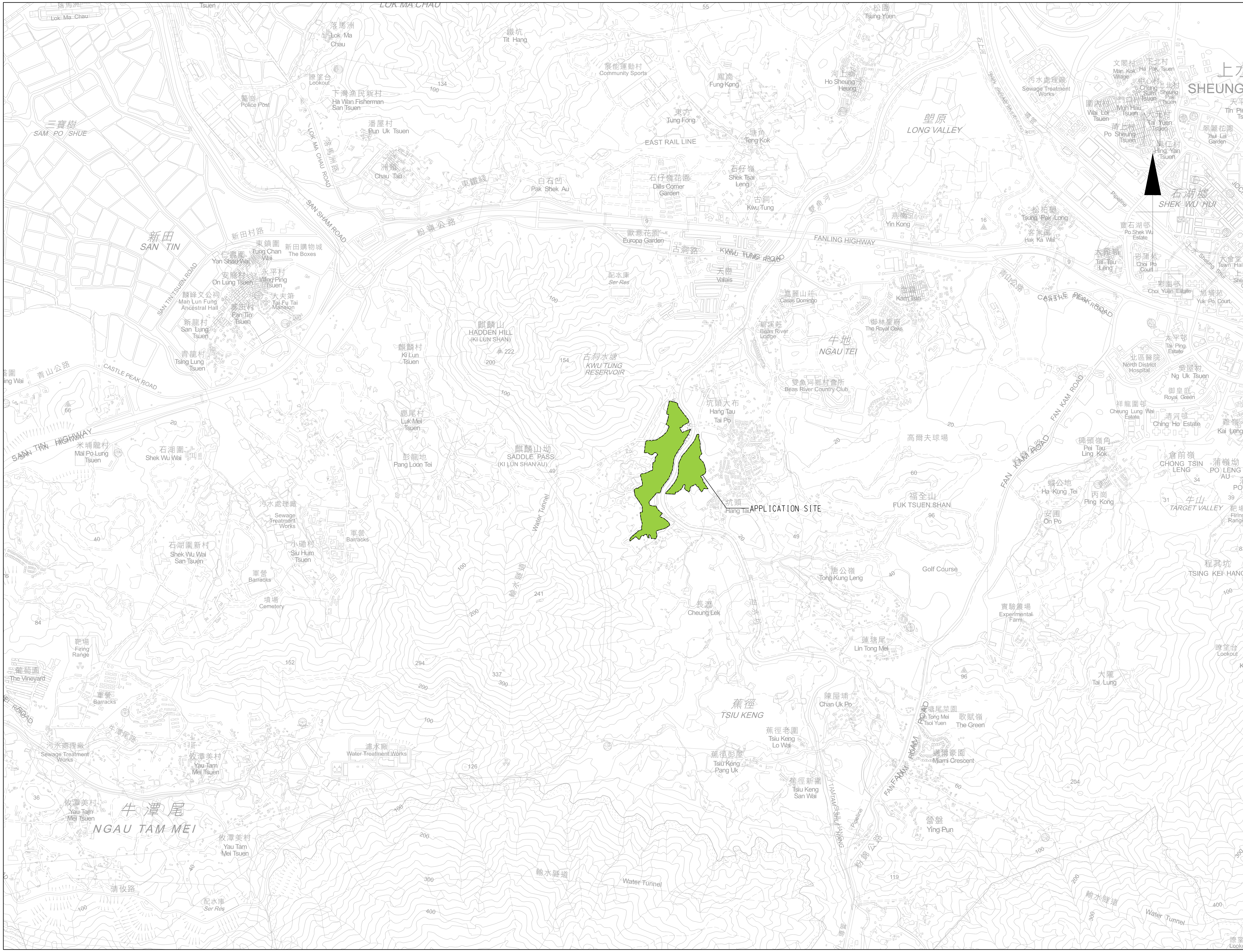
7.1.1 The runoff from the Proposed Development and from the adjacent catchment area of the Proposed Development will be diverted by the project proponent. The runoff will be conveyed by the proposed 1000 mm to 1800 mm diameter drains along public road inside Application Site.

7.1.2 The runoff generated from the Proposed Development and its adjacent catchment would only utilize about 84% of the proposed 1000 mm diameter drain, about 87% of the proposed 1500 mm diameter drain, about 52% of the proposed 1650 mm diameter drain and about 85% of the proposed 1800 mm diameter drain. The proposed drain in public road inside Application Site discharges into the upstream section of the River Beas.

7.1.3 Temporary drainage measures shall be implemented to ensure that the flooding conditions will not be worsened during construction. Periodic inspection by the Authorized Person or his representative will be carried out during construction.

7.1.4 With the implementation of the above proposed drainage measures and temporary drainage works, the Proposed Development at the Application Site is technically feasible from drainage impact point of view.

Figures



LEGEND:

THE APPLICATION SITE

Initial	Date	Checked	Date

Project

S16 APPLICATION FOR PROPOSED INTERNATIONAL SCHOOL IN KWU TUNG SOUTH

Title

LOCATION PLAN

Figure No. K1

Scale A3 1 : 20000

binnies

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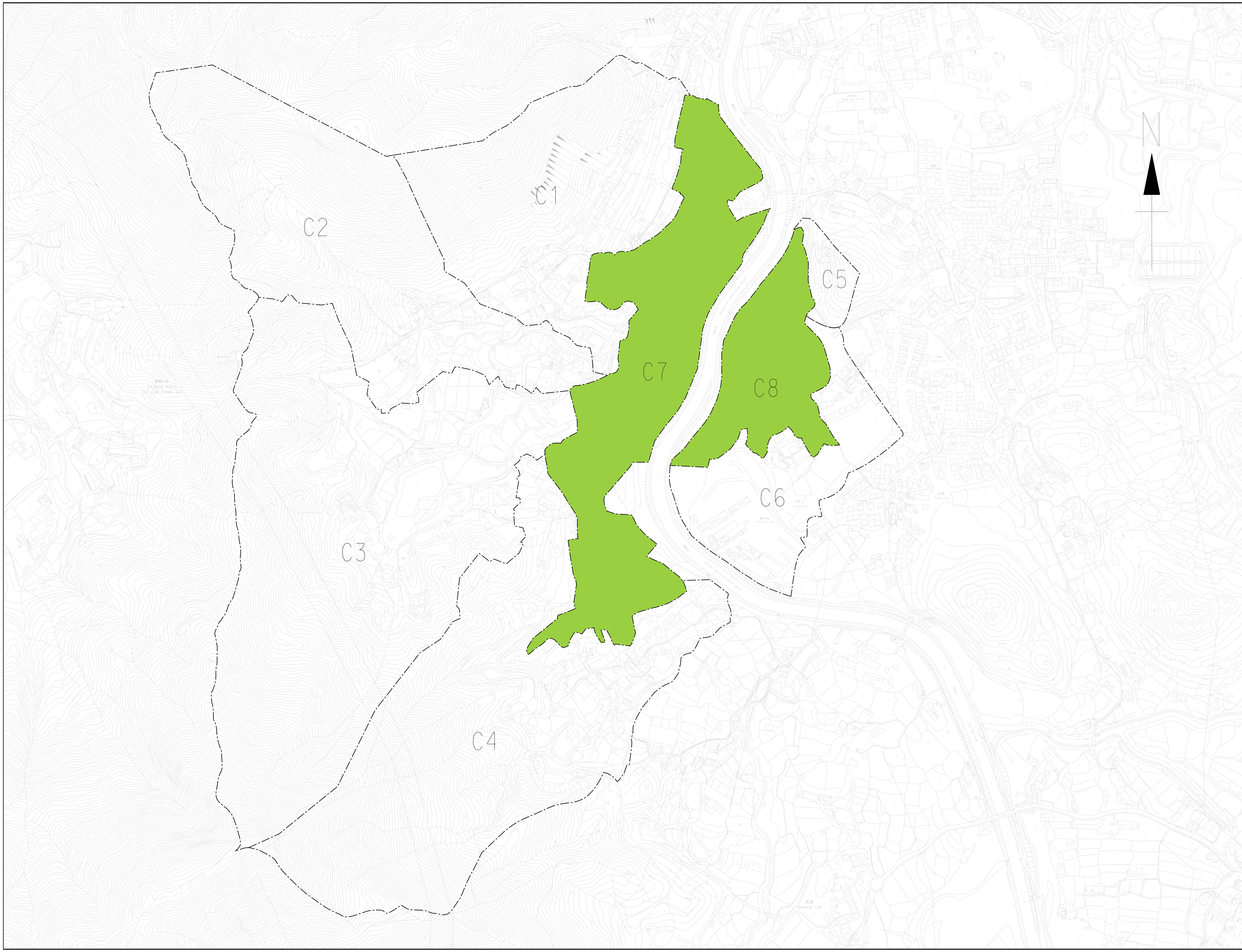

LEGEND:

THE APPLICATION SITE

CATCHMENT	AREA (m^2)
C1	99045
C2	122826
C3	211950
C4	164692
C5	7603
C6	46806
C7	91816
C8	35300

Initial	Date	Checked	Date

Project

S16 APPLICATION FOR PROPOSED INTERNATIONAL SCHOOL IN KWU TUNG SOUTH

Title

EXISTING CATCHMENT AREA

Figure No. K2

Scale A3 1 : 5000

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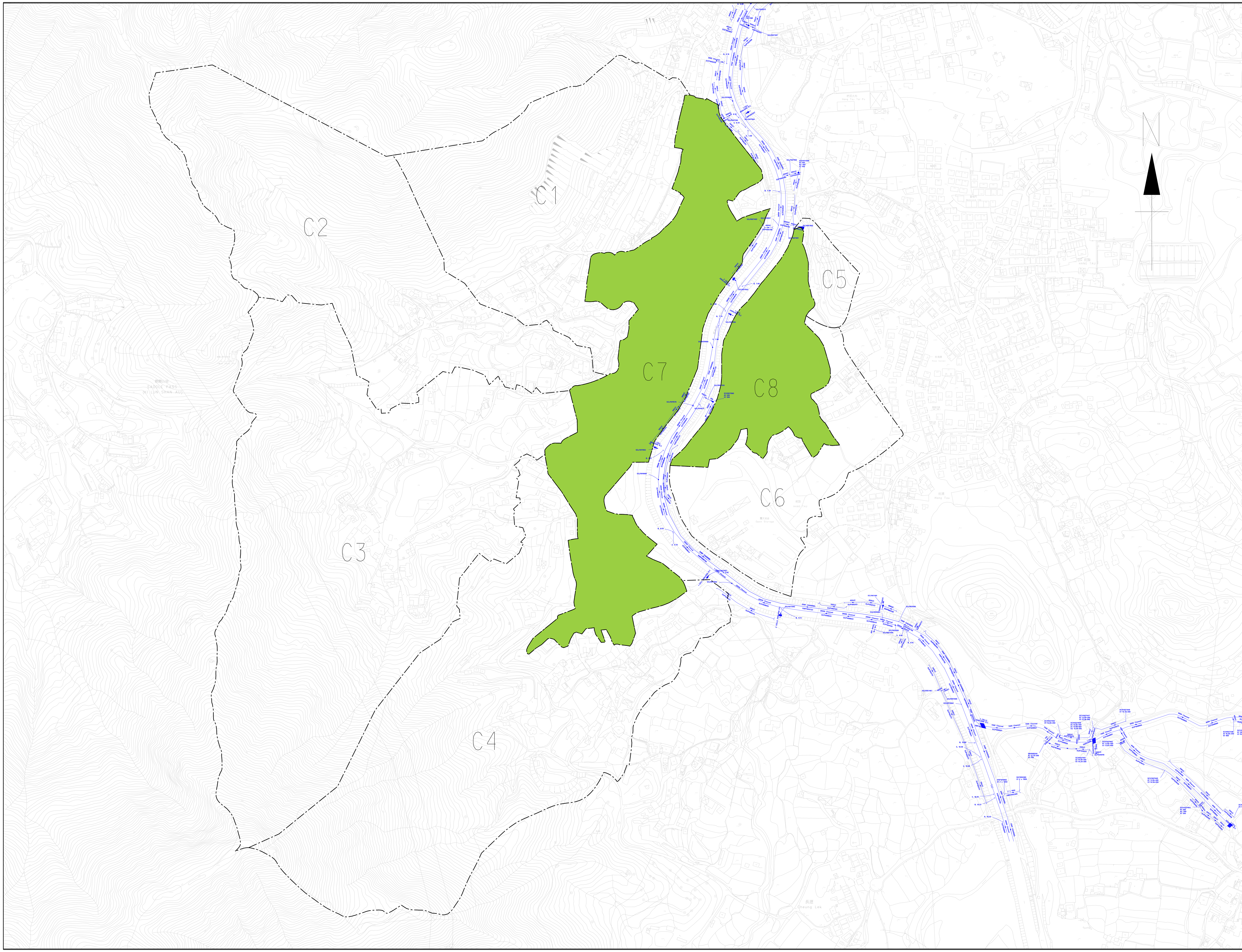

LEGEND:

- EXISTING CATCHPIT
- THE APPLICATION SITE
- EXISTING DRAINAGE PIPE/ CHANNEL

Initial	Date	Checked	Date

Project

S16 APPLICATION FOR PROPOSED INTERNATIONAL SCHOOL IN KWU TUNG SOUTH

Title

EXISTING DRAINAGE SYSTEMS

Figure No.	Scale
K3	A3 1 : 5000

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Plot Date = 2025/12/4

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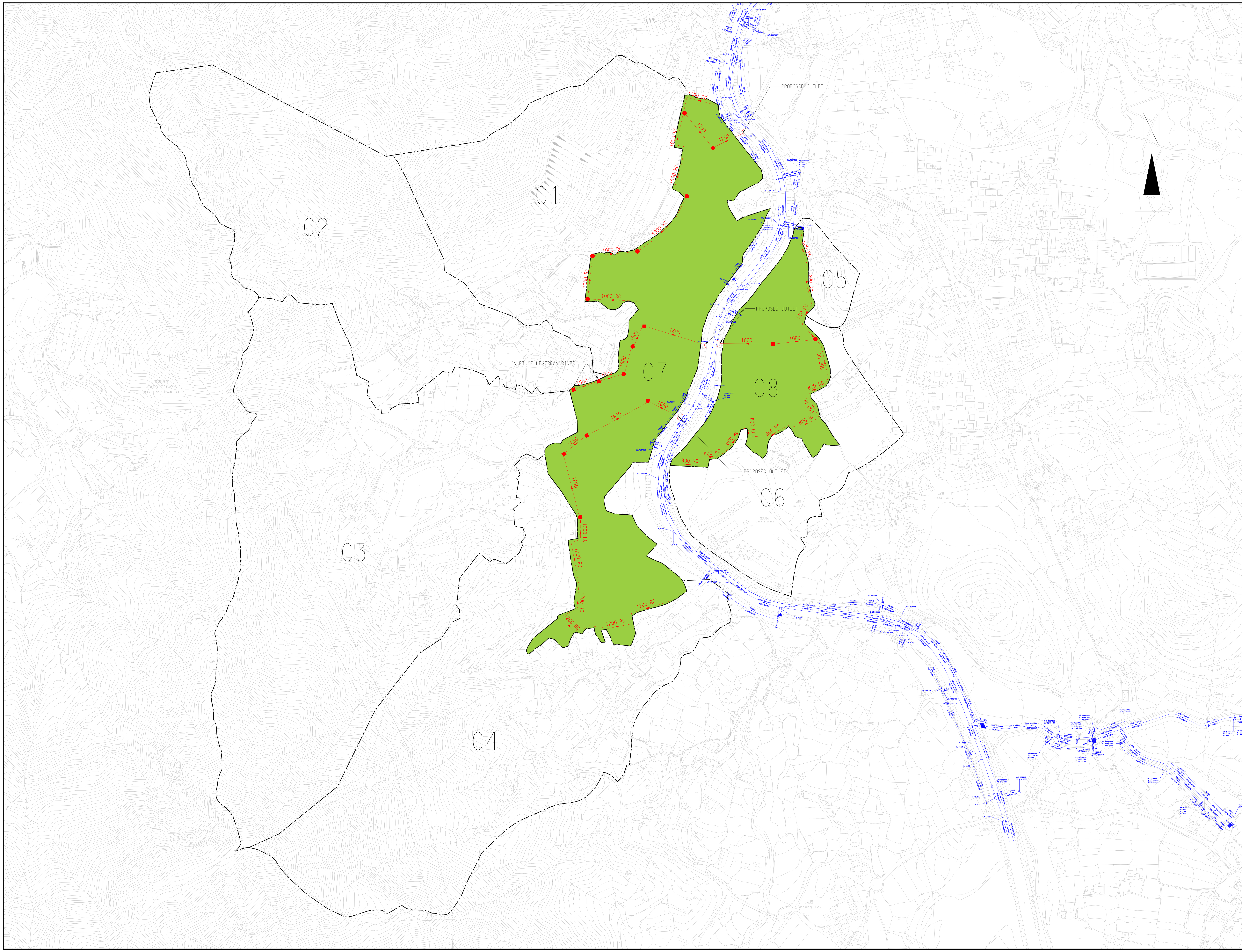

LEGEND:

- EXISTING CATCHPIT
- THE APPLICATION SITE
- EXISTING DRAINAGE PIPE/ CHANNEL
- PROPOSED CATCHPIT
- PROPOSED MANHOLE
- RC. 800 — PROPOSED 800mm RECTANGULAR CHANNEL
- RC. 1000 — PROPOSED 1000mm RECTANGULAR CHANNEL
- RC. 1200 — PROPOSED 1200mm RECTANGULAR CHANNEL
- DIA. 1000 — PROPOSED 1000mm DIAMETER STORMWATER DRAIN
- DIA. 1200 — PROPOSED 1500mm DIAMETER STORMWATER DRAIN
- DIA. 1500 — PROPOSED 1500mm DIAMETER STORMWATER DRAIN
- DIA. 1650 — PROPOSED 1650mm DIAMETER STORMWATER DRAIN
- DIA. 1800 — PROPOSED 1650mm DIAMETER STORMWATER DRAIN
- PROPOSED OUTLET

CATCHMENT	AREA (m^2)
C1	99045
C2	122826
C3	211950
C4	164692
C5	7603
C6	46806
C7	91816
C8	35300

Initial	Date	Checked	Date

Project

S16 APPLICATION FOR PROPOSED INTERNATIONAL SCHOOL IN KWU TUNG SOUTH

Title

EXISTING DRAINAGE SYSTEMS

Figure No. K4

Scale A3 1 : 5000

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Plot Date = 2025/12/4

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Annex 1
Master Layout Plan

Rev.	Description	Drawn	Checked	Approved	Date
–	PLANNING SUBMISSION	HKO	JHK	JHY	9-2025
A	PLANNING SUBMISSION	HKO	JHK	JHY	11-2025

Check all measurements on site. Do not scale off drawings.

This drawing is to be read in conjunction with the specification and any discrepancies are to be immediately reported to the Architect.

B.D. Ref. _
F.S.D. Ref. _
D.L.O. Ref. _

Drawn	HKO	Date	11-2025
Checked	JHK	Date	11-2025
Approved	JHY	Date	11-2025

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呂元祥建築師事務所

Project Title
PROPOSED INTERNATIONAL SCHOOL DEVELOPMENT AT KWU TUNG SOUTH

Drawing Title
FULL PHASE – MASTER LAYOUT PLAN

Project No. 25018NT
Scale 1 : 1000
Issue Date NOV 2025
Drawing No. A/GBP_01_

Drawing Purpose

Rev.	Description	Drawn	Checked	Approved	Date
–	PLANNING SUBMISSION	HKO	JHK	JHY	9–2025
A	PLANNING SUBMISSION	HKO	JHK	JHY	11–2025

Check all measurements on site. Do not scale off drawings.

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B.D. Ref. –
F.S.D. Ref. –
D.L.O. Ref. –
Drawn HKO Date 11–2025
Checked JHK Date 11–2025
Approved JHY Date 11–2025
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Project Title

Drawing Title
FULL PHASE – FIRST FLOOR PLAN

Project No. 25018NT
Scale 1 : 1000 Issue Date NOV 2025
Drawing No. A/GBP_03

Drawing Purpose

Rev.	Description	Drawn	Checked	Approved	Date
–	PLANNING SUBMISSION	HKO	JHK	JHY	9–2025
A	PLANNING SUBMISSION	HKO	JHK	JHY	11–2025

Rev.	Description	Drawn	Checked	Approved	Date

Check all measurements on site. Do not scale off drawings.

This drawing is to be read in conjunction with the specification and any discrepancies are to be immediately reported to the Architect.

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F.S.D. Ref. _
D.L.O. Ref. _
Drawn HKO Date 11–2025
Checked JHK Date 11–2025
Approved JHY Date 11–2025
Cad File No. P:\JHK\25018NT\planning submission\PLOT_BD\GBP_04

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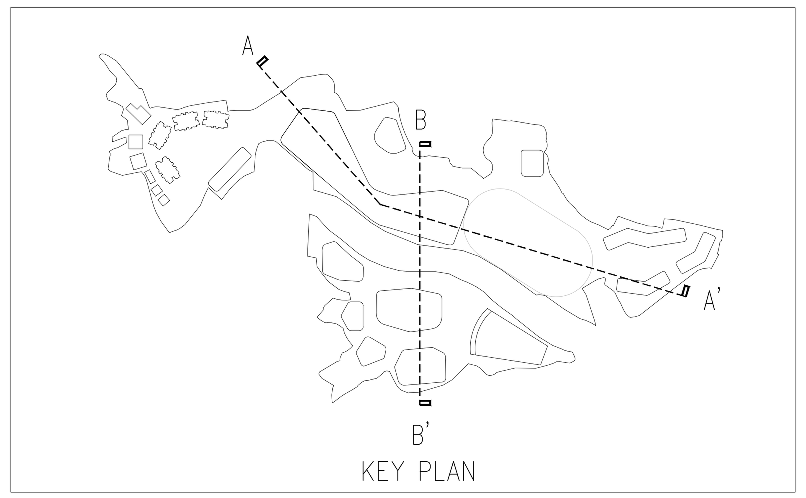
Project Title

Drawing Title
FULL PHASE –
GROUND FLOOR PLAN

Project No. 25018NT
Scale 1 : 1000 Issue Date NOV 2025
Drawing No. A/GBP_04

Drawing Purpose



LEGEND

- SITE BOUNDARY
- SCHOOL
- DORMITORY
- OUTDOOR SPORTS FACILITIES
- CARPARK & L/UL
- E&M

SECTION A-A'

SECTION A-A' cont.

Rev.	Description	Drawn	Checked	Approved	Date
–	PLANNING SUBMISSION	HKO	JHK	JHY	9–2025
A	PLANNING SUBMISSION	HKO	JHK	JHY	11–2025

Rev.	Description	Drawn	Checked	Approved	Date

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Project Title

Drawing Title SECTION A–A

Project No. 25018NT
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Drawing No. A/GBP_05

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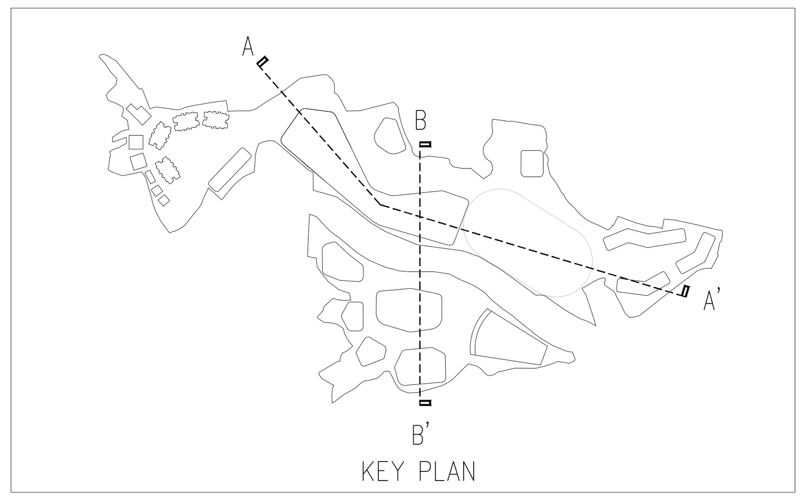
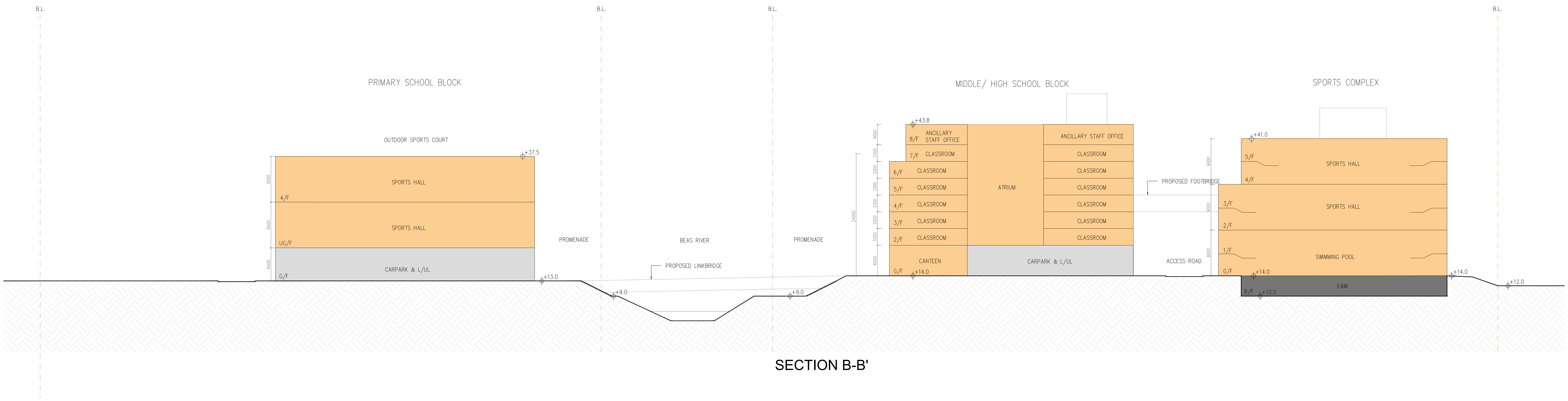


LEGEND

- SITE BOUNDARY
- SCHOOL
- DORMITORY
- OUTDOOR SPORTS FACILITIES
- CARPARK & L/UL
- E&M



SECTION B-B'

Rev.	Description	Drawn	Checked	Approved	Date
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Rev.	Description	Drawn	Checked	Approved	Date

Check all measurements on site. Do not scale off drawings.

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B.D. Ref. _
F.S.D. Ref. _
D.L.O. Ref. _

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Approved	JHY	Date	11-2025

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Project Title

Drawing Title
SECTION B-B

Project No. 25018NT
Scale 1:400 Issue Date NOV 2025
Drawing No. A/GBP_06

Drawing Purpose

Annex 2
Runoff Calculations

Capacity Check: Catchment C7 and C8 (Before development) (50 years)

Design Parameters				
Design storm		50	year return period	
Storm constants	a	474.6		
	b	2.9		
	c	0.371		
Average Slope	H	0.30	m/100m	
Length of flow	L	110	m	
Inlet time $t_0=0.14465L/H^{0.2}A^{0.1}$	t_0	6.25	min	
Unpaved area	A_U	88900	m^2	
Runoff coef.	C_U	0.35		
Paved area	A_P	38100	m^2	
Runoff coef.	C_P	0.95		
Catchment area	A_{Total}	127,000	m^2	
Runoff coef.	$C_{average}$	0.53		
Surface roughness	k_s	0.6	mm	For Poor Precast Concrete Pipes
kinematic viscosity	v	1.14	mm^2/s	
Frictional gradient	S_f 1 in	100		

Capacity Check:	Catchment C7 and C8 (Before development) (50 years)					
Peak Runoff						
Flow time	t_f	=	Lj / Vj			
		=	3.38	min		
Time of concentration	t_c	=	$t_0 + t_f$			
		=	9.63	min		
Intensity	i	=	$a / (t_c + b)^c$	x	1.281	*(Climate Change Factor)*
		=	238.01	mm/hr		(SDM Table 28)
Peak runoff	Q_p	=	0.278 C i A			
		=	**4.454**	m^3/s		

Capacity Check: Catchment C7 and C8 (After development) (50 years)

Design Parameters				
Design storm		50	year return period	
Storm constants	a	474.6		
	b	2.9		
	c	0.371		
Average Slope	H	0.30	m/100m	
Length of flow	L	110	m	
Inlet time $t_0=0.14465L/H^{0.2}A^{0.1}$	t_0	6.25	min	
Unpaved area	A_U	38100	m^2	
Runoff coef.	C_U	0.35		
Paved area	A_P	88900	m^2	
Runoff coef.	C_P	0.95		
Catchment area	A_{Total}	127,000	m^2	
Runoff coef.	$C_{average}$	0.77		
Surface roughness	k_s	0.6	mm	For Poor Precast Concrete Pipes
kinematic viscosity	v	1.14	mm^2/s	
Frictional gradient	S_f 1 in	100		

Capacity Check:	Catchment C7 and C8 (After development) (50 years)					
Peak Runoff						
Flow time	t_f	=	Lj / Vj			
		=	3.38	min		
Time of concentration	t_c	=	$t_0 + t_f$			
		=	9.63	min		
Intensity	i	=	$a / (t_c + b)^c$	x	1.281	*(Climate Change Factor)*
		=	238.01	mm/hr		(SDM Table 28)
Peak runoff	Q_p	=	0.278 C i A			
		=	**6.470**	m^3/s		

Capacity Check:	Catchment C7 and C8 (Before development) (200 years)			
Design Parameters				
Design storm		200	year return period	
Storm constants	a	501.4		
	b	2.45		
	c	0.348		
Average Slope	H	0.30	m/100m	
Length of flow	L	110	m	
Inlet time $t_0=0.14465L/H^{0.2}A^{0.1}$	t_0	6.25	min	
Unpaved area	A_U	88900	m^2	
Runoff coef.	C_U	0.35		
Paved area	A_P	38100	m^2	
Runoff coef.	C_P	0.95		
Catchment area	A_{Total}	127,000	m^2	
Runoff coef.	$C_{average}$	0.53		
Surface roughness	k_s	0.6	mm	For Poor Precast Concrete Pipes
kinematic viscosity	v	1.14	mm^2/s	
Frictional gradient	S_f 1 in	100		

Capacity Check:	Catchment C7 and C8 (Before development) (200 years)					
Peak Runoff						
Flow time	t_f	=	Lj / Vj			
		=	3.38	min		
Time of concentration	t_c	=	$t_0 + t_f$			
		=	9.63	min		
Intensity	i	=	$a / (t_c + b)^c$	x	1.281	*(Climate Change Factor)*
		=	269.91	mm/hr		(SDM Table 28)
Peak runoff	Q_p	=	0.278 C i A			
		=	**5.051**	m^3/s		

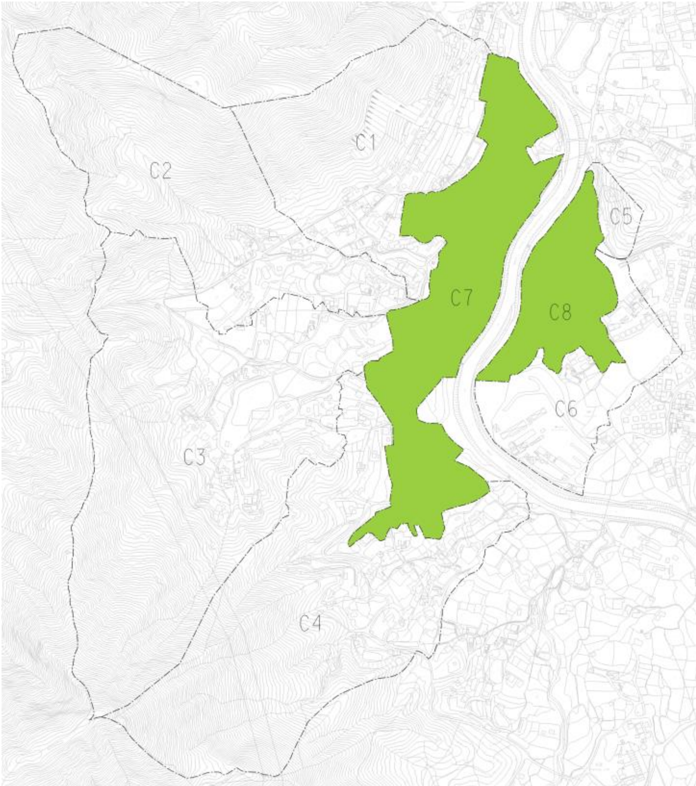
Capacity Check: Catchment C7 and C8 (After development) (200 years)

Design Parameters				
Design storm		200	year return period	
Storm constants	a	501.4		
	b	2.45		
	c	0.348		
Average Slope	H	0.30	m/100m	
Length of flow	L	110	m	
Inlet time $t_0=0.14465L/H^{0.2}A^{0.1}$	t_0	6.25	min	
Unpaved area	A_U	38100	m^2	
Runoff coef.	C_U	0.35		
Paved area	A_P	88900	m^2	
Runoff coef.	C_P	0.95		
Catchment area	A_{Total}	127,000	m^2	
Runoff coef.	$C_{average}$	0.77		
Surface roughness	k_s	0.6	mm	For Poor Precast Concrete Pipes
kinematic viscosity	v	1.14	mm^2/s	
Frictional gradient	S_f 1 in	100		

Capacity Check:	Catchment C7 and C8 (After development) (200 years)				
Peak Runoff					
Flow time	t_f	=	Lj / Vj		
		=	3.38	min	
Time of concentration	t_c	=	$t_0 + t_f$		
		=	9.63	min	
Intensity	i	=	$a / (t_c + b)^c$	x 1.281	*(Climate Change Factor)*
		=	269.91	mm/hr	(SDM Table 28)
Peak runoff	Q_p	=	0.278 C i A		
		=	**7.338**	m^3/s	

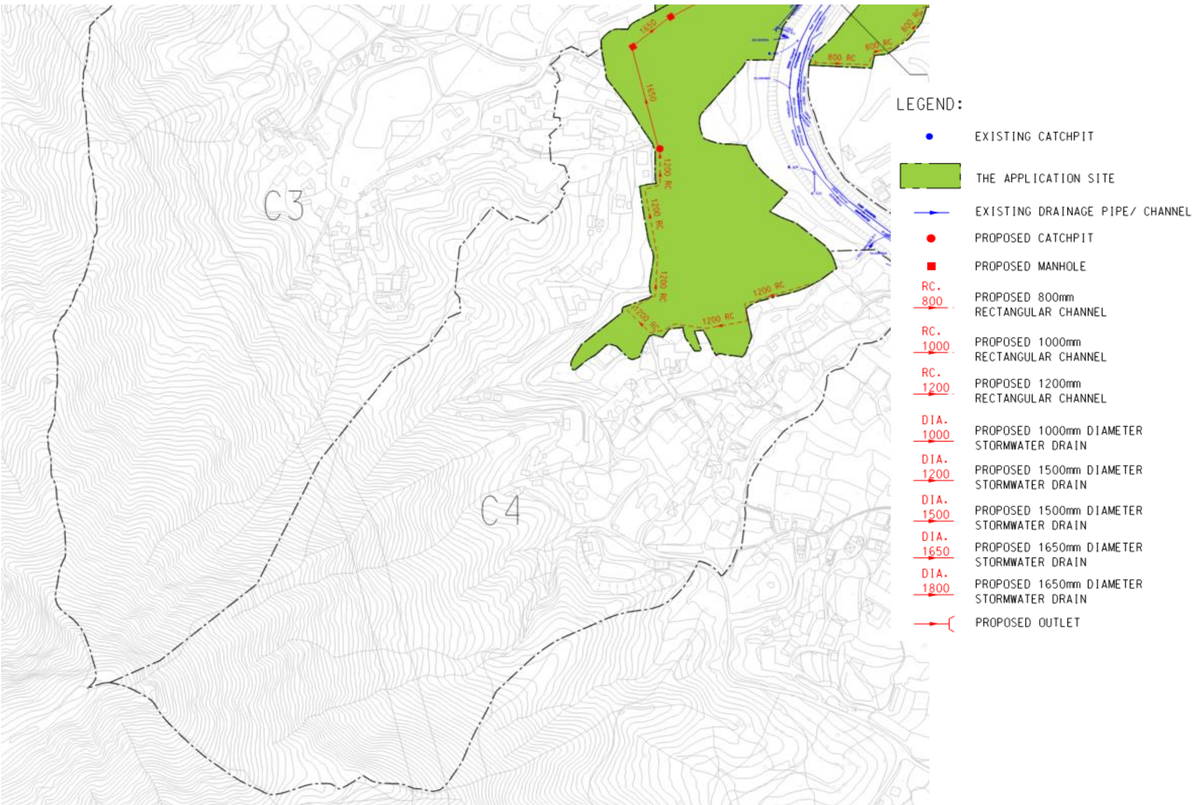
Annex 3
Design of Drainage System

Summary of Catchment Characteristic



Cachment	Area (m²)	Before Development		After Development		Runoff Coefficient	
		Paved Area (m²)	Unpaved Area (m²)	Paved Area (m²)	Unpaved Area (m²)	Paved	Unpaved
C1	99045	29,714	69,332	29,714	69,332	0.95	0.35
C2	122,826	36,848	85,978	36,848	85,978	0.95	0.35
C3	211,950	63,585	148,365	63,585	148,365	0.95	0.35
C4	164,692	49,408	115,284	49,408	115,284	0.95	0.35
C5	7,603	2,281	5,322	2,281	5,322	0.95	0.35
C6	46,806	14,042	32,764	14,042	32,764	0.95	0.35

Capacity Check: Catchment C4



Design Parameters

Design storm		50	year return period	
Storm constants	a	474.6		
	b	2.9		
	c	0.371		
Average Slope	H	28.00	m/100m	
Length of flow	L	770	m	
Inlet time $t_0=0.14465L/H^{0.2}A^{0.1}$	t_0	17.21	min	
Unpaved area	A_U	115284	m^2	
Runoff coef.	C_U	0.35		
Paved area	A_P	49408	m^2	
Runoff coef.	C_P	0.95		
Catchment area	A_{Total}	164,692	m^2	
Runoff coef.	$C_{average}$	0.53		
Surface roughness	k_s	0.6	mm	For Poor Precast Concrete Pipes
kinematic viscosity	v	1.14	mm^2/s	
Frictional gradient	S_f 1 in	100		

Capacity Check: Catchment C4

Peak Runoff

Flow time	t_f	=	Lj / Vj			
		=	3.38	min		
Time of concentration	t_c	=	$t_0 + t_f$			
		=	20.58	min		
Intensity	i	=	$a / (t_c + b)^c$	x	1.281	*(Climate Change Factor)*
		=	188.51	mm/hr		(SDM Table 28)
Peak runoff	Q_p	=	0.278 C i A			
		=	**4.574**	m^3/s		

Using Manning's Equation for Rectangular-Channel Geometry

Width	**1200**	**mm**	Input Parameter
Height	**1200**	**mm**	Input Parameter
Area	1.440	m^2	
Wetted Perimeter	3.600	m	
Hydraulic Radius	0.400	m	
Slope [Decimal]	**0.01**		Slope = tan θ
Manning's Roughness	**0.015**		for Fair concrete Pipe

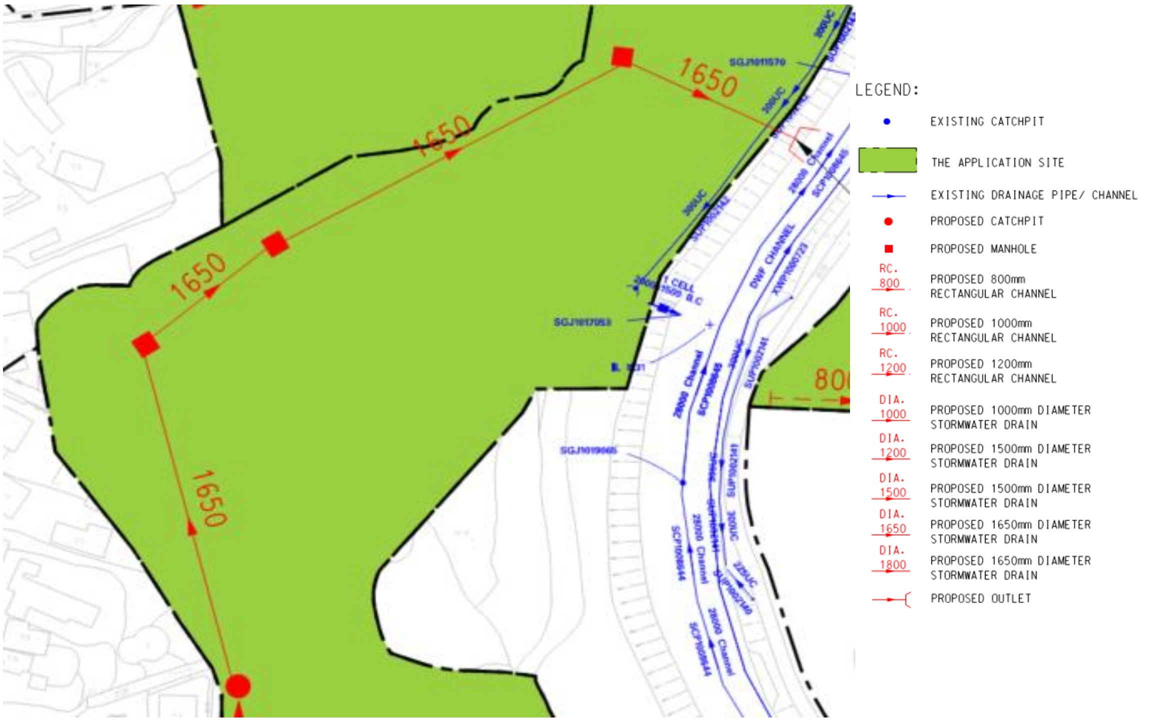
Full Flow Velocity Vu	3.62	m/s
Full Flow Discharge	5.21	m^3/s
	312701	l/min

Assume the maximum water depth in the Rectangular-channel be 100% of the size

Water Depth	Area	Wetted Perimeter	Hydraulic Radius	Velocity	Discharge
[mm]	m^2	m	m	m/s	m^3/s
1200	1.440	3.600	0.400	3.619	**5.212**

> Peak runoff Q_p

Capacity Check: Proposed 1650mm Drain



Design Parameters

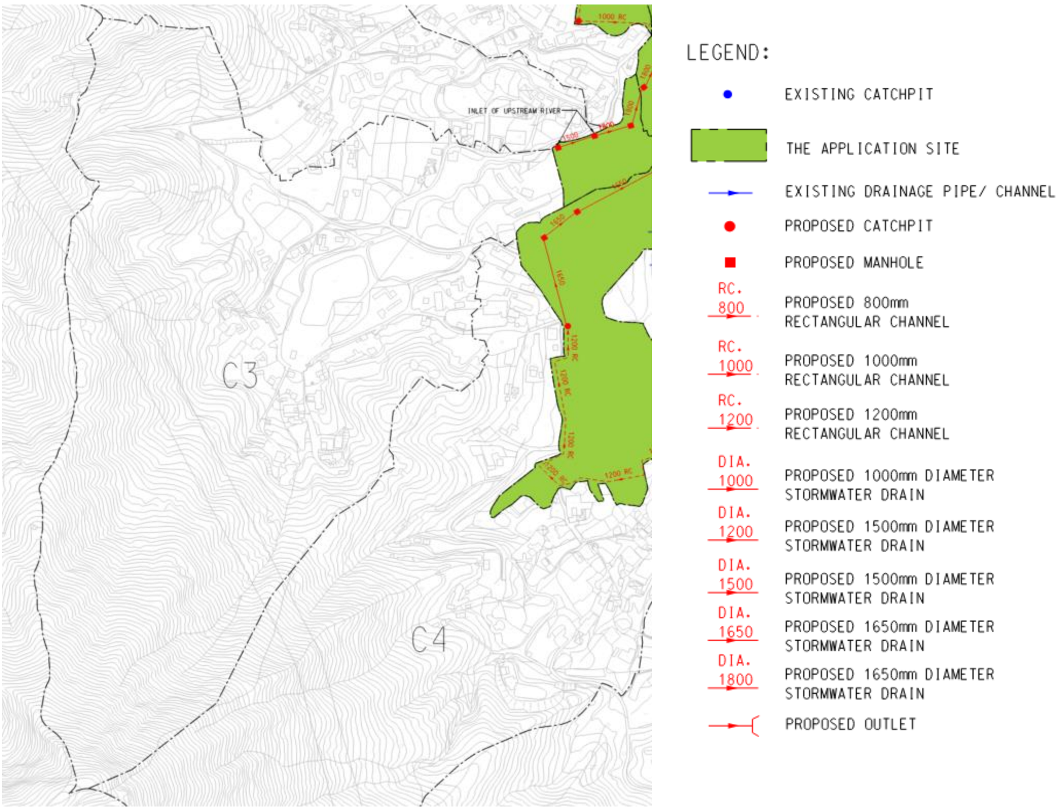
Surface roughness	k_s		0.6	mm	For Poor Precast Concrete Pipes
kinematic viscosity	v		1.14	mm^2/s	
Frictional gradient	S_f	1 in	100		

Peak runoff from C3 = 4.57 m^3/s

Capacity of Drain

Trial pipe size	D	=	**1650**	mm
Hydraulic radius	R = D/4	=	0.4125	m
Mean velocity (Colebrook-White)	$\bar{V}$	=	$-\sqrt{32gRS_f}\log[\frac{k_s}{14.8R}+\frac{1.255v}{R\sqrt{(32gRS_f)}}]$	
		=		
		=	4.55	m/s
Capacity provided	Q	=	V x Cross Section Area of Drain	
		=	**9.72**	m^3/s
Allow 10% Area for Siltation	$Q_{90\%}$	=	**8.75**	m^3/s
		>	Peak runoff Q_p	
Utilization		=	$Qp/Q_{90\%}$	
		=	52%	

Capacity Check: Catchment C3

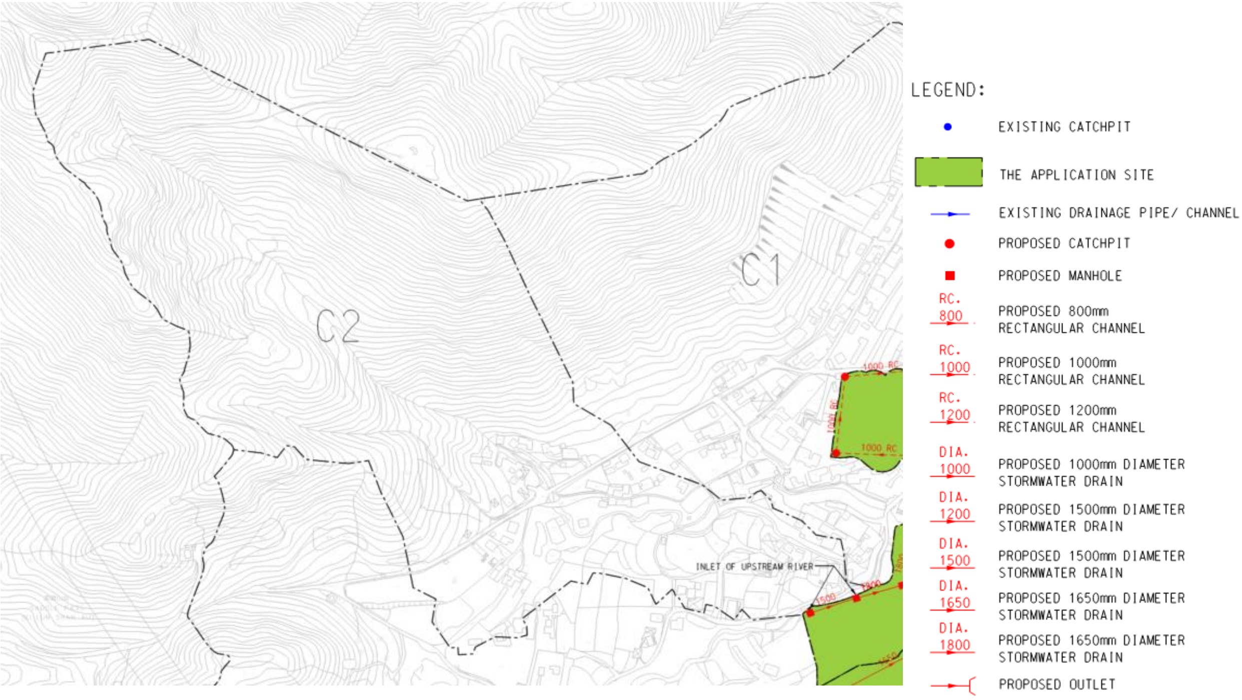


Design Parameters				
Design storm		50	year return period	
Storm constants	a	474.6		
	b	2.9		
	c	0.371		
Average Slope	H	26.00	m/100m	
Length of flow	L	770	m	
Inlet time $t_0=0.14465L/H^{0.2}A^{0.1}$	t_0	17.03	min	
Unpaved area	A_U	148365	m^2	
Runoff coef.	C_U	0.35		
Paved area	A_P	63585	m^2	
Runoff coef.	C_P	0.95		
Catchment area	A_{Total}	211,950	m^2	
Runoff coef.	$C_{average}$	0.53		
Surface roughness	k_s	0.6	mm	For Poor Precast Concrete Pipes
kinematic viscosity	v	1.14	mm^2/s	
Frictional gradient	S_f 1 in	100		

Capacity Check:	Catchment C3					
Peak Runoff						
Flow time	t_f	=	Lj / Vj			
		=	3.20	min		
Time of concentration	t_c	=	$t_0 + t_f$			
		=	20.23	min		
Intensity	i	=	$a / (t_c + b)^c$	x	1.281	*(Climate Change Factor)*
		=	189.57	mm/hr		(SDM Table 28)
Peak runoff	Q_p	=	0.278 C i A			
		=	**5.920**	m^3/s		

Capacity of Drain				
Trial pipe size	D	=	**1500**	mm
Hydraulic radius	R = D/4	=	0.375	m
Mean velocity (Colebrook-White)	$\bar{V}$	=	$-\sqrt{32gRS_f}\log[\frac{k_s}{14.8R}+\frac{1.255v}{R\sqrt{(32gRS_f)}}]$	
		=		
		=	4.29	m/s
Capacity provided	Q	=	V x Cross Section Area of Drain	
		=	**7.58**	m^3/s
Allow 10% Area for Siltation	$Q_{90\%}$	=	**6.82**	m^3/s
		<	Peak runoff Q_p	
Utilization		=	$Qp/Q_{90\%}$	
		=	87%	

Capacity Check: Catchment C2

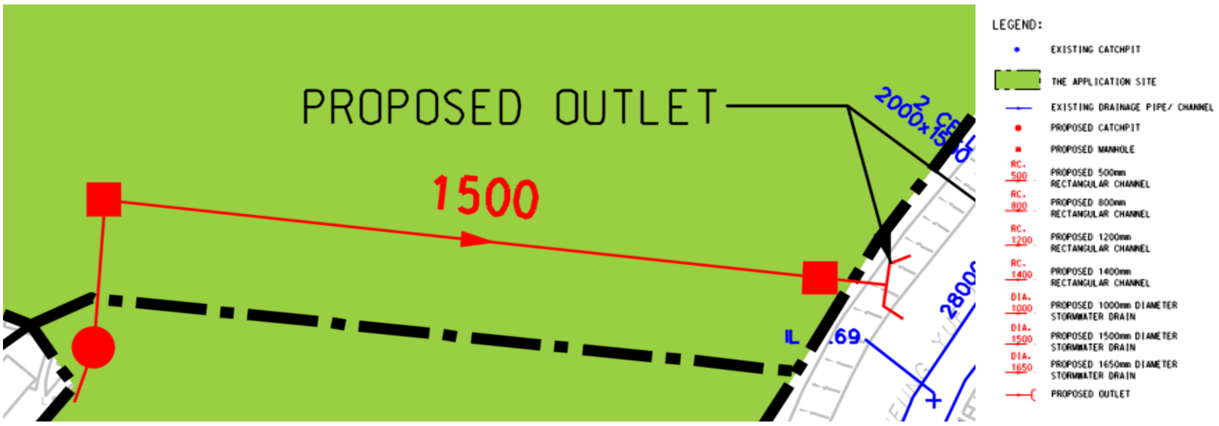


Design Parameters					
Design storm			50	year return period	
Storm constants	a		474.6		
	b		2.9		
	c		0.371		
Average Slope	H		26.00	m/100m	
Length of flow	L		770	m	
Inlet time $t_0=0.14465L/H^{0.2}A^{0.1}$	t_0		17.98	min	
Unpaved area	A_U		85978	m^2	
Runoff coef.	C_U		0.35		
Paved area	A_P		36848	m^2	
Runoff coef.	C_P		0.95		
Catchment area	A_{Total}		122,826	m^2	
Runoff coef.	$C_{average}$		0.53		
Surface roughness	k_s		0.6	mm	For Poor Precast Concrete Pipes
kinematic viscosity	v		1.14	mm^2/s	
Frictional gradient	S_f	1 in	100		

Capacity Check: Catchment C2

Peak Runoff						
Flow time	t_f	=	Lj / Vj			
		=	3.20	min		
Time of concentration	t_c	=	$t_0 + t_f$			
		=	21.18	min		
Intensity	i	=	$a / (t_c + b)^c$	x	1.281	*(Climate Change Factor)*
		=	186.75	mm/hr		(SDM Table 28)
Peak runoff	Q_p	=	0.278 C i A			
		=	**3.380**	m^3/s		
Peak runoff from catchment 3		=	**5.920**	m^3/s		
Total runoff		=	**9.300**			
Capacity of Drain						
Trial pipe size	D	=	**1800**	mm		
Hydraulic radius	R = D/4	=	0.45	m		
Mean velocity (Colebrook-White)	$\bar{V}$	=	$-\sqrt{32gRS_f}\log[\frac{k_s}{14.8R}+\frac{1.255v}{R\sqrt{(32gRS_f)}}]$			
		=				
		=	4.79	m/s		
Capacity provided	Q	=	V x Cross Section Area of Drain			
		=	**12.20**	m^3/s		
Allow 10% Area for Siltation	$Q_{90\%}$	=	**10.98**	m^3/s		
		<	Peak runoff Q_p			
Utilization		=	$Qp/Q_{90\%}$			
		=	85%			

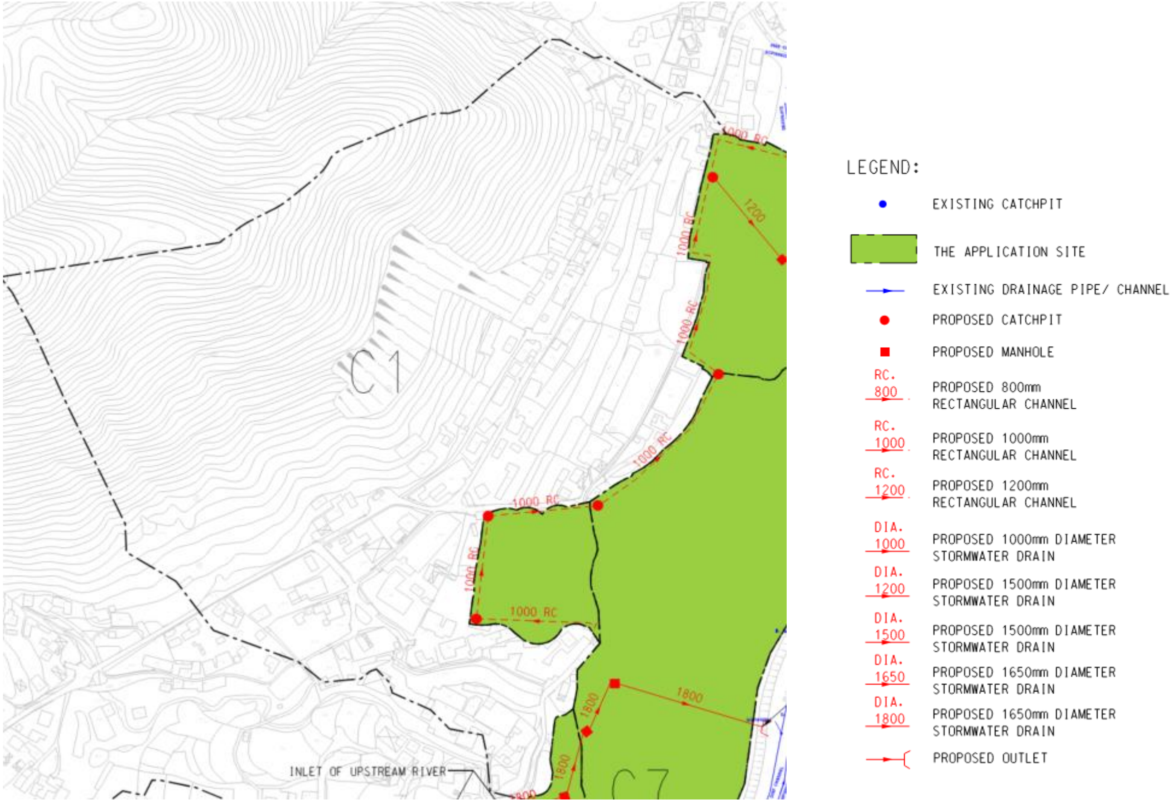
Capacity Check: Proposed 1500mm Drain for Catchment C2



Design Parameters					
Surface roughness	k_s		0.6	mm	For Poor Precast Concrete Pipes
kinematic viscosity	ν		1.14	mm^2/s	
Frictional gradient	S_f	1 in	100		
Peak runoff from C2		=	5.92	m^3/s	

Capacity of Drain				
Trial pipe size	D	=	**1500**	mm
Hydraulic radius	R = D/4	=	0.375	m
Mean velocity (Colebrook-White)	$\bar{V}$	=	$-\sqrt{32gRS_f}\,\log[\frac{k_s}{14.8R}+\frac{1.255\nu}{R\sqrt{(32gRS_f)}}]$	
		=		
		=	4.29	m/s
Capacity provided	Q	=	V x Cross Section Area of Drain	
		=	**7.58**	m^3/s
Allow 10% Area for Siltation	$Q_{90\%}$	=	**6.82**	m^3/s
		>	Peak runoff Q_p	
Utilization		=	$Qp/Q_{90\%}$	
		=	87%	

Capacity Check: Catchment C1



Design Parameters				
Design storm		50	year return period	
Storm constants	a	474.6		
	b	2.9		
	c	0.371		
Average Slope	H	20.00	m/100m	
Length of flow	L	770	m	
Inlet time $t_0=0.14465L/H^{0.2}A^{0.1}$	t_0	19.37	min	
Unpaved area	A_U	69332	m^2	
Runoff coef.	C_U	0.35		
Paved area	A_P	29714	m^2	
Runoff coef.	C_P	0.95		
Catchment area	A_{Total}	99,045	m^2	
Runoff coef.	$C_{average}$	0.53		
Surface roughness	k_s	0.6	mm	For Poor Precast Concrete Pipes
kinematic viscosity	v	1.14	mm^2/s	
Frictional gradient	S_f 1 in	100		

Capacity Check: Catchment C1

Peak Runoff

Flow time	t_f	=	Lj / Vj			
		=	3.81	min		
Time of concentration	t_c	=	$t_0 + t_f$			
		=	23.18	min		
Intensity	i	=	$a / (t_c + b)^c$	x	1.281	*(Climate Change Factor)*
		=	181.32	mm/hr		(SDM Table 28)
Peak runoff	Q_p	=	0.278 C i A			
		=	**2.646**	m^3/s		

Using Manning's Equation for Rectangular-Channel Geometry

Width	**1000**	**mm**	Input Parameter
Height	**1000**	**mm**	Input Parameter
Area	1.000	m^2	
Wetted Perimeter	3.000	m	
Hydraulic Radius	0.333	m	
Slope [Decimal]	**0.01**		Slope = tan θ
Manning's Roughness	**0.015**		for Fair concrete Pipe

Full Flow Velocity Vu	3.20	m/s
Full Flow Discharge	3.20	m^3/s
	192300	l/min

Assume the maximum water depth in the Rectangular-channel be 100% of the size

Water Depth	Area	Wetted Perimeter	Hydraulic Radius	Velocity	Discharge
[mm]	m^2	m	m	m/s	m^3/s
1000	1.000	3.000	0.333	3.205	**3.205**

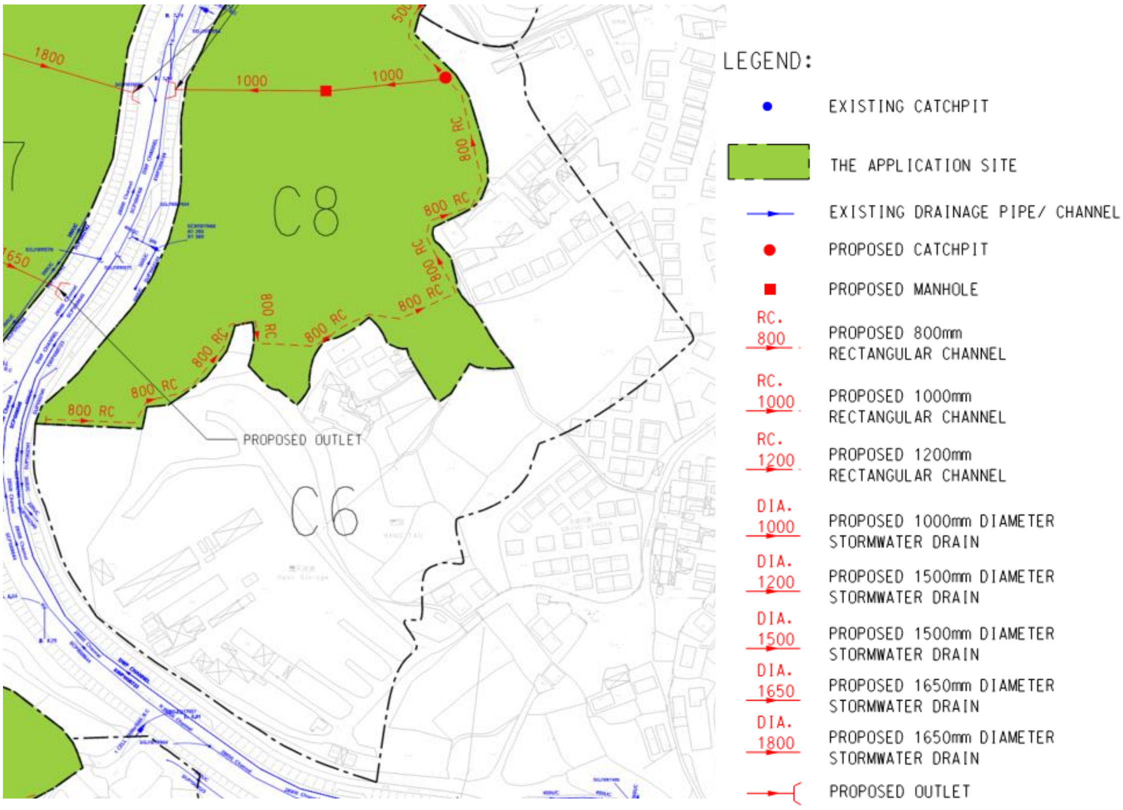
> Peak runoff Q_p

Capacity Check: Proposed 1200mm Drain for Catchment C1

Design Parameters					
Surface roughness	k_s		0.6	mm	For Poor Precast Concrete Pipes
kinematic viscosity	ν		1.14	mm^2/s	
Frictional gradient	S_f	1 in	100		
Peak runoff from C1	=		2.65	m^3/s	

Capacity of Drain				
Trial pipe size	D	=	**1200**	mm
Hydraulic radius	R = D/4	=	0.3	m
Mean velocity (Colebrook-White)	$\bar{V}$	=	$-\sqrt{32gRS_f}\log\left[\frac{k_s}{14.8R}+\frac{1.255\nu}{R\sqrt{(32gRS_f)}}\right]$	
		=		
		=	3.74	m/s
Capacity provided	Q	=	V x Cross Section Area of Drain	
		=	**4.23**	m^3/s
Allow 10% Area for Siltation	$Q_{90\%}$	=	**3.81**	m^3/s
		>	Peak runoff Q_p	
Utilization		=	$Qp/Q_{90\%}$	
		=	70%	

Capacity Check: Catchment C6



Design Parameters				
Design storm		50	year return period	
Storm constants	a	474.6		
	b	2.9		
	c	0.371		
Average Slope	H	0.30	m/100m	
Length of flow	L	240	m	
Inlet time $t_0=0.14465L/H^{0.2}A^{0.1}$	t_0	15.07	min	
Unpaved area	A_U	23403	m^2	
Runoff coef.	C_U	0.35		
Paved area	A_P	23403	m^2	
Runoff coef.	C_P	0.95		
Catchment area	A_{Total}	46,806	m^2	
Runoff coef.	$C_{average}$	0.65		
Surface roughness	k_s	0.6	mm	For Poor Precast Concrete Pipes
kinematic viscosity	v	1.14	mm^2/s	
Frictional gradient	S_f 1 in	100		

Capacity Check: Catchment C6

Peak Runoff

Flow time	t_f	=	Lj / Vj			
		=	4.42	min		
Time of concentration	t_c	=	$t_0 + t_f$			
		=	19.49	min		
Intensity	i	=	$a / (t_c + b)^c$	x	1.281	*(Climate Change Factor)*
		=	191.86	mm/hr		(SDM Table 28)
Peak runoff	Q_p	=	0.278 C i A			
		=	**1.623**	m^3/s		

Using Manning's Equation for Rectangular-Channel Geometry

Width	**800**	**mm**	Input Parameter
Height	**800**	**mm**	Input Parameter
Area	0.640	m^2	
Wetted Perimeter	2.400	m	
Hydraulic Radius	0.267	m	
Slope [Decimal]	**0.01**		Slope = tan θ
Manning's Roughness	**0.015**		for Fair concrete Pipe

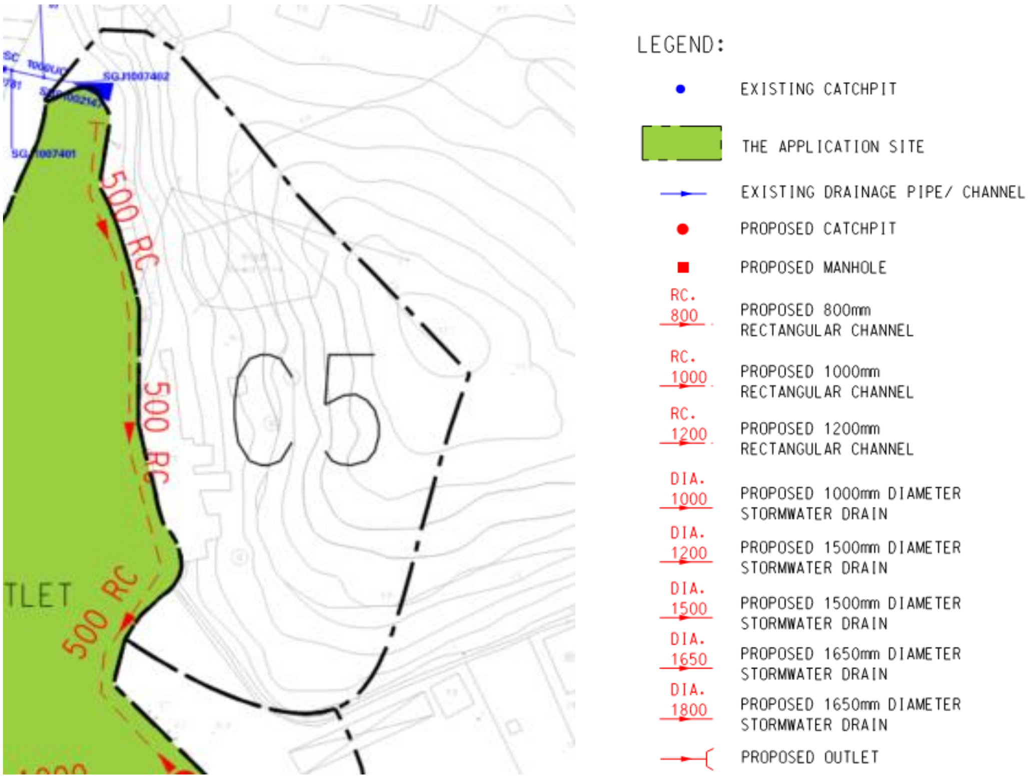
Full Flow Velocity Vu	2.76	m/s
Full Flow Discharge	1.77	m^3/s
	106060	l/min

Assume the maximum water depth in the Rectangular-channel be 100% of the size

Water Depth	Area	Wetted Perimeter	Hydraulic Radius	Velocity	Discharge
[mm]	m^2	m	m	m/s	m^3/s
800	0.640	2.400	0.267	2.762	**1.768**

> Peak runoff Q_p

Capacity Check: Catchment C5



Design Parameters

Design storm		50	year return period	
Storm constants	a	474.6		
	b	2.9		
	c	0.371		
Average Slope	H	3.00	m/100m	
Length of flow	L	70	m	
Inlet time $t_0=0.14465L/H^{0.2}A^{0.1}$	t_0	3.33	min	
Unpaved area	AU	3041	m^2	
Runoff coef.	CU	0.35		
Paved area	AP	4562	m^2	
Runoff coef.	CP	0.95		
Catchment area	ATotal	7,603	m^2	
Runoff coef.	Caverage	0.71		
Surface roughness	k_s	0.6	mm	For Poor Precast Concrete Pipes
kinematic viscosity	v	1.14	mm^2/s	
Frictional gradient	S_f 1 in	100		

Capacity Check: Catchment C5

Peak Runoff

Flow time	t_f	=	Lj / Vj			
		=	6.05	min		
Time of concentration	t_c	=	$t_0 + t_f$			
		=	9.38	min		
Intensity	i	=	$a / (t_c + b)^c$	x	1.281	*(Climate Change Factor)*
		=	239.79	mm/hr		(SDM Table 28)
Peak runoff	Q_p	=	0.278 C i A			
		=	**0.360**	m^3/s		

Using Manning's Equation for Rectangular-Channel Geometry

Width	**500**	**mm**	Input Parameter
Height	**500**	**mm**	Input Parameter
Area	0.250	m^2	
Wetted Perimeter	1.500	m	
Hydraulic Radius	0.167	m	
Slope [Decimal]	**0.01**		Slope = tan θ
Manning's Roughness	**0.015**		for Fair concrete Pipe

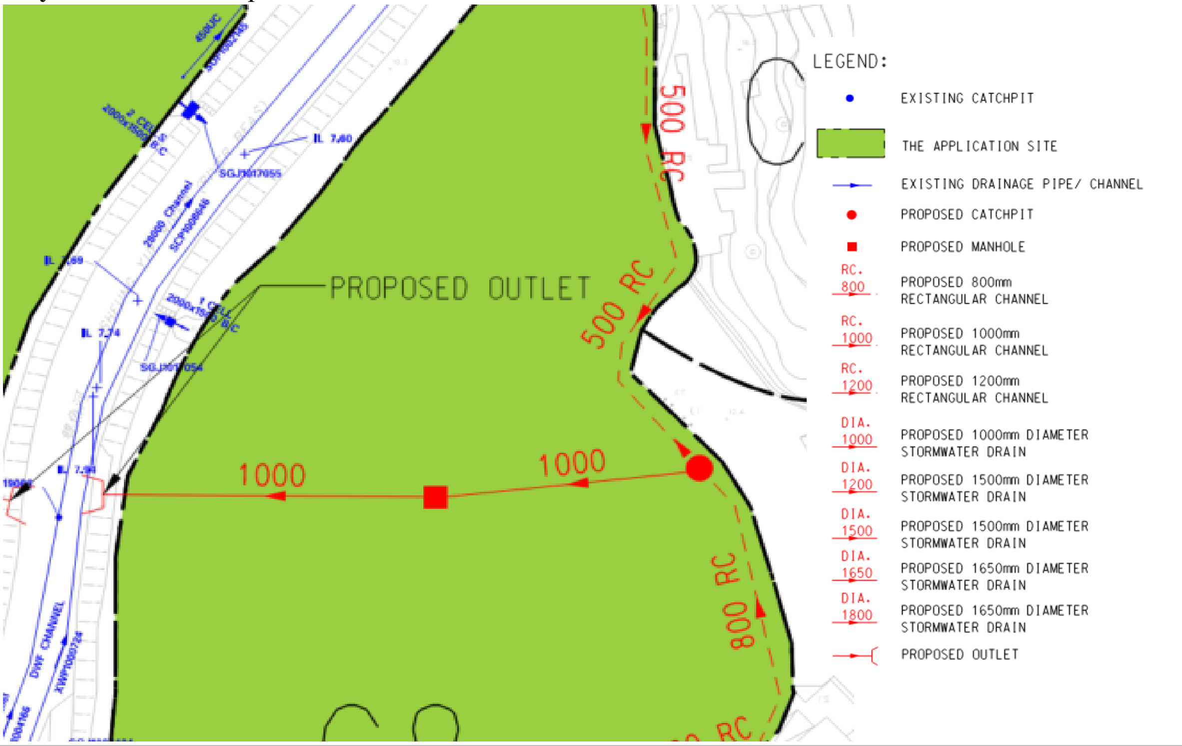
Full Flow Velocity Vu	2.02	m/s
Full Flow Discharge	0.50	m^3/s
	30285	l/min

Assume the maximum water depth in the Rectangular-channel be 90% of the size

Water Depth	Area	Wetted Perimeter	Hydraulic Radius	Velocity	Discharge
[mm]	m^2	m	m	m/s	m^3/s
450	0.250	1.500	0.167	2.019	**0.505**

> Peak runoff Q_p

Capacity Check: Proposed 1000mm Drain for Catchment C5 and C6



Design Parameters

Surface roughness	k_s		0.6	mm	For Poor Precast Concrete Pipes
kinematic viscosity	v		1.14	mm^2/s	
Frictional gradient	S_f	1 in	100		

Peak runoff from C5 = 0.36 m^3/s

Peak runoff from C6 = 1.62 m^3/s

Total runoff = 1.98 m^3/s

Capacity of Drain

Trial pipe size D = **1000** mm

Hydraulic radius $R = D/4$ = 0.25 m

Mean velocity (Colebrook-White) $\bar{V}$ = $-\sqrt{32gRS_f}\,\log[\frac{k_s}{14.8R}+\frac{1.255v}{R\sqrt{(32gRS_f)}}]$

=

= 3.34 m/s

Capacity provided Q = V x Cross Section Area of Drain

= **2.63** m^3/s

Allow 10% Area for Siltation $Q_{90\%}$ = **2.36** m^3/s

> Peak runoff Q_p

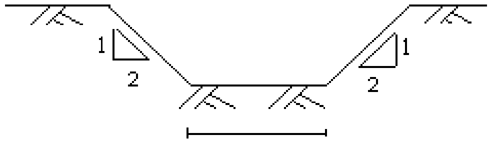
Utilization = $Qp/Q_{90\%}$

= 84%

Annex 4
Sensitivity Checking of River Beas

Annex 4 **Hydraulic calculation at River Beas**

$$Q = \frac{A}{n} S^{1/2} R^{2/3}$$



16m

Area of flow	A =	47.380	m^2	(Based on as-built drawing)
Wetted Perimeter	P =	26.286	m	
Hydraulic radius	R =	1.802		
Hydraulic gradient	S =	0.002		From as-built
Mannings Coefficient	n =	0.035		Table 13 of SDM

Capacity of Channel Q = $\frac{A}{n}$ x s^(1/2) x R^(2/3)

= 93.910 m^3/s

Increase rate of discharge Q' = 2.28 m^3/s (Refer to Appendix 2)

Percentage with respect to
Full flow of River Beas = 2.43%