Response-to-Comment to Drainage Impact Assessment Report

Comments from Drainage Services Department, dated 31 December 2025

Items	Comments	Response
Comments on Drainage Impact Assessment from DSD		
a	According to paragraph 4.2 of DSD Advice Note No. 1, this report should be signed and certified by the registered professional engineer in charge of this DIA study.	Noted.
b	The applicant should be advised that the limited desk-top checking by Government on the DIA covers only the fundamental aspects of the drainage design which will by no means relieve his obligations to ensure that (i) the proposed drainage works will not cause any adverse drainage or environmental impacts in the vicinity; and (ii) the proposed drainage works and the downstream drainage systems have the adequate capacity and are in good conditions to accommodate all discharge water collected from his lot and all upstream catchments. The applicant shall effect any subsequent upgrading of these proposed works and the downstream drainage systems whenever necessary.	Noted.

Items	Comments	Response
c	Section 2.2 refers. (i) The applicant should advise whether site formation works would be carried out. If so, details of the site formation works should be supplemented in this section. (ii) Details of the change in surface characteristic of the site should be supplemented in this section.	 (i) Noted and revised. (ii) Noted and supplemented. Please refer to Section 2.2.
d	Section 3.2 refers. (i) The applicant should clarify whether surface runoff from catchment G will be discharged into stream 1 or stream 2. (ii) The applicant should specify the dimensions and spacing of the proposed openings on walls. (iii) The applicant should advise the percentage of paved/unpaved area before and after implementation of the proposed development.	 (i) Noted and revised. It is clarified that surface runoff from catchment G will be discharged into stream 1. (ii) Noted and specified. Please refer to Section 3.2. (iii) Noted and revised. Please refer to Section 3.2.

Items	Comments	Response
e	Figure 3.2 refers.	
	(i) The applicant should indicate the invert levels of the proposed catch pits and manholes.	(i) Noted and revised. Please refer to Figure 3.2.
	(ii) (ii) The applicant is reminded that the minimum cover from the surface of the carriageway to the top of the pipeline shall be 900 mm. For footway, the minimum cover shall be 450 mm.	(ii) Noted. It is confirmed that the minimum cover from the surface to the top of the pipeline is 900 mm for the carriageway and 450 mm for the footway.
	(iii) Manholes should be provided where a stormwater drain changes direction.	(iii) Noted and provided. Please refer to Figure 3.2.
	(iv) The applicant should indicate the material of the proposed underground circular pipe.	(iv) Noted and indicated. Polyethylene pipe will be adopted for all proposed underground circular pipe.
	(v) The applicant should use a different legend for catch pit and manhole for clarity.	(v) Noted and revised. Please refer to Figure 3.2.
	(vi) The applicant should indicate the site formation levels and fall direction of the subject site.	(vi) Noted and revised. The details of Site formation level is provided in Appendix G.

Items	Comments	Response
f	Appendix C refers.	
	(i) As stream 1 would also collect surface runoff from the areas to the south of Sha Tau Kok Road, the applicant should also consider these areas when checking the hydraulic capacity of stream 1.	(i) Noted and revised. The catchment located to the south of Sha Tau Kok Road is included in the assessment. Please refer to Appendix C and Figure 3.2.
	(ii) The applicant should advise whether stream 2 will also collect surface runoff from its left bank, and revise the calculation as necessary.	(ii) Noted. As the surface runoff from the left banks of stream 2 will not flow into stream 2, it will not be included in the calculation. Please refer to Figure 3.1 for the direction of flow in such catchment.
	(iii) The applicant should supplement hydraulic checking of the culvert underneath Sha Tau Kok Road.	(iii) Noted. The nearest culvert underneath Sha Tau Kok Road is located approximately 130m west of the site. As this culvert is situated upstream while the surface runoff from the proposed development will discharge downstream, the development will have no impact on the flow within the culvert.
	(iv) The applicant should advise the free board of stream 1 and stream 2 before and after the proposed development.	(iv) Noted and advised. Please refer to Appendix F

Items	Comments	Response
g	The applicant should supplement typical details of the proposed drainage facilities (e.g. manhole, catchpit, catch pit with trap, u-channel, grating, concrete cover, connection to the existing stream etc.).	Noted and supplemented. Please refer to Figure 3.4.
h	The applicant should supplement sufficient cross-sections showing clearly any walls would be erected or kerbs would be laid along the boundary of the site, the proposed and existing drainage facilities, flow direction, the existing ground level of the adjacent lands and the formation level of the subject site.	Noted and revised. Please refer to Figure 3.5.
i	The cover levels of proposed u-channels, manholes, and catch pits should be flush with the adjoining ground level.	Noted.
j	The applicant should check and ensure that the existing drainage system to which the proposed connection will be made have adequate capacity and satisfactory condition to cater for the additional discharge from the captioned lot. He should also ensure that the flow from this site will not overload the existing drainage system.	Noted.

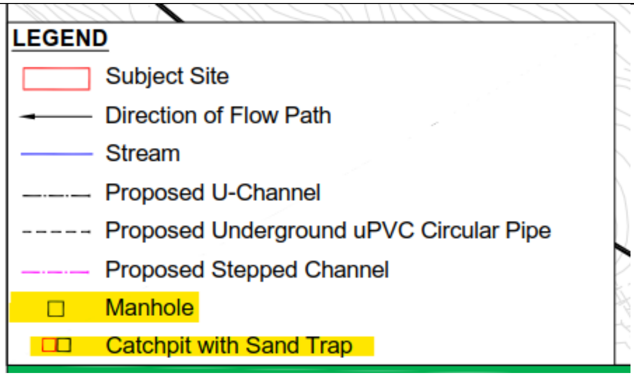
Items	Comments	Response
k	The existing discharge location to which the applicant proposed to discharge the stormwater from the subject site is not maintained by DSD. The applicant should identify the owner of the existing discharge location to which the proposed connection will be made and obtain agreement from the owner prior to commencement of proposed works.	Noted.
l	The proposed drainage works, whether within or outside the lot boundary, should be constructed and maintained by the applicant at his own expense.	Noted.
m	For works to be undertaken outside the lot boundary, the applicant should obtain prior agreement from the District Lands Officer/North, Lands Department and/or relevant private lot owners.	Noted.
n	The applicant is reminded that all existing flow paths as well as the run-off falling onto and passing through the site should be intercepted and disposed of via proper discharge points. The applicant shall also ensure that no works, including any site formation works, shall be carried out as may adversely interfere with the free flow condition of the existing drain, channels and	Noted. It is confirmed that existing flow paths as well as the run-off falling onto and passing through the site will be intercepted and disposed of via proper discharge points.

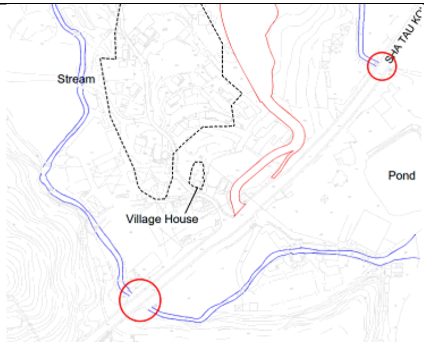
Items	Comments	Response
	watercourses on or in the vicinity of the subject site any time during or after the works.	
o	The applicant should make good all the adjacent affected areas upon the completion of the drainage works.	Noted.
p	The applicant should construct and maintain the proposed drainage works properly and rectify the system if it is found to be inadequate or ineffective during operation.	Noted.
q	As usual, Government should be empowered to inspect conditions of the private drainage system and to enforce its cleansing by the owners, if necessity arises (e.g. upon receipt of complaints).	Noted.
r	The existing drainage facilities, watercourse, river, channel and the like should not be affected and obstructed by the construction materials, waste or debris from the proposed development.	Noted. It is confirmed that the existing drainage facilities, watercourse, river, channel will not be affected and obstructed by the construction materials, waste or debris from the Proposed Development.

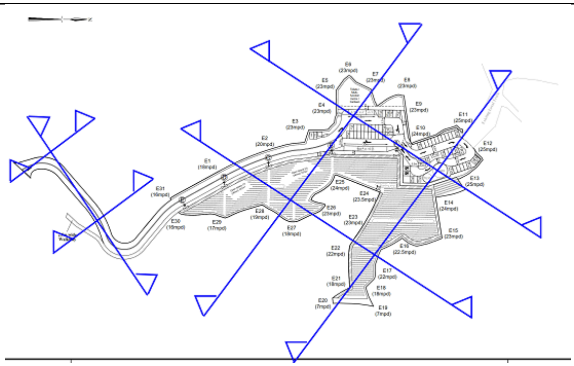
URBAN GREEN

Comments from Planning Department, dated 8 January 2026

Items	Comments	Response
Comments on Drainage Impact Assessment from DSD		
1	This report should be signed and certified by the Registered Professional Engineer (RPE) in charge of this DIA study. The full name, RPE number, and signature of the RPE should be shown on the cover page of the DIA report.	Noted and revised. Please refer to the cover page of the DIA report.
2	Section 3.2: (a) As clarified by the applicant in the RtoC, catchment G will be discharged to stream 1. The applicant should update the catchment areas collected by stream 2 in this section for consistency.	Noted and revised. It is clarified that surface runoff from catchment A to catchment E, catchment G and catchment J to catchment M will be discharged to Stream 1 while catchments F and catchment H to catchment I will be discharged into Stream 2. Please refer to Section 3.2 and Appendix B.
	(b) The applicant should specify the spacing of the proposed openings on walls, and indicate the wall that requires openings. Please note that sufficient openings should be provided to ensure the surface runoff from catchments C to F and I could be conveyed to the proposed drainage system through the wall openings.	Noted and specified. It is clarified that the 300mm (W) x 200mm (H) openings will be provided on the fence wall. For the detailed location of the openings and the fence wall. Please refer to Section 3.2 and Figure 3.3 – Figure 3.4.
3	Table 3.1: The applicant should review the table as it shows that the area of concrete paving will be reduced after the proposed development.	Noted and revised. Please refer to Table 3.1.
4	Figure 3.2 refers. (a) The applicant should review the feasibility of constructing deep catchpits and u-channels (e.g. the depth of u-channel is approximately 5m at catchpit B3).	Noted and revised. The depth of the manhole has been adjusted. As stepped channels are provided in locations with steep gradient, manholes with more than 5m depth are not required. Please refer to Figure 3.2 and Appendix B.
	(b) The applicant should indicate the material of the proposed underground circular pipe on this figure.	Noted and revised. It is indicated that uPVC circular pipe will be adopted in Figure 3.2.

	(c) The applicant should add a legend for catch pit, which should be different from the legend for manhole.	 Noted. It is confirmed that there are different legends for manhole and catchpit. Please refer to Figure 3.2.
	(d) The applicant should indicate which sections of channel will be in the form of stepped channel.	Noted and revised. Please refer to Figure 3.2.
5	Appendix B refers. (a) The applicant should clarify how the surface runoff from catchment areas R1-R5 could be collected by the proposed drainage system which is underground.	Noted and revised. The flow of R1 – R5 will be accumulated along the proposed circular pipe and will eventually enter the existing Stream 1 via CA1 pipe. Please refer to Appendix B.
	(b) As stream 1 would also collect surface runoff from the areas to the south of Sha Tau Kok Road (not just catchment R1-R5), the applicant should also consider these areas when checking the hydraulic capacity of stream 1.	Noted and revised. The catchment located to the south of Sha Tau Kok Road has been included into the assessment. Please refer to Figure 3.2.
	(c) The applicant should supplement hydraulic checking of the culverts underneath Sha Tau Kok Road (culverts connected to streams 1 and 2 circled in red below).	Noted. The hydraulic calculation is provided in Appendix B with the site verification on 12 January 2026. Please refer to Appendix F for the photos of the culverts.

		
	(d) As mentioned in section 3.3, some sections of channel will be in the form of stepped channel. However, there is no design calculation of stepped channel. The applicant should review.	Noted and revised. The detailed calculation on the capacity of stepped channels is provided in Appendix B.
6	The applicant should supplement typical details of all proposed drainage facilities (e.g. stepped channel, manhole, grating, concrete cover, connection to the existing stream etc.).	Noted and supplemented. The typical detailed drawings of the proposed drainage facilities are provided in Appendix H.
7	Appendix F: The applicant should compare the free board of stream 1 and stream 2 before and after the proposed development, and advise if any existing connections to these streams will be partially submerged/submerged after the proposed development. A plan showing the details of existing connections to these stream (types, dimensions, invert levels etc.) should be supplemented.	Noted and revised. The calculation freeboard of the streams before and after the development is provided in Appendix F and the details of connection to the two existing stream is provided in Figure 3.8 – Figure 3.9.
8	Appendix G: The applicant should supplement the following cross-sections of the site showing clearly any walls would be erected or kerbs would be laid along the boundary of the site, the proposed and existing drainage facilities, flow direction, the existing ground level of the adjacent lands and the formation level of the subject site.	Noted and supplemented. Please refer to Figure 3.6 and Figure 3.7A – Figure 3.7G.

Comments from Planning Department, dated 16 January 2026

Items	Comments	Response
Comments on Drainage Impact Assessment from DSD		
1	Section 3.1 (a) Please specify the climate change scenarios in the assumptions	Noted and specified. Please refer to Section 3.1.5 and Section 3.1.6.
2	Section 2.2 (a) Please supplement where the change of surface characteristic of the Site is provided in. It is missing from the paragraph.	Noted and supplemented. It is clarified that the change of surface characteristic is provided in Table 3.1. Please refer to Section 2.2.
	(b) Please supplement which Appendix is the Site Formation Level Plan is provided. It is missing from the paragraph.	Noted and supplemented. It is clarified that the Site Formation Level Plan is provided in Appendix I.
3	Section 3.2 (a) It is noted that land filling and construction of boundary wall are proposed. Please elaborate on whether the change of surface elevation and the erection of fence wall will impede or alter the existing overland flow from/to adjacent catchments. Detailed information on the potentially affected catchments (e.g., Catchments C to F) should be included, such as topography, existing land use, existing flow paths, site photos, etc.	Following the construction of the Proposed Boundary Wall, the overland flow paths will be changed. Wall openings are incorporated into the proposed fence wall design to ensure that runoff from the affected catchments is conveyed to the proposed drainage system. Please refer to Section 3.2.2, 2nd para.
	(b) The 4th paragraph of Section 3.2 is incomplete. Please supplement.	The paragraph is duplicated and removed.
	(c) Figure 3.2 shows that the stormwater are discharged to Stream 1 and Stream 2 by underground pipe. However, it appears on Figures 3.8 and 3.9	Noted and revised. It is confirmed that the surface runoff from the Site is discharged to the two streams via a series of underground pipes. Please refer to Figure 3.10 and Figure 3.11.

Items	Comments	Response
	that the 900mm dia. and 750mm dia discharge pipe are above ground. Please clarify.	
	(d) RtC 2(a) - Please check and clarify whether the surface runoff from catchment A to catchment E, catchment G and catchment J to catchment N (instead of M) will be discharged to Stream 1.	Noted and clarified. Please refer to Table 3.2 (new figure no.).
	(e) RtC 2(b) - While an elevation is provided in Figure 3.3, please provide a typical cross-sectional detail of the fence wall, indicating any provisions for wall openings.	Noted and provided. Please refer to Figure 3.4 and Figure 3.5 (new figure no.).
	(f) RtC 2(b) and Figure 3.4 - Please confirm there is no fence wall at the boundary between manhole B5 and manhole B10 (i.e. along Catchment I)	It is confirmed that there is fence wall along the boundary between manhole B5 to manhole B10. Please refer to Figure 3.6 (new figure no.).
4	Section 3.3 (a) Table 3.8 - Please confirm whether the table shows the assessment result of Stream 1 and Stream 2, instead of Culvert 1 and Culvert 2 as shown in the caption of the Table.	Noted. It is confirmed that Table 3.9 (new table no.) presents the estimated capacities of the two existing streams.
	(b) Table 3.9 - Please clarify if Culvert 2 is a box culvert or a circular pipe	Noted and clarified. Please refer to Table 3.10 (new table no.).
	(c) Table 3.9 - Please specify the number of cells for Culvert 1.	Noted and specified. Please refer to Table 3.10 (new table no.).
	(d) Table 3.9 - The last column of Culvert 2 should read "N", as there is not sufficient capacity.	Noted and revised. Please refer to Table 3.10 (new table no.).

Items	Comments	Response
5	Section 3.5 (a) Please specify the source of the rainfall increase percentages.	Noted and specified. Please refer to Section 3.1.6.
6	Section 3.6 (a) Please double check the Corrigendum number.	Noted and revised. Please refer to Section 3.1.6.
	(b) It appears that sea level rise and storm surge due to climate change, as well as design allowance were not incorporated. Please provide justification.	Noted and supplemented. The sea level rise, storm surge and design allowance has been considered in the assessment. Please refer to Section 3.1.5, Section 3.1.6 and Appendix B to E.
7	Figure 3.2 (a) RtC 4(d) - U-channels are usually connected by catchpit rather than manhole. Please review.	Noted and revised. Please refer to Figure 3.2.
8	Appendix B. Table A (a) Please advise if catchment runoff calculation refer to the scenario without climate change.	It is clarified that the calculation refer to the scenario without climate change.
	(b) Please clarify whether the surface types used in the calculations refer to the existing conditions or the post-development scenario.	Noted and clarified. The calculation refers to post-development scenario. Please refer to the “Note” in Table A – Table D in Appendix B to E.
9	Appendix C and D	Noted. Due to the deposition of sediment in stormwater channels and pipes, it is assumed that the flow area is reduced 10% in the assessment. Please refer to Section 3.1.4 and Appendix B to E.

Items	Comments	Response
	(a) For calculation of channel capacity, please advise if potential flow area reduction due to sedimentation has been considered.	
10	Appendix E (a) Refer to page 61 and 63 of the PDF, please clearly label scenarios for each of the table to avoid confusion.	Noted and revised.
	(b) Please indicate on a layout plan the specific check points where the capacity calculations for Stream 1 and Stream 2 have been performed.	Noted and revised. Please refer to Figure 3.3.

Comments from Planning Department, dated 10 February 2026

Items	Comments	Response
Comments on Drainage Impact Assessment from DSD		
1	Figure 3.2 refers (a) The applicant should review the design of the proposed underground uPVC pipes as their tops protrude above ground levels (e.g. at manholes A25, E1). The applicant is reminded that the minimum cover from the surface of the carriageway to the top of the pipeline shall be 900 mm. For footway, the minimum cover shall be 450 mm.	Noted and revised. The designed cover from the surface of the carriageway and footway to the top of the pipeline is at least 900 mm and 450 mm, respectively. Please refer to Figure 3.2 and Appendix B.
	(b) The applicant should review the invert levels of catch pits and u-channels with consideration of thickness of concrete cover/grating to ensure the depths of u-channels are adequate. For instance, the depth of u-channel is less than 450mm at catch pit D2.	Noted and revised. The thickness of the concrete cover/grating has been considered in the design of the invert levels of the catchpits and U-channels. Please refer to Figure 3.2 and Appendix B.
	(c) The applicant should review whether u-channels along the eastern and southeastern boundary of catchment areas J and K are required to intercept the overland flow.	Noted and revised. U-channels are proposed along the eastern and southeastern boundaries of Catchment J and K to ensure that all overland flow within the Site and upper catchments is collected by the proposed drainage system. Please refer to Figure 3.2 and Appendix B.
	(d) The applicant should indicate the dimensions of the proposed stepped channels.	Noted and indicated. Please refer to Figure 3.8A – Figure 3.8C.
2	Figure 3.6: Both the orange and green lines represent fence wall without opening. The applicant should review.	Noted and revised. The orange lines represent the fence wall with openings, while the green lines represent the fence wall without openings. Please refer to Figure 3.6.
3	Figures 3.9A to 3.9G: The site boundary should be shown in these figures.	Noted and revised. Please refer to Figure 3.10A – Figure 3.10G.

Items	Comments	Response
4	It is noted that culvert 2 is proposed to be upgraded under this development. The applicant is reminded to identify the owner of this culvert and seek his comment on the proposed upgrading works.	Noted.

Section 12A Rezoning Application for Proposed Columbarium on Various Lots in D.D.41 Sha Tau Kok, New Territories

Drainage Impact Assessment Report

Reference: P036/02 Issue 5
Date: 12 Febuary 2026
Confidential

Ir. Leung Wing Kit
RPE (Civil) No.: RP0806160

Section 12A Rezoning Application for Proposed Columbarium on Various Lots in D.D.41 Sha Tau Kok, New Territories

Drainage Impact Assessment Report

Reference: P036/02 Issue 5

Date: 12 February 2026

Issue	Prepared By	Date	Checked by	Date	Approved By	Date
1	Yan Lee	11/11/2025	Cheryl Chan	11/11/2025	Joan Choi	11/11/2025
2	Yan Lee	07/01/2026	Cheryl Chan	07/01/2026	Joan Choi	07/01/2026
3	Yan Lee	13/01/2026	Cheryl Chan	13/01/2026	Joan Choi	13/01/2026
4	Yan Lee	26/01/2026	Cheryl Chan	26/01/2026	Joan Choi	26/01/2026
5	Yan Lee	12/02/2026	Cheryl Chan	12/02/2026	Joan Choi	12/02/2026

[redacted]

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1 Introduction

1.1 Background

The Applicant intends to operate a columbarium located at various Lots in D.D. 41, Sha Tau Kok, New Territories (hereafter as “the Site”).

The Applicant proposes to rezone the Site to "Other Specified Uses" annotated "Columbarium" (“OU (Columbarium)”) under Section 12A of Town Planning Ordinance (TPO).

Owing to concerns on possible drainage impact arising from the proposed redevelopment, Urban Green Consultants Ltd. (UGC) has been commissioned to conduct a Drainage Impact Assessment (DIA) to demonstrate the acceptability of drainage impact upon the surrounding environment. This DIA Report has been prepared as a supporting document.

1.2 Study Objectives

The objectives of this DIA are to assess the possible drainage impacts may be caused by the Proposed Development and to recommend the mitigation measures to alleviate such impacts if necessary.

1.3 Report Structure

The remaining chapters of this report are shown below:

Chapter 2 – Site Context

Chapter 3 – Drainage Analysis

Chapter 4 – Recommendations

Chapter 5 – Conclusion

2 Site Context

2.1 Site Location and Its Environs

The Site is located in Sha Tau Kok and to the north of Sha Tau Kok Road. Currently, to the north and west of the Site are village houses of Tong To Tsuen. Vegetated slopes are located to the east and south of the Site. The Site area is about 13,382m^2. Figure 2.1 shows the Site location and its environs.

2.2 Site Characteristics and Proposed Use

The Proposed Development will include area for columbarium, office, multi-function rooms and toilets. Proper landscape and tree planting areas are planned at the remaining area of the Site. Given that the Site is located in an undeveloped area, site formation would greatly reduce the vegetated portion of the Site. The change of surface characteristic of the Site is provided in Table 3.1 . The development plan is presented in Appendix A. The site formation level plan is provided in Appendix I.

2.3 Existing Drainage Condition

A site survey was conducted in July 2025 and 12 January 2026 to collect the updated information of the drainage characteristics, catchments, topography and existing drainage facilities in the vicinity. The photo records or hydraulic checking of the nearby culvert is provided in Appendix F. The land-based survey was conducted with reference to the survey map to identify the existing drainage facilities, flow path and the surface type within the Site and its surroundings.

Drainage plans (plan no.: 3-NE-17B-1, 3-NE-12D-3 and 3-NE-12D-4) were obtained from Drainage Services Department (DSD) in July 2023 and 19 May 2025 to gather the background information on drainage infrastructure in the vicinity of the Site. Based on the drainage plans, the site is not currently served by any form of DSD's drainage facility. However, one existing stream to the southwest of the Site and one to the east of the Site with approx. 3-4m width were identified as shown in Figure 2.1. The surface runoff from the Site may be discharged into Stream 1 and Stream 2 via underground circular pipes and u-channels.

3 Drainage Analysis

3.1 Assessment Methodology and Assumptions

This DIA has adopted the Rational Method for runoff estimation:

$$Q_p = 0.278\, i \sum C_j\, A_j$$

where
Q_p is peak runoff (m^3/s);
i is rainfall intensity (mm/hr);
A_j is the j^{th} catchment (km^2);
C_j is the runoff coefficient of the j^{th} catchment (dimensionless).

The details of the Rational Method can be referred to the *Stormwater Drainage Manual* (SDM) (DSD, 2018).

3.1.1 Runoff Coefficient

Based on a 1:50 year flood protection standard in the SDM and the estimated time of concentration, the appropriate rainfall intensities (i) were calculated based on linear interpolation of the intermediate table values.

The assumptions of this DIA are summarised below:

- Rainstorm return period – 1 in 50 years
- Runoff coefficient for concrete – 0.95
- Runoff coefficient for flatted grassland (heavysoil) – 0.25
- Runoff coefficient for steep grassland (heavysoil) – 0.35

3.1.2 Roughness Value of the Proposed U-channels, Stepped Channels and Circular Pipes

The capacities of the proposed U-channels, stepped channels and circular pipes were checked by comparing with magnitudes of different combinations of the catchments. Manning's roughness coefficient of 0.030 for "Natural-stream channels — Clean, straight bank, full stage, no rifts or deep pools" in fair condition is adopted for all proposed U-channels and stepped channels. The k_s roughness value of 0.03mm for uPVC circular pipes under Table 14 of SDM was assumed for the underground pipes as referred in the SDM.

3.1.3 Manning Roughness of the Existing Streams

The capacities of the two existing streams at the discharge points of the Site were estimated to compared with the total runoff generated from the identified catchments. Manning roughness of 0.040 for bad condition for canals with rough stony beds, weeds on earth banks under Table 13 of SDM is adopted.

3.1.4 Sedimentation in Channels and Pipes

Deposition of sediment in stormwater channels and pipes have been considered in the design, a 10% reduction in flow area has been applied to all proposed pipes and channels.

3.1.5 Mean Sea Level Rise and Storm Surge Increase due to Climate Change

According to Table 8 of SDM Corrigendum No. 1/2022, Tai Po Kau is the nearest tidal station to the Proposed, design extreme sea level with a 50-year return period of 4.41 mPD is adopted for the assessment.

Mean sea level rise due to climate change is also taking into account. According to Table 29 of SDM Corrigendum No. 1/2022, the projected mean sea level rise of 0.47m at the end of the 21st century is considered in the assessment.

Furthermore, according to Table 30b of SDM Corrigendum No. 1/2022, storm surge increase of 0.25m at Tai Po Kau at the end of the 21st century is considered in the assessment. Therefore, the extreme sea level at the end of the 21st century is estimated to be 5.13 mPD (i.e. 4.41mPD +0.47m +0.25m =5.13mPD).

3.1.6 Rainfall Increase due to Climate Change

According to Table 28 and Table 31 of SDM Corrigendum No. 1/2022, rainfall increase of 11.1% and 16.0% at the mid-21st century and end of 21st Century, as well as design allowance at the end of 21st century of 12.1% are considered in the assessment.

3.2 Design Parameters

3.2.1 Identified Catchments and Surface Characteristics

Based on the geographical characteristics of the Site and its surroundings, 48 catchments (Catchments A to N, AA to AZ, BA to BL, CA-CC, CG and CH) were identified and its nearby areas as shown in Figure 3.2. The surface characteristics of the catchments within the Proposed Development is shown in Table 3.1.

Table 3.1 Surface Characteristics within the Proposed Development

On-Site Catchment Area	Before Proposed Development		After the Proposed Development	
	Permeable (Vegetated) (%)	Concrete Paving (%)	Permeable (Vegetated) (%)	Concrete Paving (%)
A	95	5	10	90
B	90	10	10	90
G	80	20	15	85
H	95	5	10	90

On-Site Catchment Area	Before Proposed Development		After the Proposed Development	
	Permeable (Vegetated) (%)	Concrete Paving (%)	Permeable (Vegetated) (%)	Concrete Paving (%)
J	95	5	0	100
K	95	5	0	100
L	95	5	0	100
M	95	5	0	100

3.2.2 Proposed Drainage System

A series of proposed U-channels, stepped channels and underground pipes will be provided to collect the surface runoff from catchment A to N and R1 to R5. The surface runoff from catchment A to E, G and J to N will be discharged into Stream 1 via underground circular pipes E1 – E6 and CA1. While the surface runoff from catchment F,H and I will be discharged into Stream 2 via underground circular pipes CB1. The drainage proposal is shown in Figure 3.2.

As land filling and construction of fence wall are proposed, the existing overland flow will be changed. Therefore, proposed wall openings with dimensions of 300mm (W) x 200mm (H) and distributed at a regular spacing of 2m will be provided along the fence wall to ensure the surface runoff from the affected catchments could be conveyed to the proposed drainage system within the Proposed Development. Figure 3.7 and Figure 3.1A shows the rainwater flow path under existing conditions and after the Proposed Development, respectively. Figure 3.4 and Figure 3.5 show the elevation and cross section of the proposed fence walls while the location of fence wall with opening is provided in Figure 3.6.

Due to the steep gradient in certain site locations, stepped channels are provided to reduce the runoff velocity. The location of proposed stepped channels is provided in Figure 3.2. The dimension of the Proposed Stepped Channel is provided in Figure 3.8.

The cross section of existing and proposed ground level is provided in Figure 3.9 and Figure 3.10 and the details of connection to the two existing streams are provided in Figure 3.11 and Figure 3.12.

The details of the u-channel, catchpit, stepped channel, grating, concrete cover and sand traps are provided in Appendix H.

3.2.3 Surface Runoff from Other Catchments

The surface runoff from catchments AA to AZ and catchments BA to BL will be discharged to existing Stream 1 and Stream 2, respectively. Table 3.2 summarises the catchment served for Stream 1 and Stream 2.

Table 3.2 Surface Runoff from Catchments to Stream 1 and Stream 2

Stream	Catchment served
1	AA to AZ A to E, G, J to N R1 to R5
2	BA to BL F, H, I

3.3 Assessment Results

The surface runoff from the Site and relevant catchments has been estimated. The capacity of the proposed U-channels, circular pipes, stepped channels, nearby culverts and existing streams were also assessed. Detailed calculations are provided in Appendix B. The location of checkpoints for Stream 1 and Stream 2 is provided in Figure 3.3. The results are summarised in Table 3.2 to Table 3.9.

Table 3.3 Estimated Capacities of the U-Channel Associated with Existing Stream 1

Channel Segment	Diameter / Width, m	Depth, m	Gradient	Catchment Runoff, m3/s	Capacity with Sedimentation, m3/s	% of capacity flow	Sufficient Capacity?
A1 - A2	0.600	0.600	0.017	0.199	0.375	53%	Y
A2 - A3	0.600	0.600	0.020	0.199	0.411	48%	Y
A3 - A4	0.600	0.600	0.029	0.199	0.491	41%	Y
A4 - A5	0.800	0.800	0.025	0.528	0.989	53%	Y
A5 - A6	0.800	0.800	0.013	0.528	0.722	73%	Y
A6 - A7	0.800	0.800	0.013	0.528	0.722	73%	Y
A7 - A8	0.800	0.800	0.013	0.528	0.722	73%	Y
A8 - A9	0.800	0.800	0.013	0.528	0.722	73%	Y
A9 - A10	0.800	0.800	0.013	0.528	0.722	73%	Y
A10 - A11	0.800	0.800	0.013	0.528	0.722	73%	Y
A11 - A12	0.800	0.800	0.013	0.528	0.722	73%	Y
A12 - A13	0.800	0.800	0.014	0.528	0.748	71%	Y
A14 - A15	0.800	0.800	0.020	0.736	1.022	72%	Y
A15 - A16	0.800	0.800	0.020	0.736	1.022	72%	Y
A17 - A18	0.900	0.900	0.017	0.765	1.301	59%	Y
A18 - A19	0.900	0.900	0.017	0.765	1.301	59%	Y
A19 - A20	0.900	0.900	0.017	0.783	1.301	60%	Y

Channel Segment	Diameter / Width, m	Depth, m	Gradient	Catchment Runoff, m3/s	Capacity with Sedimentation, m3/s	% of capacity flow	Sufficient Capacity?
A20 - A21	0.900	0.900	0.017	0.783	1.301	60%	Y
A21 - A22	0.900	0.900	0.017	0.827	1.301	64%	Y
A22 - A23	0.900	0.900	0.017	0.827	1.290	64%	Y
A23 - A24	0.900	0.900	0.014	0.827	1.194	69%	Y
A24 - A25	0.900	0.900	0.014	0.877	1.194	73%	Y
C1 - C2	0.700	0.700	0.020	0.528	0.723	73%	Y
C2 - C3	0.700	0.700	0.020	0.528	0.723	73%	Y
C3 - C4	0.800	0.800	0.019	0.736	1.012	73%	Y
C5 - C6	0.850	0.850	0.013	0.736	0.971	76%	Y
C6 -C7	0.850	0.850	0.018	0.736	1.160	63%	Y
C7 - C8	0.850	0.850	0.018	0.736	1.160	63%	Y
C9 - C10	0.850	0.850	0.017	0.765	1.107	69%	Y
C10 - C11	0.850	0.850	0.017	0.765	1.107	69%	Y
C11 - C12	0.850	0.850	0.018	0.783	1.157	68%	Y
C12 - C13	0.850	0.850	0.018	0.789	1.157	68%	Y
C13 - C14	0.850	0.850	0.016	0.789	1.081	73%	Y
C14 - C15	0.850	0.850	0.015	0.789	1.047	75%	Y

Table 3.4 Estimated Capacities of the Stepped Channel Associated with Existing Stream 1

Channel Segment	Depth , m	Width, m	Gradient (Degree)	Catchment Runoff, m3/s	Capacity with Sedimentation, m3/s	% of capacity flow	Sufficient Capacity?
A13 - A14	0.850	900	20	0.7360	1.319	56%	Y
A16 - A17	0.850	0.900	20	0.736	1.319	56%	Y
C4 - C5	0.850	0.900	20	0.736	1.319	56%	Y

Table 3.5 Estimated Capacities of the Circular Pipes Associated with Existing Stream 1

Channel Segment	Diameter / Width, m	Depth, m	Gradient	Catchment Runoff, m3/s	Capacity with Sedimentation, m3/s	% of capacity flow	Sufficient Capacity?
A25 - E1	0.900	0.900	0.033	0.883	4.303	21%	Y
E1 - E2	0.900	0.900	0.033	0.888	4.303	21%	Y
E2 - E3	0.900	0.900	0.033	0.891	4.303	21%	Y
E3 - E4	0.900	0.900	0.033	0.893	4.303	21%	Y
E4 - E5	0.900	0.900	0.033	0.894	4.303	21%	Y
E5 - E6	0.900	0.900	0.010	0.895	2.277	39%	Y
CA 1	1.050	1.050	0.0014	0.895	1.225	73%	Y

Table 3.6 Estimated Capacities of the U-Channels Associated with the Existing Stream 2

Channel Segment	Diameter / Width, m	Depth, m	Gradient	Catchment Runoff, m3/s	Capacity with Sedimentation, m3/s	% of capacity flow	Sufficient Capacity?
A1 - B1	0.300	0.300	0.011	0.041	0.056	74%	Y
B1 - B2	0.300	0.300	0.011	0.041	0.056	74%	Y
B2 -B3	0.300	0.300	0.033	0.041	0.097	43%	Y
B3 - B4	0.450	0.450	0.033	0.210	0.287	73%	Y
B4 - B5	0.450	0.450	0.033	0.210	0.287	73%	Y
B5 - B6	0.450	0.450	0.040	0.237	0.315	75%	Y
B6 - B7	0.450	0.450	0.040	0.237	0.315	75%	Y
B8 - B9	0.600	0.600	0.029	0.237	0.573	41%	Y
B10 - B11	0.650	0.650	0.008	0.237	0.383	62%	Y
D1 - D2	0.450	0.450	0.042	0.1682	0.321	52%	Y
D2 - D3	0.450	0.450	0.040	0.1682	0.315	53%	Y
D4 - D5	0.600	0.600	0.020	0.168	0.479	35%	Y

Table 3.7 Estimated Capacities of the Stepped Channel Associated with the Existing Stream 2

Channel Segment	Depth, m	Width, m	Gradient (Degree)	Catchment Runoff, m3/s	Capacity with Sedimentation, m3/s	% of capacity flow	Sufficient Capacity?
B7 - B8	0.575	0.450	20	0.237	0.34	70%	Y
B9 - B10	0.650	0.600	46	0.237	0.37	63%	Y
D3 - D4	0.575	0.450	20	0.168	0.34	50%	Y
D5 - B11	0.650	0.600	42	0.168	0.40	42%	Y

Table 3.8 Estimated Capacities of the Circular Pipes Associated to Existing Stream 2

Channel Segment	Diameter / Width, m	Depth, m	Gradient	Catchment Runoff, m3/s	Capacity with Sedimentation, m3/s	% of capacity flow	Sufficient Capacity?
CB1	0.650	0.650	0.020	0.237	1.426	17%	Y

Table 3.9 Estimated Capacities of the Existing Stream 1 and Stream 2

Stream	Diameter / Width, m	Depth, m	Gradient	Catchment Runoff, m3/s	Capacity, m3/s	% of capacity flow	Sufficient Capacity?
Stream 1	Top Width: 4 Bottom Width: 2	1.300	0.100	15.691	25.193	62%	Y
Stream 2	Top Width: 3 Bottom Width: 1	1.300	0.050	5.081	10.425	49%	Y

Table 3.10 Estimated Runoffs to the Existing Culvert 1 and Culvert 2

Culvert	Diameter / Width, m	Depth, m	Gradient	Catchment Runoff, m3/s	Capacity with Sedimentation, m3/s	% of capacity flow	Sufficient Capacity?
Culvert 1 (Box Culvert)	1m per cell (2 cells in total)	1.600	0.100	14.082	43.31	33%	Y

Culvert 2 (Circular Culvert)	0.850	-	0.050	4.848	1.233	393%	N

With the provision of the proposed drainage system, the surface runoff will eventually discharge into the two existing streams and the two culverts underneath Sha Tau Kok Road as shown in Figure 3.2. Given the estimated capacities of culvert 2 is insufficient to cater the estimated runoff, an upgrading works in the culvert is proposed. The estimated capacity of Culvert 2 after the upgrading works is summarised in Table 3.11.

Table 3.11 Estimated Capacities of Culvert 2 After Upgrading Work

Culvert	Diameter / Width, m	Depth, m	Gradient	Catchment Runoff, m3/s	Capacity with Sedimentation, m3/s	% of capacity flow	Sufficient Capacity?
Culvert 2 (Circular Culvert)	1.600	-	0.050	4.848	7.237	67%	Y

After the Proposed Upgrading works, Culvert 2 will have sufficient capacity to cater the estimated runoff. Therefore, no adverse drainage impact assessment is anticipated.

3.4 Freeboard of the Existing Streams

Freeboard is assessed to ensure there is sufficient safety margin to prevent overtopping and flooding. The Freeboard before and after the Proposed Development has increased 15% and 13% in Stream 1 and Stream 2. Respectively. As the freeboard of the two streams before and after the Proposed Development exceeds 300 mm, no adverse impacts on the streams are expected to result from the Proposed Development. The identified catchment without the Proposed Development is indicated in Figure 3.7. Detailed calculations of the freeboard for both streams before and after the Proposed Development is provided in Appendix F and Appendix G, respectively and the result of freeboard calculation is provided in Table 3.12.

Table 3.12 Freeboard before and after the Proposed Development

Stream	Freeboard before the Proposed Development, m	Freeboard after the Proposed Development, m	Percentage Increase, %
Stream 1	0.4205	0.5712	15%
Stream 2	0.3977	0.5208	13%

Therefore, the Proposed Development would not cause any adverse drainage impacts or increase in the flooding susceptibility of the surrounding areas.

3.5 Climate Change

As per Section 3.1.6, rainfall increase due to climate change of 11.1% and 16.0% at the mid-21st century and end of 21st Century, as well as design allowance at the end of 21st century of 12.1% are considered in the assessment. The hydraulic calculation is provided in Appendix C to Appendix E. The result shows that the proposed drainage system and downstream watercourses would have sufficient capacity for the additional runoff from the proposed site development due to increase of rainfall intensity.

3.6 Tidal Effect

As per Section 3.1.5, the extreme sea level at the end of the 21st century is estimated to be 5.13 mPD. The invert level of the proposed underground circular pipe is 5.18 mPD for CA1 and 5.60mPD for CB1. Therefore, the proposed scheme would not be affected by tidal effect obstructing the discharge of the surface runoff from the subject lots.

4 Recommendations

4.1 Construction stage

For the construction stage, the engineer and contractor will be appointed by the Project Proponent to prepare drainage proposal for temporary works or temporary mitigation measures and monitoring requirements / programme, which will be submitted to DSD for approval before the commencement of the construction works. The approved drainage impact mitigation measures and the monitoring requirements / programme during the construction stage will be implemented to ensure that the expected drainage performance of the project is achieved.

4.2 Operation Stage

Upon detailed design stage, the Project Proponent will appoint the engineer and contractor to design and construct the proposed drainage system. The detailed arrangement of the proposed drainage system, proposed upgrading works and new drainage connections will be further investigated at the detailed design stage. Detailed information of the proposed drainage system will be prepared and submitted to the DSD and relevant parties during the detailed design stage.

The applicant undertakes to properly construct and maintain the proposed drainage works and upgrading works; and to rectify the drainage system if inadequate or ineffective is found during operation.

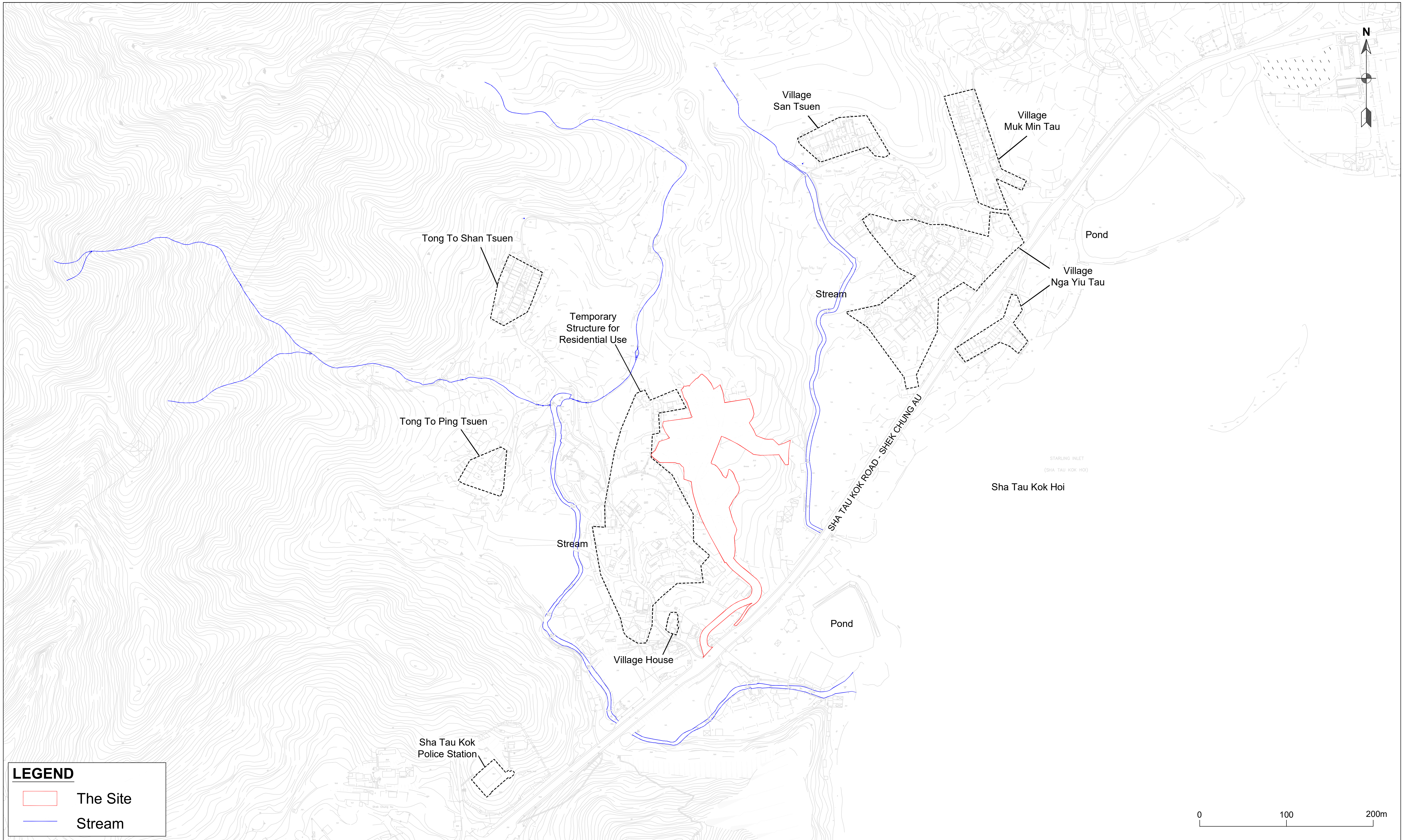
5 Conclusion

A Drainage Impact Assessment (DIA) has been conducted by Urban Green Consultants Ltd. (UGC) to serve as a supporting document for the Proposed Development at the Site at Sha Tau Kok, New Territories.

For collecting surface runoff within the Site, a series of U-channels, stepped channels and underground circular pipes should be designed and constructed. The detailed arrangement of the drainage system shall require further investigation at the detailed design stage.

The drainage analysis has demonstrated that subject to the implementation of the proposed drainage systems, the Proposed Development would not cause adverse drainage impacts or increase in the flooding susceptibility of the adjacent areas.

Figures



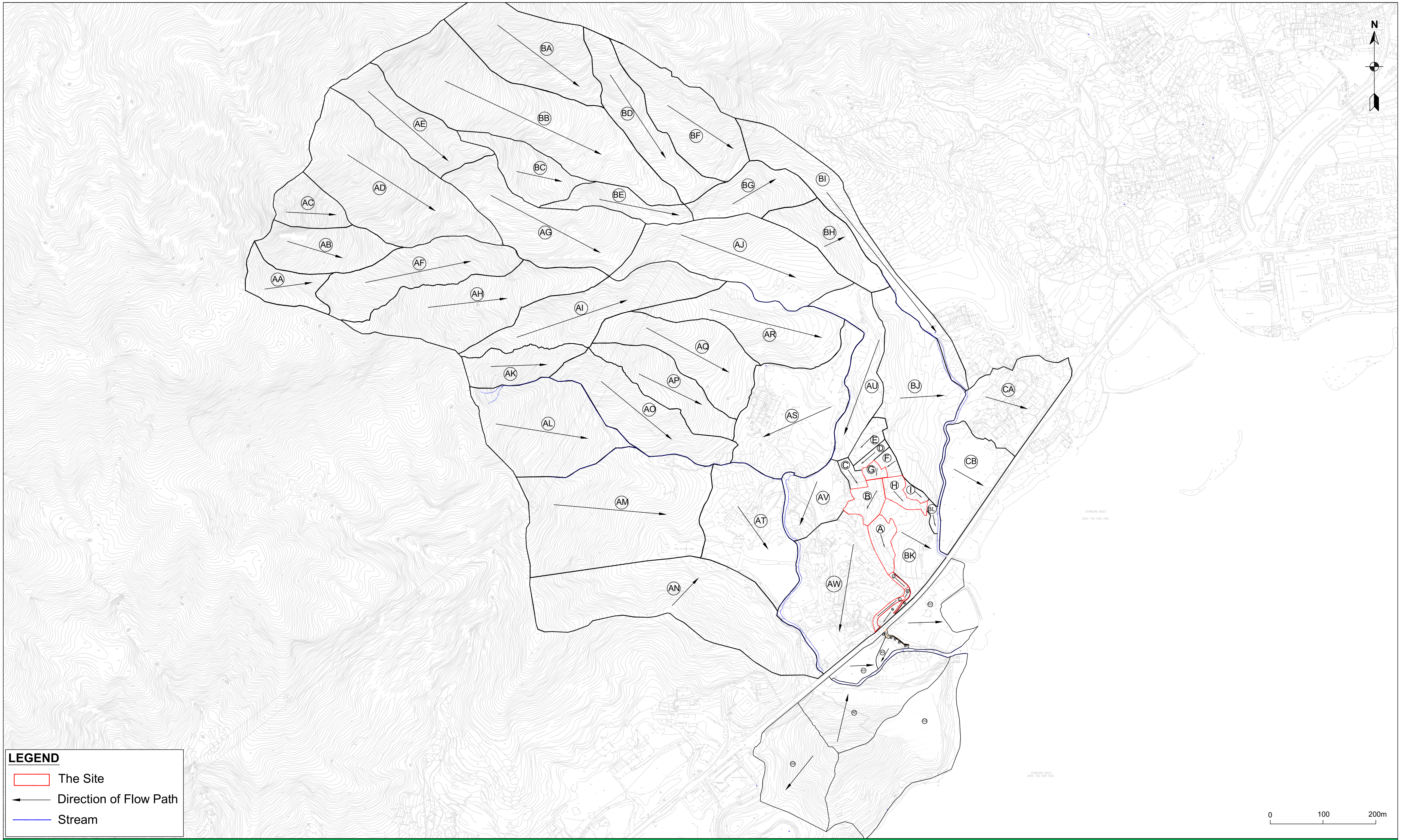
URBAN GREEN

Section 12A Rezoning Application for Proposed Columbarium on Various Lots in D.D.41, Sha Tau Kok, New Territories

Site Location and Its Envrions

Figure 2.1

Rev. 0



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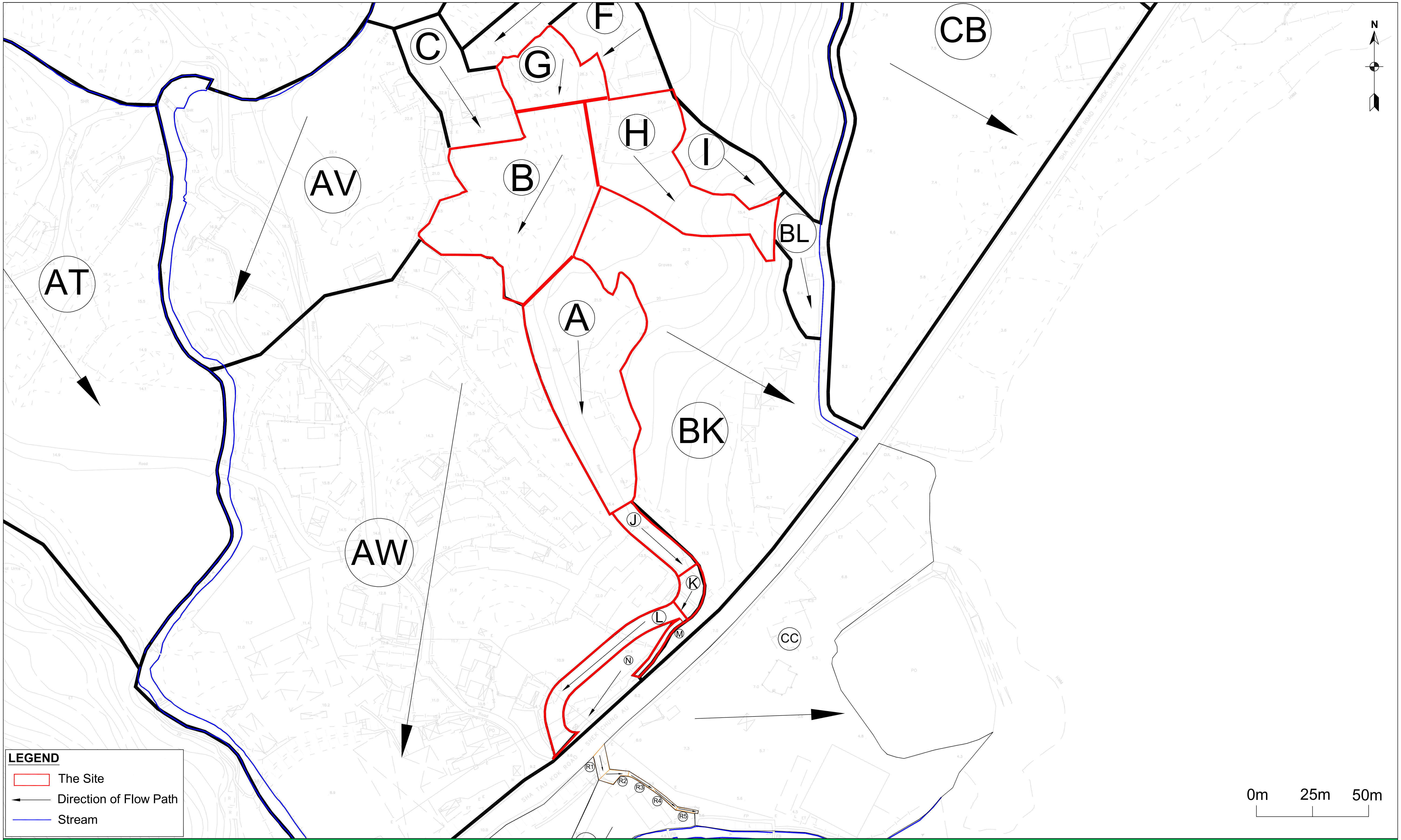
S12A Rezoning Application for Proposed Columbarium on Various Lots in D.D.41, Sha Tau Kok, New Territories

Identified Catchment Areas

Figure 3.1A

Rev. 0



S12A Rezoning Application for Proposed Columbarium on Various Lots in D.D.41, Sha Tau Kok, New Territories

Identified Catchment Areas

Figure 3.1B

Rev. 0

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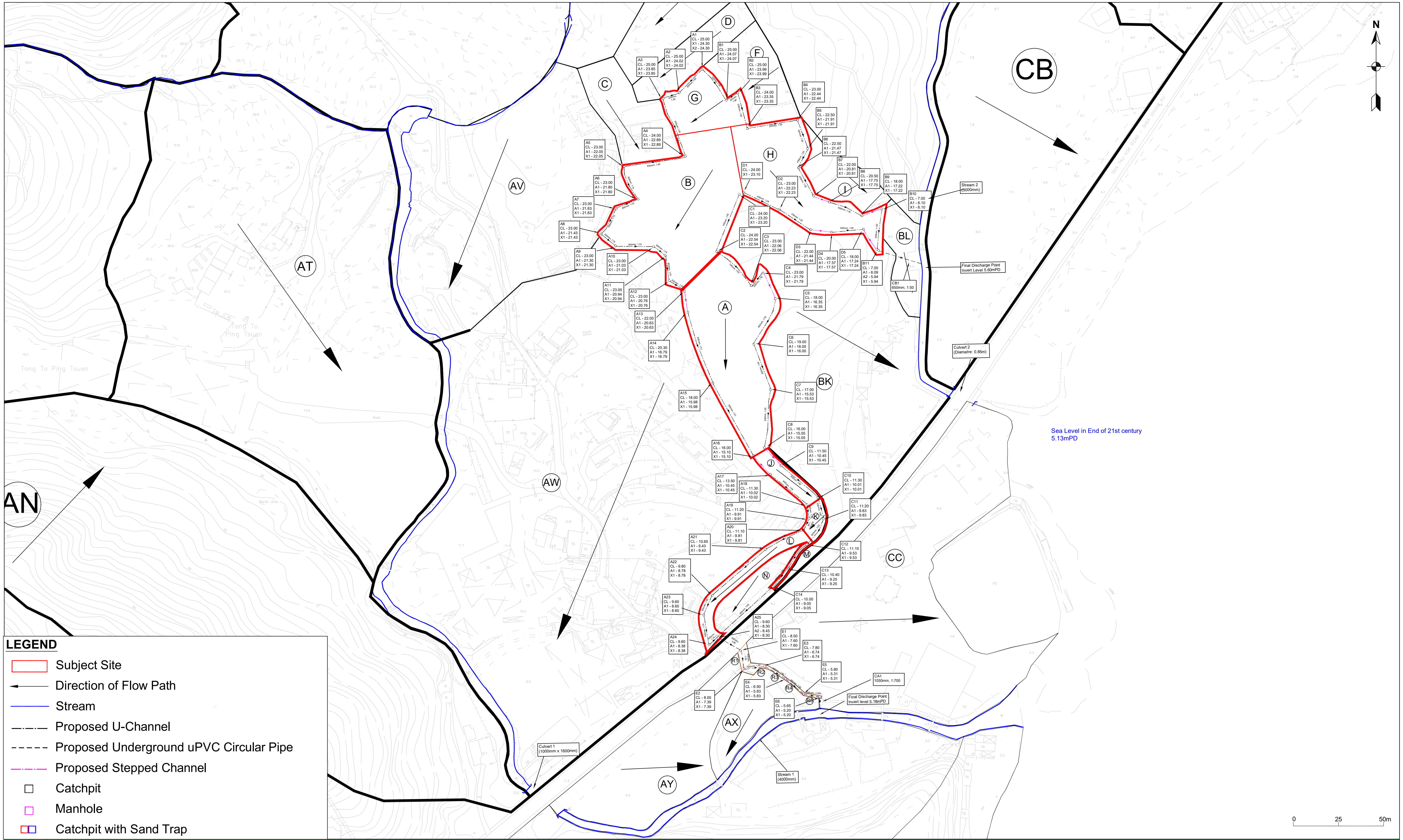

S12A Rezoning Application for Proposed Columbarium at Various Lots in D.D.41, Sha Tau Kok, New Territories

Drainage Proposal

Figure 3.2

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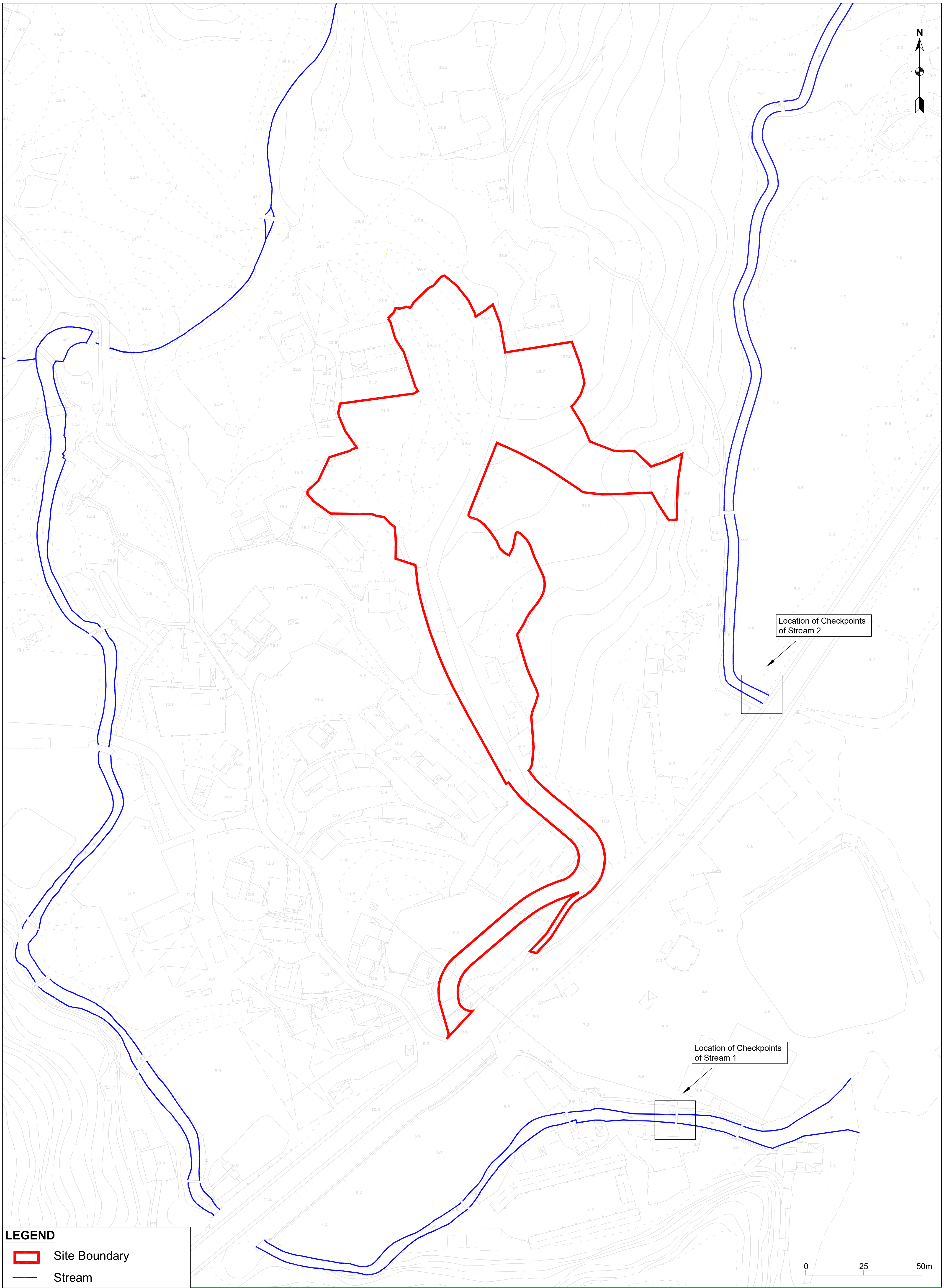

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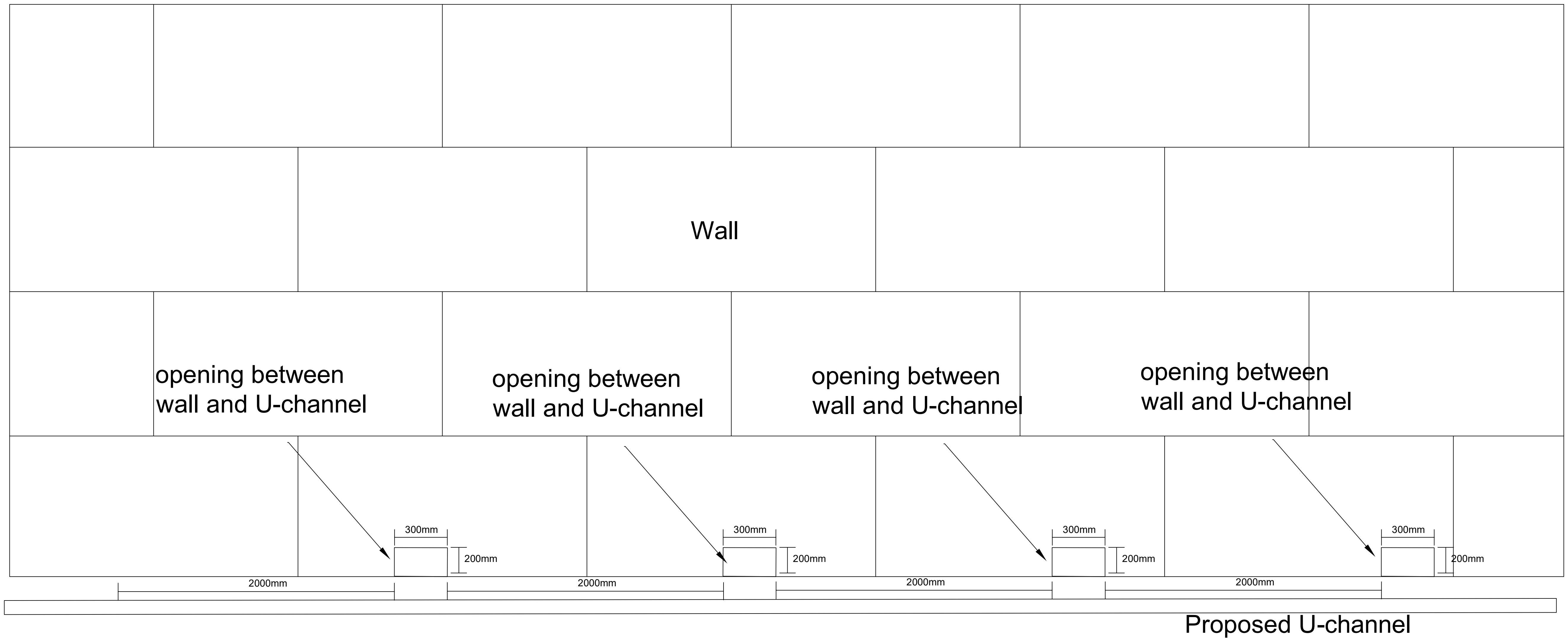
S12A Rezoning Application for Proposed Columbarium on Various Lots in D.D.41, Sha Tau Kok, New Territories

Location of Checkpoints for the Two Existing Streams

Figure 3.3

Rev. 0



Not In Scale

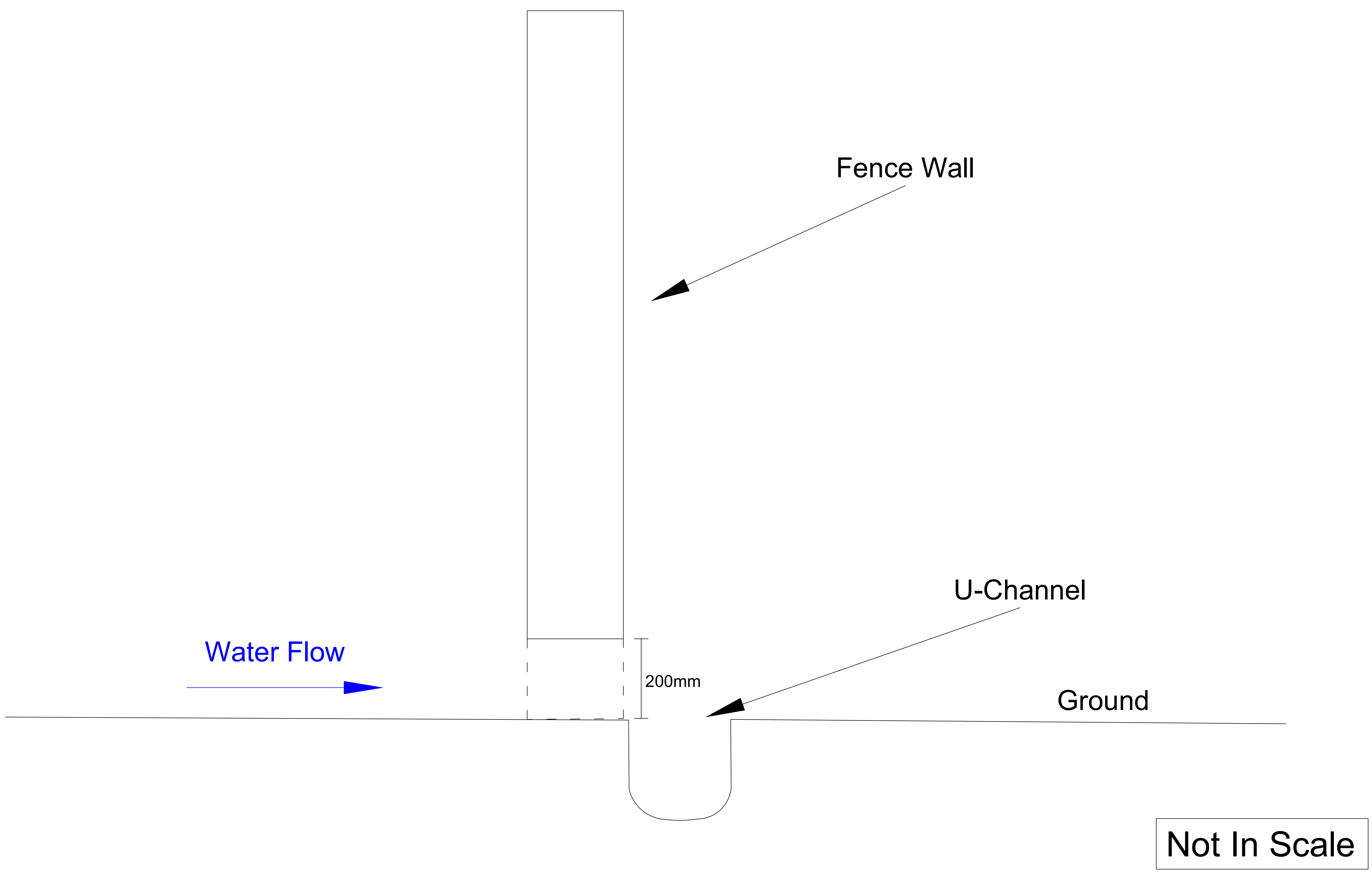
URBAN GREEN

S12A Rezoning Application for Proposed Columbarium on Various Lots in D.D.41, Sha Tau Kok, New Territories

Elevation of the Proposed Fence Wall

Figure 3.4

Rev. 0



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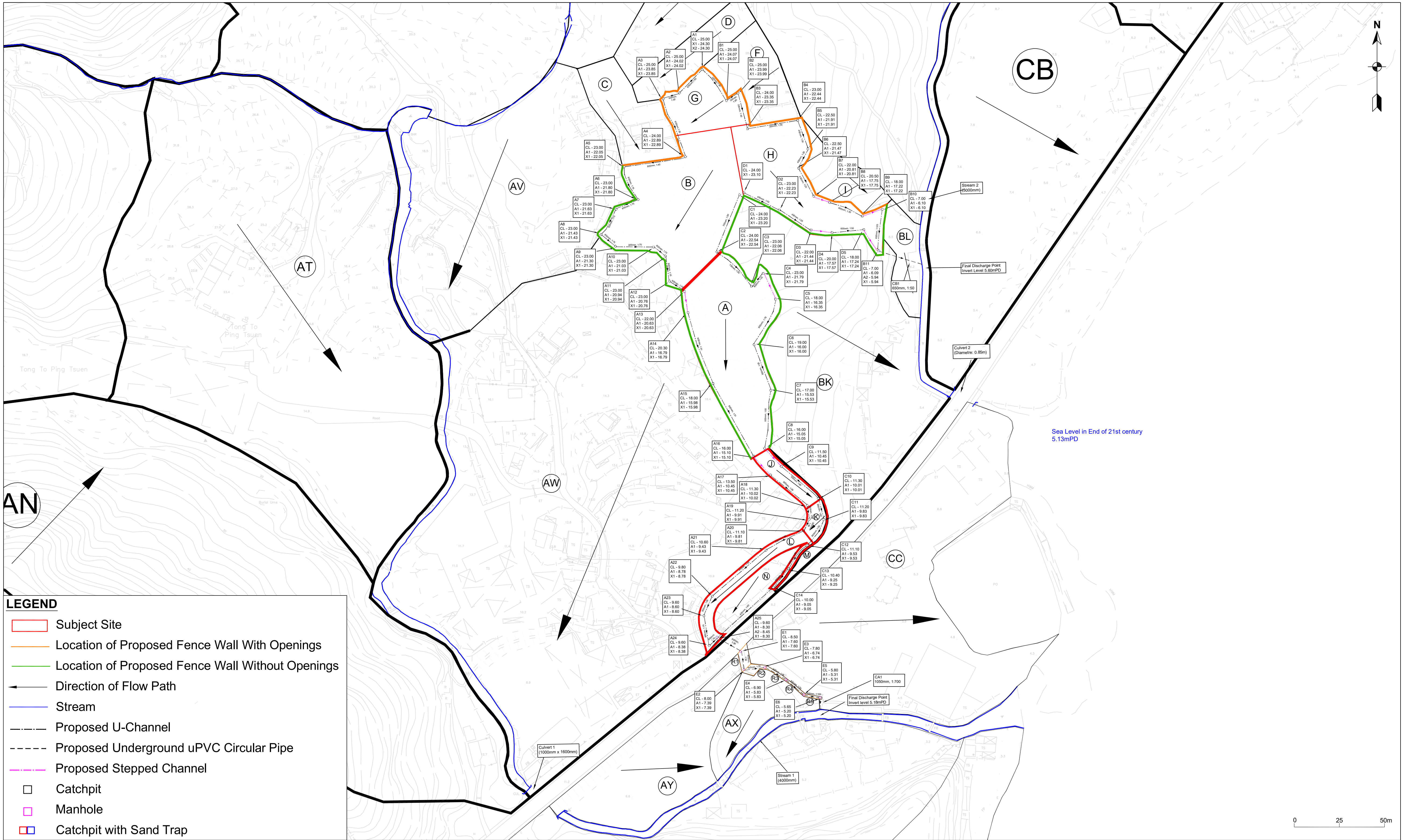
S12A Rezoning Application for Proposed Columbarium on Various Lots in D.D.41, Sha Tau Kok, New Territories

Cross Section of the Proposed Fence Wall

Figure 3.5

Rev. 0



S12A Rezoning Application for Proposed Columbarium at Various Lots in D.D.41, Sha Tau Kok, New Territories

Location of Proposed Fence Wall

Figure 3.6

Rev. 0

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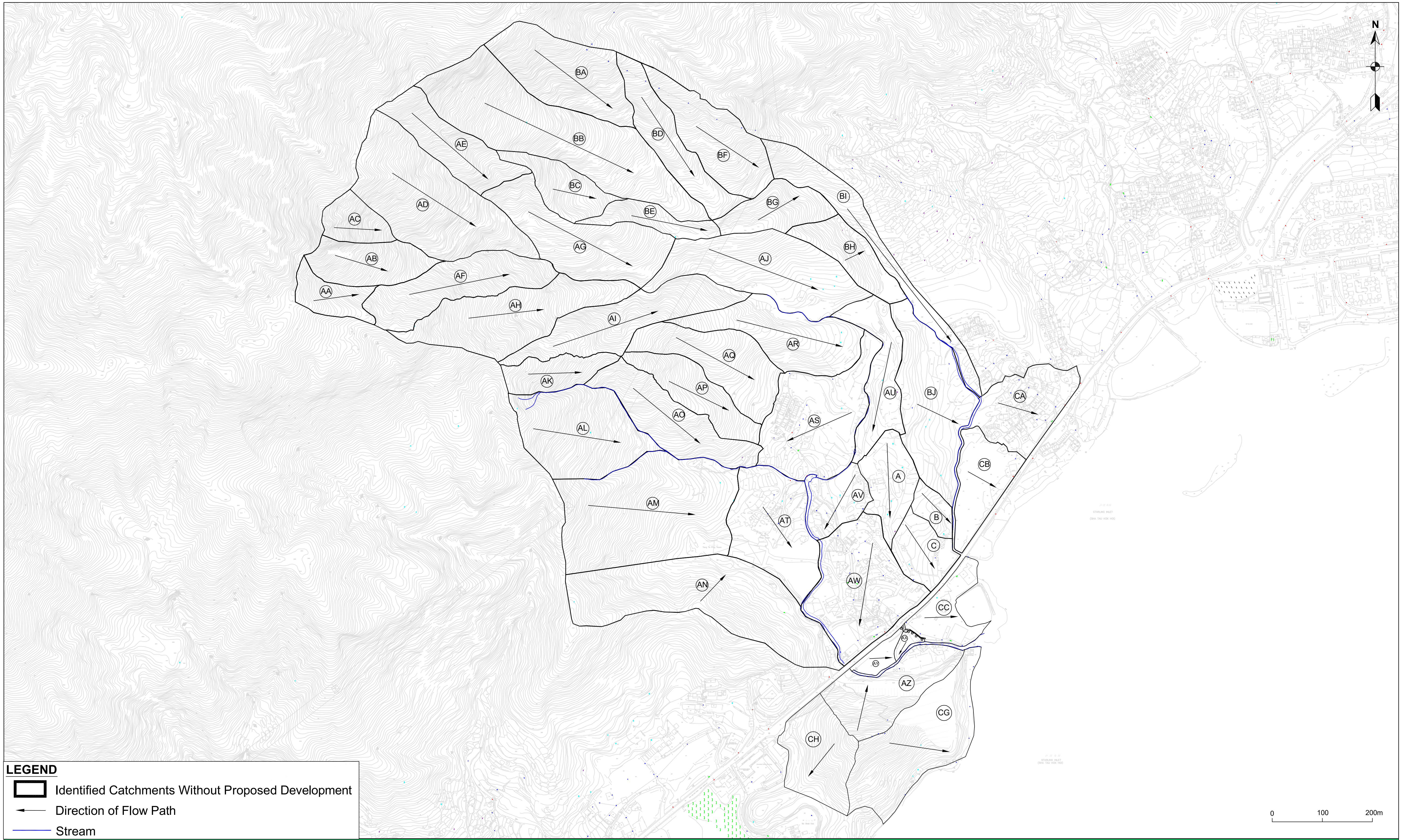

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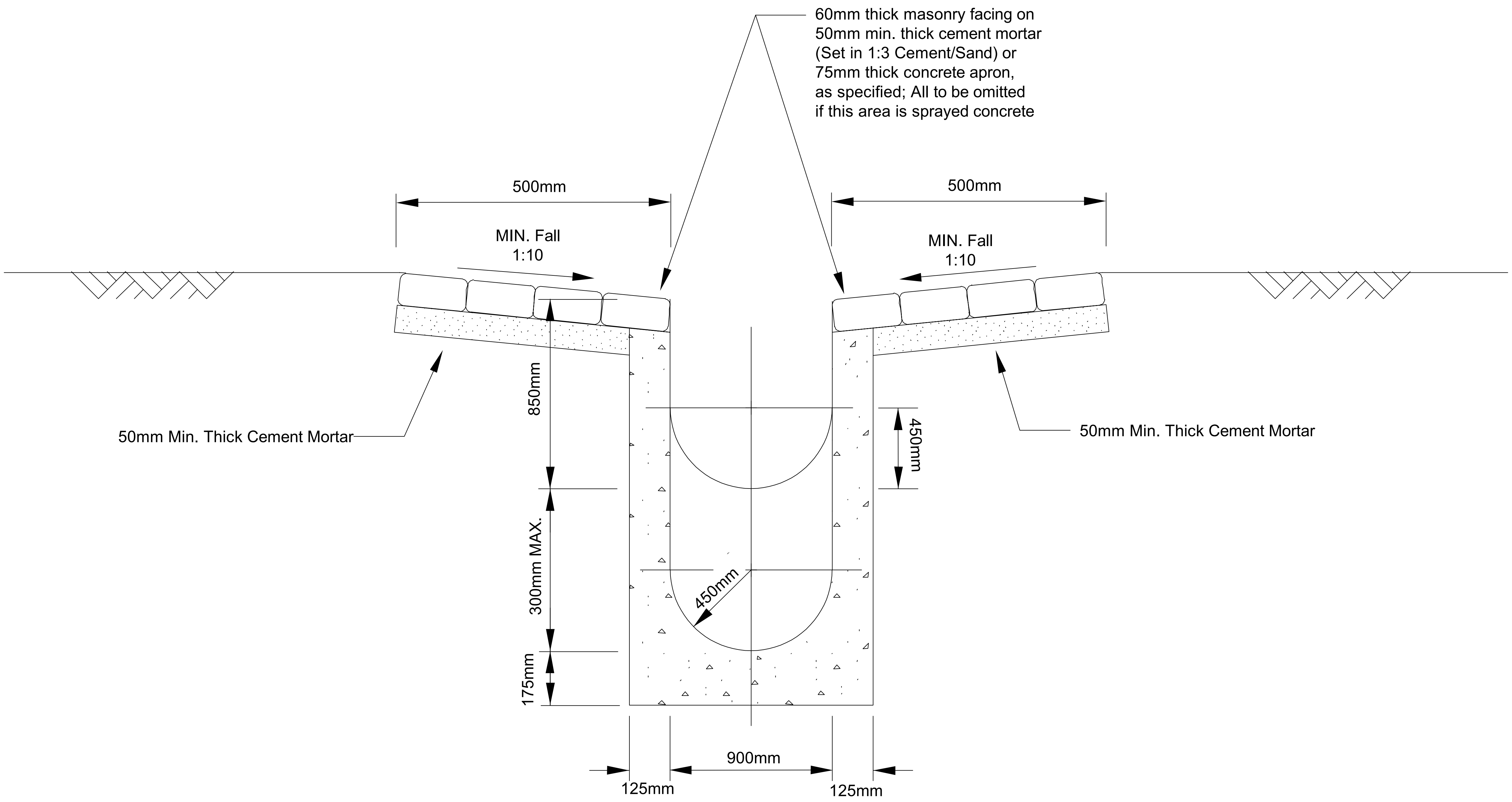
S12A Rezoning Application for Proposed Columbarium at Various Lots in D.D.41, Sha Tau Kok, New Territories

Identified Catchments Before the Proposed Development

Figure 3.7

Rev. 0



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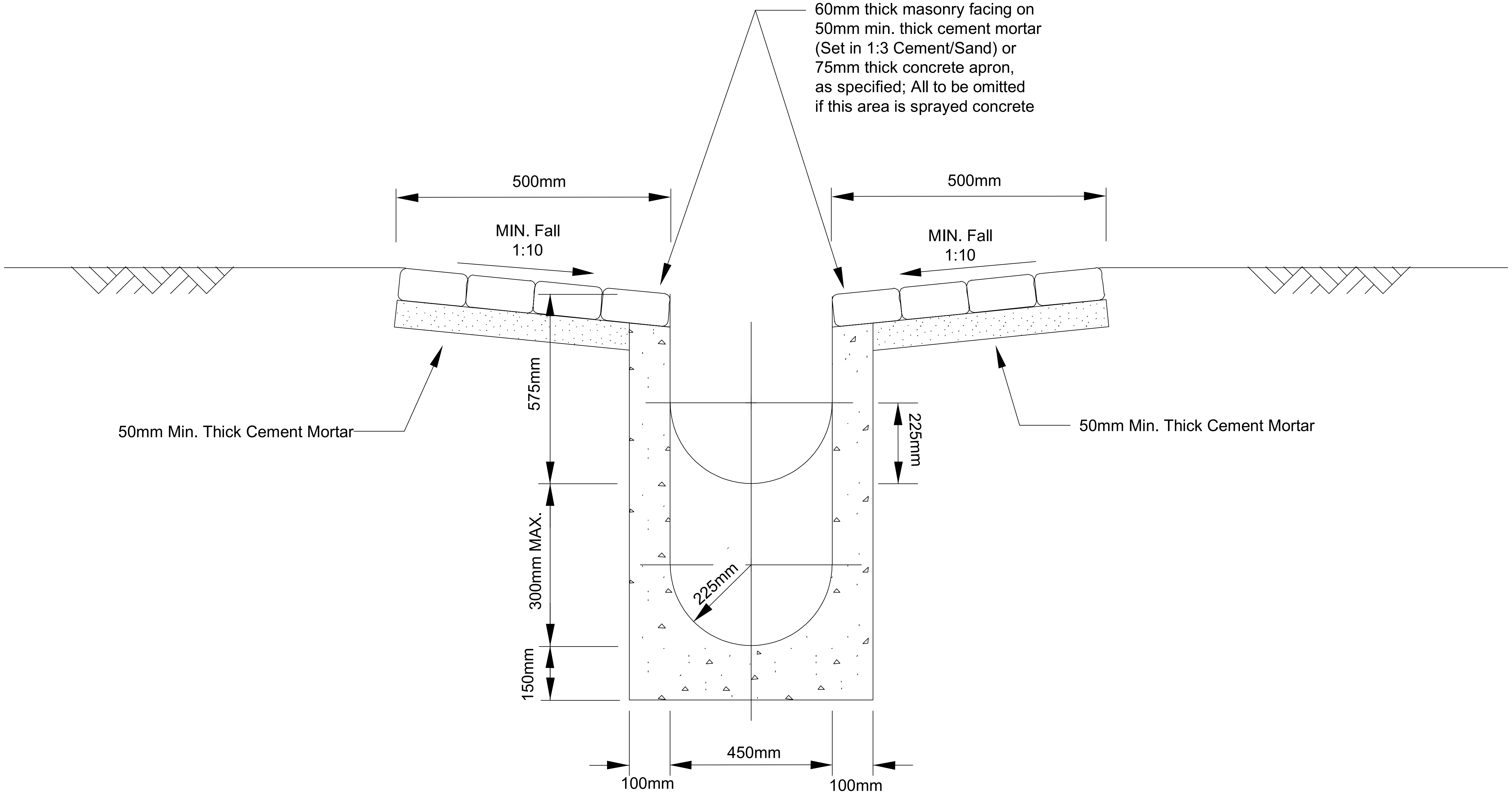
S12A Rezoning Application for Proposed Columbarium at Various Lots in D.D.41, Sha Tau Kok, New Territories

Dimensions of Proposed Stepped Channels (Segment A13 - A14, Segment A16 - A17 and Segment C4 - C5)

Figure 3.8A

Rev. 0



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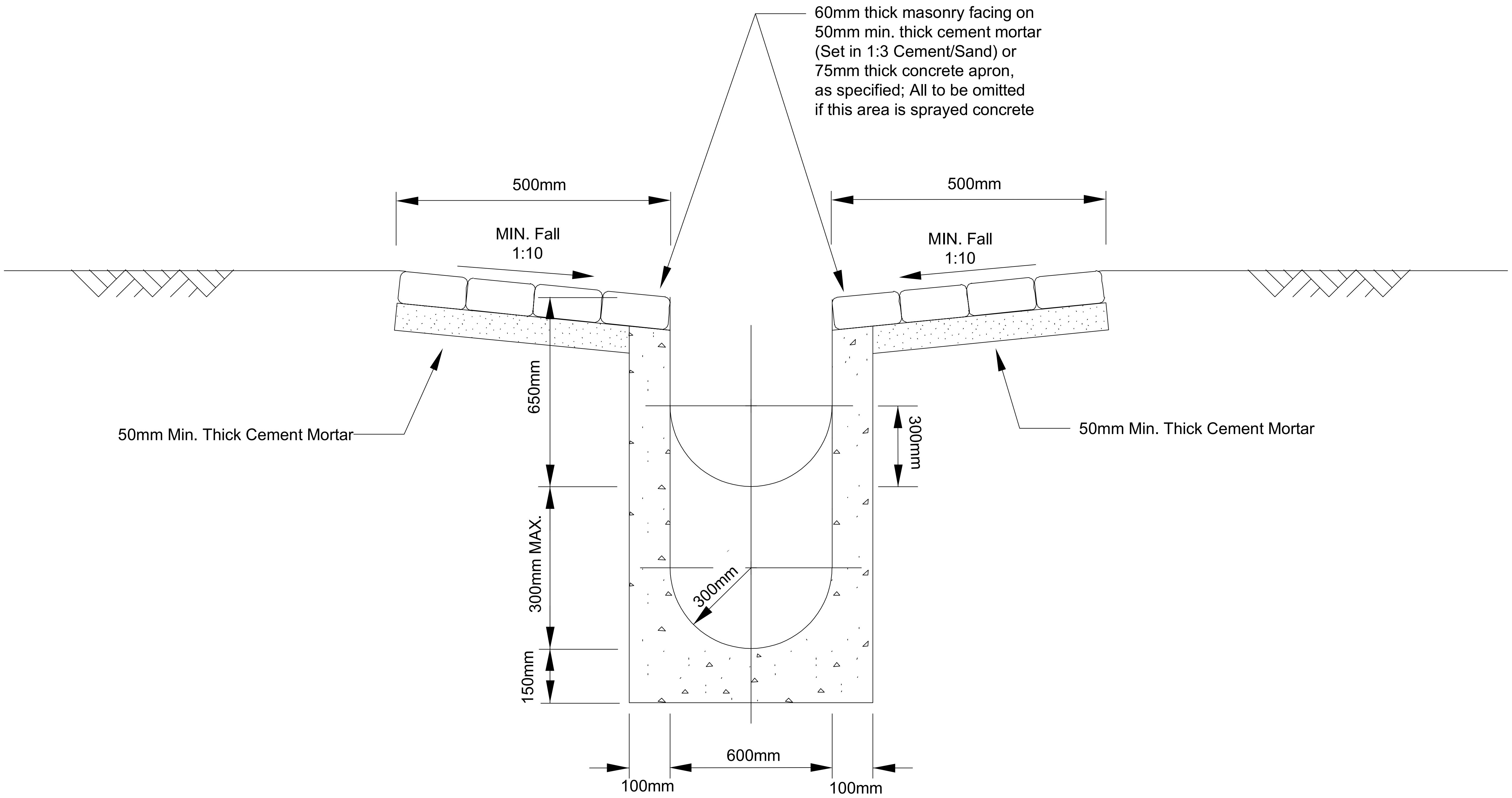
S12A Rezoning Application for Proposed Columbarium at Various Lots in D.D.41, Sha Tau Kok, New Territories

Dimensions of Proposed Stepped Channels (Segment B7 - B8 and Segment D3 - D4)

Figure 3.8B

Rev. 0



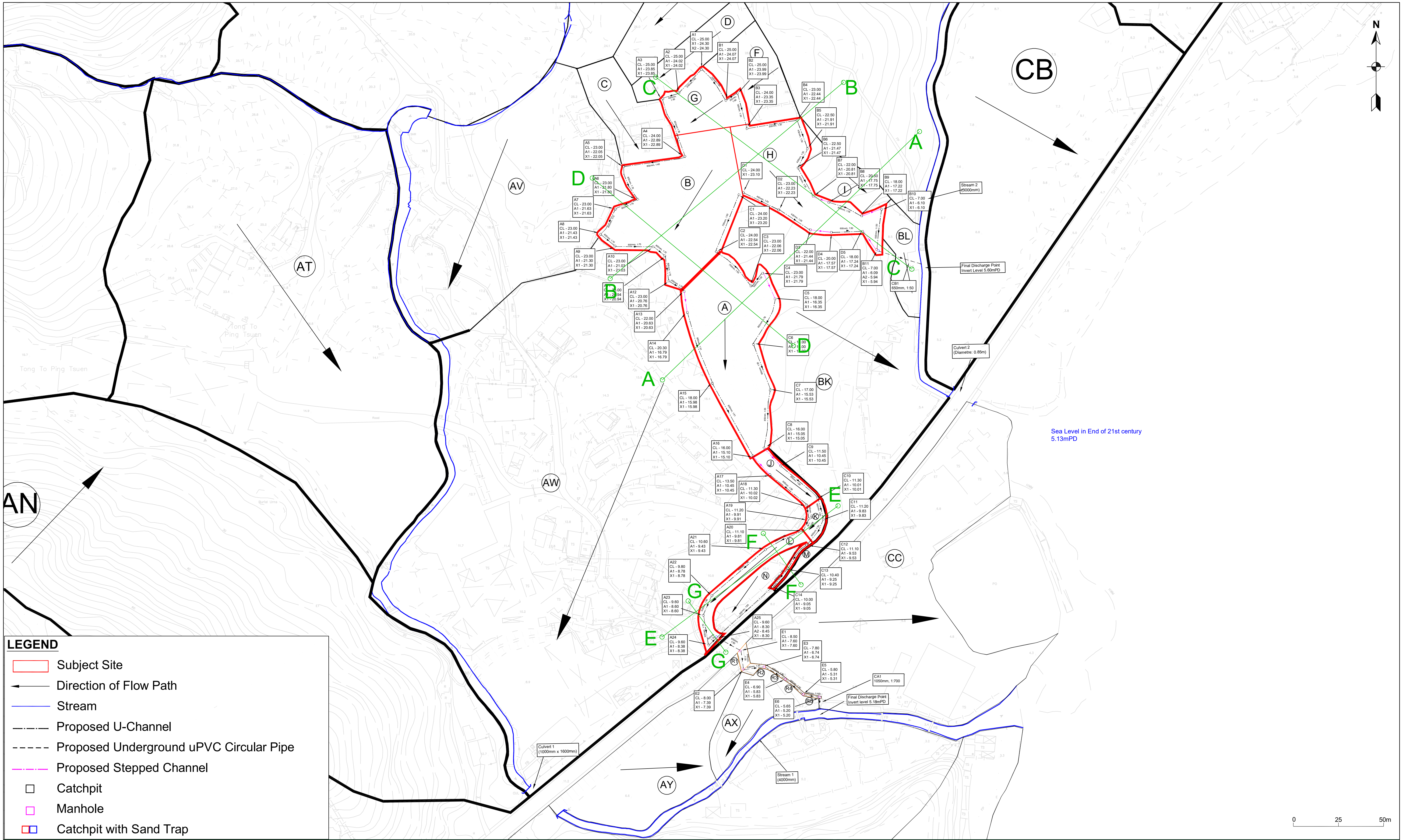
S12A Rezoning Application for Proposed Columbarium at Various Lots in D.D.41, Sha Tau Kok, New Territories

Dimensions of Proposed Stepped Channels (Segment B9 - B10 and Segment D5 - B11)

Figure 3.8C

Rev. 0

URBAN GREEN



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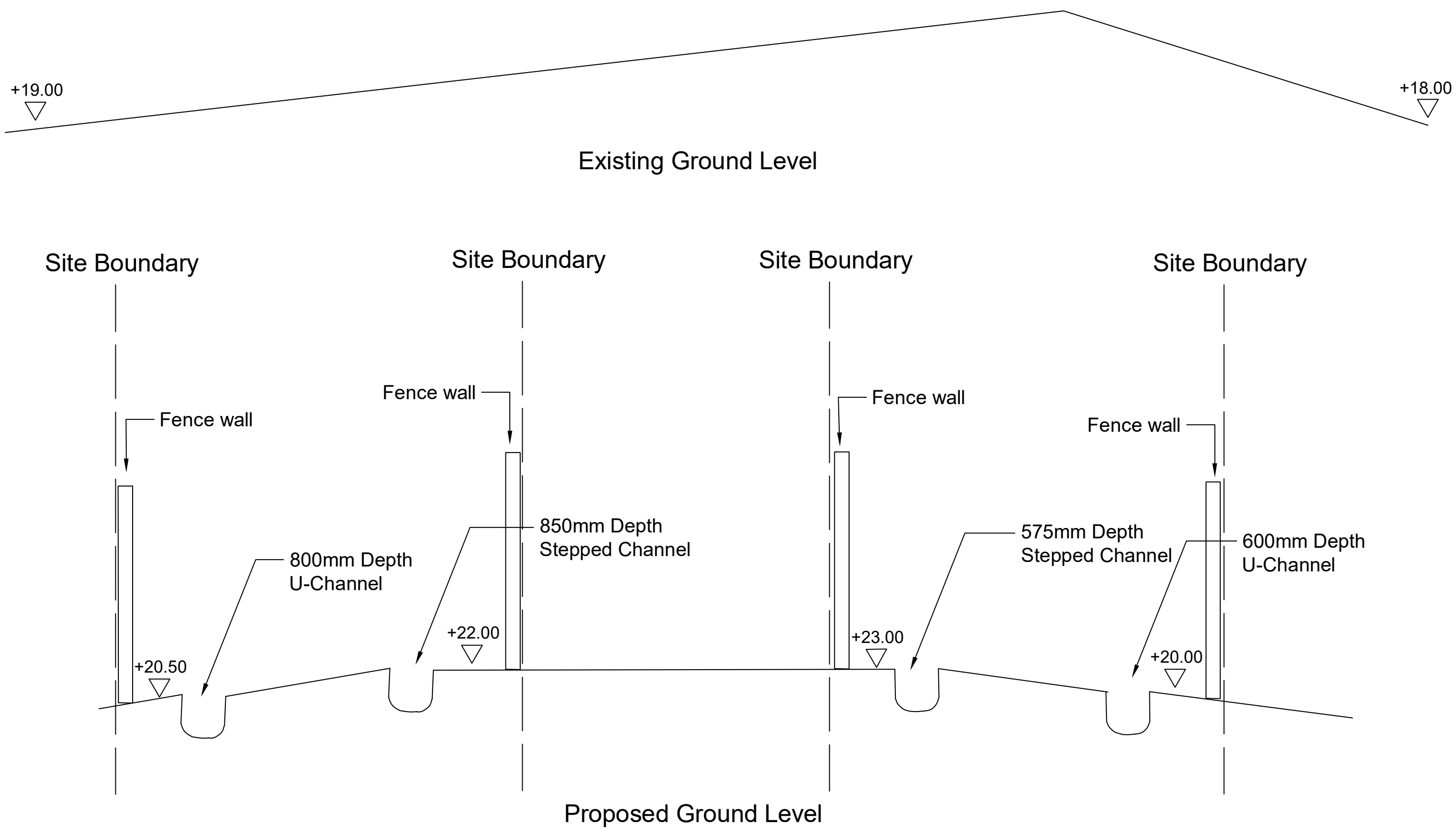
S12A Rezoning Application for Proposed Columbarium at Various Lots in D.D.41, Sha Tau Kok, New Territories

Cross Section of Existing and Proposed Ground Level

Figure 3.9

Rev. 0



SECTION A-A

NOT IN SCALE

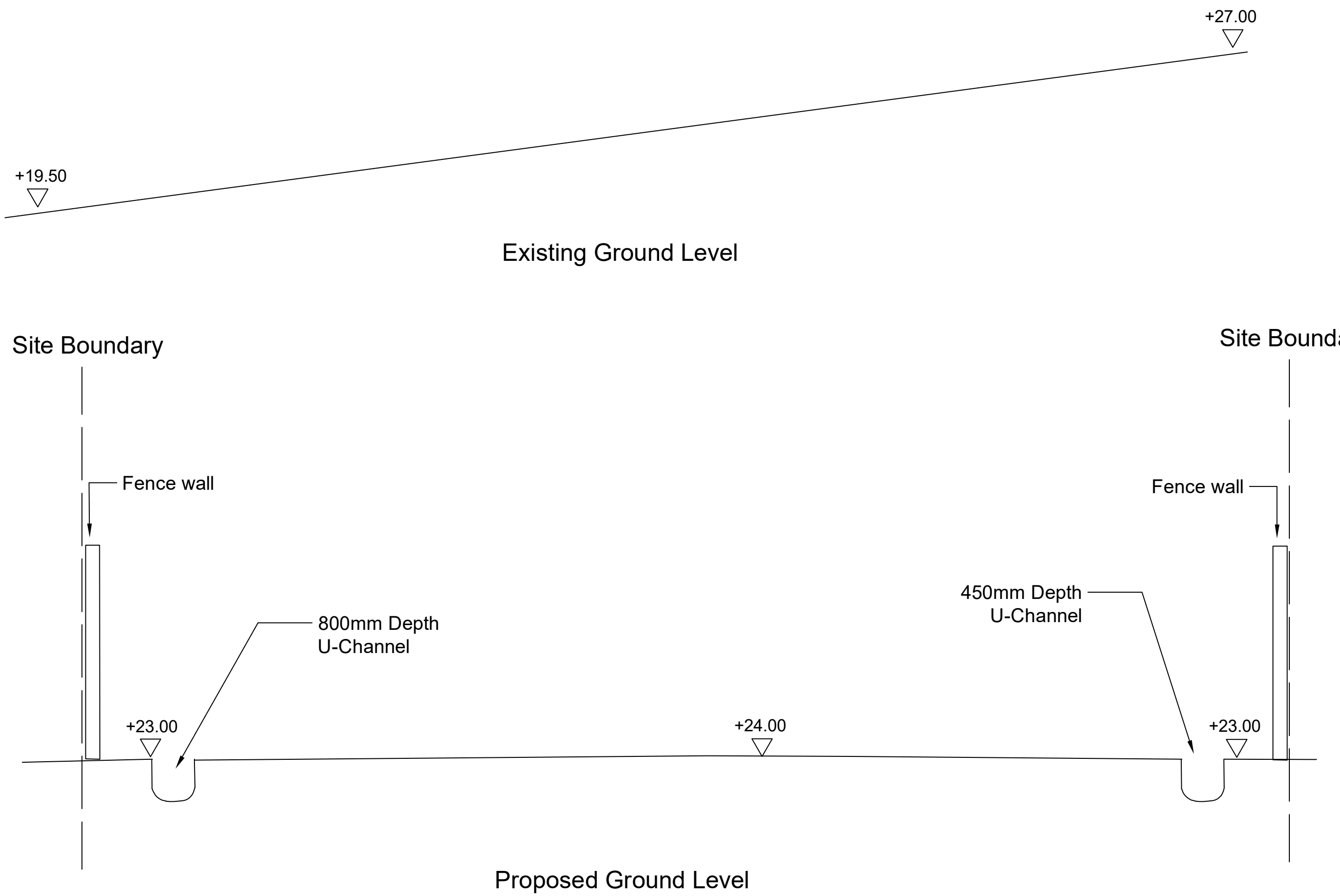
URBAN GREEN

S12A Rezoning Application for Proposed Columbarium on Various Lots in D.D.41, Sha Tau Kok, New Territories

Cross Section - Section A-A

Figure 3.10A

Rev. 0



SECTION B-B

NOT IN SCALE

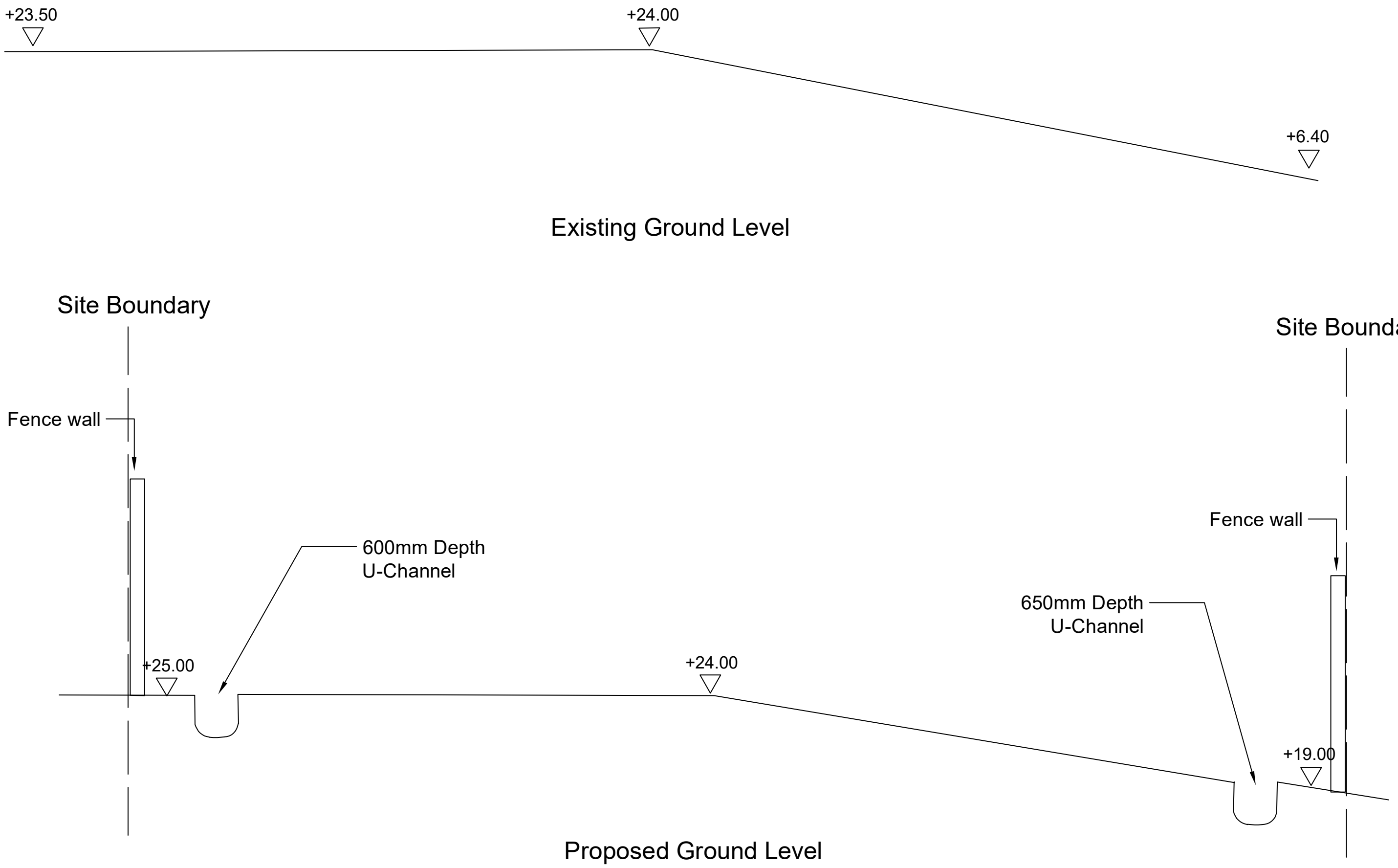
URBAN GREEN

S12A Rezoning Application for Proposed Columbarium on Various Lots in D.D.41, Sha Tau Kok, New Territories

Cross Section - Section B-B

Figure 3.10B

Rev. 0



SECTION C-C

NOT IN SCALE

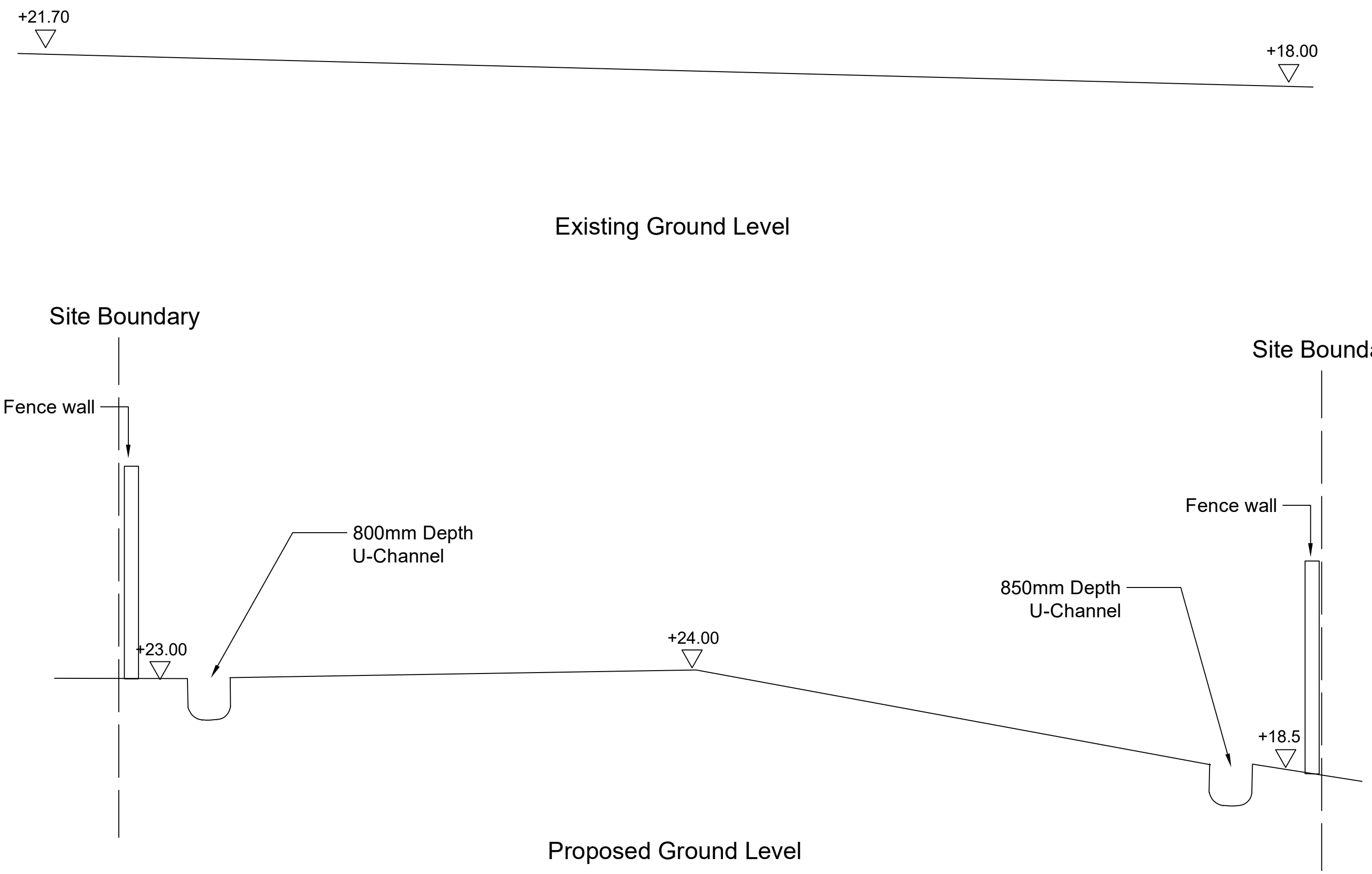
URBAN GREEN

S12A Rezoning Application for Proposed Columbarium on Various Lots in D.D.41, Sha Tau Kok, New Territories

Cross Section - Section C-C

Figure 3.10C

Rev. 0



SECTION D-D

NOT IN SCALE

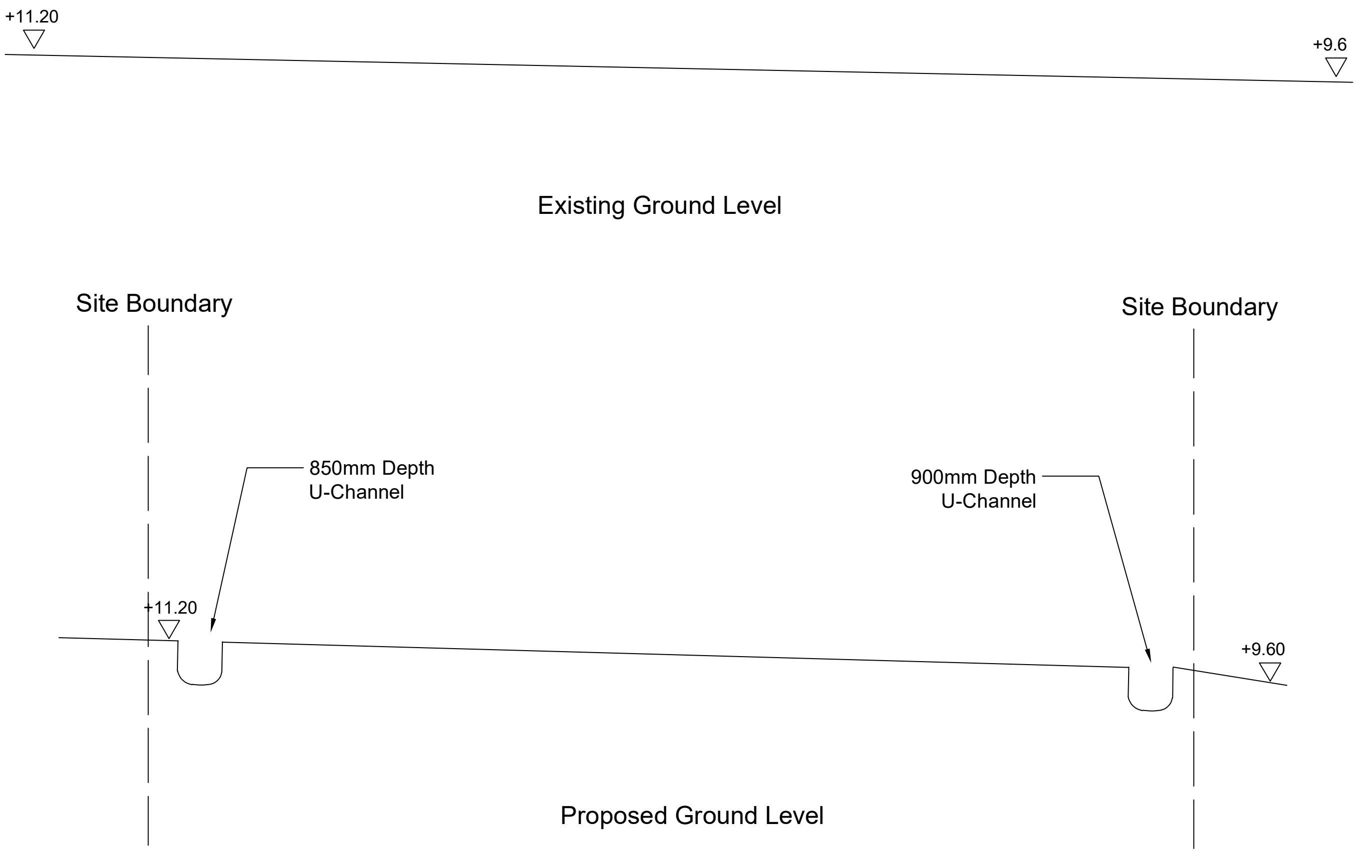
URBAN GREEN

S12A Rezoning Application for Proposed Columbarium on Various Lots in D.D.41, Sha Tau Kok, New Territories

Cross Section - Section D-D

Figure 3.10D

Rev. 0



SECTION E-E

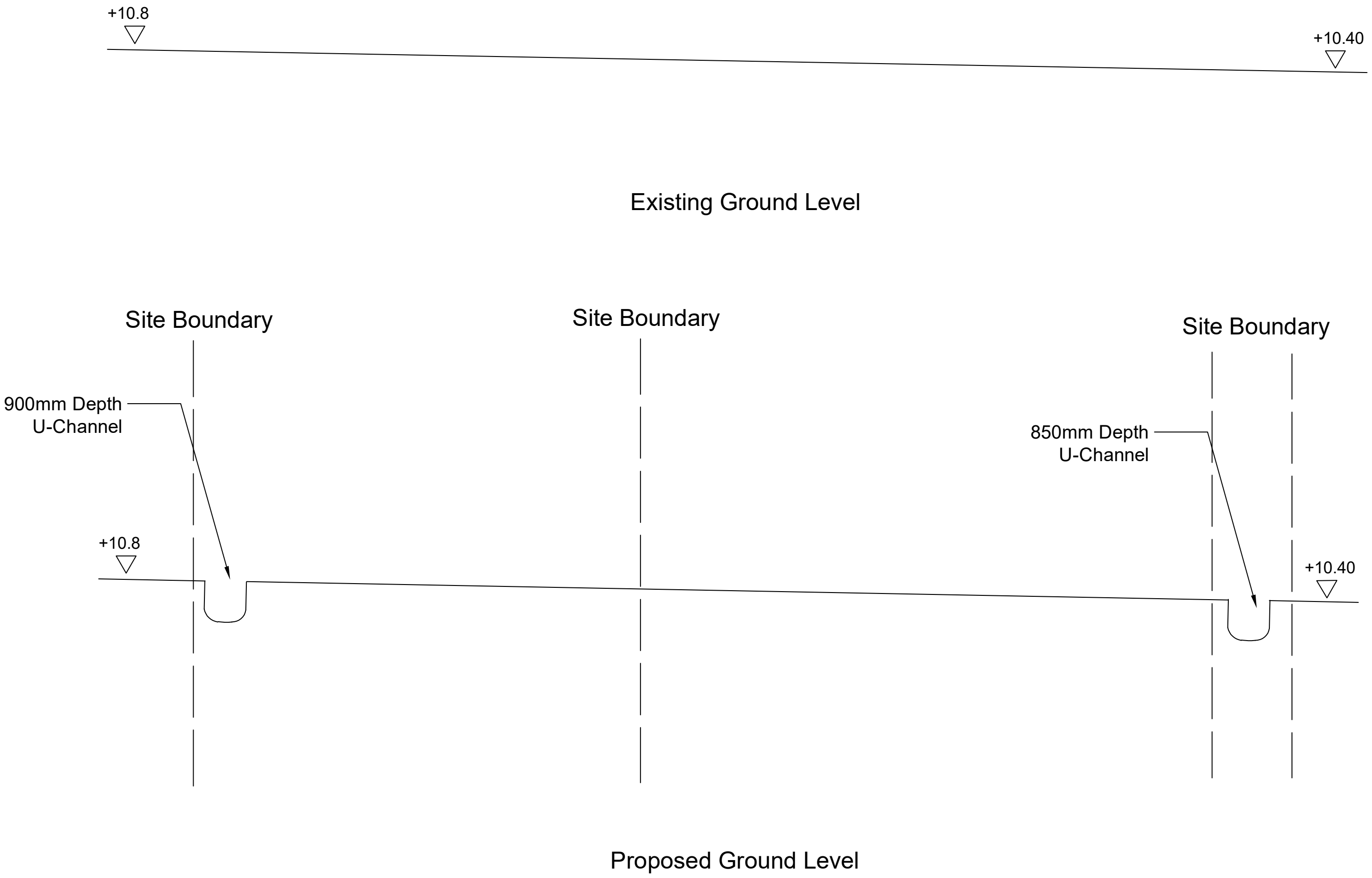
NOT IN SCALE

S12A Rezoning Application for Proposed Columbarium on Various Lots in D.D.41, Sha Tau Kok, New Territories

Cross Section - Section E-E

Figure 3.10E

Rev. 0



SECTION F-F

NOT IN SCALE

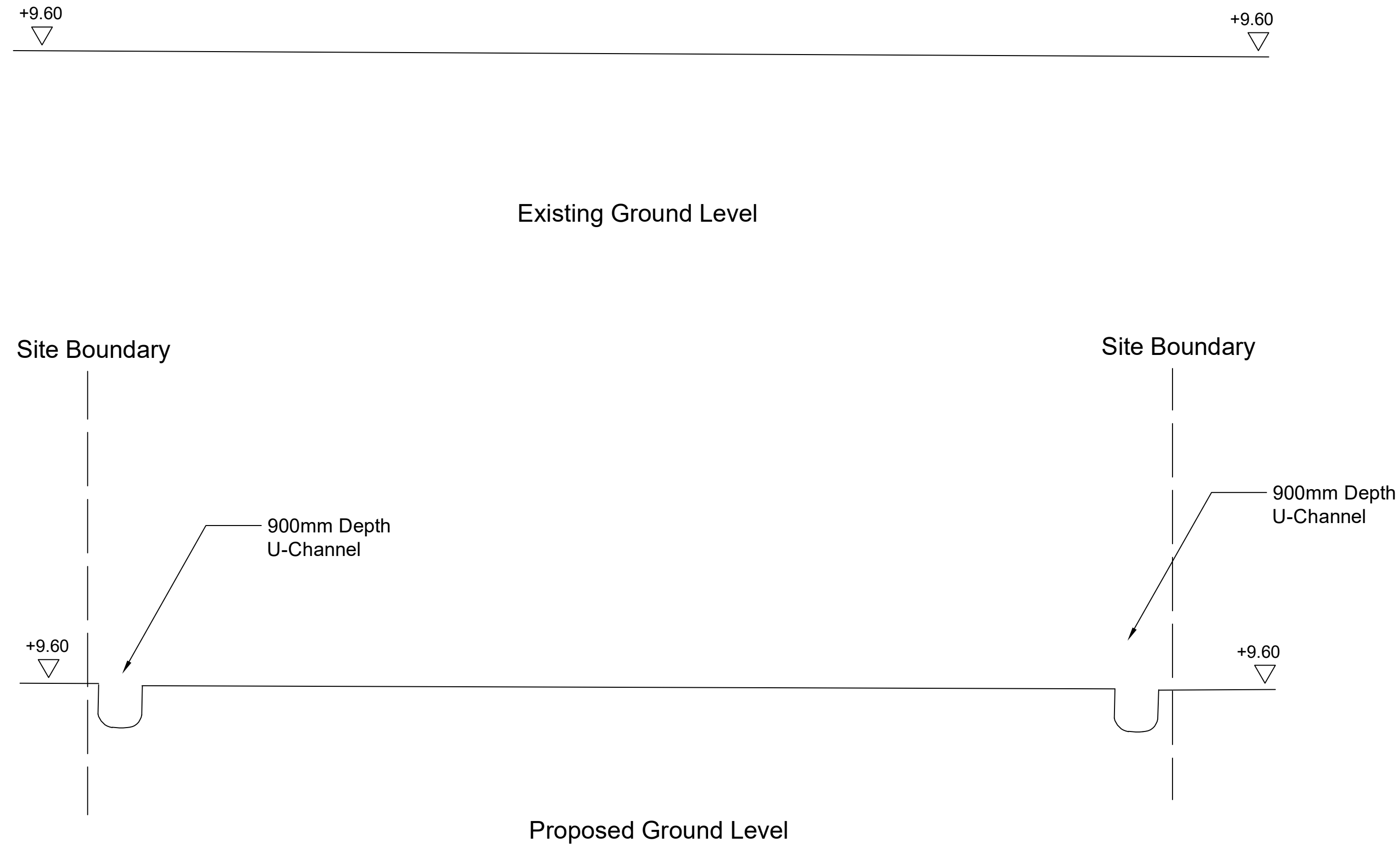
URBAN GREEN

S12A Rezoning Application for Proposed Columbarium on Various Lots in D.D.41, Sha Tau Kok, New Territories

Cross Section - Section F-F

Figure 3.10F

Rev. 0



SECTION G-G

NOT IN SCALE

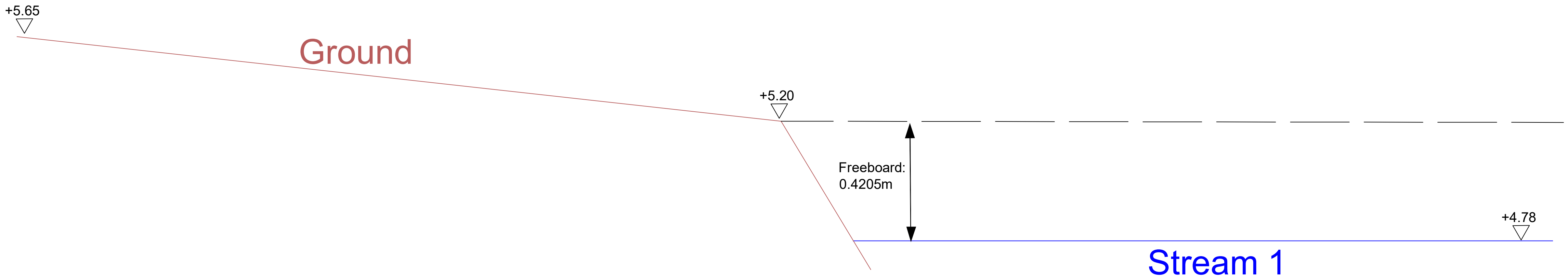
URBAN GREEN

S12A Rezoning Application for Proposed Columbarium on Various Lots in D.D.41, Sha Tau Kok, New Territories

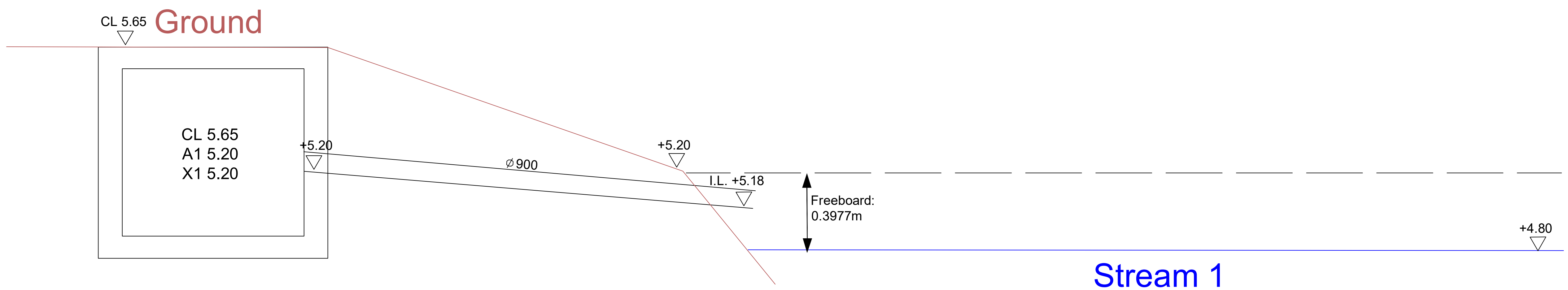
Cross Section - Section G-G

Figure 3.10G

Rev. 0



Stream Level Before the Proposed Development



Stream Level After the Proposed Development

Not in Scale

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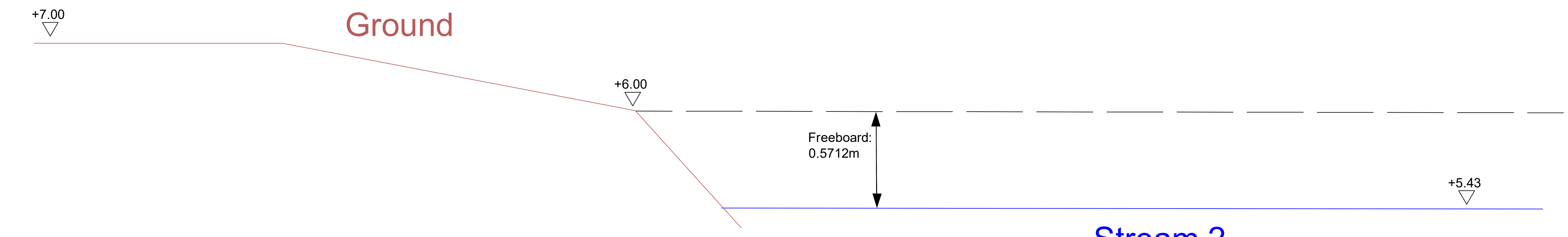
S12A Rezoning Application for Proposed Columbarium at Various Lots in D.D.41, Sha Tau Kok, New Territories

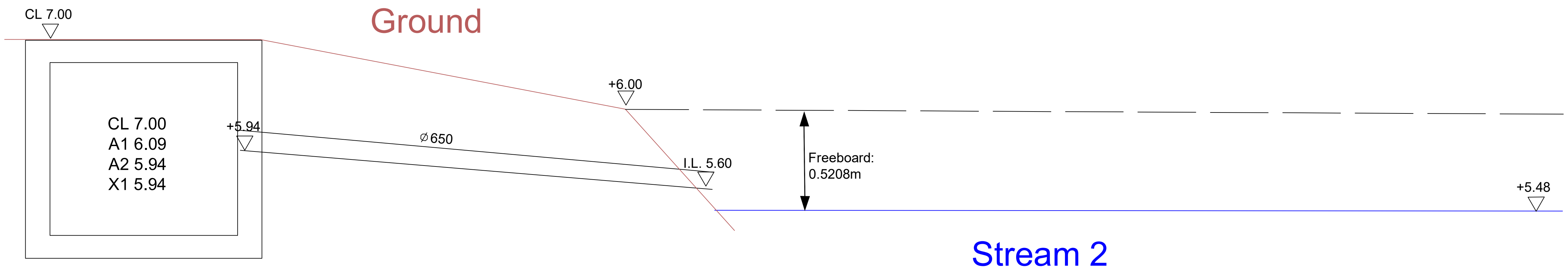
Details of Proposed Connections to Stream 1

Figure 3.11

Rev. 0



Stream Level Before the Proposed Development



Stream Level After the Proposed Development

Not in Scale

URBAN GREEN

S12A Rezoning Application for Proposed Columbarium at Various Lots in D.D.41, Sha Tau Kok, New Territories

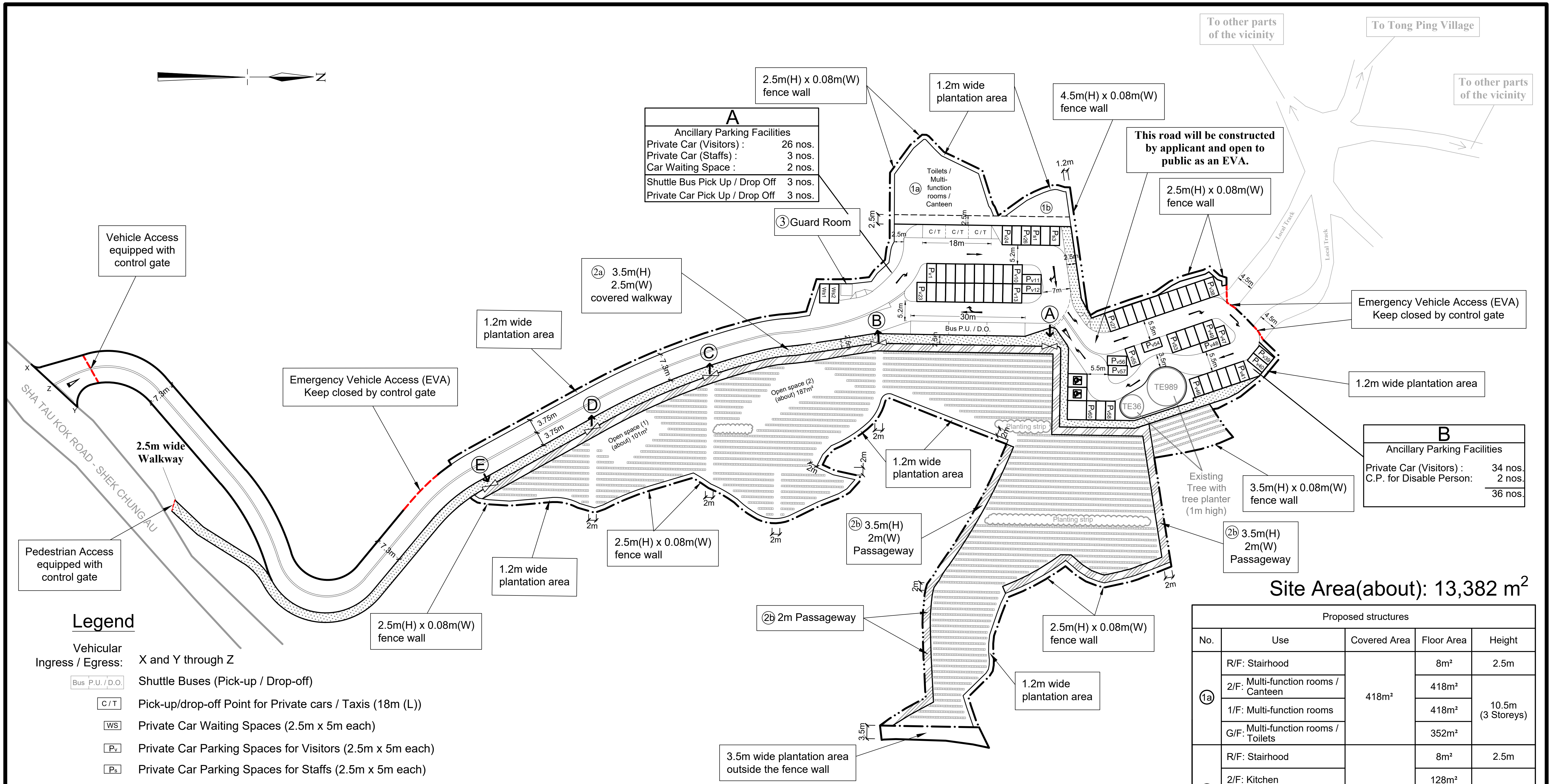
Details of Proposed Connections to Stream 2

Figure 3.12

Rev. 0

Appendix A

Proposed Layout Plan



Site Area(about): 13,382 m²

Legend

- Vehicular Ingress / Egress: X and Y through Z
- Bus P.U. / D.O. — Shuttle Buses (Pick-up / Drop-off)
- C/T — Pick-up/drop-off Point for Private cars / Taxis (18m (L))
- WS — Private Car Waiting Spaces (2.5m x 5m each)
- Pv — Private Car Parking Spaces for Visitors (2.5m x 5m each)
- Ps — Private Car Parking Spaces for Staffs (2.5m x 5m each)
- Private Car Parking Spaces for Visitors (Disabled Persons) (3.5m x 5m each)
- Pedestrian access
- Canopy over walk-way
- Canopy over passageway
- Planting Strip (about 125m²)
- 2.5m high fence wall
- 3.5m high fence wall
- 4.5m high fence wall

Ancillary Parking Facilities	Private Car Parking Spaces for Visitors	Private Car Parking Spaces for Visitors (Disabled Persons)	Total Private Car Parking Space for Visitors	Private Car Parking Spaces for staffs	Private Car Waiting Spaces	Pick-up/drop-off Point for Private cars / Taxis	Lay-by for Shuttle Buses
Car park A	26	-		3	2	3	3
Car park B	34	2		-	-	-	-
Total	60	2	62	3	2	3	3

Niche count	
	No. of niches
At-grade niche blocks	6,495 nos. x 1 = 6,495

Proposed structures				
No.	Use	Covered Area	Floor Area	Height
1a	R/F: Stairhood	418m²	8m²	2.5m
	2/F: Multi-function rooms / Canteen		418m²	10.5m (3 Storeys)
	1/F: Multi-function rooms		418m²	
	G/F: Multi-function rooms / Toilets		352m²	
1b	R/F: Stairhood	128m²	8m²	2.5m
	2/F: Kitchen		128m²	10.5m (3 Storeys)
	1/F: Multi-function rooms		128m²	
	G/F: Office / Storeroom		78m²	
2a	Canopy over walk-way	832m²	832m²	3.5m (1 Storey)
2b	Canopy over passageway	748m²	748m²	3.5m (1 Storey)
3	1/F: Guard room	9m²	9m²	6m (2 Storeys)
	G/F: Guard room		9m²	
	Total	2,135m²	3,136m²	

1 : 1000 (A3)	Master Layout Plan	Goldrich Planners & Surveyors Ltd.
February 2026	Rezoning Application from “AGR” and “GB” to “OU (Columbarium)” on various Lots in D. D. 41 and Adjoining Government Land, Tong To, Sha Tau Kok, N.T.	Plan 4b (P 17106)

Appendix B

Detailed Drainage Analysis

Section 12A Rezoning Application for Proposed Columbarium on Various Lots in D.D.41 Sha Tau Kok, New Territories
Capacity Flow Estimation for Proposed Catchments and Drainage System with 50 Year Return Period

A. Calculation of Catchment Runoff Received by the Site Without Climate Change

Catchment ID	Surface Type	Catchment Area (A), m^2	Catchment Area (A), km^2	Average slope (H), m/100m	Flow path length (L), m	Inlet time (t_o), min	Time of Concentration (t_c), min	Duration (t_d), min	a (50 year return period)	b (50 year return period)	c (50 year return period)	Runoff intensity (i), mm/hr	Runoff coefficient (C)	C x A	Peak runoff (Q_p), m^3/s
A	90% Concrete + 10% Grassland (heavysoil), flat	3,757	0.00376	5.95	100.9	4.49	4.49	4.49	474.6	2.9	0.37	226	0.88	0.0033	0.2077
B	90% Concrete + 10% Grassland (heavysoil), flat	4,229	0.00423	1.29	77.5	4.62	4.62	4.62	474.6	2.9	0.37	224	0.88	0.0037	0.2322
C	80% Concrete + 20% Grassland (heavysoil), steep	1,705	0.00171	4.60	58.7	2.97	2.97	2.97	474.6	2.9	0.37	246	0.83	0.0014	0.0968
D	100% Grassland (heavysoil), steep	1,272	0.00127	7.36	76.0	3.61	3.61	3.61	474.6	2.9	0.37	237	0.35	0.0004	0.0293
E	10% Concrete + 90% Grassland (heavysoil), steep	3,597	0.00360	8.30	92.8	3.88	3.88	3.88	474.6	2.9	0.37	233	0.41	0.0015	0.0957
F	100% Grassland (heavysoil), steep	1,573	0.00157	6.68	34.4	1.63	1.63	1.63	474.6	2.9	0.37	271	0.35	0.0006	0.0415
G	85% Concrete + 15% Grassland (heavysoil), steep	1,178	0.00118	5.18	38.6	1.98	1.98	1.98	474.6	2.9	0.37	264	0.86	0.0010	0.0742
H	90% Concrete + 10% Grassland (heavysoil), flat	2,762	0.00276	15.59	73.8	2.79	2.79	2.79	474.6	2.9	0.37	249	0.88	0.0024	0.1682
I	100% Grassland (heavysoil), steep	1,031	0.00103	21.74	46.0	1.80	1.80	1.80	474.6	2.9	0.37	267	0.35	0.0004	0.0268
J	100% Concrete	416	0.00042	6.79	39.8	2.15	2.15	2.15	474.6	2.9	0.37	260	0.95	0.0004	0.0286
K	100% Concrete	232	0.00023	13.16	7.6	0.38	0.38	0.38	474.6	2.9	0.37	305	0.95	0.0002	0.0187
L	100% Concrete	729	0.00073	2.61	68.9	4.25	4.25	4.25	474.6	2.9	0.37	229	0.95	0.0007	0.0440
M	100% Concrete	81	0.00008	3.60	30.5	2.20	2.20	2.20	474.6	2.9	0.37	259	0.95	0.0001	0.0056
N	100% Concrete	805	0.00081	1.30	54.0	3.80	3.80	3.80	474.6	2.9	0.37	234	0.95	0.0008	0.0498
														Total	**1.1192**

Note: The surface types of catchments used in the calculation refer to the post-development scenario.

B. Calculation of Catchment Runoff Received by Existing Stream 1 Without Climate Change

Catchment ID	Surface Type	Catchment Area (A), m^2	Catchment Area (A), km^2	Average slope (H), m/100m	Flow path length (L), m	Inlet time (t_0), min	Time of Concentration (t_c), min	Duration (t_d), min	a (50 year return period)	b (50 year return period)	c (50 year return period)	Runoff intensity (i), mm/hr	Runoff coefficient (C)	C x A	Peak runoff (Q_p), m^3/s
AA	100% Grassland (heavysoil), steep	10,468	0.01047	53.54	151.30	3.91	3.91	3.91	474.6	2.9	0.37	233	0.35	0.0037	0.2372
AB	100% Grassland (heavysoil), steep	18,920	0.01892	70.41	196.00	4.52	4.52	4.52	474.6	2.9	0.37	226	0.35	0.0066	0.4153
AC	100% Grassland (heavysoil), steep	10,196	0.01020	88.19	129.50	3.04	3.04	3.04	474.6	2.9	0.37	245	0.35	0.0036	0.2431
AD	100% Grassland (heavysoil), steep	52,671	0.05267	62.61	405.71	8.65	8.65	8.65	474.6	2.9	0.37	191	0.35	0.0184	0.9813
AE	100% Grassland (heavysoil), steep	22,926	0.02293	67.68	257.11	5.87	5.87	5.87	474.6	2.9	0.37	212	0.35	0.0080	0.4731
AF	100% Grassland (heavysoil), steep	29,391	0.02939	49.39	380.65	9.02	9.02	9.02	474.6	2.9	0.37	189	0.35	0.0103	0.5412
AG	100% Grassland (heavysoil), steep	37,189	0.03719	38.34	354.70	8.64	8.64	8.64	474.6	2.9	0.37	192	0.35	0.0130	0.6931
AH	100% Grassland (heavysoil), steep	38,374	0.03837	51.54	419.06	9.59	9.59	9.59	474.6	2.9	0.37	186	0.35	0.0134	0.6945
AI	100% Grassland (heavysoil), steep	32,527	0.03253	36.21	469.53	11.72	11.72	11.72	474.6	2.9	0.37	175	0.35	0.0114	0.5552
AJ	100% Grassland (heavysoil), steep	43,371	0.04337	19.83	342.86	9.38	9.38	9.38	474.6	2.9	0.37	187	0.35	0.0152	0.7898
AK	100% Grassland (heavysoil), steep	12,505	0.01250	51.10	180.04	4.62	4.62	4.62	474.6	2.9	0.37	225	0.35	0.0044	0.2732
AL	100% Grassland (heavysoil), steep	38,295	0.03830	58.25	271.24	6.06	6.06	6.06	474.6	2.9	0.37	210	0.35	0.0134	0.7840
AM	100% Grassland (heavysoil), steep	66,715	0.06672	37.02	318.70	7.37	7.37	7.37	474.6	2.9	0.37	200	0.35	0.0234	1.2982
AN	100% Grassland (heavysoil), steep	62,139	0.06214	42.78	119.21	2.70	2.70	2.70	474.6	2.9	0.37	250	0.35	0.0217	1.5145
AO	100% Grassland (heavysoil), steep	27,601	0.02760	36.09	315.87	8.02	8.02	8.02	474.6	2.9	0.37	195	0.35	0.0097	0.5250
AP	100% Grassland (heavysoil), steep	18,727	0.01873	39.88	255.78	6.62	6.62	6.62	474.6	2.9	0.37	206	0.35	0.0066	0.3748
AQ	100% Grassland (heavysoil), steep	27,808	0.02781	39.27	273.22	6.82	6.82	6.82	474.6	2.9	0.37	204	0.35	0.0097	0.5524
AR	100% Grassland (heavysoil), steep	30,327	0.03033	18.92	295.94	8.47	8.47	8.47	474.6	2.9	0.37	193	0.35	0.0106	0.5683
AS	10% Concrete + 90% Grassland (heavysoil), flat	40,285	0.04028	1.49	168.25	7.79	7.79	7.79	474.6	2.9	0.37	197	0.32	0.0129	0.7062
AT	5% Concrete + 95% Grassland (heavysoil), flat	33,841	0.03384	8.19	244.27	8.18	8.18	8.18	474.6	2.9	0.37	194	0.29	0.0096	0.5214
AU	100% Grassland (heavysoil), flat	19,765	0.01976	3.59	244.98	10.20	10.20	10.20	474.6	2.9	0.37	183	0.25	0.0049	0.2510
AV	5% Concrete + 95% Grassland (heavysoil), flat	13,325	0.01333	7.26	132.24	4.98	4.98	4.98	474.6	2.9	0.37	221	0.29	0.0038	0.2330
AW	20% Concrete + 80% Grassland (heavysoil), flat	43,594	0.04359	3.44	270.60	10.51	10.51	10.51	474.6	2.9	0.37	181	0.39	0.0170	0.8563
AX	20% Concrete + 80% Grassland (heavysoil), flat	1,485	0.00149	0.56	195.40	15.27	15.27	15.27	474.6	2.9	0.37	162	0.39	0.0006	0.0261
AY	100% Grassland (heavysoil), flat	4,127	0.00413	1.27	70.71	4.24	4.24	4.24	474.6	2.9	0.37	229	0.25	0.0010	0.0656
AZ	100% Grassland (heavysoil), steep	26,118	0.02612	54.73	131.00	3.08	3.08	3.08	474.6	2.9	0.37	244	0.35	0.0091	0.6213
														Total	**14.7954**

Note: The surface types of catchments used in the calculation refer to the post-development scenario.

C. Calculation of Catchment Runoff Received by Existing Stream 2 Without Climate Change

Catchment ID	Surface Type	Catchment Area (A), m^2	Catchment Area (A), km^2	Average slope (H), m/100m	Flow path length (L), m	Inlet time (t_0), min	Time of Concentration (t_c), min	Duration (t_d), min	a (50 year return period)	b (50 year return period)	c (50 year return period)	Runoff intensity (i), mm/hr	Runoff coefficient (C)	C x A	Peak runoff (Q_p), m^3/s
BA	100% Grassland (heavysoil), steep	34,288	0.03429	65.73	304.27	6.71	6.71	6.71	474.6	2.9	0.37	205	0.35	0.0120	0.6840
BB	100% Grassland (heavysoil), steep	67,748	0.06775	54.12	617.15	13.21	13.21	13.21	474.6	2.9	0.37	169	0.35	0.0237	1.1156
BC	100% Grassland (heavysoil), steep	14,692	0.01469	40.00	200.00	5.30	5.30	5.30	474.6	2.9	0.37	217	0.35	0.0051	0.3108
BD	100% Grassland (heavysoil), steep	22,149	0.02215	49.01	375.45	9.17	9.17	9.17	474.6	2.9	0.37	188	0.35	0.0078	0.4060
BE	100% Grassland (heavysoil), steep	10,272	0.01027	24.75	222.26	6.72	6.72	6.72	474.6	2.9	0.37	205	0.35	0.0036	0.2048
BF	100% Grassland (heavysoil), steep	2,779	0.00278	49.97	296.20	8.87	8.87	8.87	474.6	2.9	0.37	190	0.35	0.0010	0.0514
BG	100% Grassland (heavysoil), steep	15,947	0.01595	25.95	169.55	4.86	4.86	4.86	474.6	2.9	0.37	222	0.35	0.0056	0.3444
BH	30% Grassland (heavysoil), flat + 70% Grassland (heavysoil), steep	15,375	0.01538	2.71	73.80	3.34	3.34	3.34	474.6	2.9	0.37	241	0.32	0.0049	0.3292
BI	70% Grassland (heavysoil), flat + 30% Grassland (heavysoil), steep	24,849	0.02485	13.81	550.37	17.12	17.12	17.12	474.6	2.9	0.37	156	0.28	0.0070	0.3020
BJ	70% Grassland (heavysoil), flat + 30% Grassland (heavysoil), steep	39,109	0.03911	13.62	147.62	4.40	4.40	4.40	474.6	2.9	0.37	227	0.28	0.0110	0.6911
BK	15% Concrete + 15% Grassland (heavysoil), flat + 70% Grassland (heavysoil), steep	12,273	0.01227	12.35	103.61	3.54	3.54	3.54	474.6	2.9	0.37	238	0.43	0.0052	0.3449
BL	100% Concrete	929	0.00093	7.30	58.88	2.89	2.89	2.89	474.6	2.9	0.37	247	0.95	0.0009	0.0607
														Total	**4.8449**

D. Calculation of Road Catchment Runoff Without Climate Change

Catchment ID	Surface Type	Catchment Area (A), m^2	Catchment Area (A), km^2	Average slope (H), m/100m	Flow path length (L), m	Inlet time (t_0), min	Time of Concentration (t_c), min	Duration (t_d), min	a (50 year return period)	b (50 year return period)	c (50 year return period)	Runoff intensity (i), mm/hr	Runoff coefficient (C)	C x A	Peak runoff (Q_p), m^3/s
R1	100% Concrete	66	0.00007	13.84	11.20	0.63	0.63	0.63	474.6	2.9	0.37	297	0.95	0.0001	0.0052
R2	100% Concrete	46	0.00005	4.38	10.27	0.75	0.75	0.75	474.6	2.9	0.37	293	0.95	0.0000	0.0036
R3	100% Concrete	20	0.00002	0.74	13.42	1.53	1.53	1.53	474.6	2.9	0.37	273	0.95	0.0000	0.0014
R4	100% Concrete	18	0.00002	8.48	12.98	0.91	0.91	0.91	474.6	2.9	0.37	289	0.95	0.0000	0.0014
R5	100% Concrete	13	0.00001	4.20	9.52	0.80	0.80	0.80	474.6	2.9	0.37	292	0.95	0.0000	0.0010
														Total	**0.0127**

Note: The surface types of catchments used in the calculation refer to the post-development scenario.

Calculation of Capacity of U-Channel A1 - A13

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)	Remarks
A1 - A2	U-Channel	0.600	0.600	24.30	24.02	16.96	0.017	0.035	0.321	1.542	0.208	1.296	0.417	0.375	D,E,G	0.199	53%	Y	
A2 - A3	U-Channel	0.600	0.600	24.02	23.85	8.59	0.020	0.035	0.321	1.542	0.208	1.420	0.456	0.411	D,E,G	0.199	48%	Y	
A3 - A4	U-Channel	0.600	0.600	23.85	22.89	33.29	0.029	0.035	0.321	1.542	0.208	1.697	0.545	0.491	D,E,G	0.199	41%	Y	
A4 - A5	U-Channel	0.800	0.800	22.89	22.05	33.71	0.025	0.035	0.571	2.057	0.278	1.923	1.099	0.989	B,C,D,E,G	0.528	53%	Y	
A5 - A6	U-Channel	0.800	0.800	22.05	21.80	19.10	0.013	0.035	0.571	2.057	0.278	1.405	0.802	0.722	B,C,D,E,G	0.528	73%	Y	
A6 - A7	U-Channel	0.800	0.800	21.80	21.63	12.47	0.013	0.035	0.571	2.057	0.278	1.405	0.802	0.722	B,C,D,E,G	0.528	73%	Y	
A7 - A8	U-Channel	0.800	0.800	21.63	21.43	15.43	0.013	0.035	0.571	2.057	0.278	1.405	0.802	0.722	B,C,D,E,G	0.528	73%	Y	
A8 - A9	U-Channel	0.800	0.800	21.43	21.30	9.22	0.013	0.035	0.571	2.057	0.278	1.405	0.802	0.722	B,C,D,E,G	0.528	73%	Y	
A9 - A10	U-Channel	0.800	0.800	21.30	21.03	20.17	0.013	0.035	0.571	2.057	0.278	1.405	0.802	0.722	B,C,D,E,G	0.528	73%	Y	
A10 - A11	U-Channel	0.800	0.800	21.03	20.94	7.27	0.013	0.035	0.571	2.057	0.278	1.405	0.802	0.722	B,C,D,E,G	0.528	73%	Y	
A11 - A12	U-Channel	0.800	0.800	20.94	20.76	13.21	0.013	0.035	0.571	2.057	0.278	1.405	0.802	0.722	B,C,D,E,G	0.528	73%	Y	
A12 - A13	U-Channel	0.800	0.800	20.76	20.63	9.22	0.014	0.035	0.571	2.057	0.278	1.454	0.831	0.748	B,C,D,E,G	0.528	71%	Y	

Calculation of Capacity of Stepped Channel A13 - A14

Pipe Segement	Shape	Gradient, a°	Horizontal Distance, m	Slant Distance, m	Depth, mm	Width, mm	Initial mPD,X(m)	Ending mPD, A(m)	C_e	x	f	f_e	Y_{90}, m	d_0, m	Cross Section Area, m_2	P_w, m	D_H, m	Gravity, m/s^2	V_0, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchment Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
A13 - A14	Stepped Channel	20	10.55	25.9	850	900	20.63	16.79	0.31	0.60	1.00	0.77	0.80	0.55	0.50	2.01	0.99	9.81	2.95	1.47	1.319	A, B,C,D,E,G	0.7360	56%	Y

Calculation of Capacity of U-Channel A14 - A16

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)	Remarks
A14 - A15	U-Channel	0.800	0.800	16.79	15.98	41.00	0.020	0.030	0.571	2.057	0.278	1.987	1.135	1.022	A, B,C,D,E,G	0.736	72%	Y	
A15 - A16	U-Channel	0.800	0.800	15.98	15.10	44.92	0.020	0.030	0.571	2.057	0.278	1.987	1.135	1.022	A, B,C,D,E,G	0.736	72%	Y	

Calculation of Capacity of Stepped Channel A16 - A17

Pipe Segement	Shape	Gradient, a°	Horizontal Distance, m	Slant Distance, m	Depth, mm	Width, mm	Initial mPD,X(m)	Ending mPD, A(m)	C_e	x	f	f_e	Y_{90}, m	d_0, m	Cross Section Area, m_2	P_w, m	D_H, m	Gravity, m/s^2	V_0, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchment Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
A16 - A17	Stepped Channel	20	12.78	31.3	850	900	15.10	10.45	0.31	0.60	1.00	0.77	0.80	0.55	0.50	2.01	0.99	9.81	2.95	1.47	1.319	A, B,C,D,E,G	0.736	56%	Y

Calculation of Capacity of U-Channel A17 - A25

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)	Remarks
A17 - A18	U-Channel	0.900	0.900	10.45	10.02	25.40	0.017	0.030	0.723	2.314	0.313	1.999	1.445	1.301	A,B,C,D,E,G,J	0.765	59%	Y	
A18 - A19	U-Channel	0.900	0.900	10.02	9.91	6.50	0.017	0.030	0.723	2.314	0.313	1.999	1.445	1.301	A,B,C,D,E,G,J	0.765	59%	Y	
A19 - A20	U-Channel	0.900	0.900	9.91	9.81	6.06	0.017	0.030	0.723	2.314	0.313	1.999	1.445	1.301	A,B,C,D,E,G,J,K	0.783	60%	Y	
A20 - A21	U-Channel	0.900	0.900	9.81	9.43	22.23	0.017	0.030	0.723	2.314	0.313	1.999	1.445	1.301	A,B,C,D,E,G,J,K	0.783	60%	Y	
A21 - A22	U-Channel	0.900	0.900	9.43	8.78	38.20	0.017	0.030	0.723	2.314	0.313	1.999	1.445	1.301	A,B,C,D,E,G,J,K L	0.827	64%	Y	
A22 - A23	U-Channel	0.900	0.900	8.78	8.60	10.82	0.017	0.030	0.723	2.314	0.313	1.982	1.433	1.290	A,B,C,D,E,G,J,K L	0.827	64%	Y	
A23 - A24	U-Channel	0.900	0.900	8.60	8.38	15.78	0.014	0.030	0.723	2.314	0.313	1.835	1.327	1.194	A,B,C,D,E,G,J,K L	0.827	69%	Y	
A24 - A25	U-Channel	0.900	0.900	8.38	8.30	5.32	0.014	0.030	0.723	2.314	0.313	1.835	1.327	1.194	A,B,C,D,E,G,J,K L,N	0.877	73%	Y	

Calculation of Capacity of U-Channel C1 - C4

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)	Remarks
C1 - C2	U-Channel	0.700	0.700	23.20	22.54	33.23	0.020	0.030	0.437	1.800	0.243	1.836	0.803	0.723	B,C,D,E,G	0.528	73%	Y	
C2 - C3	U-Channel	0.700	0.700	22.54	22.06	23.74	0.020	0.030	0.437	1.800	0.243	1.836	0.803	0.723	B,C,D,E,G	0.528	73%	Y	
C3 - C4	U-Channel	0.800	0.800	22.06	21.79	13.91	0.019	0.030	0.571	2.057	0.278	1.968	1.124	1.012	A,B,C,D,E,G	0.736	73%	Y	

Calculation of Capacity of Stepped Channel C4 - C5

Pipe Segement	Shape	Gradient, a°	Horizontal Distance, m	Slant Distance, m	Depth, mm	Width, mm	Initial mPD,X(m)	Ending mPD, A(m)	C_e	x	f	f_e	Y_{90}, m	d_0, m	Cross Section Area, m_2	P_w, m	D_H, m	Gravity, m/s^2	V_0, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchment Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
C4 - C5	Stepped Channel	20	14.96	36.7	850	900	21.79	16.35	0.31	0.60	1.00	0.77	0.80	0.55	0.50	2.01	0.99	9.81	2.95	1.47	1.319	A,B,C,D,E,G	0.736	56%	Y

Calculation of Capacity of U-Channel C5 - C8

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)	Remarks
C5 - C6	U-Channel	0.850	0.850	16.35	16.00	27.36	0.013	0.030	0.645	2.185	0.295	1.673	1.079	0.971	A,B,C,D,E,G	0.736	76%	Y	
C6 -C7	U-Channel	0.850	0.850	16.00	15.53	25.80	0.018	0.030	0.645	2.185	0.295	1.998	1.289	1.160	A,B,C,D,E,G	0.736	63%	Y	
C7 - C8	U-Channel	0.850	0.850	15.53	15.05	25.83	0.018	0.030	0.645	2.185	0.295	1.998	1.289	1.160	A,B,C,D,E,G	0.736	63%	Y	

Calculation of Capacity of Stepped Channel C8 - C9

Pipe Segement	Shape	Gradient, a°	Horizontal Distance, m	Slant Distance, m	Depth, mm	Width, mm	Initial mPD,X(m)	Ending mPD, A(m)	C_e	x	f	f_e	Y_{90}, m	d_0, m	Cross Section Area, m_2	P_w, m	D_H, m	Gravity, m/s^2	V_0, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchment Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
C8 - C9	Stepped Channel	20	12.640	31.0	850	900	15.05	10.45	0.31	0.60	1.00	0.77	0.80	0.55	0.50	2.01	0.99	9.81	2.95	1.47	1.319	A,B,C,D,E,G	0.736	56%	Y

Calculation of Capacity of U-Channel C9 - C15

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)	Remarks
C9 - C10	U-Channel	0.850	0.850	10.45	10.01	26.60	0.017	0.030	0.645	2.185	0.295	1.908	1.230	1.107	A,B,C,D,E,G, J	0.765	69%	Y	
C10 - C11	U-Channel	0.850	0.850	10.01	9.83	11.07	0.017	0.030	0.645	2.185	0.295	1.908	1.230	1.107	A,B,C,D,E,G, J	0.765	69%	Y	
C11 - C12	U-Channel	0.850	0.850	9.83	9.53	16.23	0.018	0.030	0.645	2.185	0.295	1.993	1.285	1.157	A,B,C,D,E,G, J, K	0.783	68%	Y	
C12 - C13	U-Channel	0.850	0.850	9.53	9.25	15.60	0.018	0.030	0.645	2.185	0.295	1.993	1.285	1.157	A,B,C,D,E,G, J, K,M	0.789	68%	Y	
C13 - C14	U-Channel	0.850	0.850	9.25	9.05	12.13	0.016	0.030	0.645	2.185	0.295	1.862	1.201	1.081	A,B,C,D,E,G, J, K,M	0.789	73%	Y	
C14 - C15	U-Channel	0.850	0.850	9.05	8.45	40.53	0.015	0.030	0.645	2.185	0.295	1.804	1.163	1.047	A,B,C,D,E,G, J, K,M	0.789	75%	Y	

Calculation of Capacity of Circular Pipes A25 - CA1

Pipe Segment	Length	Level (out)	Level (in)	Diameter	Depth	A_w	k_s [1]	v	s	g	V	Capacity Flow	Reduced Capacity Flow	Catchment Served	Q_p	Is $Q_c > Q_p$?	% of capacity	Remarks
	m	mPD	mPD	m	m	m^2	m	m^2/s	-	m/s^2	m/s	m^3/s	m^3/s		m^3/s	Y/N	%	
A25 - E1	21.05	8.30	7.60	0.900	0.900	0.636	0.00003	1E-06	0.033	9.810	7.5157	4.781	4.303	A,B,C,D,E,G,J,K, L,M,N	0.883	Y	21%	
E1 - E2	6.46	7.60	7.39	0.900	0.900	0.636	0.00003	1E-06	0.033	9.810	7.5157	4.781	4.303	A,B,C,D,E,G,J,K, L,M,N, R1	0.888	Y	21%	
E2 - E3	19.46	7.39	6.74	0.900	0.900	0.636	0.00003	1E-06	0.033	9.810	7.5157	4.781	4.303	A,B,C,D,E,G,J,K, L,M,N, R1 - R2	0.891	Y	21%	
E3 - E4	27.29	6.74	5.83	0.900	0.900	0.636	0.00003	1E-06	0.033	9.810	7.5157	4.781	4.303	A,B,C,D,E,G,J,K, L,M,N, R1 - R3	0.893	Y	21%	
E4 - E5	15.68	5.83	5.31	0.900	0.900	0.636	0.00003	1E-06	0.033	9.810	7.5157	4.781	4.303	A,B,C,D,E,G,J,K, L,M,N, R1 - R4	0.894	Y	21%	
E5 - E6	11.02	5.31	5.20	0.900	0.900	0.636	0.00003	1E-06	0.010	9.810	3.9772	2.530	2.277	A,B,C,D,E,G,J,K, L,M,N, R1 - R5	0.895	Y	39%	
CA 1	16.52	5.20	5.18	1.050	1.050	0.866	0.00003	1E-06	0.0014	9.810	1.5718	1.361	1.225	A,B,C,D,E,G,J,K, L,M,N, R1 - R5	0.895	Y	73%	

Calculation of Capacity of U-Channel A1 - B7

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
A1 - B1	U-Channel	0.300	0.300	24.30	24.07	21.05	0.011	0.030	0.080	0.771	0.104	0.778	0.062	0.056	F	0.041	74%	Y
B1 - B2	U-Channel	0.300	0.300	24.07	23.99	6.46	0.011	0.030	0.080	0.771	0.104	0.778	0.062	0.056	F	0.041	74%	Y
B2 -B3	U-Channel	0.300	0.300	23.99	23.35	19.46	0.033	0.030	0.080	0.771	0.104	1.347	0.108	0.097	F	0.041	43%	Y
B3 - B4	U-Channel	0.450	0.450	23.35	22.44	27.29	0.033	0.030	0.181	1.157	0.156	1.766	0.319	0.287	F,H	0.210	73%	Y
B4 - B5	U-Channel	0.450	0.450	22.44	21.91	15.68	0.033	0.030	0.181	1.157	0.156	1.766	0.319	0.287	F,H	0.210	73%	Y
B5 - B6	U-Channel	0.450	0.450	21.91	21.47	11.02	0.040	0.030	0.181	1.157	0.156	1.934	0.350	0.315	F,H,I	0.237	75%	Y
B6 - B7	U-Channel	0.450	0.450	21.47	20.81	16.52	0.040	0.030	0.181	1.157	0.156	1.934	0.350	0.315	F,H,I	0.237	75%	Y

Calculation of Capacity of Stepped Channel B7 - B8

Pipe Segement	Shape	Gradient, a°	Horizontal Distance, m	Slant Distance, m	Depth, mm	Width, mm	Initial mPD,X(m)	Ending mPD, A(m)	C_e	x	f	f_e	Y_{90}, m	d_0, m	Cross Section Area, m_2	P_w, m	D_H, m	Gravity, m/s^2	V_0, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchment Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
B7 - B8	Stepped Channel	20	8.4	20.6	575	450	20.81	17.75	0.31	0.60	1.00	0.77	0.54	0.37	0.17	1.20	0.56	9.81	2.22	0.37	0.34	F,H,I	0.237	70%	Y

Calculation of Capacity of U-Channel B8 - B9

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
B8 - B9	U-Channel	0.600	0.600	17.75	17.22	18.73	0.029	0.030	0.321	1.542	0.208	1.980	0.636	0.573	F,H,I	0.237	41%	Y

Calculation of Capacity of Stepped Channel B9 - B10

Pipe Segement	Shape	Gradient, a°	Horizontal Distance, m	Slant Distance, m	Depth, mm	Width, mm	Initial mPD,X(m)	Ending mPD, A(m)	C_e	x	f	f_e	Y_{90}, m	d_0, m	Cross Section Area, m_2	P_w, m	D_H, m	Gravity, m/s^2	V_0, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchment Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
B9 - B10	Stepped Channel	46	10.74	26.3	650	600	17.22	6.10	0.64	-0.36	1.00	0.33	0.45	0.16	0.10	0.92	0.42	9.81	4.25	0.41	0.37	F,H,I	0.237	63%	Y

Calculation of Capacity of U-Channel B10 - B11

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
B10 - B11	U-Channel	0.650	0.650	6.10	5.94	18.73	0.008	0.030	0.377	1.671	0.226	1.128	0.425	0.383	F,H,I	0.237	62%	Y

Calculation of Capacity of U-Channel D1 - D3

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
D1 - D2	U-Channel	0.450	0.450	23.10	22.23	20.79	0.042	0.030	0.181	1.157	0.156	1.974	0.357	0.321	H	0.1682	52%	Y
D2 - D3	U-Channel	0.450	0.450	22.23	21.44	19.96	0.040	0.030	0.181	1.157	0.156	1.934	0.350	0.315	H	0.1682	53%	Y

Calculation of Capacity of Stepped Channel D3 - D4

Pipe Segement	Shape	Gradient, a°	Horizontal Distance, m	Slant Distance, m	Depth, mm	Width, mm	Initial mPD,X(m)	Ending mPD, A(m)	C_e	x	f	f_e	Y_{90}, m	d_0, m	Cross Section Area, m_2	P_w, m	D_H, m	Gravity, m/s^2	V_0, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchment Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
D3 - D4	Stepped Channel	20	10.61	26.0	575	450	21.44	17.57	0.31	0.60	1.00	0.77	0.54	0.37	0.17	1.20	0.56	9.81	2.22	0.37	0.34	H	0.168	50%	Y

Calculation of Capacity of U-Channel D4 - D5

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
D4 - D5	U-Channel	0.600	0.600	17.57	17.24	16.64	0.020	0.030	0.321	1.542	0.208	1.657	0.532	0.479	H	0.168	35%	Y

Calculation of Capacity of Stepped Channel D5 - B11

Pipe Segement	Shape	Gradient, a°	Horizontal Distance, m	Slant Distance, m	Depth, mm	Width, mm	Initial mPD,X(m)	Ending mPD, A(m)	C_e	x	f	f_e	Y_{90}, m	d_0, m	Cross Section Area, m_2	P_w, m	D_H, m	Gravity, m/s^2	V_0, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchment Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
D5 - B11	Stepped Channel	42	12.38	30.3	650	600	17.24	6.09	0.62	-0.31	1.00	0.35	0.48	0.18	0.11	0.96	0.45	9.81	4.11	0.45	0.40	H	0.168	42%	Y

Calculation of Capacity of Circular Pipes CB1

Pipe Segment	Length	Level (out)	Level (in)	Diameter	Depth	A_w	k_s [1]	v	s	g	V	Capacity Flow	Reduced Capacity Flow	Catchment Served	Q_p	Is $Q_c > Q_p$?	% of capacity	Remarks
	m	mPD	mPD	m	m	m^2	m	m^2/s	-	m/s^2	m/s	m^3/s	m^3/s		m^3/s	Y/N	%	
CB1	24.39	6.09	5.60	0.650	0.650	0.3318	0.00003	1E-06	0.020	9.810	4.7739	1.584	1.426	F,H,I	0.237	Y	17%	

D. Capacity Flow Estimation and Adequacy Check for Existing Streams and Culvert

Culvert	Width[3]	Depth[4]	A_w[5]	k_s	v	s	g	V	Capacity Flow	Reduced Capacity Flow	Catchment Served	Q_p	Is $Q_c > Q_p$?	% of capacity	Remarks
	m	m	m^2	m	m^2/s	-	m/s^2	m/s	m^3/s	m^3/s		m^3/s	Y/N	%	
Culvert 1	1.000	1.600	1.6000	0.00006	1E-06	0.100	9.810	15.0391	48.125	43.313	AA - AW	14.082	Y	33%	

Culvert	Diameter	Depth	A_w	k_s	v	s	g	V	Capacity Flow	Reduced Capacity Flow	Catchment Served	Q_p	Is $Q_c > Q_p$?	% of capacity	Remarks
	m	m	m^2	m	m^2/s	-	m/s^2	m/s	m^3/s	m^3/s		m^3/s	Y/N	%	
Culvert 2	0.850	-	0.5675	0.15000	1E-06	0.050	9.810	2.4135	1.370	1.233	F, H, I and BA to BL	4.848	***N***	393.3%	

Stream	Top Width, m	Bottom Width, m	Depth, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted perimeter, m	Hydraulic radius, m	Mean velocity, m/s	Capacity flow, m^3/s	Catchments Served	Runoff, m^3/s	Contribution from Identified Catchments, %	Sufficient Capacity? (Y/N)
Stream 1	4.0	2	1.3	0.100	0.040	3.900	5.280	0.74	6.46	25.193	A to E, G, J to N and AA to AZ, R1 - R5	15.691	62%	Y
Stream 2	3.0	1	1.3	0.050	0.040	2.600	4.280	0.61	4.01	10.425	F, H, I and BA to BL	5.081	49%	Y

Note: Adequacy in capacities of the stream have been checked based on the most narrow section of the existing stream at the stormwater discharge point.

E. Proposed Upgrading Works

Culvert	Diameter	Depth	A_w	k_s	v	s	g	V	Capacity Flow	Reduced Capacity Flow	Catchment Served	Q_p	Is $Q_c > Q_p$?	% of capacity	Remarks
	m	m	m^2	m	m^2/s	-	m/s^2	m/s	m^3/s	m^3/s		m^3/s	Y/N	%	
Culvert 2	1.600	1.600	2.0106	0.15000	1E-06	0.050	9.810	3.9996	8.042	7.237	F, H, I and BA to BL	4.848	Y	67.0%	

Note:
[1] Runoff is calculated in accordance with DSD's "Stormwater Drainage Manual - Planning, Design and Management" (SDM), Fifth edition, Jan 2018.
[2] Stepped Channel is adopted in some section to align with the topography of the Site. The Hydraulic Design of Stepped Channels is based on GEO Technical Guidance Note No. 27.
[3] Since Culvert 1 is a double-cell box culvert with identical cells, the width refers to the span of a single cell.
[4] Since Culvert 1 is a double-cell box culvert with identical cells, the depth refers to the depth of a single cell.
[5] Since Culvert 1 is a double-cell box culvert with identical cells, the A_w refers to the cross section area of one cell.
[6] Since Culvert 1 is a double-cell box culvert with identical cells, the Q^c is multiplied by 2 to represent the total capcity of the two cells of the culvert.
[7] A Manning's roughness coefficient of 0.030 for "Natural-stream channels — Clean, straight bank, full stage, no rifts or deep pools" in fair condition will be adopted for all proposed U-channels.
[8] A Manning's roughness coefficient of 0.040 for "Natural-stream channels — Winding, with some pools and shoals, clean with some weeds and stone" in good condition will be adopted for both streams based on site observation.
[9] The roughness value k_s of 0.006 mm for uPVC in normal condition will be adopted for all proposed circular pipes.
[10] The roughness value k_s of 0.06 mm for "Prestressed Concrete" in normal condition will be adopted for Culvert 1 based on the site observation.
[11] The absolute roughness value k_s of 150 mm for "Unlined Rock Tunnels" in normal condition will be adopted for Culvert 2 based on the site observation.
[12] Due to sedimentation, it is assumed that there is a 10% reduction in the capacity flow of the U-channels and circular pipes.

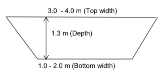
Equations Used

$$t_0 = \frac{0.14465L}{H^{0.2} A^{0.1}}$$

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

$$t_c = t_0 + t_f$$

$$Q_p = 0.278\, C\, i\, A$$



Schematic Section of the Streamcourse

Colebrook-White Equation (for circular pipes flowing full):

$$V = -\sqrt{(8gDs)}\log\left(\frac{ks}{3.7D} + \frac{2.51v}{D\sqrt{(2gDs)}}\right)$$

Appendix C

Detailed Drainage Analysis with 11.1% Increased Rainfall with Climate Change Impact

Section 12A Rezoning Application for Proposed Columbarium on Various Lots in D.D.41 Sha Tau Kok, New Territories
Capacity Flow Estimation for Proposed Catchments and Drainage System with 50 Year Return Period at End of 21st Century (11.1% Rainfall Increase)

A. Calculation of Catchment Runoff Received by the Site With 11.1% Rainfall Increase

Catchment ID	Surface Type	Catchment Area (A), m^2	Catchment Area (A), km^2	Average slope (H), m/100m	Flow path length (L), m	Inlet time (t_0), min	Time of Concentration (t_c), min	Duration (t_d), min	a (50 year return period)	b (50 year return period)	c (50 year return period)	Runoff intensity with 11.1% increase (i) mm/hr	Runoff coefficient (C)	C x A	Peak runoff (Q_p), m^3/s
A	90% Concrete + 10% Grassland (heavysoil), flat	3,757	0.00376	5.95	100.9	4.49	4.49	4.49	474.6	2.9	0.37	251	0.88	0.0033	0.2308
B	90% Concrete + 10% Grassland (heavysoil), flat	4,229	0.00423	1.29	77.5	4.62	4.62	4.62	474.6	2.9	0.37	249	0.88	0.0037	0.2580
C	80% Concrete + 20% Grassland (heavysoil), steep	1,705	0.00171	4.60	58.7	2.97	2.97	2.97	474.6	2.9	0.37	273	0.83	0.0014	0.1076
D	100% Grassland (heavysoil), steep	1,272	0.00127	7.36	76.0	3.61	3.61	3.61	474.6	2.9	0.37	263	0.35	0.0004	0.0326
E	10% Concrete + 90% Grassland (heavysoil), steep	3,597	0.00360	8.30	92.8	3.88	3.88	3.88	474.6	2.9	0.37	259	0.41	0.0015	0.1063
F	100% Grassland (heavysoil), steep	1,573	0.00157	6.68	34.4	1.63	1.63	1.63	474.6	2.9	0.37	301	0.35	0.0006	0.0461
G	85% Concrete + 15% Grassland (heavysoil), steep	1,178	0.00118	5.18	38.6	1.98	1.98	1.98	474.6	2.9	0.37	293	0.86	0.0010	0.0825
H	90% Concrete + 10% Grassland (heavysoil), flat	2,762	0.00276	15.59	73.8	2.79	2.79	2.79	474.6	2.9	0.37	277	0.88	0.0024	0.1869
I	100% Grassland (heavysoil), steep	1,031	0.00103	21.74	46.0	1.80	1.80	1.80	474.6	2.9	0.37	297	0.35	0.0004	0.0298
J	100% Concrete	416	0.00042	6.79	39.8	2.15	2.15	2.15	474.6	2.9	0.37	289	0.95	0.0004	0.0317
K	100% Concrete	232	0.00023	13.16	7.6	0.38	0.38	0.38	474.6	2.9	0.37	339	0.95	0.0002	0.0208
L	100% Concrete	729	0.00073	2.61	68.9	4.25	4.25	4.25	474.6	2.9	0.37	254	0.95	0.0007	0.0489
M	100% Concrete	81	0.00008	3.60	30.5	2.20	2.20	2.20	474.6	2.9	0.37	288	0.95	0.0001	0.0062
N	100% Concrete	805	0.00081	1.30	54.0	3.80	3.80	3.80	474.6	2.9	0.37	260	0.95	0.0008	0.0554
														Total	**1.2435**

Note: The surface types of catchments used in the calculation refer to the post-development scenario.

B. Calculation of Catchment Runoff Received by Existing Stream 1 With 11.1% Rainfall Increase

Catchment ID	Surface Type	Catchment Area (A), m^2	Catchment Area (A), km^2	Average slope (H), m/100m	Flow path length (L), m	Inlet time (t_0), min	Time of Concentration (t_c), min	Duration (t_d), min	a (50 year return period)	b (50 year return period)	c (50 year return period)	Runoff intensity with 11.1% increase (i) mm/hr	Runoff coefficient (C)	C x A	Peak runoff (Q_p), m^3/s
AA	100% Grassland (heavysoil), steep	10,468	0.01047	53.54	151.30	3.91	3.91	3.91	474.6	2.9	0.37	259	0.35	0.0037	0.2636
AB	100% Grassland (heavysoil), steep	18,920	0.01892	70.41	196.00	4.52	4.52	4.52	474.6	2.9	0.37	251	0.35	0.0066	0.4614
AC	100% Grassland (heavysoil), steep	10,196	0.01020	88.19	129.50	3.04	3.04	3.04	474.6	2.9	0.37	272	0.35	0.0036	0.2701
AD	100% Grassland (heavysoil), steep	52,671	0.05267	62.61	405.71	8.65	8.65	8.65	474.6	2.9	0.37	213	0.35	0.0184	1.0902
AE	100% Grassland (heavysoil), steep	22,926	0.02293	67.68	257.11	5.87	5.87	5.87	474.6	2.9	0.37	236	0.35	0.0080	0.5257
AF	100% Grassland (heavysoil), steep	29,391	0.02939	49.39	380.65	9.02	9.02	9.02	474.6	2.9	0.37	210	0.35	0.0103	0.6012
AG	100% Grassland (heavysoil), steep	37,189	0.03719	38.34	354.70	8.64	8.64	8.64	474.6	2.9	0.37	213	0.35	0.0130	0.7700
AH	100% Grassland (heavysoil), steep	38,374	0.03837	51.54	419.06	9.59	9.59	9.59	474.6	2.9	0.37	207	0.35	0.0134	0.7716
AI	100% Grassland (heavysoil), steep	32,527	0.03253	36.21	469.53	11.72	11.72	11.72	474.6	2.9	0.37	195	0.35	0.0114	0.6169
AJ	100% Grassland (heavysoil), steep	43,371	0.04337	19.83	342.86	9.38	9.38	9.38	474.6	2.9	0.37	208	0.35	0.0152	0.8775
AK	100% Grassland (heavysoil), steep	12,505	0.01250	51.10	180.04	4.62	4.62	4.62	474.6	2.9	0.37	249	0.35	0.0044	0.3036
AL	100% Grassland (heavysoil), steep	38,295	0.03830	58.25	271.24	6.06	6.06	6.06	474.6	2.9	0.37	234	0.35	0.0134	0.8710
AM	100% Grassland (heavysoil), steep	66,715	0.06672	37.02	318.70	7.37	7.37	7.37	474.6	2.9	0.37	222	0.35	0.0234	1.4423
AN	100% Grassland (heavysoil), steep	62,139	0.06214	42.78	119.21	2.70	2.70	2.70	474.6	2.9	0.37	278	0.35	0.0217	1.6827
AO	100% Grassland (heavysoil), steep	27,601	0.02760	36.09	315.87	8.02	8.02	8.02	474.6	2.9	0.37	217	0.35	0.0097	0.5833
AP	100% Grassland (heavysoil), steep	18,727	0.01873	39.88	255.78	6.62	6.62	6.62	474.6	2.9	0.37	229	0.35	0.0066	0.4164
AQ	100% Grassland (heavysoil), steep	27,808	0.02781	39.27	273.22	6.82	6.82	6.82	474.6	2.9	0.37	227	0.35	0.0097	0.6137
AR	100% Grassland (heavysoil), steep	30,327	0.03033	18.92	295.94	8.47	8.47	8.47	474.6	2.9	0.37	214	0.35	0.0106	0.6314
AS	10% Concrete + 90% Grassland (heavysoil), flat	40,285	0.04028	1.49	168.25	7.79	7.79	7.79	474.6	2.9	0.37	219	0.32	0.0129	0.7846
AT	5% Concrete + 95% Grassland (heavysoil), flat	33,841	0.03384	8.19	244.27	8.18	8.18	8.18	474.6	2.9	0.37	216	0.29	0.0096	0.5793
AU	100% Grassland (heavysoil), flat	19,765	0.01976	3.59	244.98	10.20	10.20	10.20	474.6	2.9	0.37	203	0.25	0.0049	0.2788
AV	5% Concrete + 95% Grassland (heavysoil), flat	13,325	0.01333	7.26	132.24	4.98	4.98	4.98	474.6	2.9	0.37	245	0.29	0.0038	0.2588
AW	20% Concrete + 80% Grassland (heavysoil), flat	43,594	0.04359	3.44	270.60	10.51	10.51	10.51	474.6	2.9	0.37	201	0.39	0.0170	0.9514
AX	20% Concrete + 80% Grassland (heavysoil), flat	1,485	0.00149	0.56	195.40	15.27	15.27	15.27	474.6	2.9	0.37	180	0.39	0.0006	0.0290
AY	100% Grassland (heavysoil), flat	4,127	0.00413	1.27	70.71	4.24	4.24	4.24	474.6	2.9	0.37	254	0.25	0.0010	0.0729
AZ	100% Grassland (heavysoil), steep	26,118	0.02612	54.73	131.00	3.08	3.08	3.08	474.6	2.9	0.37	272	0.35	0.0091	0.6902
														Total	**16.4377**

Note: The surface types of catchments used in the calculation refer to the post-development scenario.

C. Calculation of Catchment Runoff Received by Existing Stream 2 With 11.1% Rainfall Increase

Catchment ID	Surface Type	Catchment Area (A), m^2	Catchment Area (A), km^2	Average slope (H), m/100m	Flow path length (L), m	Inlet time (t_0), min	Time of Concentration (t_c), min	Duration (t_d), min	a (50 year return period)	b (50 year return period)	c (50 year return period)	Runoff intensity with 11.1% increase (i) mm/hr	Runoff coefficient (C)	C x A	Peak runoff (Q_p), m^3/s
BA	100% Grassland (heavysoil), steep	34,288	0.03429	65.73	304.27	6.71	6.71	6.71	474.6	2.9	0.37	228	0.35	0.0120	0.7599
BB	100% Grassland (heavysoil), steep	67,748	0.06775	54.12	617.15	13.21	13.21	13.21	474.6	2.9	0.37	188	0.35	0.0237	1.2394
BC	100% Grassland (heavysoil), steep	14,692	0.01469	40.00	200.00	5.30	5.30	5.30	474.6	2.9	0.37	242	0.35	0.0051	0.3453
BD	100% Grassland (heavysoil), steep	22,149	0.02215	49.01	375.45	9.17	9.17	9.17	474.6	2.9	0.37	209	0.35	0.0078	0.4511
BE	100% Grassland (heavysoil), steep	10,272	0.01027	24.75	222.26	6.72	6.72	6.72	474.6	2.9	0.37	228	0.35	0.0036	0.2275
BF	100% Grassland (heavysoil), steep	2,779	0.00278	49.97	296.20	8.87	8.87	8.87	474.6	2.9	0.37	211	0.35	0.0010	0.0571
BG	100% Grassland (heavysoil), steep	15,947	0.01595	25.95	169.55	4.86	4.86	4.86	474.6	2.9	0.37	247	0.35	0.0056	0.3826
BH	30% Grassland (heavysoil), flat + 70% Grassland (heavysoil), steep	15,375	0.01538	2.71	73.80	3.34	3.34	3.34	474.6	2.9	0.37	267	0.32	0.0049	0.3657
BI	70% Grassland (heavysoil), flat + 30% Grassland (heavysoil), steep	24,849	0.02485	13.81	550.37	17.12	17.12	17.12	474.6	2.9	0.37	173	0.28	0.0070	0.3355
BJ	70% Grassland (heavysoil), flat + 30% Grassland (heavysoil), steep	39,109	0.03911	13.62	147.62	4.40	4.40	4.40	474.6	2.9	0.37	252	0.28	0.0110	0.7678
BK	15% Concrete + 15% Grassland (heavysoil), flat + 70% Grassland (heavysoil), steep	12,273	0.01227	12.35	103.61	3.54	3.54	3.54	474.6	2.9	0.37	264	0.43	0.0052	0.3832
BL	100% Concrete	929	0.00093	7.30	58.88	2.89	2.89	2.89	474.6	2.9	0.37	275	0.95	0.0009	0.0675
														Total	**5.3827**

D. Calculation of Road Catchment Runoff With 11.1% Rainfall Increase

Catchment ID	Surface Type	Catchment Area (A), m^2	Catchment Area (A), km^2	Average slope (H), m/100m	Flow path length (L), m	Inlet time (t_0), min	Time of Concentration (t_c), min	Duration (t_d), min	a (50 year return period)	b (50 year return period)	c (50 year return period)	Runoff intensity with 11.1% increase (i) mm/hr	Runoff coefficient (C)	C x A	Peak runoff (Q_p), m^3/s
R1	100% Concrete	66	0.00007	13.84	11.20	0.63	0.63	0.63	474.6	2.9	0.37	330	0.95	0.0001	0.0057
R2	100% Concrete	46	0.00005	4.38	10.27	0.75	0.75	0.75	474.6	2.9	0.37	326	0.95	0.0000	0.0040
R3	100% Concrete	20	0.00002	0.74	13.42	1.53	1.53	1.53	474.6	2.9	0.37	304	0.95	0.0000	0.0016
R4	100% Concrete	18	0.00002	8.48	12.98	0.91	0.91	0.91	474.6	2.9	0.37	321	0.95	0.0000	0.0016
R5	100% Concrete	13	0.00001	4.20	9.52	0.80	0.80	0.80	474.6	2.9	0.37	325	0.95	0.0000	0.0011
														Total	**0.0141**

Note: The surface types of catchments used in the calculation refer to the post-development scenario.

Calculation of Capacity of U-Channel A1 - A13

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)	Remarks
A1 - A2	U-Channel	0.600	0.600	24.30	24.02	16.96	0.017	0.035	0.321	1.542	0.208	1.296	0.417	0.375	D,E,G	0.221	59%	Y	
A2 - A3	U-Channel	0.600	0.600	24.02	23.85	8.59	0.020	0.035	0.321	1.542	0.208	1.420	0.456	0.411	D,E,G	0.221	54%	Y	
A3 - A4	U-Channel	0.600	0.600	23.85	22.89	33.29	0.029	0.035	0.321	1.542	0.208	1.697	0.545	0.491	D,E,G	0.221	45%	Y	
A4 - A5	U-Channel	0.800	0.800	22.89	22.05	33.71	0.025	0.035	0.571	2.057	0.278	1.923	1.099	0.989	B,C,D,E,G	0.587	59%	Y	
A5 - A6	U-Channel	0.800	0.800	22.05	21.80	19.10	0.013	0.035	0.571	2.057	0.278	1.405	0.802	0.722	B,C,D,E,G	0.587	81%	Y	
A6 - A7	U-Channel	0.800	0.800	21.80	21.63	12.47	0.013	0.035	0.571	2.057	0.278	1.405	0.802	0.722	B,C,D,E,G	0.587	81%	Y	
A7 - A8	U-Channel	0.800	0.800	21.63	21.43	15.43	0.013	0.035	0.571	2.057	0.278	1.405	0.802	0.722	B,C,D,E,G	0.587	81%	Y	
A8 - A9	U-Channel	0.800	0.800	21.43	21.30	9.22	0.013	0.035	0.571	2.057	0.278	1.405	0.802	0.722	B,C,D,E,G	0.587	81%	Y	
A9 - A10	U-Channel	0.800	0.800	21.30	21.03	20.17	0.013	0.035	0.571	2.057	0.278	1.405	0.802	0.722	B,C,D,E,G	0.587	81%	Y	
A10 - A11	U-Channel	0.800	0.800	21.03	20.94	7.27	0.013	0.035	0.571	2.057	0.278	1.405	0.802	0.722	B,C,D,E,G	0.587	81%	Y	
A11 - A12	U-Channel	0.800	0.800	20.94	20.76	13.21	0.013	0.035	0.571	2.057	0.278	1.405	0.802	0.722	B,C,D,E,G	0.587	81%	Y	
A12 - A13	U-Channel	0.800	0.800	20.76	20.63	9.22	0.014	0.035	0.571	2.057	0.278	1.454	0.831	0.748	B,C,D,E,G	0.587	79%	Y	

Calculation of Capacity of Stepped Channel A13 - A14

Pipe Segement	Shape	Gradient, a°	Horizontal Distance, m	Slant Distance, m	Depth, mm	Width, mm	Initial mPD,X(m)	Ending mPD, A(m)	C_e	x	f	f_e	Y_{90}, m	d_0, m	Cross Section Area, m_2	P_w, m	D_H, m	Gravity, m/s^2	V_0, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchment Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
A13 - A14	Stepped Channel	20	10.55	25.9	850	900	20.63	16.79	0.31	0.60	1.00	0.77	0.80	0.55	0.50	2.01	0.99	9.81	2.95	1.47	1.319	A, B,C,D,E,G	0.8177	62%	Y

Calculation of Capacity of U-Channel A14 - A16

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)	Remarks
A14 - A15	U-Channel	0.800	0.800	16.79	15.98	41.00	0.020	0.030	0.571	2.057	0.278	1.987	1.135	1.022	A, B,C,D,E,G	0.818	80%	Y	
A15 - A16	U-Channel	0.800	0.800	15.98	15.10	44.92	0.020	0.030	0.571	2.057	0.278	1.987	1.135	1.022	A, B,C,D,E,G	0.818	80%	Y	

Calculation of Capacity of Stepped Channel A16 - A17

Pipe Segement	Shape	Gradient, a°	Horizontal Distance, m	Slant Distance, m	Depth, mm	Width, mm	Initial mPD,X(m)	Ending mPD, A(m)	C_e	x	f	f_e	Y_{90}, m	d_0, m	Cross Section Area, m_2	P_w, m	D_H, m	Gravity, m/s^2	V_0, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchment Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
A16 - A17	Stepped Channel	20	12.78	31.3	850	900	15.10	10.45	0.31	0.60	1.00	0.77	0.80	0.55	0.50	2.01	0.99	9.81	2.95	1.47	1.319	A, B,C,D,E,G	0.818	62%	Y

Calculation of Capacity of U-Channel A17 - A25

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)	Remarks
A17 - A18	U-Channel	0.900	0.900	10.45	10.02	25.40	0.017	0.030	0.723	2.314	0.313	1.999	1.445	1.301	A,B,C,D,E,G,J	0.849	65%	Y	
A18 - A19	U-Channel	0.900	0.900	10.02	9.91	6.50	0.017	0.030	0.723	2.314	0.313	1.999	1.445	1.301	A,B,C,D,E,G,J	0.849	65%	Y	
A19 - A20	U-Channel	0.900	0.900	9.91	9.81	6.06	0.017	0.030	0.723	2.314	0.313	1.999	1.445	1.301	A,B,C,D,E,G,J,K	0.870	67%	Y	
A20 - A21	U-Channel	0.900	0.900	9.81	9.43	22.23	0.017	0.030	0.723	2.314	0.313	1.999	1.445	1.301	A,B,C,D,E,G,J,K	0.870	67%	Y	
A21 - A22	U-Channel	0.900	0.900	9.43	8.78	38.20	0.017	0.030	0.723	2.314	0.313	1.999	1.445	1.301	A,B,C,D,E,G,J,K L	0.919	71%	Y	
A22 - A23	U-Channel	0.900	0.900	8.78	8.60	10.82	0.017	0.030	0.723	2.314	0.313	1.982	1.433	1.290	A,B,C,D,E,G,J,K L	0.919	71%	Y	
A23 - A24	U-Channel	0.900	0.900	8.60	8.38	15.78	0.014	0.030	0.723	2.314	0.313	1.835	1.327	1.194	A,B,C,D,E,G,J,K L	0.919	77%	Y	
A24 - A25	U-Channel	0.900	0.900	8.38	8.30	5.32	0.014	0.030	0.723	2.314	0.313	1.835	1.327	1.194	A,B,C,D,E,G,J,K L,N	0.974	82%	Y	

Calculation of Capacity of U-Channel C1 - C4

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)	Remarks
C1 - C2	U-Channel	0.700	0.700	23.20	22.54	33.23	0.020	0.030	0.437	1.800	0.243	1.836	0.803	0.723	B,C,D,E,G	0.587	81%	Y	
C2 - C3	U-Channel	0.700	0.700	22.54	22.06	23.74	0.020	0.030	0.437	1.800	0.243	1.836	0.803	0.723	B,C,D,E,G	0.587	81%	Y	
C3 - C4	U-Channel	0.800	0.800	22.06	21.79	13.91	0.019	0.030	0.571	2.057	0.278	1.968	1.124	1.012	A,B,C,D,E,G	0.818	81%	Y	

Calculation of Capacity of Stepped Channel C4 - C5

Pipe Segement	Shape	Gradient, a°	Horizontal Distance, m	Slant Distance, m	Depth, mm	Width, mm	Initial mPD,X(m)	Ending mPD, A(m)	C_e	x	f	f_e	Y_{90}, m	d_0, m	Cross Section Area, m_2	P_w, m	D_H, m	Gravity, m/s^2	V_0, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchment Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
C4 - C5	Stepped Channel	20	14.96	36.7	850	900	21.79	16.35	0.31	0.60	1.00	0.77	0.80	0.55	0.50	2.01	0.99	9.81	2.95	1.47	1.319	A,B,C,D,E,G	0.818	62%	Y

Calculation of Capacity of U-Channel C5 - C8

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)	Remarks
C5 - C6	U-Channel	0.850	0.850	16.35	16.00	27.36	0.013	0.030	0.645	2.185	0.295	1.673	1.079	0.971	A,B,C,D,E,G	0.818	84%	Y	
C6 -C7	U-Channel	0.850	0.850	16.00	15.53	25.80	0.018	0.030	0.645	2.185	0.295	1.998	1.289	1.160	A,B,C,D,E,G	0.818	71%	Y	
C7 - C8	U-Channel	0.850	0.850	15.53	15.05	25.83	0.018	0.030	0.645	2.185	0.295	1.998	1.289	1.160	A,B,C,D,E,G	0.818	71%	Y	

Calculation of Capacity of Stepped Channel C8 - C9

Pipe Segement	Shape	Gradient, a°	Horizontal Distance, m	Slant Distance, m	Depth, mm	Width, mm	Initial mPD,X(m)	Ending mPD, A(m)	C_e	x	f	f_e	Y_{90}, m	d_0, m	Cross Section Area, m_2	P_w, m	D_H, m	Gravity, m/s^2	V_0, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchment Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
C8 - C9	Stepped Channel	20	12.640	31.0	850	900	15.05	10.45	0.31	0.60	1.00	0.77	0.80	0.55	0.50	2.01	0.99	9.81	2.95	1.47	1.319	A,B,C,D,E,G	0.818	62%	Y

Calculation of Capacity of U-Channel C9 - C15

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)	Remarks
C9 - C10	U-Channel	0.850	0.850	10.45	10.01	26.60	0.017	0.030	0.645	2.185	0.295	1.908	1.230	1.107	A,B,C,D,E,G, J	0.849	77%	Y	
C10 - C11	U-Channel	0.850	0.850	10.01	9.83	11.07	0.017	0.030	0.645	2.185	0.295	1.908	1.230	1.107	A,B,C,D,E,G, J	0.849	77%	Y	
C11 - C12	U-Channel	0.850	0.850	9.83	9.53	16.23	0.018	0.030	0.645	2.185	0.295	1.993	1.285	1.157	A,B,C,D,E,G, J, K	0.870	75%	Y	
C12 - C13	U-Channel	0.850	0.850	9.53	9.25	15.60	0.018	0.030	0.645	2.185	0.295	1.993	1.285	1.157	A,B,C,D,E,G, J, K,M	0.876	76%	Y	
C13 - C14	U-Channel	0.850	0.850	9.25	9.05	12.13	0.016	0.030	0.645	2.185	0.295	1.862	1.201	1.081	A,B,C,D,E,G, J, K,M	0.876	81%	Y	
C14 - C15	U-Channel	0.850	0.850	9.05	8.45	40.53	0.015	0.030	0.645	2.185	0.295	1.804	1.163	1.047	A,B,C,D,E,G, J, K,M	0.876	84%	Y	

Calculation of Capacity of Circular Pipes A25 - CA1

Pipe Segment	Length	Level (out)	Level (in)	Diameter	Depth	A_w	k_s [1]	v	s	g	V	Capacity Flow	Reduced Capacity Flow	Catchment Served	Q_p	Is $Q_c > Q_p$?	% of capacity	Remarks
	m	mPD	mPD	m	m	m^2	m	m^2/s	-	m/s^2	m/s	m^3/s	m^3/s		m^3/s	Y/N	%	
A25 - E1	21.05	8.30	7.60	0.900	0.900	0.636	0.00003	1E-06	0.033	9.810	7.5157	4.781	4.303	A,B,C,D,E,G,J,K, L,M,N	0.981	Y	23%	
E1 - E2	6.46	7.60	7.39	0.900	0.900	0.636	0.00003	1E-06	0.033	9.810	7.5157	4.781	4.303	A,B,C,D,E,G,J,K, L,M,N, R1	0.986	Y	23%	
E2 - E3	19.46	7.39	6.74	0.900	0.900	0.636	0.00003	1E-06	0.033	9.810	7.5157	4.781	4.303	A,B,C,D,E,G,J,K, L,M,N, R1 - R2	0.990	Y	23%	
E3 - E4	27.29	6.74	5.83	0.900	0.900	0.636	0.00003	1E-06	0.033	9.810	7.5157	4.781	4.303	A,B,C,D,E,G,J,K, L,M,N, R1 - R3	0.992	Y	23%	
E4 - E5	15.68	5.83	5.31	0.900	0.900	0.636	0.00003	1E-06	0.033	9.810	7.5157	4.781	4.303	A,B,C,D,E,G,J,K, L,M,N, R1 - R4	0.994	Y	23%	
E5 - E6	11.02	5.31	5.20	0.900	0.900	0.636	0.00003	1E-06	0.010	9.810	3.9772	2.530	2.277	A,B,C,D,E,G,J,K, L,M,N, R1 - R5	0.995	Y	44%	
CA 1	16.52	5.20	5.18	1.050	1.050	0.866	0.00003	1E-06	0.0014	9.810	1.5718	1.361	1.225	A,B,C,D,E,G,J,K, L,M,N, R1 - R5	0.995	Y	81%	

Calculation of Capacity of U-Channel A1 - B7

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
A1 - B1	U-Channel	0.300	0.300	24.30	24.07	21.05	0.011	0.030	0.080	0.771	0.104	0.778	0.062	0.056	F	0.046	82%	Y
B1 - B2	U-Channel	0.300	0.300	24.07	23.99	6.46	0.011	0.030	0.080	0.771	0.104	0.778	0.062	0.056	F	0.046	82%	Y
B2 -B3	U-Channel	0.300	0.300	23.99	23.35	19.46	0.033	0.030	0.080	0.771	0.104	1.347	0.108	0.097	F	0.046	47%	Y
B3 - B4	U-Channel	0.450	0.450	23.35	22.44	27.29	0.033	0.030	0.181	1.157	0.156	1.766	0.319	0.287	F,H	0.233	81%	Y
B4 - B5	U-Channel	0.450	0.450	22.44	21.91	15.68	0.033	0.030	0.181	1.157	0.156	1.766	0.319	0.287	F,H	0.233	81%	Y
B5 - B6	U-Channel	0.450	0.450	21.91	21.47	11.02	0.040	0.030	0.181	1.157	0.156	1.934	0.350	0.315	F,H,I	0.263	84%	Y
B6 - B7	U-Channel	0.450	0.450	21.47	20.81	16.52	0.040	0.030	0.181	1.157	0.156	1.934	0.350	0.315	F,H,I	0.263	84%	Y

Calculation of Capacity of Stepped Channel B7 - B8

Pipe Segement	Shape	Gradient, a°	Horizontal Distance, m	Slant Distance, m	Depth, mm	Width, mm	Initial mPD,X(m)	Ending mPD, A(m)	C_e	x	f	f_e	Y_{90}, m	d_0, m	Cross Section Area, m_2	P_w, m	D_H, m	Gravity, m/s^2	V_0, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchment Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
B7 - B8	Stepped Channel	20	8.4	20.6	575	450	20.81	17.75	0.31	0.60	1.00	0.77	0.54	0.37	0.17	1.20	0.56	9.81	2.22	0.37	0.34	F,H,I	0.263	78%	Y

Calculation of Capacity of U-Channel B8 - B9

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
B8 - B9	U-Channel	0.600	0.600	17.75	17.22	18.73	0.029	0.030	0.321	1.542	0.208	1.980	0.636	0.573	F,H,I	0.263	46%	Y

Calculation of Capacity of Stepped Channel B9 - B10

Pipe Segement	Shape	Gradient, a°	Horizontal Distance, m	Slant Distance, m	Depth, mm	Width, mm	Initial mPD,X(m)	Ending mPD, A(m)	C_e	x	f	f_e	Y_{90}, m	d_0, m	Cross Section Area, m_2	P_w, m	D_H, m	Gravity, m/s^2	V_0, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchment Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
B9 - B10	Stepped Channel	46	10.74	26.3	650	600	17.22	6.10	0.64	-0.36	1.00	0.33	0.45	0.16	0.10	0.92	0.42	9.81	4.25	0.41	0.37	F,H,I	0.263	71%	Y

Calculation of Capacity of U-Channel B10 - B11

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
B10 - B11	U-Channel	0.650	0.650	6.10	5.94	18.73	0.008	0.030	0.377	1.671	0.226	1.128	0.425	0.383	F,H,I	0.263	69%	Y

Calculation of Capacity of U-Channel D1 - D3

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
D1 - D2	U-Channel	0.450	0.450	23.10	22.23	20.79	0.042	0.030	0.181	1.157	0.156	1.974	0.357	0.321	H	0.1869	58%	Y
D2 - D3	U-Channel	0.450	0.450	22.23	21.44	19.96	0.040	0.030	0.181	1.157	0.156	1.934	0.350	0.315	H	0.1869	59%	Y

Calculation of Capacity of Stepped Channel D3 - D4

Pipe Segement	Shape	Gradient, a°	Horizontal Distance, m	Slant Distance, m	Depth, mm	Width, mm	Initial mPD,X(m)	Ending mPD, A(m)	C_e	x	f	f_e	Y_{90}, m	d_0, m	Cross Section Area, m_2	P_w, m	D_H, m	Gravity, m/s^2	V_0, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchment Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
D3 - D4	Stepped Channel	20	10.61	26.0	575	450	21.44	17.57	0.31	0.60	1.00	0.77	0.54	0.37	0.17	1.20	0.56	9.81	2.22	0.37	0.34	H	0.187	56%	Y

Calculation of Capacity of U-Channel D4 - D5

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
D4 - D5	U-Channel	0.600	0.600	17.57	17.24	16.64	0.020	0.030	0.321	1.542	0.208	1.657	0.532	0.479	H	0.187	39%	Y

Calculation of Capacity of Stepped Channel D5 - B11

Pipe Segement	Shape	Gradient, a°	Horizontal Distance, m	Slant Distance, m	Depth, mm	Width, mm	Initial mPD,X(m)	Ending mPD, A(m)	C_e	x	f	f_e	Y_{90}, m	d_0, m	Cross Section Area, m_2	P_w, m	D_H, m	Gravity, m/s^2	V_0, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchment Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
D5 - B11	Stepped Channel	42	12.38	30.3	650	600	17.24	6.09	0.62	-0.31	1.00	0.35	0.48	0.18	0.11	0.96	0.45	9.81	4.11	0.45	0.40	H	0.187	46%	Y

Calculation of Capacity of Circular Pipes CB1

Pipe Segment	Length	Level (out)	Level (in)	Diameter	Depth	A_w	k_s [1]	v	s	g	V	Capacity Flow	Reduced Capacity Flow	Catchment Served	Q_p	Is $Q_c > Q_p$?	% of capacity	Remarks
	m	mPD	mPD	m	m	m^2	m	m^2/s	-	m/s^2	m/s	m^3/s	m^3/s		m^3/s	Y/N	%	
CB1	24.39	6.09	5.60	0.650	0.650	0.3318	0.00003	1E-06	0.020	9.810	4.7739	1.584	1.426	F,H,I	0.263	Y	18%	

D. Capacity Flow Estimation and Adequacy Check for Existing Streams and Culvert

Culvert	Width[3]	Depth[4]	A_w[5]	k_s	v	s	g	V	Capacity Flow	Reduced Capacity Flow	Catchment Served	Q_p	Is $Q_c > Q_p$?	% of capacity	Remarks
	m	m	m^2	m	m^2/s	-	m/s^2	m/s	m^3/s	m^3/s		m^3/s	Y/N	%	
Culvert 1	1.000	1.600	1.6000	0.00006	1E-06	0.100	9.810	15.0391	48.125	43.313	AA - AW	15.646	Y	36%	

Culvert	Diameter	Depth	A_w	k_s	v	s	g	V	Capacity Flow	Reduced Capacity Flow	Catchment Served	Q_p	Is $Q_c > Q_p$?	% of capacity	Remarks
	m	m	m^2	m	m^2/s	-	m/s^2	m/s	m^3/s	m^3/s		m^3/s	Y/N	%	
Culvert 2	0.850	-	0.5675	0.15000	1E-06	0.050	9.810	2.4135	1.370	1.233	F, H, I and BA to BL	5.386	*N*	437.0%	

Stream	Top Width, m	Bottom Width, m	Depth, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted perimeter, m	Hydraulic radius, m	Mean velocity, m/s	Capacity flow, m^3/s	Catchments Served	Runoff, m^3/s	Contribution from Identified Catchments, %	Sufficient Capacity? (Y/N)
Stream 1	4.0	2	1.3	0.100	0.040	3.900	5.280	0.74	6.46	25.193	A to E, G, J to N and AA to AZ, R1 - R5	17.432	69%	Y
Stream 2	3.0	1	1.3	0.050	0.040	2.600	4.280	0.61	4.01	10.425	F, H, I and BA to BL	5.645	54%	Y

Note: Adequacy in capacities of the stream have been checked based on the most narrow section of the existing stream at the stormwater discharge point.

E. Proposed Upgrading Works

Culvert	Diameter	Depth	A_w	k_s	v	s	g	V	Capacity Flow	Reduced Capacity Flow	Catchment Served	Q_p	Is $Q_c > Q_p$?	% of capacity	Remarks
	m	m	m^2	m	m^2/s	-	m/s^2	m/s	m^3/s	m^3/s		m^3/s	Y/N	%	
Culvert 2	1.600	1.600	2.0106	0.15000	1E-06	0.050	9.810	3.9996	8.042	7.237	F, H, I and BA to BL	5.386	Y	74.4%	

Note:
[1] Runoff is calculated in accordance with DSD's "Stormwater Drainage Manual - Planning, Design and Management" (SDM), Fifth edition, Jan 2018.
[2] Stepped Channel is adopted in some section to align with the topography of the Site. The Hydraulic Design of Stepped Channels is based on GEO Technical Guidance Note No. 27.
[3] Since Culvert 1 is a double-cell box culvert with identical cells, the width refers to the span of a single cell.
[4] Since Culvert 1 is a double-cell box culvert with identical cells, the depth refers to the depth of a single cell.
[5] Since Culvert 1 is a double-cell box culvert with identical cells, the A_w refers to the cross section area of one cell.
[6] Since Culvert 1 is a double-cell box culvert with identical cells, the Q^c is multiplied by 2 to represent the total capcity of the two cells of the culvert.
[7] A Manning's roughness coefficient of 0.030 for "Natural-stream channels — Clean, straight bank, full stage, no rifts or deep pools" in fair condition will be adopted for all proposed U-channels.
[8] A Manning's roughness coefficient of 0.040 for "Natural-stream channels — Winding, with some pools and shoals, clean with some weeds and stone" in good condition will be adopted for both streams based on site observation.
[9] The roughness value k_s of 0.006 mm for uPVC in normal condition will be adopted for all proposed circular pipes.
[10] The roughness value k_s of 0.06 mm for "Prestressed Concrete" in normal condition will be adopted for Culvert 1 based on the site observation.
[11] The absolute roughness value k_s of 150 mm for "Unlined Rock Tunnels" in normal condition will be adopted for Culvert 2 based on the site observation.
[12] Due to sedimentation, it is assumed that there is a 10% reduction in the capacity flow of the U-channels and circular pipes.

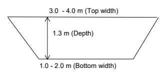
Equations Used

$$t_0 = \frac{0.14465L}{H^{0.2}A^{0.1}}$$

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

$$t_c = t_0 + t_f$$

$$Q_p = 0.278\,C\,i\,A$$



Schematic Section of the Streamcourse

Colebrook-White Equation (for circular pipes flowing full):

$$V = -\sqrt{(8gDs)}\,\log\left(\frac{ks}{3.7D} + \frac{2.51v}{D\sqrt{(2gDs)}}\right)$$

Appendix D

Detailed Drainage Analysis with 16% Increased Rainfall with Climate Change Impact

Section 12A Rezoning Application for Proposed Columbarium on Various Lots in D.D.41 Sha Tau Kok, New Territories
Capacity Flow Estimation for Proposed Catchments and Drainage System with 50 Year Return Period at End of 21st Century (16% Rainfall Increase)

A. Calculation of Catchment Runoff Received by the Site With 16% Rainfall Increase

Catchment ID	Surface Type	Catchment Area (A), m^2	Catchment Area (A), km^2	Average slope (H), m/100m	Flow path length (L), m	Inlet time (t_o), min	Time of Concentration (t_c), min	Duration (t_d), min	a (50 year return period)	b (50 year return period)	c (50 year return period)	Runoff intensity with 16.0% increase (i) mm/hr	Runoff coefficient (C)	C x A	Peak runoff (Q_p), m^3/s
A	90% Concrete + 10% Grassland (heavysoil), flat	3,757	0.00376	5.95	100.9	4.49	4.49	4.49	474.6	2.9	0.37	262	0.88	0.0033	0.2410
B	90% Concrete + 10% Grassland (heavysoil), flat	4,229	0.00423	1.29	77.5	4.62	4.62	4.62	474.6	2.9	0.37	260	0.88	0.0037	0.2694
C	80% Concrete + 20% Grassland (heavysoil), steep	1,705	0.00171	4.60	58.7	2.97	2.97	2.97	474.6	2.9	0.37	285	0.83	0.0014	0.1123
D	100% Grassland (heavysoil), steep	1,272	0.00127	7.36	76.0	3.61	3.61	3.61	474.6	2.9	0.37	275	0.35	0.0004	0.0340
E	10% Concrete + 90% Grassland (heavysoil), steep	3,597	0.00360	8.30	92.8	3.88	3.88	3.88	474.6	2.9	0.37	271	0.41	0.0015	0.1110
F	100% Grassland (heavysoil), steep	1,573	0.00157	6.68	34.4	1.63	1.63	1.63	474.6	2.9	0.37	314	0.35	0.0006	0.0481
G	85% Concrete + 15% Grassland (heavysoil), steep	1,178	0.00118	5.18	38.6	1.98	1.98	1.98	474.6	2.9	0.37	306	0.86	0.0010	0.0861
H	90% Concrete + 10% Grassland (heavysoil), flat	2,762	0.00276	15.59	73.8	2.79	2.79	2.79	474.6	2.9	0.37	289	0.88	0.0024	0.1952
I	100% Grassland (heavysoil), steep	1,031	0.00103	21.74	46.0	1.80	1.80	1.80	474.6	2.9	0.37	310	0.35	0.0004	0.0311
J	100% Concrete	416	0.00042	6.79	39.8	2.15	2.15	2.15	474.6	2.9	0.37	302	0.95	0.0004	0.0331
K	100% Concrete	232	0.00023	13.16	7.6	0.38	0.38	0.38	474.6	2.9	0.37	354	0.95	0.0002	0.0217
L	100% Concrete	729	0.00073	2.61	68.9	4.25	4.25	4.25	474.6	2.9	0.37	265	0.95	0.0007	0.0511
M	100% Concrete	81	0.00008	3.60	30.5	2.20	2.20	2.20	474.6	2.9	0.37	301	0.95	0.0001	0.0064
N	100% Concrete	805	0.00081	1.30	54.0	3.80	3.80	3.80	474.6	2.9	0.37	272	0.95	0.0008	0.0578
														Total	**1.2983**

Note: The surface types of catchments used in the calculation refer to the post-development scenario.

B. Calculation of Catchment Runoff Received by Existing Stream 1 With 16% Rainfall Increase

Catchment ID	Surface Type	Catchment Area (A), m^2	Catchment Area (A), km^2	Average slope (H), m/100m	Flow path length (L), m	Inlet time (t_0), min	Time of Concentration (t_c), min	Duration (t_d), min	a (50 year return period)	b (50 year return period)	c (50 year return period)	Runoff intensity with 16.0% increase (i) mm/hr	Runoff coefficient (C)	C x A	Peak runoff (Q_p), m^3/s
AA	100% Grassland (heavysoil), steep	10,468	0.01047	53.54	151.30	3.91	3.91	3.91	474.6	2.9	0.37	270	0.35	0.0037	0.2752
AB	100% Grassland (heavysoil), steep	18,920	0.01892	70.41	196.00	4.52	4.52	4.52	474.6	2.9	0.37	262	0.35	0.0066	0.4818
AC	100% Grassland (heavysoil), steep	10,196	0.01020	88.19	129.50	3.04	3.04	3.04	474.6	2.9	0.37	284	0.35	0.0036	0.2820
AD	100% Grassland (heavysoil), steep	52,671	0.05267	62.61	405.71	8.65	8.65	8.65	474.6	2.9	0.37	222	0.35	0.0184	1.1383
AE	100% Grassland (heavysoil), steep	22,926	0.02293	67.68	257.11	5.87	5.87	5.87	474.6	2.9	0.37	246	0.35	0.0080	0.5488
AF	100% Grassland (heavysoil), steep	29,391	0.02939	49.39	380.65	9.02	9.02	9.02	474.6	2.9	0.37	220	0.35	0.0103	0.6278
AG	100% Grassland (heavysoil), steep	37,189	0.03719	38.34	354.70	8.64	8.64	8.64	474.6	2.9	0.37	222	0.35	0.0130	0.8040
AH	100% Grassland (heavysoil), steep	38,374	0.03837	51.54	419.06	9.59	9.59	9.59	474.6	2.9	0.37	216	0.35	0.0134	0.8056
AI	100% Grassland (heavysoil), steep	32,527	0.03253	36.21	469.53	11.72	11.72	11.72	474.6	2.9	0.37	204	0.35	0.0114	0.6441
AJ	100% Grassland (heavysoil), steep	43,371	0.04337	19.83	342.86	9.38	9.38	9.38	474.6	2.9	0.37	217	0.35	0.0152	0.9162
AK	100% Grassland (heavysoil), steep	12,505	0.01250	51.10	180.04	4.62	4.62	4.62	474.6	2.9	0.37	260	0.35	0.0044	0.3169
AL	100% Grassland (heavysoil), steep	38,295	0.03830	58.25	271.24	6.06	6.06	6.06	474.6	2.9	0.37	244	0.35	0.0134	0.9095
AM	100% Grassland (heavysoil), steep	66,715	0.06672	37.02	318.70	7.37	7.37	7.37	474.6	2.9	0.37	232	0.35	0.0234	1.5059
AN	100% Grassland (heavysoil), steep	62,139	0.06214	42.78	119.21	2.70	2.70	2.70	474.6	2.9	0.37	291	0.35	0.0217	1.7569
AO	100% Grassland (heavysoil), steep	27,601	0.02760	36.09	315.87	8.02	8.02	8.02	474.6	2.9	0.37	227	0.35	0.0097	0.6090
AP	100% Grassland (heavysoil), steep	18,727	0.01873	39.88	255.78	6.62	6.62	6.62	474.6	2.9	0.37	239	0.35	0.0066	0.4348
AQ	100% Grassland (heavysoil), steep	27,808	0.02781	39.27	273.22	6.82	6.82	6.82	474.6	2.9	0.37	237	0.35	0.0097	0.6408
AR	100% Grassland (heavysoil), steep	30,327	0.03033	18.92	295.94	8.47	8.47	8.47	474.6	2.9	0.37	223	0.35	0.0106	0.6592
AS	10% Concrete + 90% Grassland (heavysoil), flat	40,285	0.04028	1.49	168.25	7.79	7.79	7.79	474.6	2.9	0.37	229	0.32	0.0129	0.8192
AT	5% Concrete + 95% Grassland (heavysoil), flat	33,841	0.03384	8.19	244.27	8.18	8.18	8.18	474.6	2.9	0.37	226	0.29	0.0096	0.6048
AU	100% Grassland (heavysoil), flat	19,765	0.01976	3.59	244.98	10.20	10.20	10.20	474.6	2.9	0.37	212	0.25	0.0049	0.2911
AV	5% Concrete + 95% Grassland (heavysoil), flat	13,325	0.01333	7.26	132.24	4.98	4.98	4.98	474.6	2.9	0.37	256	0.29	0.0038	0.2703
AW	20% Concrete + 80% Grassland (heavysoil), flat	43,594	0.04359	3.44	270.60	10.51	10.51	10.51	474.6	2.9	0.37	210	0.39	0.0170	0.9933
AX	20% Concrete + 80% Grassland (heavysoil), flat	1,485	0.00149	0.56	195.40	15.27	15.27	15.27	474.6	2.9	0.37	188	0.39	0.0006	0.0302
AY	100% Grassland (heavysoil), flat	4,127	0.00413	1.27	70.71	4.24	4.24	4.24	474.6	2.9	0.37	266	0.25	0.0010	0.0762
AZ	100% Grassland (heavysoil), steep	26,118	0.02612	54.73	131.00	3.08	3.08	3.08	474.6	2.9	0.37	284	0.35	0.0091	0.7207
														Total	**17.1626**

Note: The surface types of catchments used in the calculation refer to the post-development scenario.

C. Calculation of Catchment Runoff Received by Existing Stream 2 With 16% Rainfall Increase

Catchment ID	Surface Type	Catchment Area (A), m^2	Catchment Area (A), km^2	Average slope (H), m/100m	Flow path length (L), m	Inlet time (t_0), min	Time of Concentration (t_c), min	Duration (t_d), min	a (50 year return period)	b (50 year return period)	c (50 year return period)	Runoff intensity with 16.0% increase (i) mm/hr	Runoff coefficient (C)	C x A	Peak runoff (Q_p), m^3/s
BA	100% Grassland (heavysoil), steep	34,288	0.03429	65.73	304.27	6.71	6.71	6.71	474.6	2.9	0.37	238	0.35	0.0120	0.7934
BB	100% Grassland (heavysoil), steep	67,748	0.06775	54.12	617.15	13.21	13.21	13.21	474.6	2.9	0.37	196	0.35	0.0237	1.2940
BC	100% Grassland (heavysoil), steep	14,692	0.01469	40.00	200.00	5.30	5.30	5.30	474.6	2.9	0.37	252	0.35	0.0051	0.3606
BD	100% Grassland (heavysoil), steep	22,149	0.02215	49.01	375.45	9.17	9.17	9.17	474.6	2.9	0.37	219	0.35	0.0078	0.4709
BE	100% Grassland (heavysoil), steep	10,272	0.01027	24.75	222.26	6.72	6.72	6.72	474.6	2.9	0.37	238	0.35	0.0036	0.2376
BF	100% Grassland (heavysoil), steep	2,779	0.00278	49.97	296.20	8.87	8.87	8.87	474.6	2.9	0.37	221	0.35	0.0010	0.0596
BG	100% Grassland (heavysoil), steep	15,947	0.01595	25.95	169.55	4.86	4.86	4.86	474.6	2.9	0.37	257	0.35	0.0056	0.3995
BH	30% Grassland (heavysoil), flat + 70% Grassland (heavysoil), steep	15,375	0.01538	2.71	73.80	3.34	3.34	3.34	474.6	2.9	0.37	279	0.32	0.0049	0.3819
BI	70% Grassland (heavysoil), flat + 30% Grassland (heavysoil), steep	24,849	0.02485	13.81	550.37	17.12	17.12	17.12	474.6	2.9	0.37	181	0.28	0.0070	0.3503
BJ	70% Grassland (heavysoil), flat + 30% Grassland (heavysoil), steep	39,109	0.03911	13.62	147.62	4.40	4.40	4.40	474.6	2.9	0.37	263	0.28	0.0110	0.8016
BK	15% Concrete + 15% Grassland (heavysoil), flat + 70% Grassland (heavysoil), steep	12,273	0.01227	12.35	103.61	3.54	3.54	3.54	474.6	2.9	0.37	276	0.43	0.0052	0.4001
BL	100% Concrete	929	0.00093	7.30	58.88	2.89	2.89	2.89	474.6	2.9	0.37	287	0.95	0.0009	0.0704
														Total	**5.6201**

D. Calculation of Road Catchment Runoff With 16% Rainfall Increase

Catchment ID	Surface Type	Catchment Area (A), m^2	Catchment Area (A), km^2	Average slope (H), m/100m	Flow path length (L), m	Inlet time (t_0), min	Time of Concentration (t_c), min	Duration (t_d), min	a (50 year return period)	b (50 year return period)	c (50 year return period)	Runoff intensity with 16.0% increase (i) mm/hr	Runoff coefficient (C)	C x A	Peak runoff (Q_p), m^3/s
R1	100% Concrete	66	0.00007	13.84	11.20	0.63	0.63	0.63	474.6	2.9	0.37	345	0.95	0.0001	0.0060
R2	100% Concrete	46	0.00005	4.38	10.27	0.75	0.75	0.75	474.6	2.9	0.37	340	0.95	0.0000	0.0042
R3	100% Concrete	20	0.00002	0.74	13.42	1.53	1.53	1.53	474.6	2.9	0.37	317	0.95	0.0000	0.0017
R4	100% Concrete	18	0.00002	8.48	12.98	0.91	0.91	0.91	474.6	2.9	0.37	335	0.95	0.0000	0.0016
R5	100% Concrete	13	0.00001	4.20	9.52	0.80	0.80	0.80	474.6	2.9	0.37	339	0.95	0.0000	0.0012
														Total	**0.0147**

Note: The surface types of catchments used in the calculation refer to the post-development scenario.

Calculation of Capacity of U-Channel A1 - A13

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)	Remarks
A1 - A2	U-Channel	0.600	0.600	24.30	24.02	16.96	0.017	0.035	0.321	1.542	0.208	1.296	0.417	0.375	D,E,G	0.231	62%	Y	
A2 - A3	U-Channel	0.600	0.600	24.02	23.85	8.59	0.020	0.035	0.321	1.542	0.208	1.420	0.456	0.411	D,E,G	0.231	56%	Y	
A3 - A4	U-Channel	0.600	0.600	23.85	22.89	33.29	0.029	0.035	0.321	1.542	0.208	1.697	0.545	0.491	D,E,G	0.231	47%	Y	
A4 - A5	U-Channel	0.800	0.800	22.89	22.05	33.71	0.025	0.035	0.571	2.057	0.278	1.923	1.099	0.989	B,C,D,E,G	0.613	62%	Y	
A5 - A6	U-Channel	0.800	0.800	22.05	21.80	19.10	0.013	0.035	0.571	2.057	0.278	1.405	0.802	0.722	B,C,D,E,G	0.613	85%	Y	
A6 - A7	U-Channel	0.800	0.800	21.80	21.63	12.47	0.013	0.035	0.571	2.057	0.278	1.405	0.802	0.722	B,C,D,E,G	0.613	85%	Y	
A7 - A8	U-Channel	0.800	0.800	21.63	21.43	15.43	0.013	0.035	0.571	2.057	0.278	1.405	0.802	0.722	B,C,D,E,G	0.613	85%	Y	
A8 - A9	U-Channel	0.800	0.800	21.43	21.30	9.22	0.013	0.035	0.571	2.057	0.278	1.405	0.802	0.722	B,C,D,E,G	0.613	85%	Y	
A9 - A10	U-Channel	0.800	0.800	21.30	21.03	20.17	0.013	0.035	0.571	2.057	0.278	1.405	0.802	0.722	B,C,D,E,G	0.613	85%	Y	
A10 - A11	U-Channel	0.800	0.800	21.03	20.94	7.27	0.013	0.035	0.571	2.057	0.278	1.405	0.802	0.722	B,C,D,E,G	0.613	85%	Y	
A11 - A12	U-Channel	0.800	0.800	20.94	20.76	13.21	0.013	0.035	0.571	2.057	0.278	1.405	0.802	0.722	B,C,D,E,G	0.613	85%	Y	
A12 - A13	U-Channel	0.800	0.800	20.76	20.63	9.22	0.014	0.035	0.571	2.057	0.278	1.454	0.831	0.748	B,C,D,E,G	0.613	82%	Y	

Calculation of Capacity of Stepped Channel A13 - A14

Pipe Segement	Shape	Gradient, a°	Horizontal Distance, m	Slant Distance, m	Depth, mm	Width, mm	Initial mPD,X(m)	Ending mPD, A(m)	C_e	x	f	f_e	Y_{90}, m	d_0, m	Cross Section Area, m_2	P_w, m	D_H, m	Gravity, m/s^2	V_0, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchment Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
A13 - A14	Stepped Channel	20	10.55	25.9	850	900	20.63	16.79	0.31	0.60	1.00	0.77	0.80	0.55	0.50	2.01	0.99	9.81	2.95	1.47	1.319	A, B,C,D,E,G	0.8538	65%	Y

Calculation of Capacity of U-Channel A14 - A16

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)	Remarks
A14 - A15	U-Channel	0.800	0.800	16.79	15.98	41.00	0.020	0.030	0.571	2.057	0.278	1.987	1.135	1.022	A, B,C,D,E,G	0.854	84%	Y	
A15 - A16	U-Channel	0.800	0.800	15.98	15.10	44.92	0.020	0.030	0.571	2.057	0.278	1.987	1.135	1.022	A, B,C,D,E,G	0.854	84%	Y	

Calculation of Capacity of Stepped Channel A16 - A17

Pipe Segement	Shape	Gradient, a°	Horizontal Distance, m	Slant Distance, m	Depth, mm	Width, mm	Initial mPD,X(m)	Ending mPD, A(m)	C_e	x	f	f_e	Y_{90}, m	d_0, m	Cross Section Area, m_2	P_w, m	D_H, m	Gravity, m/s^2	V_0, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchment Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
A16 - A17	Stepped Channel	20	12.78	31.3	850	900	15.10	10.45	0.31	0.60	1.00	0.77	0.80	0.55	0.50	2.01	0.99	9.81	2.95	1.47	1.319	A, B,C,D,E,G	0.854	65%	Y

Calculation of Capacity of U-Channel A17 - A25

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)	Remarks
A17 - A18	U-Channel	0.900	0.900	10.45	10.02	25.40	0.017	0.030	0.723	2.314	0.313	1.999	1.445	1.301	A,B,C,D,E,G,J	0.887	68%	Y	
A18 - A19	U-Channel	0.900	0.900	10.02	9.91	6.50	0.017	0.030	0.723	2.314	0.313	1.999	1.445	1.301	A,B,C,D,E,G,J	0.887	68%	Y	
A19 - A20	U-Channel	0.900	0.900	9.91	9.81	6.06	0.017	0.030	0.723	2.314	0.313	1.999	1.445	1.301	A,B,C,D,E,G,J,K	0.909	70%	Y	
A20 - A21	U-Channel	0.900	0.900	9.81	9.43	22.23	0.017	0.030	0.723	2.314	0.313	1.999	1.445	1.301	A,B,C,D,E,G,J,K	0.909	70%	Y	
A21 - A22	U-Channel	0.900	0.900	9.43	8.78	38.20	0.017	0.030	0.723	2.314	0.313	1.999	1.445	1.301	A,B,C,D,E,G,J,K L	0.960	74%	Y	
A22 - A23	U-Channel	0.900	0.900	8.78	8.60	10.82	0.017	0.030	0.723	2.314	0.313	1.982	1.433	1.290	A,B,C,D,E,G,J,K L	0.960	74%	Y	
A23 - A24	U-Channel	0.900	0.900	8.60	8.38	15.78	0.014	0.030	0.723	2.314	0.313	1.835	1.327	1.194	A,B,C,D,E,G,J,K L	0.960	80%	Y	
A24 - A25	U-Channel	0.900	0.900	8.38	8.30	5.32	0.014	0.030	0.723	2.314	0.313	1.835	1.327	1.194	A,B,C,D,E,G,J,K L,N	1.017	85%	Y	

Calculation of Capacity of U-Channel C1 - C4

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)	Remarks
C1 - C2	U-Channel	0.700	0.700	23.20	22.54	33.23	0.020	0.030	0.437	1.800	0.243	1.836	0.803	0.723	B,C,D,E,G	0.613	85%	Y	
C2 - C3	U-Channel	0.700	0.700	22.54	22.06	23.74	0.020	0.030	0.437	1.800	0.243	1.836	0.803	0.723	B,C,D,E,G	0.613	85%	Y	
C3 - C4	U-Channel	0.800	0.800	22.06	21.79	13.91	0.019	0.030	0.571	2.057	0.278	1.968	1.124	1.012	A,B,C,D,E,G	0.854	84%	Y	

Calculation of Capacity of Stepped Channel C4 - C5

Pipe Segement	Shape	Gradient, a°	Horizontal Distance, m	Slant Distance, m	Depth, mm	Width, mm	Initial mPD,X(m)	Ending mPD, A(m)	C_e	x	f	f_e	Y_{90}, m	d_0, m	Cross Section Area, m_2	P_w, m	D_H, m	Gravity, m/s^2	V_0, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchment Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
C4 - C5	Stepped Channel	20	14.96	36.7	850	900	21.79	16.35	0.31	0.60	1.00	0.77	0.80	0.55	0.50	2.01	0.99	9.81	2.95	1.47	1.319	A,B,C,D,E,G	0.854	65%	Y

Calculation of Capacity of U-Channel C5 - C8

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)	Remarks
C5 - C6	U-Channel	0.850	0.850	16.35	16.00	27.36	0.013	0.030	0.645	2.185	0.295	1.673	1.079	0.971	A,B,C,D,E,G	0.854	88%	Y	
C6 -C7	U-Channel	0.850	0.850	16.00	15.53	25.80	0.018	0.030	0.645	2.185	0.295	1.998	1.289	1.160	A,B,C,D,E,G	0.854	74%	Y	
C7 - C8	U-Channel	0.850	0.850	15.53	15.05	25.83	0.018	0.030	0.645	2.185	0.295	1.998	1.289	1.160	A,B,C,D,E,G	0.854	74%	Y	

Calculation of Capacity of Stepped Channel C8 - C9

Pipe Segement	Shape	Gradient, a°	Horizontal Distance, m	Slant Distance, m	Depth, mm	Width, mm	Initial mPD,X(m)	Ending mPD, A(m)	C_e	x	f	f_e	Y_{90}, m	d_0, m	Cross Section Area, m_2	P_w, m	D_H, m	Gravity, m/s^2	V_0, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchment Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
C8 - C9	Stepped Channel	20	12.640	31.0	850	900	15.05	10.45	0.31	0.60	1.00	0.77	0.80	0.55	0.50	2.01	0.99	9.81	2.95	1.47	1.319	A,B,C,D,E,G	0.854	65%	Y

Calculation of Capacity of U-Channel C9 - C15

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)	Remarks
C9 - C10	U-Channel	0.850	0.850	10.45	10.01	26.60	0.017	0.030	0.645	2.185	0.295	1.908	1.230	1.107	A,B,C,D,E,G, J	0.887	80%	Y	
C10 - C11	U-Channel	0.850	0.850	10.01	9.83	11.07	0.017	0.030	0.645	2.185	0.295	1.908	1.230	1.107	A,B,C,D,E,G, J	0.887	80%	Y	
C11 - C12	U-Channel	0.850	0.850	9.83	9.53	16.23	0.018	0.030	0.645	2.185	0.295	1.993	1.285	1.157	A,B,C,D,E,G, J, K	0.909	79%	Y	
C12 - C13	U-Channel	0.850	0.850	9.53	9.25	15.60	0.018	0.030	0.645	2.185	0.295	1.993	1.285	1.157	A,B,C,D,E,G, J, K,M	0.915	79%	Y	
C13 - C14	U-Channel	0.850	0.850	9.25	9.05	12.13	0.016	0.030	0.645	2.185	0.295	1.862	1.201	1.081	A,B,C,D,E,G, J, K,M	0.915	85%	Y	
C14 - C15	U-Channel	0.850	0.850	9.05	8.45	40.53	0.015	0.030	0.645	2.185	0.295	1.804	1.163	1.047	A,B,C,D,E,G, J, K,M	0.915	87%	Y	

Calculation of Capacity of Circular Pipes A25 - CA1

Pipe Segment	Length	Level (out)	Level (in)	Diameter	Depth	A_w	k_s [1]	v	s	g	V	Capacity Flow	Reduced Capacity Flow	Catchment Served	Q_p	Is $Q_c > Q_p$?	% of capacity	Remarks
	m	mPD	mPD	m	m	m^2	m	m^2/s	-	m/s^2	m/s	m^3/s	m^3/s		m^3/s	Y/N	%	
A25 - E1	21.05	8.30	7.60	0.900	0.900	0.636	0.00003	1E-06	0.033	9.810	7.5157	4.781	4.303	A,B,C,D,E,G,J,K, L,M,N	1.024	Y	24%	
E1 - E2	6.46	7.60	7.39	0.900	0.900	0.636	0.00003	1E-06	0.033	9.810	7.5157	4.781	4.303	A,B,C,D,E,G,J,K, L,M,N, R1	1.030	Y	24%	
E2 - E3	19.46	7.39	6.74	0.900	0.900	0.636	0.00003	1E-06	0.033	9.810	7.5157	4.781	4.303	A,B,C,D,E,G,J,K, L,M,N, R1 - R2	1.034	Y	24%	
E3 - E4	27.29	6.74	5.83	0.900	0.900	0.636	0.00003	1E-06	0.033	9.810	7.5157	4.781	4.303	A,B,C,D,E,G,J,K, L,M,N, R1 - R3	1.036	Y	24%	
E4 - E5	15.68	5.83	5.31	0.900	0.900	0.636	0.00003	1E-06	0.033	9.810	7.5157	4.781	4.303	A,B,C,D,E,G,J,K, L,M,N, R1 - R4	1.037	Y	24%	
E5 - E6	11.02	5.31	5.20	0.900	0.900	0.636	0.00003	1E-06	0.010	9.810	3.9772	2.530	2.277	A,B,C,D,E,G,J,K, L,M,N, R1 - R5	1.039	Y	46%	
CA 1	16.52	5.20	5.18	1.050	1.050	0.866	0.00003	1E-06	0.0014	9.810	1.5718	1.361	1.225	A,B,C,D,E,G,J,K, L,M,N, R1 - R5	1.039	Y	85%	

Calculation of Capacity of U-Channel A1 - B7

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
A1 - B1	U-Channel	0.300	0.300	24.30	24.07	21.05	0.011	0.030	0.080	0.771	0.104	0.778	0.062	0.056	F	0.048	86%	Y
B1 - B2	U-Channel	0.300	0.300	24.07	23.99	6.46	0.011	0.030	0.080	0.771	0.104	0.778	0.062	0.056	F	0.048	86%	Y
B2 -B3	U-Channel	0.300	0.300	23.99	23.35	19.46	0.033	0.030	0.080	0.771	0.104	1.347	0.108	0.097	F	0.048	49%	Y
B3 - B4	U-Channel	0.450	0.450	23.35	22.44	27.29	0.033	0.030	0.181	1.157	0.156	1.766	0.319	0.287	F,H	0.243	85%	Y
B4 - B5	U-Channel	0.450	0.450	22.44	21.91	15.68	0.033	0.030	0.181	1.157	0.156	1.766	0.319	0.287	F,H	0.243	85%	Y
B5 - B6	U-Channel	0.450	0.450	21.91	21.47	11.02	0.040	0.030	0.181	1.157	0.156	1.934	0.350	0.315	F,H,I	0.274	87%	Y
B6 - B7	U-Channel	0.450	0.450	21.47	20.81	16.52	0.040	0.030	0.181	1.157	0.156	1.934	0.350	0.315	F,H,I	0.274	87%	Y

Calculation of Capacity of Stepped Channel B7 - B8

Pipe Segement	Shape	Gradient, a°	Horizontal Distance, m	Slant Distance, m	Depth, mm	Width, mm	Initial mPD,X(m)	Ending mPD, A(m)	C_e	x	f	f_e	Y_{90}, m	d_0, m	Cross Section Area, m_2	P_w, m	D_H, m	Gravity, m/s^2	V_0, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchment Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
B7 - B8	Stepped Channel	20	8.4	20.6	575	450	20.81	17.75	0.31	0.60	1.00	0.77	0.54	0.37	0.17	1.20	0.56	9.81	2.22	0.37	0.34	F,H,I	0.274	82%	Y

Calculation of Capacity of U-Channel B8 - B9

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
B8 - B9	U-Channel	0.600	0.600	17.75	17.22	18.73	0.029	0.030	0.321	1.542	0.208	1.980	0.636	0.573	F,H,I	0.274	48%	Y

Calculation of Capacity of Stepped Channel B9 - B10

Pipe Segement	Shape	Gradient, a°	Horizontal Distance, m	Slant Distance, m	Depth, mm	Width, mm	Initial mPD,X(m)	Ending mPD, A(m)	C_e	x	f	f_e	Y_{90}, m	d_0, m	Cross Section Area, m_2	P_w, m	D_H, m	Gravity, m/s^2	V_0, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchment Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
B9 - B10	Stepped Channel	46	10.74	26.3	650	600	17.22	6.10	0.64	-0.36	1.00	0.33	0.45	0.16	0.10	0.92	0.42	9.81	4.25	0.41	0.37	F,H,I	0.274	74%	Y

Calculation of Capacity of U-Channel B10 - B11

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
B10 - B11	U-Channel	0.650	0.650	6.10	5.94	18.73	0.008	0.030	0.377	1.671	0.226	1.128	0.425	0.383	F,H,I	0.274	72%	Y

Calculation of Capacity of U-Channel D1 - D3

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
D1 - D2	U-Channel	0.450	0.450	23.10	22.23	20.79	0.042	0.030	0.181	1.157	0.156	1.974	0.357	0.321	H	0.1952	61%	Y
D2 - D3	U-Channel	0.450	0.450	22.23	21.44	19.96	0.040	0.030	0.181	1.157	0.156	1.934	0.350	0.315	H	0.1952	62%	Y

Calculation of Capacity of Stepped Channel D3 - D4

Pipe Segement	Shape	Gradient, a°	Horizontal Distance, m	Slant Distance, m	Depth, mm	Width, mm	Initial mPD,X(m)	Ending mPD, A(m)	C_e	x	f	f_e	Y_{90}, m	d_0, m	Cross Section Area, m_2	P_w, m	D_H, m	Gravity, m/s^2	V_0, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchment Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
D3 - D4	Stepped Channel	20	10.61	26.0	575	450	21.44	17.57	0.31	0.60	1.00	0.77	0.54	0.37	0.17	1.20	0.56	9.81	2.22	0.37	0.34	H	0.195	58%	Y

Calculation of Capacity of U-Channel D4 - D5

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
D4 - D5	U-Channel	0.600	0.600	17.57	17.24	16.64	0.020	0.030	0.321	1.542	0.208	1.657	0.532	0.479	H	0.195	41%	Y

Calculation of Capacity of Stepped Channel D5 - B11

Pipe Segement	Shape	Gradient, a°	Horizontal Distance, m	Slant Distance, m	Depth, mm	Width, mm	Initial mPD,X(m)	Ending mPD, A(m)	C_e	x	f	f_e	Y_{90}, m	d_0, m	Cross Section Area, m_2	P_w, m	D_H, m	Gravity, m/s^2	V_0, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchment Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
D5 - B11	Stepped Channel	42	12.38	30.3	650	600	17.24	6.09	0.62	-0.31	1.00	0.35	0.48	0.18	0.11	0.96	0.45	9.81	4.11	0.45	0.40	H	0.195	48%	Y

Calculation of Capacity of Circular Pipes CB1

Pipe Segment	Length	Level (out)	Level (in)	Diameter	Depth	A_w	k_s [1]	v	s	g	V	Capacity Flow	Reduced Capacity Flow	Catchment Served	Q_p	Is $Q_c > Q_p$?	% of capacity	Remarks
	m	mPD	mPD	m	m	m^2	m	m^2/s	-	m/s^2	m/s	m^3/s	m^3/s		m^3/s	Y/N	%	
CB1	24.39	6.09	5.60	0.650	0.650	0.3318	0.00003	1E-06	0.020	9.810	4.7739	1.584	1.426	F,H,I	0.274	Y	19%	

D. Capacity Flow Estimation and Adequacy Check for Existing Streams and Culvert

Culvert	Width[3]	Depth[4]	A_w[5]	k_s	v	s	g	V	Capacity Flow	Reduced Capacity Flow	Catchment Served	Q_p	Is $Q_c > Q_p$?	% of capacity	Remarks
	m	m	m^2	m	m^2/s	-	m/s^2	m/s	m^3/s	m^3/s		m^3/s	Y/N	%	
Culvert 1	1.000	1.600	1.6000	0.00006	1E-06	0.100	9.810	15.0391	48.125	43.313	AA - AW	16.336	Y	38%	

Culvert	Diameter	Depth	A_w	k_s	v	s	g	V	Capacity Flow	Reduced Capacity Flow	Catchment Served	Q_p	Is $Q_c > Q_p$?	% of capacity	Remarks
	m	m	m^2	m	m^2/s	-	m/s^2	m/s	m^3/s	m^3/s		m^3/s	Y/N	%	
Culvert 2	0.850	-	0.5675	0.15000	1E-06	0.050	9.810	2.4135	1.370	1.233	F, H, I and BA to BL	5.623	***N***	456.2%	

Stream	Top Width, m	Bottom Width, m	Depth, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted perimeter, m	Hydraulic radius, m	Mean velocity, m/s	Capacity flow, m^3/s	Catchments Served	Runoff, m^3/s	Contribution from Identified Catchments, %	Sufficient Capacity? (Y/N)
Stream 1	4.0	2	1.3	0.100	0.040	3.900	5.280	0.74	6.46	25.193	A to E, G, J to N and AA to AZ, R1 - R5	18.201	72%	Y
Stream 2	3.0	1	1.3	0.050	0.040	2.600	4.280	0.61	4.01	10.425	F, H, I and BA to BL	5.894	57%	Y

Note: Adequacy in capacities of the stream have been checked based on the most narrow section of the existing stream at the stormwater discharge point.

E. Proposed Upgrading Works

Culvert	Diameter	Depth	A_w	k_s	v	s	g	V	Capacity Flow	Reduced Capacity Flow	Catchment Served	Q_p	Is $Q_c > Q_p$?	% of capacity	Remarks
	m	m	m^2	m	m^2/s	-	m/s^2	m/s	m^3/s	m^3/s		m^3/s	Y/N	%	
Culvert 2	1.600	1.600	2.0106	0.15000	1E-06	0.050	9.810	3.9996	8.042	7.237	F, H, I and BA to BL	5.623	Y	77.7%	

Note:
[1] Runoff is calculated in accordance with DSD's "Stormwater Drainage Manual - Planning, Design and Management" (SDM), Fifth edition, Jan 2018.
[2] Stepped Channel is adopted in some section to align with the topography of the Site. The Hydraulic Design of Stepped Channels is based on GEO Technical Guidance Note No. 27.
[3] Since Culvert 1 is a double-cell box culvert with identical cells, the width refers to the span of a single cell.
[4] Since Culvert 1 is a double-cell box culvert with identical cells, the depth refers to the depth of a single cell.
[5] Since Culvert 1 is a double-cell box culvert with identical cells, the A_w refers to the cross section area of one cell.
[6] Since Culvert 1 is a double-cell box culvert with identical cells, the Q^c is multiplied by 2 to represent the total capcity of the two cells of the culvert.
[7] A Manning's roughness coefficient of 0.030 for "Natural-stream channels — Clean, straight bank, full stage, no rifts or deep pools" in fair condition will be adopted for all proposed U-channels.
[8] A Manning's roughness coefficient of 0.040 for "Natural-stream channels — Winding, with some pools and shoals, clean with some weeds and stone" in good condition will be adopted for both streams based on site observation.
[9] The roughness value k_s of 0.006 mm for uPVC in normal condition will be adopted for all proposed circular pipes.
[10] The roughness value k_s of 0.06 mm for "Prestressed Concrete" in normal condition will be adopted for Culvert 1 based on the site observation.
[11] The absolute roughness value k_s of 150 mm for "Unlined Rock Tunnels" in normal condition will be adopted for Culvert 2 based on the site observation.
[12] Due to sedimentation, it is assumed that there is a 10% reduction in the capacity flow of the U-channels and circular pipes.

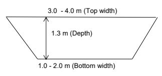
Equations Used

$$t_0 = \frac{0.14465L}{H^{0.2}A^{0.1}}$$

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

$$t_c = t_0 + t_f$$

$$Q_p = 0.278\ C\ i\ A$$



Schematic Section of the Streamcourse

Colebrook-White Equation (for circular pipes flowing full):

$$V = -\sqrt{(8gDs)}\log\left(\frac{ks}{3.7D} + \frac{2.51v}{D\sqrt{(2gDs)}}\right)$$

Appendix E

Detailed Drainage Analysis with 16% Increased Rainfall and 12.1% Design Allowance with Climate Change Impact

Section 12A Rezoning Application for Proposed Columbarium on Various Lots in D.D.41 Sha Tau Kok, New Territories
Capacity Flow Estimation for Proposed Catchments and Drainage System with 50 Year Return Period at End of 21st Century (16% Rainfall Increase + 12.1% Design Allowance)

A. Calculation of Catchment Runoff Received by the Site With 16% Rainfall Increase + 12.1% Design Allowance

Catchment ID	Surface Type	Catchment Area (A), m^2	Catchment Area (A), km^2	Average slope (H), m/100m	Flow path length (L), m	Inlet time (t_0), min	Time of Concentration (t_c), min	Duration (t_d), min	a (50 year return period)	b (50 year return period)	c (50 year return period)	Runoff intensity with 28.1% increase (i) mm/hr	Runoff coefficient (C)	C x A	Peak runoff (Q_p), m^3/s
A	90% Concrete + 10% Grassland (heavysoil), flat	3,757	0.00376	5.95	100.9	4.49	4.49	4.49	474.6	2.9	0.37	290	0.88	0.0033	0.2661
B	90% Concrete + 10% Grassland (heavysoil), flat	4,229	0.00423	1.29	77.5	4.62	4.62	4.62	474.6	2.9	0.37	288	0.88	0.0037	0.2975
C	80% Concrete + 20% Grassland (heavysoil), steep	1,705	0.00171	4.60	58.7	2.97	2.97	2.97	474.6	2.9	0.37	315	0.83	0.0014	0.1240
D	100% Grassland (heavysoil), steep	1,272	0.00127	7.36	76.0	3.61	3.61	3.61	474.6	2.9	0.37	303	0.35	0.0004	0.0376
E	10% Concrete + 90% Grassland (heavysoil), steep	3,597	0.00360	8.30	92.8	3.88	3.88	3.88	474.6	2.9	0.37	299	0.41	0.0015	0.1226
F	100% Grassland (heavysoil), steep	1,573	0.00157	6.68	34.4	1.63	1.63	1.63	474.6	2.9	0.37	347	0.35	0.0006	0.0531
G	85% Concrete + 15% Grassland (heavysoil), steep	1,178	0.00118	5.18	38.6	1.98	1.98	1.98	474.6	2.9	0.37	338	0.86	0.0010	0.0951
H	90% Concrete + 10% Grassland (heavysoil), flat	2,762	0.00276	15.59	73.8	2.79	2.79	2.79	474.6	2.9	0.37	319	0.88	0.0024	0.2155
I	100% Grassland (heavysoil), steep	1,031	0.00103	21.74	46.0	1.80	1.80	1.80	474.6	2.9	0.37	343	0.35	0.0004	0.0344
J	100% Concrete	416	0.00042	6.79	39.8	2.15	2.15	2.15	474.6	2.9	0.37	333	0.95	0.0004	0.0366
K	100% Concrete	232	0.00023	13.16	7.6	0.38	0.38	0.38	474.6	2.9	0.37	391	0.95	0.0002	0.0239
L	100% Concrete	729	0.00073	2.61	68.9	4.25	4.25	4.25	474.6	2.9	0.37	293	0.95	0.0007	0.0564
M	100% Concrete	81	0.00008	3.60	30.5	2.20	2.20	2.20	474.6	2.9	0.37	332	0.95	0.0001	0.0071
N	100% Concrete	805	0.00081	1.30	54.0	3.80	3.80	3.80	474.6	2.9	0.37	300	0.95	0.0008	0.0638
														Total	**1.4337**

Note: The surface types of catchments used in the calculation refer to the post-development scenario.

B. Calculation of Catchment Runoff Received by Existing Stream 1 With 16% Rainfall Increase + 12.1% Design Allowance

Catchment ID	Surface Type	Catchment Area (A), m^2	Catchment Area (A), km^2	Average slope (H), m/100m	Flow path length (L), m	Inlet time (t_0), min	Time of Concentration (t_c), min	Duration (t_d), min	a (50 year return period)	b (50 year return period)	c (50 year return period)	Runoff intensity with 28.1% increase (i) mm/hr	Runoff coefficient (C)	C x A	Peak runoff (Q_p), m^3/s
AA	100% Grassland (heavysoil), steep	10,468	0.01047	53.54	151.30	3.91	3.91	3.91	474.6	2.9	0.37	298	0.35	0.0037	0.3039
AB	100% Grassland (heavysoil), steep	18,920	0.01892	70.41	196.00	4.52	4.52	4.52	474.6	2.9	0.37	289	0.35	0.0066	0.5320
AC	100% Grassland (heavysoil), steep	10,196	0.01020	88.19	129.50	3.04	3.04	3.04	474.6	2.9	0.37	314	0.35	0.0036	0.3115
AD	100% Grassland (heavysoil), steep	52,671	0.05267	62.61	405.71	8.65	8.65	8.65	474.6	2.9	0.37	245	0.35	0.0184	1.2570
AE	100% Grassland (heavysoil), steep	22,926	0.02293	67.68	257.11	5.87	5.87	5.87	474.6	2.9	0.37	272	0.35	0.0080	0.6061
AF	100% Grassland (heavysoil), steep	29,391	0.02939	49.39	380.65	9.02	9.02	9.02	474.6	2.9	0.37	242	0.35	0.0103	0.6932
AG	100% Grassland (heavysoil), steep	37,189	0.03719	38.34	354.70	8.64	8.64	8.64	474.6	2.9	0.37	245	0.35	0.0130	0.8879
AH	100% Grassland (heavysoil), steep	38,374	0.03837	51.54	419.06	9.59	9.59	9.59	474.6	2.9	0.37	238	0.35	0.0134	0.8896
AI	100% Grassland (heavysoil), steep	32,527	0.03253	36.21	469.53	11.72	11.72	11.72	474.6	2.9	0.37	225	0.35	0.0114	0.7112
AJ	100% Grassland (heavysoil), steep	43,371	0.04337	19.83	342.86	9.38	9.38	9.38	474.6	2.9	0.37	240	0.35	0.0152	1.0118
AK	100% Grassland (heavysoil), steep	12,505	0.01250	51.10	180.04	4.62	4.62	4.62	474.6	2.9	0.37	288	0.35	0.0044	0.3500
AL	100% Grassland (heavysoil), steep	38,295	0.03830	58.25	271.24	6.06	6.06	6.06	474.6	2.9	0.37	270	0.35	0.0134	1.0043
AM	100% Grassland (heavysoil), steep	66,715	0.06672	37.02	318.70	7.37	7.37	7.37	474.6	2.9	0.37	256	0.35	0.0234	1.6630
AN	100% Grassland (heavysoil), steep	62,139	0.06214	42.78	119.21	2.70	2.70	2.70	474.6	2.9	0.37	321	0.35	0.0217	1.9401
AO	100% Grassland (heavysoil), steep	27,601	0.02760	36.09	315.87	8.02	8.02	8.02	474.6	2.9	0.37	250	0.35	0.0097	0.6725
AP	100% Grassland (heavysoil), steep	18,727	0.01873	39.88	255.78	6.62	6.62	6.62	474.6	2.9	0.37	264	0.35	0.0066	0.4802
AQ	100% Grassland (heavysoil), steep	27,808	0.02781	39.27	273.22	6.82	6.82	6.82	474.6	2.9	0.37	262	0.35	0.0097	0.7076
AR	100% Grassland (heavysoil), steep	30,327	0.03033	18.92	295.94	8.47	8.47	8.47	474.6	2.9	0.37	247	0.35	0.0106	0.7280
AS	10% Concrete + 90% Grassland (heavysoil), flat	40,285	0.04028	1.49	168.25	7.79	7.79	7.79	474.6	2.9	0.37	252	0.32	0.0129	0.9047
AT	5% Concrete + 95% Grassland (heavysoil), flat	33,841	0.03384	8.19	244.27	8.18	8.18	8.18	474.6	2.9	0.37	249	0.29	0.0096	0.6679
AU	100% Grassland (heavysoil), flat	19,765	0.01976	3.59	244.98	10.20	10.20	10.20	474.6	2.9	0.37	234	0.25	0.0049	0.3215
AV	5% Concrete + 95% Grassland (heavysoil), flat	13,325	0.01333	7.26	132.24	4.98	4.98	4.98	474.6	2.9	0.37	283	0.29	0.0038	0.2985
AW	20% Concrete + 80% Grassland (heavysoil), flat	43,594	0.04359	3.44	270.60	10.51	10.51	10.51	474.6	2.9	0.37	232	0.39	0.0170	1.0969
AX	20% Concrete + 80% Grassland (heavysoil), flat	1,485	0.00149	0.56	195.40	15.27	15.27	15.27	474.6	2.9	0.37	207	0.39	0.0006	0.0334
AY	100% Grassland (heavysoil), flat	4,127	0.00413	1.27	70.71	4.24	4.24	4.24	474.6	2.9	0.37	293	0.25	0.0010	0.0841
AZ	100% Grassland (heavysoil), steep	26,118	0.02612	54.73	131.00	3.08	3.08	3.08	474.6	2.9	0.37	313	0.35	0.0091	0.7958
														Total	**18.9529**

Note: The surface types of catchments used in the calculation refer to the post-development scenario.

C. Calculation of Catchment Runoff Received by Existing Stream 2 With 16% Rainfall Increase + 12.1% Design Allowance

Catchment ID	Surface Type	Catchment Area (A), m^2	Catchment Area (A), km^2	Average slope (H), m/100m	Flow path length (L), m	Inlet time (t_0), min	Time of Concentration (t_c), min	Duration (t_d), min	a (50 year return period)	b (50 year return period)	c (50 year return period)	Runoff intensity with 28.1% increase (i) mm/hr	Runoff coefficient (C)	C x A	Peak runoff (Q_p), m^3/s
BA	100% Grassland (heavysoil), steep	34,288	0.03429	65.73	304.27	6.71	6.71	6.71	474.6	2.9	0.37	263	0.35	0.0120	0.8762
BB	100% Grassland (heavysoil), steep	67,748	0.06775	54.12	617.15	13.21	13.21	13.21	474.6	2.9	0.37	217	0.35	0.0237	1.4290
BC	100% Grassland (heavysoil), steep	14,692	0.01469	40.00	200.00	5.30	5.30	5.30	474.6	2.9	0.37	279	0.35	0.0051	0.3982
BD	100% Grassland (heavysoil), steep	22,149	0.02215	49.01	375.45	9.17	9.17	9.17	474.6	2.9	0.37	241	0.35	0.0078	0.5201
BE	100% Grassland (heavysoil), steep	10,272	0.01027	24.75	222.26	6.72	6.72	6.72	474.6	2.9	0.37	263	0.35	0.0036	0.2624
BF	100% Grassland (heavysoil), steep	2,779	0.00278	49.97	296.20	8.87	8.87	8.87	474.6	2.9	0.37	244	0.35	0.0010	0.0659
BG	100% Grassland (heavysoil), steep	15,947	0.01595	25.95	169.55	4.86	4.86	4.86	474.6	2.9	0.37	284	0.35	0.0056	0.4411
BH	30% Grassland (heavysoil), flat + 70% Grassland (heavysoil), steep	15,375	0.01538	2.71	73.80	3.34	3.34	3.34	474.6	2.9	0.37	308	0.32	0.0049	0.4217
BI	70% Grassland (heavysoil), flat + 30% Grassland (heavysoil), steep	24,849	0.02485	13.81	550.37	17.12	17.12	17.12	474.6	2.9	0.37	200	0.28	0.0070	0.3869
BJ	70% Grassland (heavysoil), flat + 30% Grassland (heavysoil), steep	39,109	0.03911	13.62	147.62	4.40	4.40	4.40	474.6	2.9	0.37	291	0.28	0.0110	0.8853
BK	15% Concrete + 15% Grassland (heavysoil), flat + 70% Grassland (heavysoil), steep	12,273	0.01227	12.35	103.61	3.54	3.54	3.54	474.6	2.9	0.37	305	0.43	0.0052	0.4418
BL	100% Concrete	929	0.00093	7.30	58.88	2.89	2.89	2.89	474.6	2.9	0.37	317	0.95	0.0009	0.0778
														Total	**6.2063**

D. Calculation of Road Catchment Runoff With 16% Rainfall Increase + 12.1% Design Allowance

Catchment ID	Surface Type	Catchment Area (A), m^2	Catchment Area (A), km^2	Average slope (H), m/100m	Flow path length (L), m	Inlet time (t_0), min	Time of Concentration (t_c), min	Duration (t_d), min	a (50 year return period)	b (50 year return period)	c (50 year return period)	Runoff intensity with 28.1% increase (i) mm/hr	Runoff coefficient (C)	C x A	Peak runoff (Q_p), m^3/s
R1	100% Concrete	66	0.00007	13.84	11.20	0.63	0.63	0.63	474.6	2.9	0.37	381	0.95	0.0001	0.0066
R2	100% Concrete	46	0.00005	4.38	10.27	0.75	0.75	0.75	474.6	2.9	0.37	376	0.95	0.0000	0.0046
R3	100% Concrete	20	0.00002	0.74	13.42	1.53	1.53	1.53	474.6	2.9	0.37	350	0.95	0.0000	0.0019
R4	100% Concrete	18	0.00002	8.48	12.98	0.91	0.91	0.91	474.6	2.9	0.37	370	0.95	0.0000	0.0018
R5	100% Concrete	13	0.00001	4.20	9.52	0.80	0.80	0.80	474.6	2.9	0.37	374	0.95	0.0000	0.0013
														Total	**0.0162**

Note: The surface types of catchments used in the calculation refer to the post-development scenario.

Calculation of Capacity of U-Channel A1 - A13

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)	Remarks
A1 - A2	U-Channel	0.600	0.600	24.30	24.02	16.96	0.017	0.035	0.321	1.542	0.208	1.296	0.417	0.375	D,E,G	0.255	68%	Y	
A2 - A3	U-Channel	0.600	0.600	24.02	23.85	8.59	0.020	0.035	0.321	1.542	0.208	1.420	0.456	0.411	D,E,G	0.255	62%	Y	
A3 - A4	U-Channel	0.600	0.600	23.85	22.89	33.29	0.029	0.035	0.321	1.542	0.208	1.697	0.545	0.491	D,E,G	0.255	52%	Y	
A4 - A5	U-Channel	0.800	0.800	22.89	22.05	33.71	0.025	0.035	0.571	2.057	0.278	1.923	1.099	0.989	B,C,D,E,G	0.677	68%	Y	
A5 - A6	U-Channel	0.800	0.800	22.05	21.80	19.10	0.013	0.035	0.571	2.057	0.278	1.405	0.802	0.722	B,C,D,E,G	0.677	94%	Y	
A6 - A7	U-Channel	0.800	0.800	21.80	21.63	12.47	0.013	0.035	0.571	2.057	0.278	1.405	0.802	0.722	B,C,D,E,G	0.677	94%	Y	
A7 - A8	U-Channel	0.800	0.800	21.63	21.43	15.43	0.013	0.035	0.571	2.057	0.278	1.405	0.802	0.722	B,C,D,E,G	0.677	94%	Y	
A8 - A9	U-Channel	0.800	0.800	21.43	21.30	9.22	0.013	0.035	0.571	2.057	0.278	1.405	0.802	0.722	B,C,D,E,G	0.677	94%	Y	
A9 - A10	U-Channel	0.800	0.800	21.30	21.03	20.17	0.013	0.035	0.571	2.057	0.278	1.405	0.802	0.722	B,C,D,E,G	0.677	94%	Y	
A10 - A11	U-Channel	0.800	0.800	21.03	20.94	7.27	0.013	0.035	0.571	2.057	0.278	1.405	0.802	0.722	B,C,D,E,G	0.677	94%	Y	
A11 - A12	U-Channel	0.800	0.800	20.94	20.76	13.21	0.013	0.035	0.571	2.057	0.278	1.405	0.802	0.722	B,C,D,E,G	0.677	94%	Y	
A12 - A13	U-Channel	0.800	0.800	20.76	20.63	9.22	0.014	0.035	0.571	2.057	0.278	1.454	0.831	0.748	B,C,D,E,G	0.677	91%	Y	

Calculation of Capacity of Stepped Channel A13 - A14

Pipe Segement	Shape	Gradient, a°	Horizontal Distance, m	Slant Distance, m	Depth, mm	Width, mm	Initial mPD,X(m)	Ending mPD, A(m)	C_e	x	f	f_e	Y_{90}, m	d_0, m	Cross Section Area, m_2	P_w, m	D_H, m	Gravity, m/s^2	V_0, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchment Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
A13 - A14	Stepped Channel	20	10.55	25.9	850	900	20.63	16.79	0.31	0.60	1.00	0.77	0.80	0.55	0.50	2.01	0.99	9.81	2.95	1.47	1.319	A, B,C,D,E,G	0.9428	71%	Y

Calculation of Capacity of U-Channel A14 - A16

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)	Remarks
A14 - A15	U-Channel	0.800	0.800	16.79	15.98	41.00	0.020	0.030	0.571	2.057	0.278	1.987	1.135	1.022	A, B,C,D,E,G	0.943	92%	Y	
A15 - A16	U-Channel	0.800	0.800	15.98	15.10	44.92	0.020	0.030	0.571	2.057	0.278	1.987	1.135	1.022	A, B,C,D,E,G	0.943	92%	Y	

Calculation of Capacity of Stepped Channel A16 - A17

Pipe Segement	Shape	Gradient, a°	Horizontal Distance, m	Slant Distance, m	Depth, mm	Width, mm	Initial mPD,X(m)	Ending mPD, A(m)	C_e	x	f	f_e	Y_{90}, m	d_0, m	Cross Section Area, m_2	P_w, m	D_H, m	Gravity, m/s^2	V_0, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchment Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
A16 - A17	Stepped Channel	20	12.78	31.3	850	900	15.10	10.45	0.31	0.60	1.00	0.77	0.80	0.55	0.50	2.01	0.99	9.81	2.95	1.47	1.319	A, B,C,D,E,G	0.943	71%	Y

Calculation of Capacity of U-Channel A17 - A25

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)	Remarks
A17 - A18	U-Channel	0.900	0.900	10.45	10.02	25.40	0.017	0.030	0.723	2.314	0.313	1.999	1.445	1.301	A,B,C,D,E,G,J	0.979	75%	Y	
A18 - A19	U-Channel	0.900	0.900	10.02	9.91	6.50	0.017	0.030	0.723	2.314	0.313	1.999	1.445	1.301	A,B,C,D,E,G,J	0.979	75%	Y	
A19 - A20	U-Channel	0.900	0.900	9.91	9.81	6.06	0.017	0.030	0.723	2.314	0.313	1.999	1.445	1.301	A,B,C,D,E,G,J,K	1.003	77%	Y	
A20 - A21	U-Channel	0.900	0.900	9.81	9.43	22.23	0.017	0.030	0.723	2.314	0.313	1.999	1.445	1.301	A,B,C,D,E,G,J,K	1.003	77%	Y	
A21 - A22	U-Channel	0.900	0.900	9.43	8.78	38.20	0.017	0.030	0.723	2.314	0.313	1.999	1.445	1.301	A,B,C,D,E,G,J,K L	1.060	81%	Y	
A22 - A23	U-Channel	0.900	0.900	8.78	8.60	10.82	0.017	0.030	0.723	2.314	0.313	1.982	1.433	1.290	A,B,C,D,E,G,J,K L	1.060	82%	Y	
A23 - A24	U-Channel	0.900	0.900	8.60	8.38	15.78	0.014	0.030	0.723	2.314	0.313	1.835	1.327	1.194	A,B,C,D,E,G,J,K L	1.060	89%	Y	
A24 - A25	U-Channel	0.900	0.900	8.38	8.30	5.32	0.014	0.030	0.723	2.314	0.313	1.835	1.327	1.194	A,B,C,D,E,G,J,K L,N	1.124	94%	Y	

Calculation of Capacity of U-Channel C1 - C4

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)	Remarks
C1 - C2	U-Channel	0.700	0.700	23.20	22.54	33.23	0.020	0.030	0.437	1.800	0.243	1.836	0.803	0.723	B,C,D,E,G	0.677	94%	Y	
C2 - C3	U-Channel	0.700	0.700	22.54	22.06	23.74	0.020	0.030	0.437	1.800	0.243	1.836	0.803	0.723	B,C,D,E,G	0.677	94%	Y	
C3 - C4	U-Channel	0.800	0.800	22.06	21.79	13.91	0.019	0.030	0.571	2.057	0.278	1.968	1.124	1.012	A,B,C,D,E,G	0.943	93%	Y	

Calculation of Capacity of Stepped Channel C4 - C5

Pipe Segement	Shape	Gradient, a°	Horizontal Distance, m	Slant Distance, m	Depth, mm	Width, mm	Initial mPD,X(m)	Ending mPD, A(m)	C_e	x	f	f_e	Y_{90}, m	d_0, m	Cross Section Area, m_2	P_w, m	D_H, m	Gravity, m/s^2	V_0, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchment Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
C4 - C5	Stepped Channel	20	14.96	36.7	850	900	21.79	16.35	0.31	0.60	1.00	0.77	0.80	0.55	0.50	2.01	0.99	9.81	2.95	1.47	1.319	A,B,C,D,E,G	0.943	71%	Y

Calculation of Capacity of U-Channel C5 - C8

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)	Remarks
C5 - C6	U-Channel	0.850	0.850	16.35	16.00	27.36	0.013	0.030	0.645	2.185	0.295	1.673	1.079	0.971	A,B,C,D,E,G	0.943	97%	Y	
C6 -C7	U-Channel	0.850	0.850	16.00	15.53	25.80	0.018	0.030	0.645	2.185	0.295	1.998	1.289	1.160	A,B,C,D,E,G	0.943	81%	Y	
C7 - C8	U-Channel	0.850	0.850	15.53	15.05	25.83	0.018	0.030	0.645	2.185	0.295	1.998	1.289	1.160	A,B,C,D,E,G	0.943	81%	Y	

Calculation of Capacity of Stepped Channel C8 - C9

Pipe Segement	Shape	Gradient, a°	Horizontal Distance, m	Slant Distance, m	Depth, mm	Width, mm	Initial mPD,X(m)	Ending mPD, A(m)	C_e	x	f	f_e	Y_{90}, m	d_0, m	Cross Section Area, m_2	P_w, m	D_H, m	Gravity, m/s^2	V_0, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchment Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
C8 - C9	Stepped Channel	20	12.640	31.0	850	900	15.05	10.45	0.31	0.60	1.00	0.77	0.80	0.55	0.50	2.01	0.99	9.81	2.95	1.47	1.319	A,B,C,D,E,G	0.943	71%	Y

Calculation of Capacity of U-Channel C9 - C15

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)	Remarks
C9 - C10	U-Channel	0.850	0.850	10.45	10.01	26.60	0.017	0.030	0.645	2.185	0.295	1.908	1.230	1.107	A,B,C,D,E,G, J	0.979	88%	Y	
C10 - C11	U-Channel	0.850	0.850	10.01	9.83	11.07	0.017	0.030	0.645	2.185	0.295	1.908	1.230	1.107	A,B,C,D,E,G, J	0.979	88%	Y	
C11 - C12	U-Channel	0.850	0.850	9.83	9.53	16.23	0.018	0.030	0.645	2.185	0.295	1.993	1.285	1.157	A,B,C,D,E,G, J, K	1.003	87%	Y	
C12 - C13	U-Channel	0.850	0.850	9.53	9.25	15.60	0.018	0.030	0.645	2.185	0.295	1.993	1.285	1.157	A,B,C,D,E,G, J, K,M	1.010	87%	Y	
C13 - C14	U-Channel	0.850	0.850	9.25	9.05	12.13	0.016	0.030	0.645	2.185	0.295	1.862	1.201	1.081	A,B,C,D,E,G, J, K,M	1.010	94%	Y	
C14 - C15	U-Channel	0.850	0.850	9.05	8.45	40.53	0.015	0.030	0.645	2.185	0.295	1.804	1.163	1.047	A,B,C,D,E,G, J, K,M	1.010	97%	Y	

Calculation of Capacity of Circular Pipes A25 - CA1

Pipe Segment	Length	Level (out)	Level (in)	Diameter	Depth	A_w	k_s [1]	v	s	g	V	Capacity Flow	Reduced Capacity Flow	Catchment Served	Q_p	Is $Q_c > Q_p$?	% of capacity	Remarks
	m	mPD	mPD	m	m	m^2	m	m^2/s	-	m/s^2	m/s	m^3/s	m^3/s		m^3/s	Y/N	%	
A25 - E1	21.05	8.30	7.60	0.900	0.900	0.636	0.00003	1E-06	0.033	9.810	7.5157	4.781	4.303	A,B,C,D,E,G,J,K, L,M,N	1.131	Y	26%	
E1 - E2	6.46	7.60	7.39	0.900	0.900	0.636	0.00003	1E-06	0.033	9.810	7.5157	4.781	4.303	A,B,C,D,E,G,J,K, L,M,N, R1	1.137	Y	26%	
E2 - E3	19.46	7.39	6.74	0.900	0.900	0.636	0.00003	1E-06	0.033	9.810	7.5157	4.781	4.303	A,B,C,D,E,G,J,K, L,M,N, R1 - R2	1.142	Y	27%	
E3 - E4	27.29	6.74	5.83	0.900	0.900	0.636	0.00003	1E-06	0.033	9.810	7.5157	4.781	4.303	A,B,C,D,E,G,J,K, L,M,N, R1 - R3	1.144	Y	27%	
E4 - E5	15.68	5.83	5.31	0.900	0.900	0.636	0.00003	1E-06	0.033	9.810	7.5157	4.781	4.303	A,B,C,D,E,G,J,K, L,M,N, R1 - R4	1.146	Y	27%	
E5 - E6	11.02	5.31	5.20	0.900	0.900	0.636	0.00003	1E-06	0.010	9.810	3.9772	2.530	2.277	A,B,C,D,E,G,J,K, L,M,N, R1 - R5	1.147	Y	50%	
CA 1	16.52	5.20	5.18	1.050	1.050	0.866	0.00003	1E-06	0.0014	9.810	1.5718	1.361	1.225	A,B,C,D,E,G,J,K, L,M,N, R1 - R5	1.147	Y	94%	

Calculation of Capacity of U-Channel A1 - B7

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
A1 - B1	U-Channel	0.300	0.300	24.30	24.07	21.05	0.011	0.030	0.080	0.771	0.104	0.778	0.062	0.056	F	0.053	94%	N
B1 - B2	U-Channel	0.300	0.300	24.07	23.99	6.46	0.011	0.030	0.080	0.771	0.104	0.778	0.062	0.056	F	0.053	94%	N
B2 -B3	U-Channel	0.300	0.300	23.99	23.35	19.46	0.033	0.030	0.080	0.771	0.104	1.347	0.108	0.097	F	0.053	55%	Y
B3 - B4	U-Channel	0.450	0.450	23.35	22.44	27.29	0.033	0.030	0.181	1.157	0.156	1.766	0.319	0.287	F,H	0.269	94%	N
B4 - B5	U-Channel	0.450	0.450	22.44	21.91	15.68	0.033	0.030	0.181	1.157	0.156	1.766	0.319	0.287	F,H	0.269	94%	N
B5 - B6	U-Channel	0.450	0.450	21.91	21.47	11.02	0.040	0.030	0.181	1.157	0.156	1.934	0.350	0.315	F,H,I	0.303	96%	Y
B6 - B7	U-Channel	0.450	0.450	21.47	20.81	16.52	0.040	0.030	0.181	1.157	0.156	1.934	0.350	0.315	F,H,I	0.303	96%	Y

Calculation of Capacity of Stepped Channel B7 - B8

Pipe Segement	Shape	Gradient, a°	Horizontal Distance, m	Slant Distance, m	Depth, mm	Width, mm	Initial mPD,X(m)	Ending mPD, A(m)	C_e	x	f	f_e	Y_{90}, m	d_0, m	Cross Section Area, m_2	P_w, m	D_H, m	Gravity, m/s^2	V_0, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchment Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
B7 - B8	Stepped Channel	20	8.4	20.6	575	450	20.81	17.75	0.31	0.60	1.00	0.77	0.54	0.37	0.17	1.20	0.56	9.81	2.22	0.37	0.34	F,H,I	0.303	90%	Y

Calculation of Capacity of U-Channel B8 - B9

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
B8 - B9	U-Channel	0.600	0.600	17.75	17.22	18.73	0.029	0.030	0.321	1.542	0.208	1.980	0.636	0.573	F,H,I	0.303	53%	Y

Calculation of Capacity of Stepped Channel B9 - B10

Pipe Segement	Shape	Gradient, a°	Horizontal Distance, m	Slant Distance, m	Depth, mm	Width, mm	Initial mPD,X(m)	Ending mPD, A(m)	C_e	x	f	f_e	Y_{90}, m	d_0, m	Cross Section Area, m_2	P_w, m	D_H, m	Gravity, m/s^2	V_0, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchment Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
B9 - B10	Stepped Channel	46	10.74	26.3	650	600	17.22	6.10	0.64	-0.36	1.00	0.33	0.45	0.16	0.10	0.92	0.42	9.81	4.25	0.41	0.37	F,H,I	0.303	81%	Y

Calculation of Capacity of U-Channel B10 - B11

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
B10 - B11	U-Channel	0.650	0.650	6.10	5.94	18.73	0.008	0.030	0.377	1.671	0.226	1.128	0.425	0.383	F,H,I	0.303	79%	Y

Calculation of Capacity of U-Channel D1 - D3

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
D1 - D2	U-Channel	0.450	0.450	23.10	22.23	20.79	0.042	0.030	0.181	1.157	0.156	1.974	0.357	0.321	H	0.2155	67%	Y
D2 - D3	U-Channel	0.450	0.450	22.23	21.44	19.96	0.040	0.030	0.181	1.157	0.156	1.934	0.350	0.315	H	0.2155	68%	Y

Calculation of Capacity of Stepped Channel D3 - D4

Pipe Segement	Shape	Gradient, a°	Horizontal Distance, m	Slant Distance, m	Depth, mm	Width, mm	Initial mPD,X(m)	Ending mPD, A(m)	C_e	x	f	f_e	Y_{90}, m	d_0, m	Cross Section Area, m_2	P_w, m	D_H, m	Gravity, m/s^2	V_0, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchment Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
D3 - D4	Stepped Channel	20	10.61	26.0	575	450	21.44	17.57	0.31	0.60	1.00	0.77	0.54	0.37	0.17	1.20	0.56	9.81	2.22	0.37	0.34	H	0.216	64%	Y

Calculation of Capacity of U-Channel D4 - D5

Pipe Segement	Shape	Diameter, m	Depth, m	Initial mPD,X(m)	Ending mPD, A(m)	Length, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted Perimeter, m	Hydraulic Radius, m	Mean Velocity, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchments Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
D4 - D5	U-Channel	0.600	0.600	17.57	17.24	16.64	0.020	0.030	0.321	1.542	0.208	1.657	0.532	0.479	H	0.216	45%	Y

Calculation of Capacity of Stepped Channel D5 - B11

Pipe Segement	Shape	Gradient, a°	Horizontal Distance, m	Slant Distance, m	Depth, mm	Width, mm	Initial mPD,X(m)	Ending mPD, A(m)	C_e	x	f	f_e	Y_{90}, m	d_0, m	Cross Section Area, m_2	P_w, m	D_H, m	Gravity, m/s^2	V_0, m/s	Capacity Flow, m^3/s	Reduced Capacity Flow, m^3/s	Catchment Served	Runoff, m^3/s	% of Capacity Flow	Sufficient Capacity? (Y/N)
D5 - B11	Stepped Channel	42	12.38	30.3	650	600	17.24	6.09	0.62	-0.31	1.00	0.35	0.48	0.18	0.11	0.96	0.45	9.81	4.11	0.45	0.40	H	0.216	53%	Y

Calculation of Capacity of Circular Pipes CB1

Pipe Segment	Length	Level (out)	Level (in)	Diameter	Depth	A_w	k_s [1]	v	s	g	V	Capacity Flow	Reduced Capacity Flow	Catchment Served	Q_p	Is $Q_c > Q_p$?	% of capacity	Remarks
	m	mPD	mPD	m	m	m^2	m	m^2/s	-	m/s^2	m/s	m^3/s	m^3/s		m^3/s	Y/N	%	
CB1	24.39	6.09	5.60	0.650	0.650	0.3318	0.00003	1E-06	0.020	9.810	4.7739	1.584	1.426	F,H,I	0.303	Y	21%	

D. Capacity Flow Estimation and Adequacy Check for Existing Streams and Culvert

Culvert	Width[3]	Depth[4]	A_w[5]	k_s	v	s	g	V	Capacity Flow	Reduced Capacity Flow	Catchment Served	Q_p	Is $Q_c > Q_p$?	% of capacity	Remarks
	m	m	m^2	m	m^2/s	-	m/s^2	m/s	m^3/s	m^3/s		m^3/s	Y/N	%	
Culvert 1	1.000	1.600	1.6000	0.00006	1E-06	0.100	9.810	15.0391	48.125	43.313	AA - AW	18.040	Y	42%	

Culvert	Diameter	Depth	A_w	k_s	v	s	g	V	Capacity Flow	Reduced Capacity Flow	Catchment Served	Q_p	Is $Q_c > Q_p$?	% of capacity	Remarks
	m	m	m^2	m	m^2/s	-	m/s^2	m/s	m^3/s	m^3/s		m^3/s	Y/N	%	
Culvert 2	0.850	-	0.5675	0.15000	1E-06	0.050	9.810	2.4135	1.370	1.233	F, H, I and BA to BL	6.210	***N***	503.8%	

Stream	Top Width, m	Bottom Width, m	Depth, m	Slope	Manning's Roughness Coefficient	Cross Section Area, m^2	Wetted perimeter, m	Hydraulic radius, m	Mean velocity, m/s	Capacity flow, m^3/s	Catchments Served	Runoff, m^3/s	Contribution from Identified Catchments, %	Sufficient Capacity? (Y/N)
Stream 1	4.0	2	1.3	0.100	0.040	3.900	5.280	0.74	6.46	25.193	A to E, G, J to N and AA to AZ, R1 - R5	20.100	80%	Y
Stream 2	3.0	1	1.3	0.050	0.040	2.600	4.280	0.61	4.01	10.425	F, H, I and BA to BL	6.509	62%	Y

Note: Adequacy in capacities of the stream have been checked based on the most narrow section of the existing stream at the stormwater discharge point.

E. Proposed Upgrading Works

Culvert	Diameter	Depth	A_w	k_s	v	s	g	V	Capacity Flow	Reduced Capacity Flow	Catchment Served	Q_p	Is $Q_c > Q_p$?	% of capacity	Remarks
	m	m	m^2	m	m^2/s	-	m/s^2	m/s	m^3/s	m^3/s		m^3/s	Y/N	%	
Culvert 2	1.600	1.600	2.0106	0.15000	1E-06	0.050	9.810	3.9996	8.042	7.237	F, H, I and BA to BL	6.210	Y	85.8%	

Note:
[1] Runoff is calculated in accordance with DSD's "Stormwater Drainage Manual - Planning, Design and Management" (SDM), Fifth edition, Jan 2018.
[2] Stepped Channel is adopted in some section to align with the topography of the Site. The Hydraulic Design of Stepped Channels is based on GEO Technical Guidance Note No. 27.
[3] Since Culvert 1 is a double-cell box culvert with identical cells, the width refers to the span of a single cell.
[4] Since Culvert 1 is a double-cell box culvert with identical cells, the depth refers to the depth of a single cell.
[5] Since Culvert 1 is a double-cell box culvert with identical cells, the A_w refers to the cross section area of one cell.
[6] Since Culvert 1 is a double-cell box culvert with identical cells, the Q^c is multiplied by 2 to represent the total capcity of the two cells of the culvert.
[7] A Manning's roughness coefficient of 0.030 for "Natural-stream channels — Clean, straight bank, full stage, no rifts or deep pools" in fair condition will be adopted for all proposed U-channels.
[8] A Manning's roughness coefficient of 0.040 for "Natural-stream channels — Winding, with some pools and shoals, clean with some weeds and stone" in good condition will be adopted for both streams based on site observation.
[9] The roughness value k_s of 0.006 mm for uPVC in normal condition will be adopted for all proposed circular pipes.
[10] The roughness value k_s of 0.06 mm for "Prestressed Concrete" in normal condition will be adopted for Culvert 1 based on the site observation.
[11] The absolute roughness value k_s of 150 mm for "Unlined Rock Tunnels" in normal condition will be adopted for Culvert 2 based on the site observation.
[12] Due to sedimentation, it is assumed that there is a 10% reduction in the capacity flow of the U-channels and circular pipes.

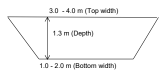
Equations Used

$$t_0 = \frac{0.14465L}{H^{0.2}A^{0.1}}$$

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

$$t_c = t_0 + t_f$$

$$Q_p = 0.278\ C\ i\ A$$



Schematic Section of the Streamcourse

Colebrook-White Equation (for circular pipes flowing full):

$$V = -\sqrt{(8gDs)}\log\left(\frac{ks}{3.7D} + \frac{2.51v}{D\sqrt{(2gDs)}}\right)$$

Appendix F

Detailed Calculation of Free Broad of the Two Streams Before the Proposed Development

Section 12A Rezoning Application for Proposed Columbarium on Various Lots in D.D.41 Sha Tau Kok, New Territories
Catchment Runoff Received by Stream 1 and Stream 2 Before the Proposed Development

A. Calculation of Catchment Runoff Received by Stream 1

Catchment ID	Surface Type	Catchment Area (A), m^2	Catchment Area (A), km^2	Average slope (H), m/100m	Flow path length (L), m	Inlet time (t_0), min	Time of Concentration (t_c), min	Duration (t_d), min	a (50 year return period)	b (50 year return period)	c (50 year return period)	Runoff intensity (i) mm/hr	Runoff coefficient (C)	C x A	Peak runoff (Q_p), m^3/s
A	20% Concrete + 80% Grassland (heavysoil), flat	3,757	0.00376	5.95	100.9	4.49	4.49	4.49	474.6	2.9	0.37	226	0.39	0.0015	0.0921
C	50% Concrete + 50% Grassland (heavysoil), steep	1,705	0.00171	4.60	58.7	2.97	2.97	2.97	474.6	2.9	0.37	246	0.65	0.0011	0.0758
AA	100% Grassland (heavysoil), steep	10,468	0.01047	53.54	151.30	3.91	3.91	3.91	474.6	2.9	0.37	233	0.35	0.0037	0.2372
AB	100% Grassland (heavysoil), steep	18,920	0.01892	70.41	196.00	4.52	4.52	4.52	474.6	2.9	0.37	226	0.35	0.0066	0.4153
AC	100% Grassland (heavysoil), steep	10,196	0.01020	88.19	129.50	3.04	3.04	3.04	474.6	2.9	0.37	245	0.35	0.0036	0.2431
AD	100% Grassland (heavysoil), steep	52,671	0.05267	62.61	405.71	8.65	8.65	8.65	474.6	2.9	0.37	191	0.35	0.0184	0.9813
AE	100% Grassland (heavysoil), steep	22,926	0.02293	67.68	257.11	5.87	5.87	5.87	474.6	2.9	0.37	212	0.35	0.0080	0.4731
AF	100% Grassland (heavysoil), steep	29,391	0.02939	49.39	380.65	9.02	9.02	9.02	474.6	2.9	0.37	189	0.35	0.0103	0.5412
AG	100% Grassland (heavysoil), steep	37,189	0.03719	38.34	354.70	8.64	8.64	8.64	474.6	2.9	0.37	192	0.35	0.0130	0.6931
AH	100% Grassland (heavysoil), steep	38,374	0.03837	51.54	419.06	9.59	9.59	9.59	474.6	2.9	0.37	186	0.35	0.0134	0.6945
AI	100% Grassland (heavysoil), steep	32,527	0.03253	36.21	469.53	11.72	11.72	11.72	474.6	2.9	0.37	175	0.35	0.0114	0.5552
AJ	100% Grassland (heavysoil), steep	43,371	0.04337	19.83	342.86	9.38	9.38	9.38	474.6	2.9	0.37	187	0.35	0.0152	0.7898
AK	100% Grassland (heavysoil), steep	12,505	0.01250	51.10	180.04	4.62	4.62	4.62	474.6	2.9	0.37	225	0.35	0.0044	0.2732
AL	100% Grassland (heavysoil), steep	38,295	0.03830	58.25	271.24	6.06	6.06	6.06	474.6	2.9	0.37	210	0.35	0.0134	0.7840
AM	100% Grassland (heavysoil), steep	66,715	0.06672	37.02	318.70	7.37	7.37	7.37	474.6	2.9	0.37	200	0.35	0.0234	1.2982
AN	100% Grassland (heavysoil), steep	62,139	0.06214	42.78	119.21	2.70	2.70	2.70	474.6	2.9	0.37	250	0.35	0.0217	1.5145
AO	100% Grassland (heavysoil), steep	27,601	0.02760	36.09	315.87	8.02	8.02	8.02	474.6	2.9	0.37	195	0.35	0.0097	0.5250
AP	100% Grassland (heavysoil), steep	18,727	0.01873	39.88	255.78	6.62	6.62	6.62	474.6	2.9	0.37	206	0.35	0.0066	0.3748
AQ	100% Grassland (heavysoil), steep	27,808	0.02781	39.27	273.22	6.82	6.82	6.82	474.6	2.9	0.37	204	0.35	0.0097	0.5524
AR	100% Grassland (heavysoil), steep	30,327	0.03033	18.92	295.94	8.47	8.47	8.47	474.6	2.9	0.37	193	0.35	0.0106	0.5683
AS	10% Concrete + 90% Grassland (heavysoil), flat	40,285	0.04028	1.49	168.25	7.79	7.79	7.79	474.6	2.9	0.37	197	0.32	0.0129	0.7062
AT	5% Concrete + 95% Grassland (heavysoil), flat	33,841	0.03384	8.19	244.27	8.18	8.18	8.18	474.6	2.9	0.37	194	0.29	0.0096	0.5214
AU	100% Grassland (heavysoil), flat	20,293	0.02029	3.59	244.98	10.18	10.18	10.18	474.6	2.9	0.37	183	0.25	0.0051	0.2579
AV	5% Concrete + 95% Grassland (heavysoil), flat	13,624	0.01362	7.30	145.11	5.44	5.44	5.44	474.6	2.9	0.37	216	0.29	0.0039	0.2332
AW	20% Concrete + 80% Grassland (heavysoil), flat	42,089	0.04209	3.44	270.60	10.54	10.54	10.54	474.6	2.9	0.37	181	0.39	0.0164	0.8259
AX	20% Concrete + 80% Grassland (heavysoil), flat	1,485	0.00149	0.56	195.40	15.27	15.27	15.27	474.6	2.9	0.37	162	0.39	0.0006	0.0261
AY	100% Grassland (heavysoil), flat	4,127	0.00413	1.27	70.71	4.24	4.24	4.24	474.6	2.9	0.37	229	0.25	0.0010	0.0656
AZ	100% Grassland (heavysoil), steep	26,118	0.02612	54.73	131.00	3.08	3.08	3.08	474.6	2.9	0.37	244	0.35	0.0091	0.6213
R1	100% Concrete	66	0.00007	13.84	11.20	0.63	0.63	0.63	474.6	2.9	0.37	297	0.95	0.0001	0.0052
R2	100% Concrete	46	0.00005	4.38	10.27	0.75	0.75	0.75	474.6	2.9	0.37	293	0.95	0.0000	0.0036
R3	100% Concrete	20	0.00002	0.74	13.42	1.53	1.53	1.53	474.6	2.9	0.37	273	0.95	0.0000	0.0014
R4	100% Concrete	18	0.00002	8.48	12.98	0.91	0.91	0.91	474.6	2.9	0.37	289	0.95	0.0000	0.0014
R5	100% Concrete	13	0.00001	4.20	9.52	0.80	0.80	0.80	474.6	2.9	0.37	292	0.95	0.0000	0.0010
														Total	**14.9526**

B. Calculation of Catchment Runoff Received by Stream 2

Catchment ID	Surface Type	Catchment Area (A), m^2	Catchment Area (A), km^2	Average slope (H), m/100m	Flow path length (L), m	Inlet time (t_0), min	Time of Concentration (t_c), min	Duration (t_d), min	a (50 year return period)	b (50 year return period)	c (50 year return period)	Runoff intensity (i) mm/hr	Runoff coefficient (C)	C x A	Peak runoff (Q_p), m^3/s
B	30% Concrete + 70% Grassland (heavysoil), flat	4,229	0.00423	1.29	77.5	4.62	4.62	4.62	474.6	2.9	0.37	224	0.46	0.0019	0.1214
BA	100% Grassland (heavysoil), steep	34,288	0.03429	65.73	304.27	6.71	6.71	6.71	474.6	2.9	0.37	205	0.35	0.0120	0.6840
BB	100% Grassland (heavysoil), steep	67,748	0.06775	54.12	617.15	13.21	13.21	13.21	474.6	2.9	0.37	169	0.35	0.0237	1.1156
BC	100% Grassland (heavysoil), steep	14,692	0.01469	40.00	200.00	5.30	5.30	5.30	474.6	2.9	0.37	217	0.35	0.0051	0.3108
BD	100% Grassland (heavysoil), steep	22,149	0.02215	49.01	375.45	9.17	9.17	9.17	474.6	2.9	0.37	188	0.35	0.0078	0.4060
BE	100% Grassland (heavysoil), steep	10,272	0.01027	24.75	222.26	6.72	6.72	6.72	474.6	2.9	0.37	205	0.35	0.0036	0.2048
BF	100% Grassland (heavysoil), steep	2,779	0.00278	49.97	296.20	8.87	8.87	8.87	474.6	2.9	0.37	190	0.35	0.0010	0.0514
BG	100% Grassland (heavysoil), steep	15,947	0.01595	25.95	169.55	4.86	4.86	4.86	474.6	2.9	0.37	222	0.35	0.0056	0.3444
BH	30% Grassland (heavysoil), flat + 70% Grassland (heavysoil), steep	15,375	0.01538	2.71	73.80	3.34	3.34	3.34	474.6	2.9	0.37	241	0.32	0.0049	0.3292
BI	70% Grassland (heavysoil), flat + 30% Grassland (heavysoil), steep	24,849	0.02485	13.81	550.37	17.12	17.12	17.12	474.6	2.9	0.37	156	0.28	0.0070	0.3020
BJ	70% Grassland (heavysoil), flat + 30% Grassland (heavysoil), steep	39,152	0.03915	13.62	147.62	4.40	4.40	4.40	474.6	2.9	0.37	227	0.28	0.0110	0.6918
														Total	**4.4400**

Freeboard Calculation

Input Data	Units	Stream 1	Stream 2	
Discharge, Q	m3/s	14.9526	4.4400	<- input
Bottom width, b	m	2	1	<- input
Side slope, z	H:V	1.3	1.3	<- input
Manning, n	-	0.04	0.04	<- input
Bed slope, S	-	0.1	0.05	<- input
Trial water depth, y	m	0.8795	0.7288	<- trial

		Stream 1	Stream 2	
Depth of stream	m	1.3	1.3	
Trial water depth	m	0.8795	0.7288	
Freeboard	**m**	**0.4205**	**0.5712**	>300mm

Geometry Calculations	Units	Stream 1	Stream 2
Flow Area, A	m2	2.7644	1.4194
Wetted Perimeter, P	m	4.8849	3.3907
Hydraulic Radius, R	m	0.5659	0.4186
Top Width, T	m	4.2866	2.8949

Calculated Discharge, Q	m3/s	14.9526	4.4400
Error, Qcalc - Q	-	2.181E-05	6.01472E-06

Appendix G

Detailed Calculation of Free Broad of the Two Streams After the Proposed Development

Section 12A Rezoning Application for Proposed Columbarium on Various Lots in D.D.41 Sha Tau Kok, New Territories
Catchment Runoff Received by Stream 1 and Stream 2 After the Proposed Development

A. Calculation of Catchment Runoff Received by Stream 1

Catchment ID	Surface Type	Catchment Area (A), m^2	Catchment Area (A), km^2	Average slope (H), m/100m	Flow path length (L), m	Inlet time (t_0), min	Time of Concentration (t_c), min	Duration (t_d), min	a (50 year return period)	b (50 year return period)	c (50 year return period)	Runoff intensity (i) mm/hr	Runoff coefficient (C)	C x A	Peak runoff (Q_p), m^3/s
A	90% Concrete + 10% Grassland (heavysoil), flat	3,757	0.00376	5.95	100.9	4.49	4.49	4.49	474.6	2.9	0.37	226	0.88	0.0033	0.2077
B	90% Concrete + 10% Grassland (heavysoil), flat	4,229	0.00423	1.29	77.5	4.62	4.62	4.62	474.6	2.9	0.37	224	0.88	0.0037	0.2322
C	80% Concrete + 20% Grassland (heavysoil), steep	1,705	0.00171	4.60	58.7	2.97	2.97	2.97	474.6	2.9	0.37	246	0.83	0.0014	0.0968
D	100% Grassland (heavysoil), steep	1,272	0.00127	7.36	76.0	3.61	3.61	3.61	474.6	2.9	0.37	237	0.35	0.0004	0.0293
E	10% Concrete + 90% Grassland (heavysoil), steep	3,597	0.00360	8.30	92.8	3.88	3.88	3.88	474.6	2.9	0.37	233	0.41	0.0015	0.0957
G	85% Concrete + 15% Grassland (heavysoil), steep	1,178	0.00118	5.18	38.6	1.98	1.98	1.98	474.6	2.9	0.37	264	0.86	0.0010	0.0742
J	100% Concrete	416	0.00042	6.79	39.8	2.15	2.15	2.15	474.6	2.9	0.37	260	0.95	0.0004	0.0286
K	100% Concrete	232	0.00023	13.16	7.6	0.38	0.38	0.38	474.6	2.9	0.37	305	0.95	0.0002	0.0187
L	100% Concrete	729	0.00073	2.61	68.9	4.25	4.25	4.25	474.6	2.9	0.37	229	0.95	0.0007	0.0440
M	100% Concrete	81	0.00008	3.60	30.5	2.20	2.20	2.20	474.6	2.9	0.37	259	0.95	0.0001	0.0056
N	100% Concrete	805	0.00081	1.30	54.0	3.80	3.80	3.80	474.6	2.9	0.37	234	0.95	0.0008	0.0498
AA	100% Grassland (heavysoil), steep	10,468	0.01047	53.54	151.30	3.91	3.91	3.91	474.6	2.9	0.37	233	0.35	0.0037	0.2372
AB	100% Grassland (heavysoil), steep	18,920	0.01892	70.41	196.00	4.52	4.52	4.52	474.6	2.9	0.37	226	0.35	0.0066	0.4153
AC	100% Grassland (heavysoil), steep	10,196	0.01020	88.19	129.50	3.04	3.04	3.04	474.6	2.9	0.37	245	0.35	0.0036	0.2431
AD	100% Grassland (heavysoil), steep	52,671	0.05267	62.61	405.71	8.65	8.65	8.65	474.6	2.9	0.37	191	0.35	0.0184	0.9813
AE	100% Grassland (heavysoil), steep	22,926	0.02293	67.68	257.11	5.87	5.87	5.87	474.6	2.9	0.37	212	0.35	0.0080	0.4731
AF	100% Grassland (heavysoil), steep	29,391	0.02939	49.39	380.65	9.02	9.02	9.02	474.6	2.9	0.37	189	0.35	0.0103	0.5412
AG	100% Grassland (heavysoil), steep	37,189	0.03719	38.34	354.70	8.64	8.64	8.64	474.6	2.9	0.37	192	0.35	0.0130	0.6931
AH	100% Grassland (heavysoil), steep	38,374	0.03837	51.54	419.06	9.59	9.59	9.59	474.6	2.9	0.37	186	0.35	0.0134	0.6945
AI	100% Grassland (heavysoil), steep	32,527	0.03253	36.21	469.53	11.72	11.72	11.72	474.6	2.9	0.37	175	0.35	0.0114	0.5552
AJ	100% Grassland (heavysoil), steep	43,371	0.04337	19.83	342.86	9.38	9.38	9.38	474.6	2.9	0.37	187	0.35	0.0152	0.7898
AK	100% Grassland (heavysoil), steep	12,505	0.01250	51.10	180.04	4.62	4.62	4.62	474.6	2.9	0.37	225	0.35	0.0044	0.2732
AL	100% Grassland (heavysoil), steep	38,295	0.03830	58.25	271.24	6.06	6.06	6.06	474.6	2.9	0.37	210	0.35	0.0134	0.7840
AM	100% Grassland (heavysoil), steep	66,715	0.06672	37.02	318.70	7.37	7.37	7.37	474.6	2.9	0.37	200	0.35	0.0234	1.2982
AN	100% Grassland (heavysoil), steep	62,139	0.06214	42.78	119.21	2.70	2.70	2.70	474.6	2.9	0.37	250	0.35	0.0217	1.5145
AO	100% Grassland (heavysoil), steep	27,601	0.02760	36.09	315.87	8.02	8.02	8.02	474.6	2.9	0.37	195	0.35	0.0097	0.5250
AP	100% Grassland (heavysoil), steep	18,727	0.01873	39.88	255.78	6.62	6.62	6.62	474.6	2.9	0.37	206	0.35	0.0066	0.3748
AQ	100% Grassland (heavysoil), steep	27,808	0.02781	39.27	273.22	6.82	6.82	6.82	474.6	2.9	0.37	204	0.35	0.0097	0.5524
AR	100% Grassland (heavysoil), steep	30,327	0.03033	18.92	295.94	8.47	8.47	8.47	474.6	2.9	0.37	193	0.35	0.0106	0.5683
AS	10% Concrete + 90% Grassland (heavysoil), flat	40,285	0.04028	1.49	168.25	7.79	7.79	7.79	474.6	2.9	0.37	197	0.32	0.0129	0.7062
AT	5% Concrete + 95% Grassland (heavysoil), flat	33,841	0.03384	8.19	244.27	8.18	8.18	8.18	474.6	2.9	0.37	194	0.29	0.0096	0.5214
AU	100% Grassland (heavysoil), flat	19,765	0.01976	3.59	244.98	10.20	10.20	10.20	474.6	2.9	0.37	183	0.25	0.0049	0.2510
AV	5% Concrete + 95% Grassland (heavysoil), flat	13,325	0.01333	7.26	132.24	4.98	4.98	4.98	474.6	2.9	0.37	221	0.29	0.0038	0.2330
AW	20% Concrete + 80% Grassland (heavysoil), flat	43,594	0.04359	3.44	270.60	10.51	10.51	10.51	474.6	2.9	0.37	181	0.39	0.0170	0.8563
AX	20% Concrete + 80% Grassland (heavysoil), flat	1,485	0.00149	0.56	195.40	15.27	15.27	15.27	474.6	2.9	0.37	162	0.39	0.0006	0.0261
AY	100% Grassland (heavysoil), flat	4,127	0.00413	1.27	70.71	4.24	4.24	4.24	474.6	2.9	0.37	229	0.25	0.0010	0.0656
AZ	100% Grassland (heavysoil), steep	26,118	0.02612	54.73	131.00	3.08	3.08	3.08	474.6	2.9	0.37	244	0.35	0.0091	0.6213

R1	100% Concrete	66	0.00007	13.84	11.20	0.63	0.63	0.63	474.6	2.9	0.37	297	0.95	0.0001	0.0052
R2	100% Concrete	46	0.00005	4.38	10.27	0.75	0.75	0.75	474.6	2.9	0.37	293	0.95	0.0000	0.0036
R3	100% Concrete	20	0.00002	0.74	13.42	1.53	1.53	1.53	474.6	2.9	0.37	273	0.95	0.0000	0.0014
R4	100% Concrete	18	0.00002	8.48	12.98	0.91	0.91	0.91	474.6	2.9	0.37	289	0.95	0.0000	0.0014
R5	100% Concrete	13	0.00001	4.20	9.52	0.80	0.80	0.80	474.6	2.9	0.37	292	0.95	0.0000	0.0010
														Total	**15.6907**

B. Calculation of Catchment Runoff Received by Stream 2

Catchment ID	Surface Type	Catchment Area (A), m^2	Catchment Area (A), km^2	Average slope (H), m/100m	Flow path length (L), m	Inlet time (t_0), min	Time of Concentration (t_c), min	Duration (t_d), min	a (50 year return period)	b (50 year return period)	c (50 year return period)	Runoff intensity (i) mm/hr	Runoff coefficient (C)	C x A	Peak runoff (Q_p), m^3/s
F	100% Grassland (heavysoil), steep	1,573	0.00157	6.68	34.4	1.63	1.63	1.63	474.6	2.9	0.37	271	0.35	0.0006	0.0415
H	90% Concrete + 10% Grassland (heavysoil), flat	2,762	0.00276	15.59	73.8	2.79	2.79	2.79	474.6	2.9	0.37	249	0.88	0.0024	0.1682
I	100% Grassland (heavysoil), steep	1,031	0.00103	21.74	46.0	1.80	1.80	1.80	474.6	2.9	0.37	267	0.35	0.0004	0.0268
BA	100% Grassland (heavysoil), steep	34,288	0.03429	65.73	304.27	6.71	6.71	6.71	474.6	2.9	0.37	205	0.35	0.0120	0.6840
BB	100% Grassland (heavysoil), steep	67,748	0.06775	54.12	617.15	13.21	13.21	13.21	474.6	2.9	0.37	169	0.35	0.0237	1.1156
BC	100% Grassland (heavysoil), steep	14,692	0.01469	40.00	200.00	5.30	5.30	5.30	474.6	2.9	0.37	217	0.35	0.0051	0.3108
BD	100% Grassland (heavysoil), steep	22,149	0.02215	49.01	375.45	9.17	9.17	9.17	474.6	2.9	0.37	188	0.35	0.0078	0.4060
BE	100% Grassland (heavysoil), steep	10,272	0.01027	24.75	222.26	6.72	6.72	6.72	474.6	2.9	0.37	205	0.35	0.0036	0.2048
BF	100% Grassland (heavysoil), steep	2,779	0.00278	49.97	296.20	8.87	8.87	8.87	474.6	2.9	0.37	190	0.35	0.0010	0.0514
BG	100% Grassland (heavysoil), steep	15,947	0.01595	25.95	169.55	4.86	4.86	4.86	474.6	2.9	0.37	222	0.35	0.0056	0.3444
BH	30% Grassland (heavysoil), flat + 70% Grassland (heavysoil), steep	15,375	0.01538	2.71	73.80	3.34	3.34	3.34	474.6	2.9	0.37	241	0.32	0.0049	0.3292
BI	70% Grassland (heavysoil), flat + 30% Grassland (heavysoil), steep	24,849	0.02485	13.81	550.37	17.12	17.12	17.12	474.6	2.9	0.37	156	0.28	0.0070	0.3020
BJ	70% Grassland (heavysoil), flat + 30% Grassland (heavysoil), steep	39,109	0.03911	13.62	147.62	4.40	4.40	4.40	474.6	2.9	0.37	227	0.28	0.0110	0.6911
BK	15% Concrete + 15% Grassland (heavysoil), flat + 70% Grassland (heavysoil), steep	12,273	0.01227	12.35	103.61	3.54	3.54	3.54	474.6	2.9	0.37	238	0.43	0.0052	0.3449
BL	100% Concrete	929	0.00093	7.30	58.88	2.89	2.89	2.89	474.6	2.9	0.37	247	0.95	0.0009	0.0607
														Total	**5.0814**

Freeboard Calculation

Input Data	Units	Stream 1	Stream 2	
Discharge, Q	m3/s	15.6907	5.0814	<- input
Bottom width, b	m	2	1	<- input
Side slope, z	H:V	1.3	1.3	<- input
Manning, n	-	0.04	0.04	<- input
Bed slope, S	-	0.1	0.05	<- input
Trial water depth, y	m	0.9023	0.7793	<- trial

		Stream 1	Stream 2	
Depth of stream	m	1.3	1.3	
Trial water depth	m	0.9023	0.7793	
Freeboard	**m**	**0.3977**	**0.5208**	>300mm

Geometry Calculations	Units	Stream 1	Stream 2
Flow Area, A	m2	2.8629	1.5686
Wetted Perimeter, P	m	4.9597	3.5561
Hydraulic Radius, R	m	0.5772	0.4411
Top Width, T	m	4.3459	3.0261

Calculated Discharge, Q	m3/s	15.6907	5.0814
Error, Qcalc - Q	-	1.55542E-05	-4.71379E-06

Appendix H

Photo Index Plan

P1

P2

P3

P4

P5

P6

P7

P8

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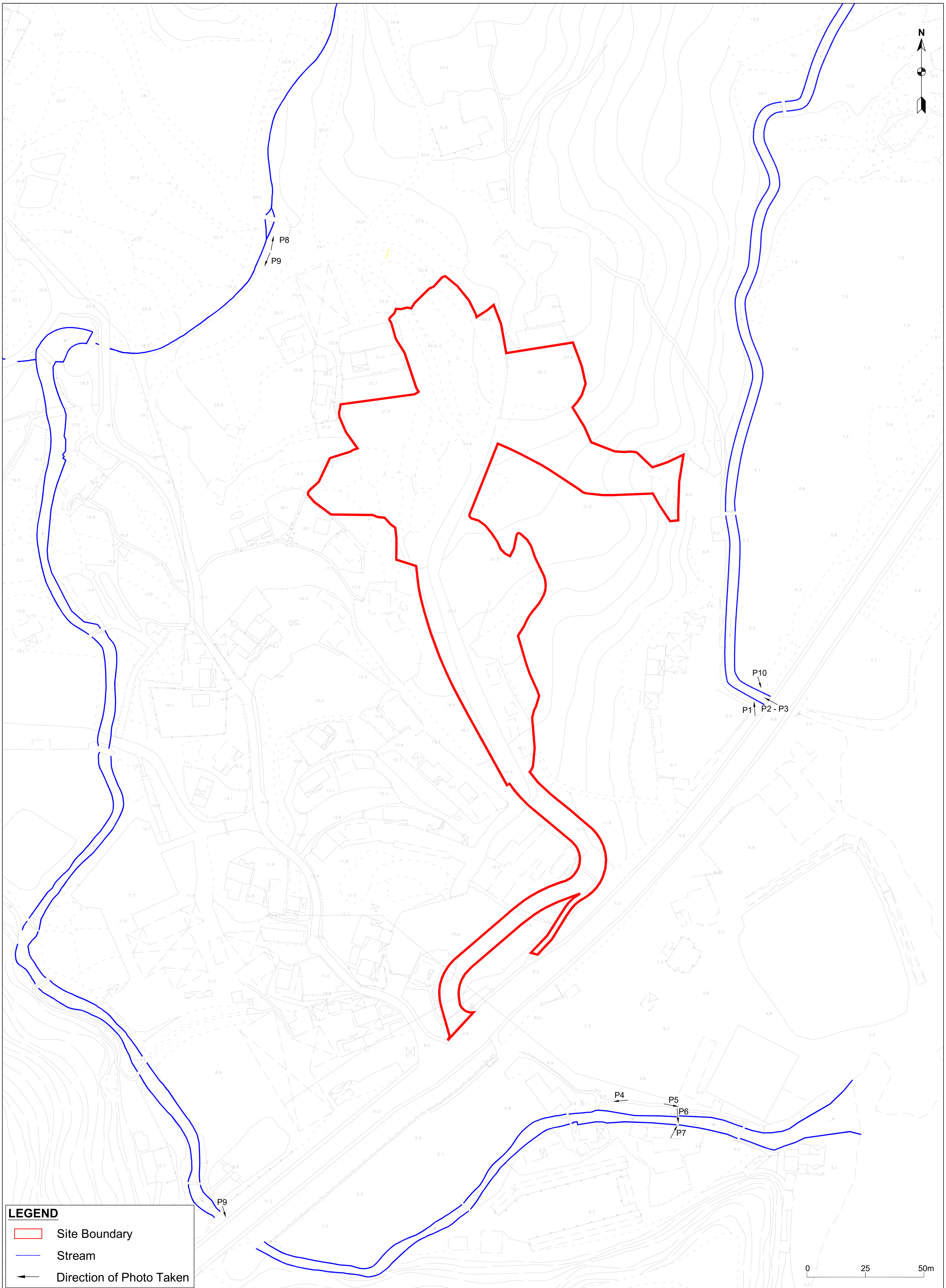
P10

P11



URBAN GREEN

S12A Rezoning Application for Proposed Columbarium on Various Lots in D.D.41, Sha Tau Kok, New Territories

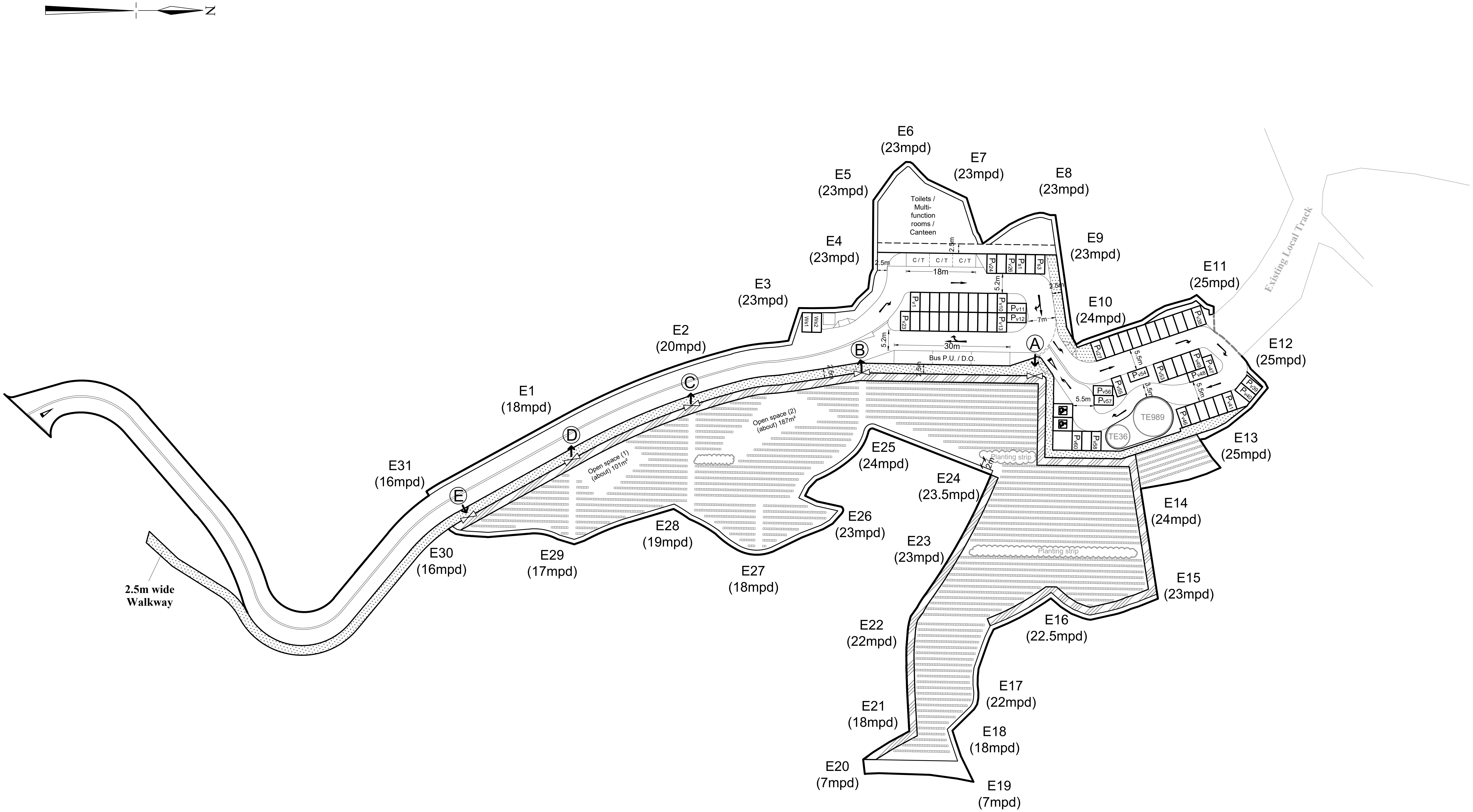
Photo Index Plan

Appendix F

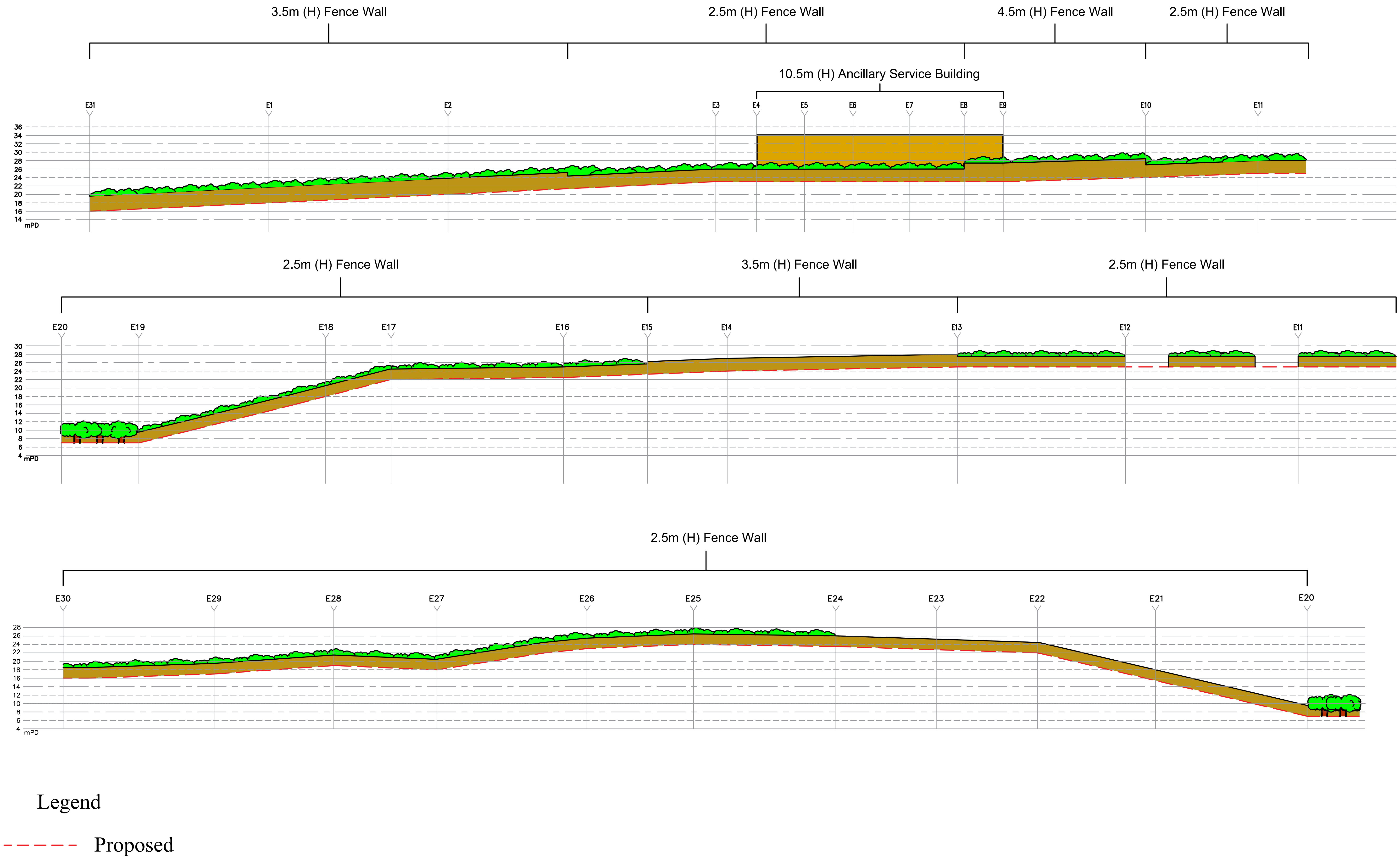
Rev. 0

Appendix I

Site Formation Level Plan



1 : 1000 (A3)	Proposed Site Formation Level	Goldrich Planners & Surveyors Ltd.
October 2025	Rezoning Application from "AGR" and "GB" to "OU (Columbarium)" on various Lots in D. D. 41 and Adjoining Government Land, Tong To, Sha Tau Kok, N.T.	Plan 19 (P 17106)



Not to Scale

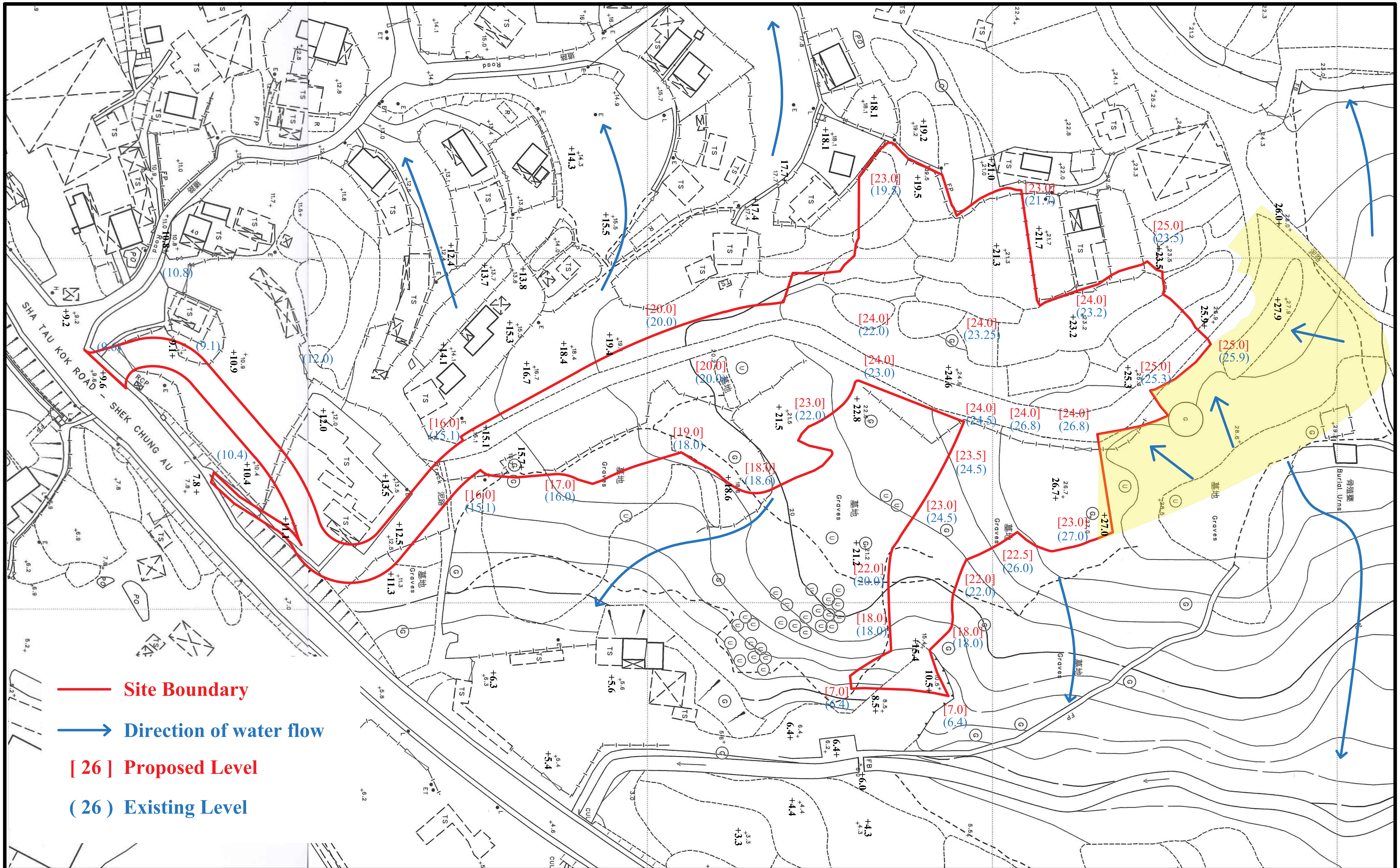
January 2026

Proposed Site Formation Level (Section)

Rezoning Application from "AGR" and "GB" to "OU (Columbarium)"
on various Lots in D. D. 41
and Adjoining Government Land, Tong To, Sha Tau Kok, N.T.

Goldrich Planners & Surveyors Ltd.

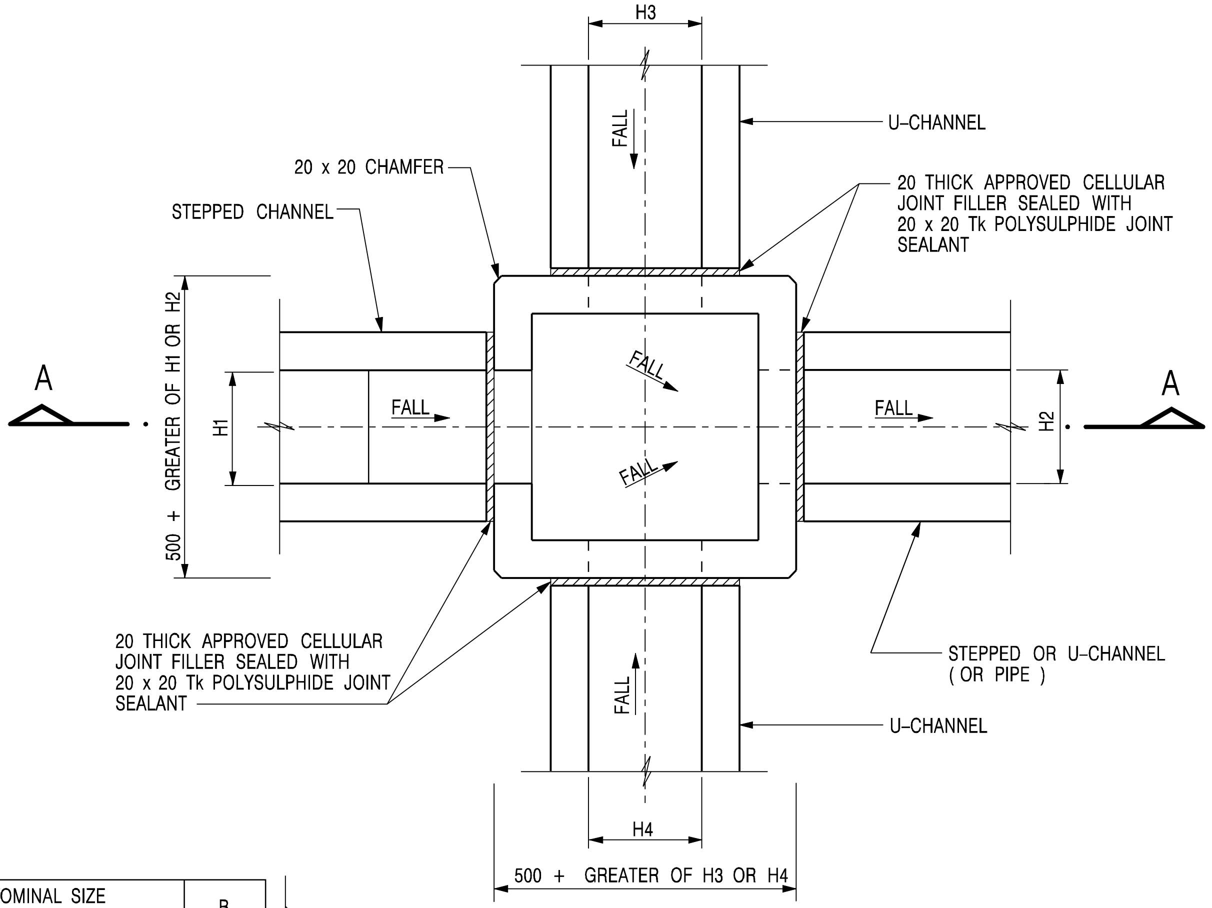
Plan 20b
(P 17106)



1 : 1000	Existing and Proposed Site Formation Level Rezoning Application from "AGR" and "GB" to "OU (Columbarium)" on various Lots in D. D. 41 and Adjoining Government Land, Tong To, Sha Tau Kok, N.T.	Goldrich Planners & Surveyors Ltd.
October 2025		Plan 18 (P 17106)

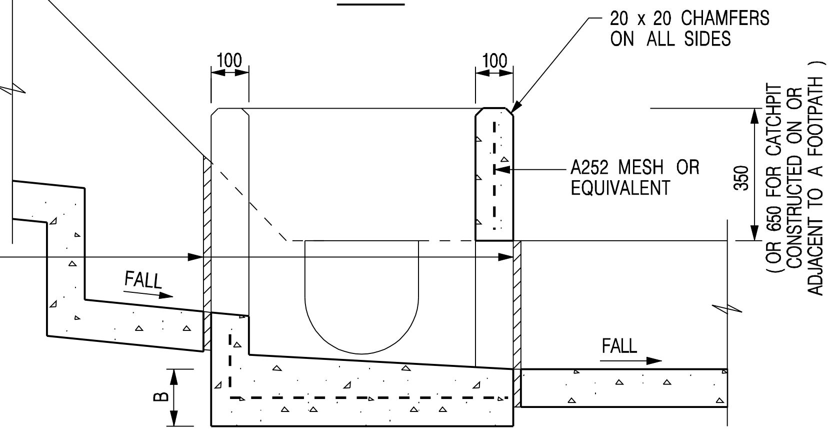
Appendix J

Detailed Drawings of Drainage Facilities

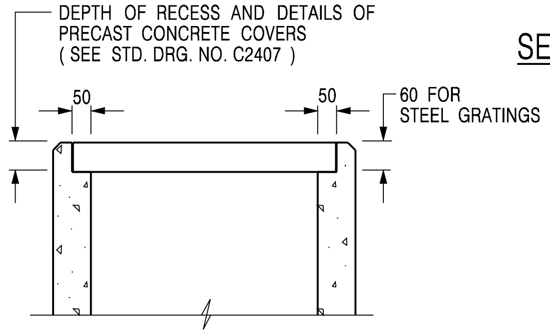


PLAN

NOMINAL SIZE (LARGEST OF H1, H2, H3 & H4)	B
300 – 600	150
675 – 900	175



SECTION A – A



ALTERNATIVE TOP SECTION FOR
PRECAST CONCRETE COVERS / GRATINGS

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES.
2. REFER TO SHEET 5 FOR OTHER NOTES.

REF.	REVISION	SIGNATURE	DATE
–	FORMER DRG. NO. C2405J.	Original Signed	03.2015

STANDARD CATCHPIT DETAILS

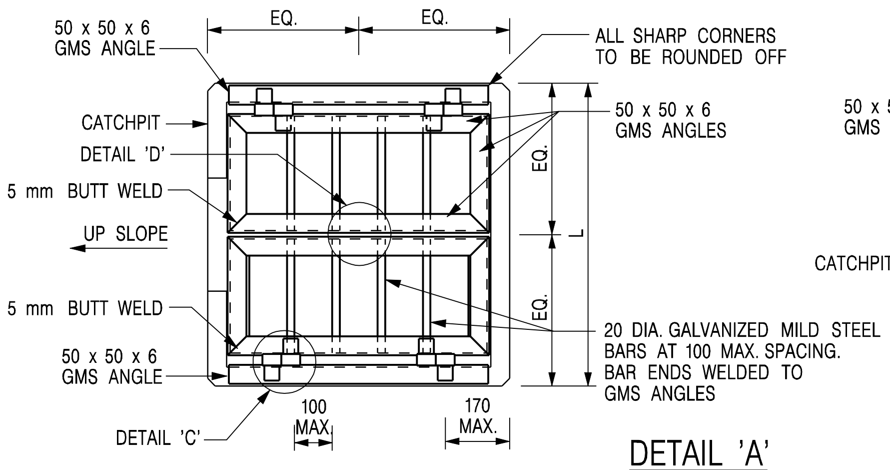
(SHEET 1 OF 5)

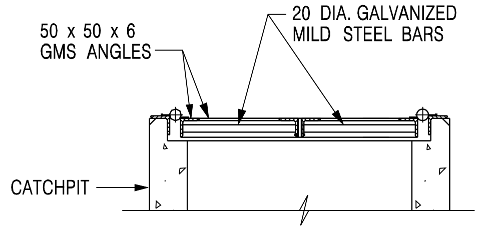
CIVIL ENGINEERING AND DEVELOPMENT DEPARTMENT

SCALE 1 : 20

DATE JAN 1991

DRAWING NO. C2405 /1



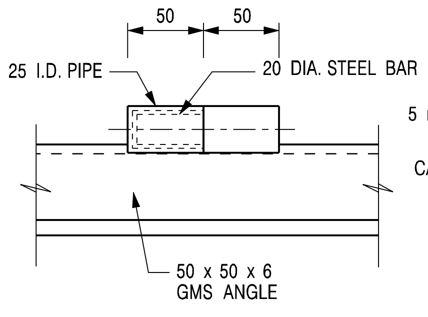


SECTIONAL ELEVATION

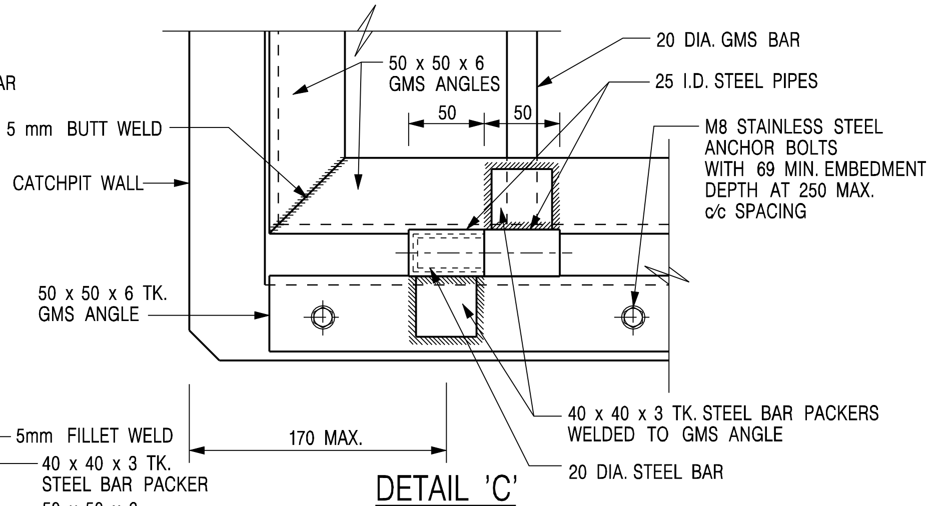
DETAIL 'A'

(DETAILS OF DOUBLE SIDE OPENING STEEL GRATING FOR L>900mm)

SCALE 1 : 20



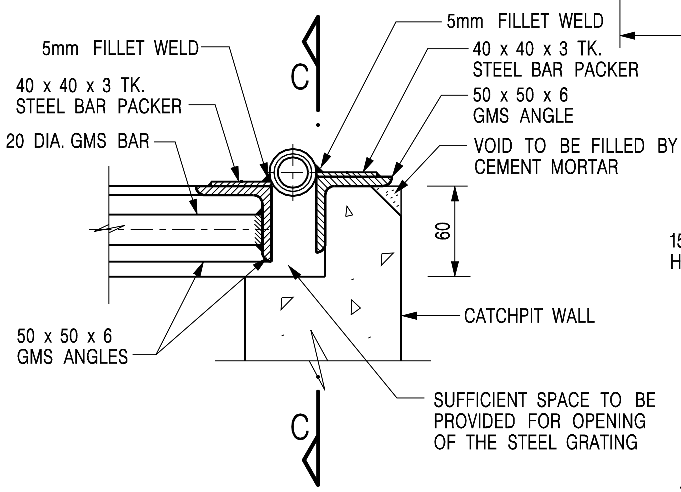
SECTION C – C



DETAIL 'C'

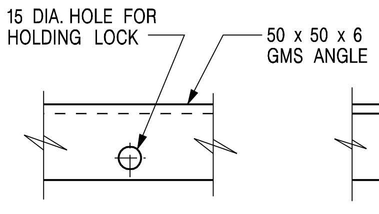
(DETAILS OF HINGE)

SCALE 1 : 5

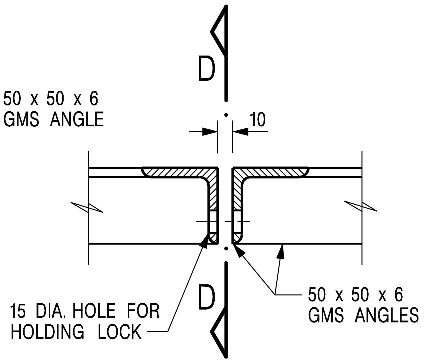


SECTIONAL ELEVATION

(DETAIL 'C')



SECTION D – D



DETAIL 'D'

(DETAILS OF HOLE FOR LOCK)

SCALE 1 : 5

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES.
2. REFER TO SHEET 5 FOR OTHER NOTES.

REF.	REVISION	SIGNATURE	DATE
–	FORMER DRG. NO. C2405J.	Original Signed	03.2015

STANDARD CATCHPIT DETAILS

(SHEET 2 OF 5)

CEDD CIVIL ENGINEERING AND DEVELOPMENT DEPARTMENT

SCALE AS SHOWN	DRAWING NO.
DATE JAN 1991	C2405 /2

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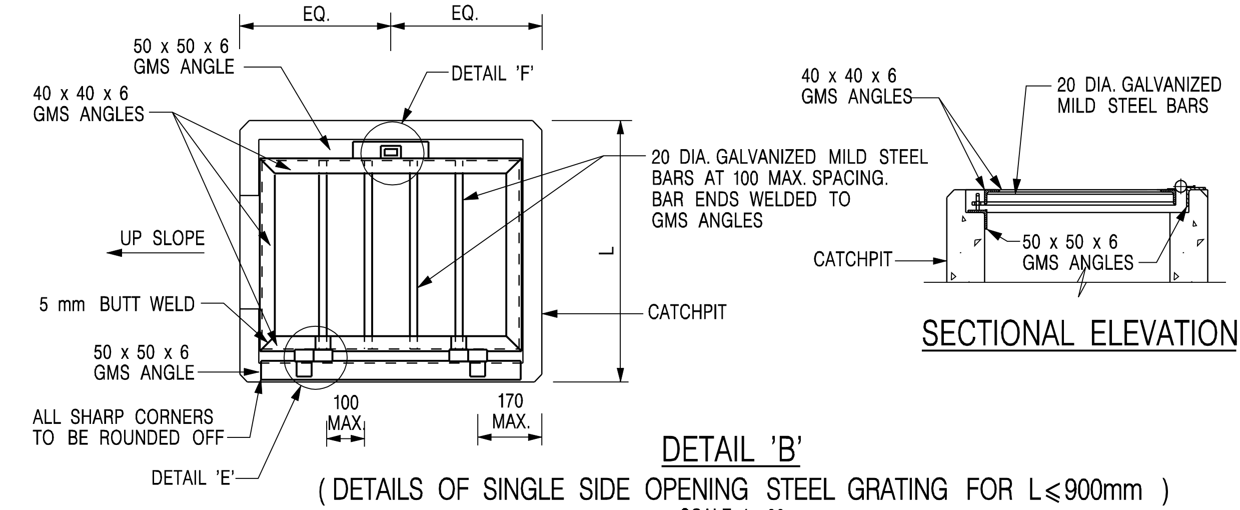
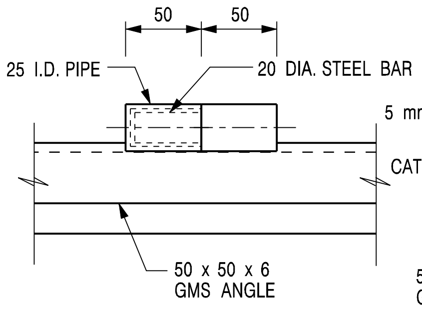


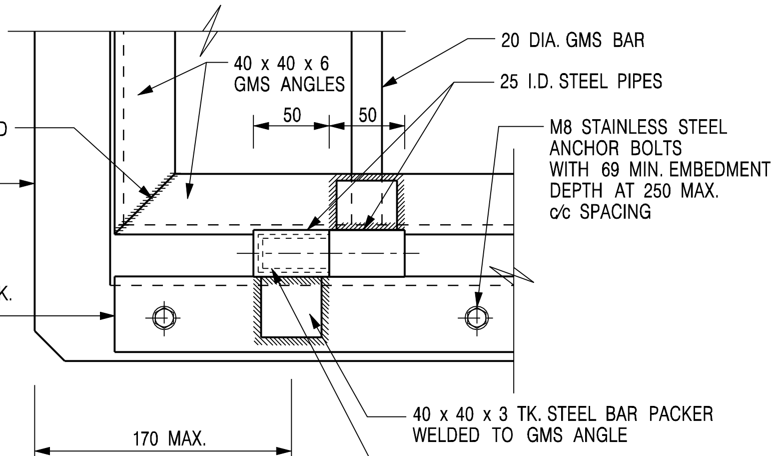
DETAIL 'B'

(DETAILS OF SINGLE SIDE OPENING STEEL GRATING FOR L⩽900mm)

SCALE 1 : 20



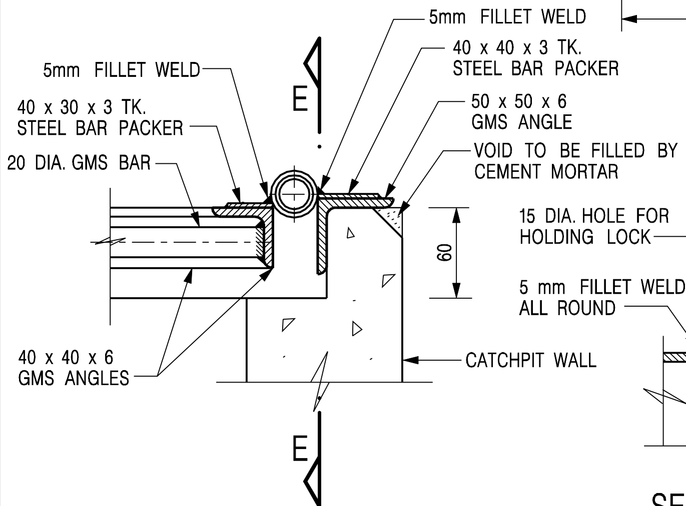
SECTION E – E



DETAIL 'E'

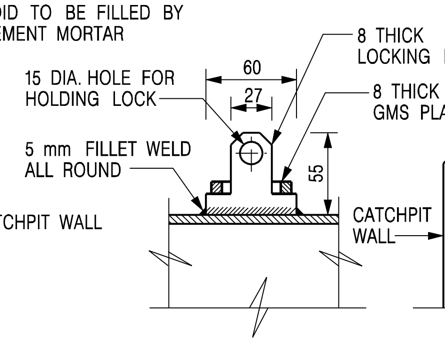
(DETAILS OF HINGE)

SCALE 1 : 5

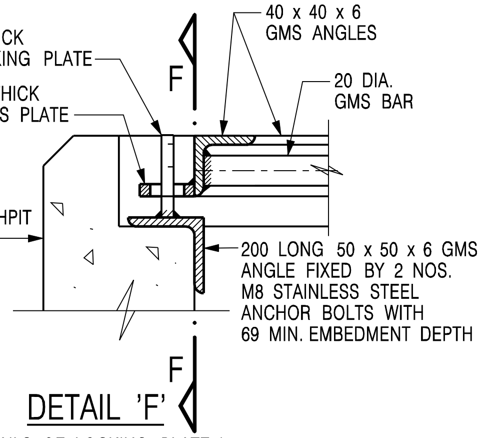


SECTIONAL ELEVATION

(DETAIL 'E')



SECTION F – F



DETAIL 'F'

(DETAILS OF LOCKING PLATE)

SCALE 1 : 5

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES.
2. REFER TO SHEET 5 FOR OTHER NOTES.

REF.	REVISION	SIGNATURE	DATE
–	FORMER DRG. NO. C2405J.	Original Signed	03.2015

STANDARD CATCHPIT DETAILS (SHEET 3 OF 5)

CIVIL ENGINEERING AND DEVELOPMENT DEPARTMENT

SCALE AS SHOWN

DATE JAN 1991

DRAWING NO. C2405 /3

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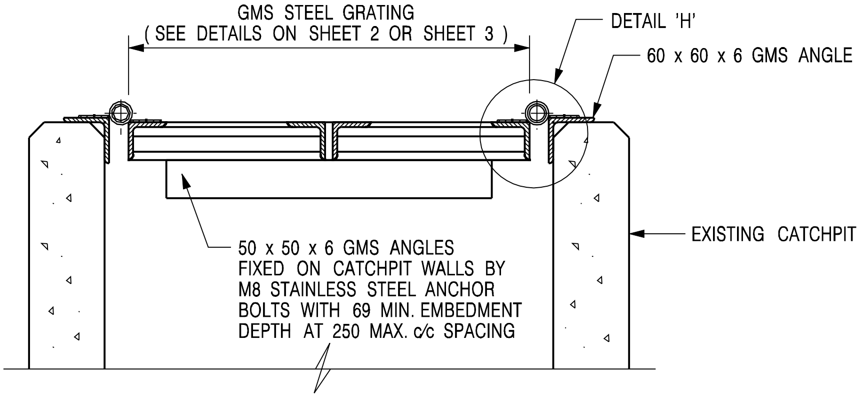
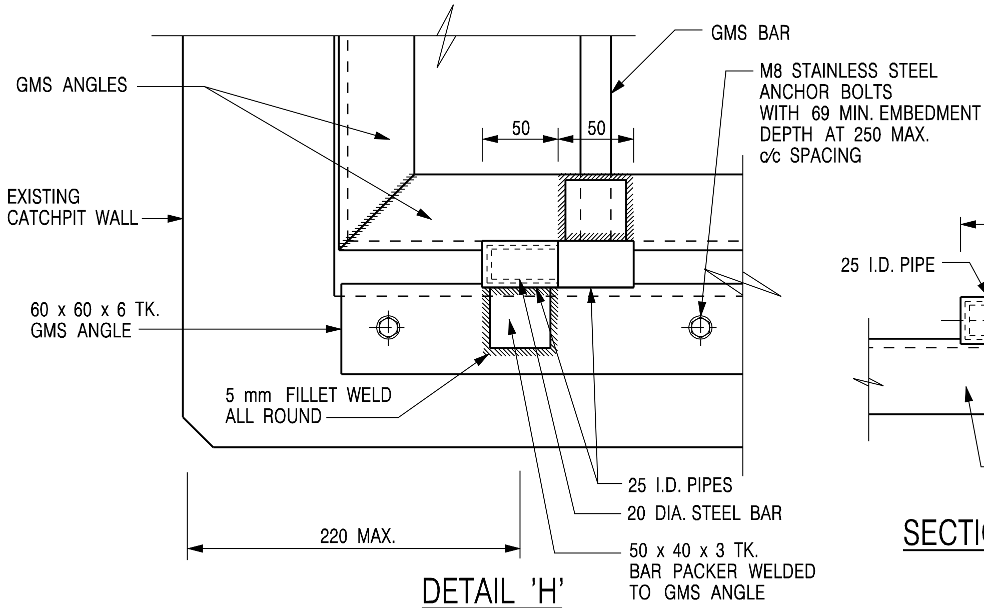


DETAIL 'G' – DETAILS OF STEEL GRATING CONSTRUCTED ON EXISTING CATCHPIT

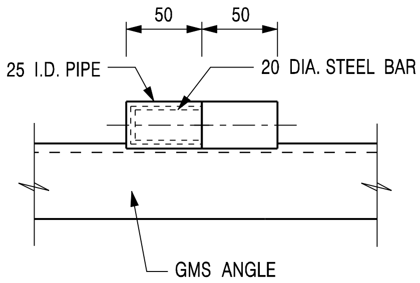
SCALE 1 : 10



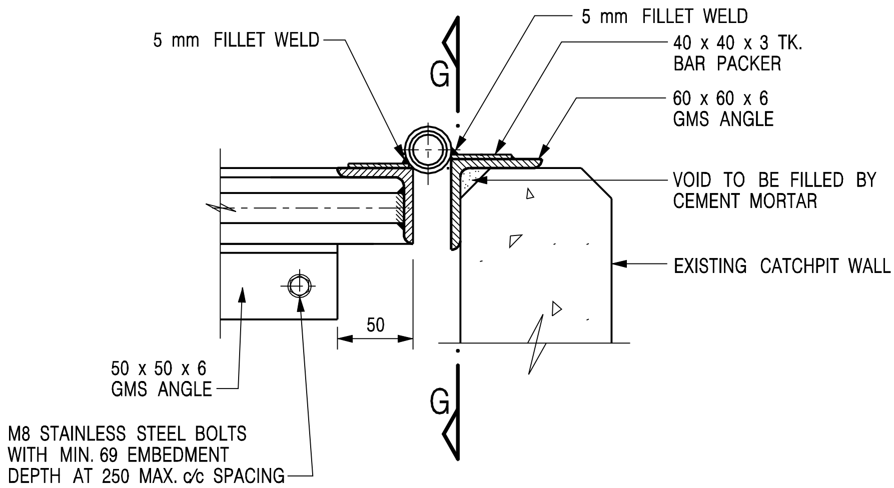
DETAIL 'H'

(DETAILS OF HINGE)

SCALE 1 : 5



SECTION G – G



SECTIONAL ELEVATION

(DETAIL 'H')

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES.
2. REFER TO SHEET 5 FOR OTHER NOTES.

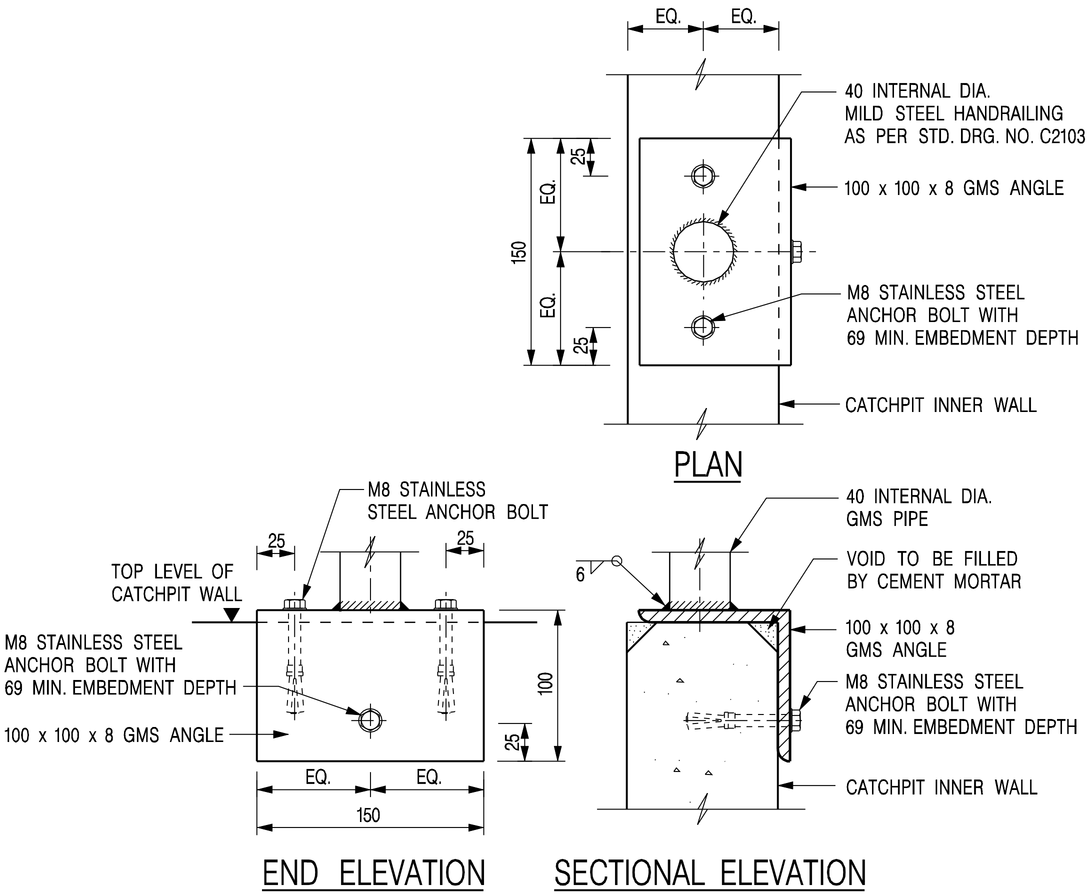
REF.	REVISION	SIGNATURE	DATE
–	FORMER DRG. NO. C2405J.	Original Signed	03.2015

STANDARD CATCHPIT DETAILS

(SHEET 4 OF 5)

CIVIL ENGINEERING AND DEVELOPMENT DEPARTMENT

SCALE AS SHOWN	DRAWING NO.
DATE JAN 1991	C2405 /4



DETAIL 'J' – FIXING DETAILS FOR HANDRAILING ON TOP OF CATCHPIT WALL

SCALE 1 : 5

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES.
2. ALL CONCRETE SHALL BE GRADE 20 /20.
3. CONCRETE SURFACE FINISH SHALL BE CLASS U2 OR F2 AS APPROPRIATE.
4. FOR DETAILS OF JOINT, REFER TO STD. DRG. NO. C2413.
5. CONCRETE TO BE COLOURED AS SPECIFIED.
6. FOR CATCHPITS CONSTRUCTED ON OR ADJACENT TO A FOOTPATH, STEEL GRATINGS (SEE DETAILS ON SHEET 2 OR SHEET 3) OR CONCRETE COVERS (SEE STD. DRG. NO. C2407) SHALL BE PROVIDED AS DIRECTED BY THE ENGINEER.
7. IF INSTRUCTED BY THE ENGINEER, HANDRAILING (SEE DETAIL 'J' ON SHEET 5; EXCEPT ON THE UPSLOPE SIDE) IN LIEU OF STEEL GRATINGS OR CONCRETE COVERS CAN BE ACCEPTED AS AN ALTERNATIVE SAFETY MEASURE FOR CATCHPITS NOT ON A FOOTPATH NOR ADJACENT TO IT. TOP OF THE HANDRAILING SHALL BE 1 000 mm MIN. MEASURED FROM THE ADJACENT GROUND LEVEL.
8. MINIMUM INTERNAL CATCHPIT WIDTH SHALL BE 1 000 mm FOR CATCHPITS WITH A HEIGHT EXCEEDING 1 000 mm MEASURED FROM THE INVERT LEVEL TO THE ADJACENT GROUND LEVEL. AND, STEP IRONS (SEE DSD STD. DRG. NO. DS1043) AT 300 mm c/c STAGGERED SHALL BE PROVIDED. THICKNESS OF CATCHPIT WALL FOR INSTALLATION OF STEP IRONS SHALL BE INCREASED TO 150 mm.
9. FOR RETROFITTING AN EXISTING CATCHPIT WITH STEEL GRATING, SEE DETAIL 'G' ON SHEET 4.
10. ALL STEEL ANGLES SHALL COMPLY WITH BS EN 10025 AND BS EN 10056.
11. UNLESS OTHERWISE SPECIFIED, ALL WELDS SHALL BE 5 mm CONTINUOUS FILLET WELDS.
12. ALL WELDS SHALL BE CHIPPED, GROUND SMOOTH, BRUSHED TO REMOVE SLAG PRIOR TO HOT-DIP GALVANIZATION.
13. ALL STEELWORK SHALL BE HOT-DIP GALVANIZED TO BS EN ISO 1461. ALL EXPOSED STEELWORK SURFACES SHALL BE TREATED AND PAINTED IN ACCORDANCE WITH THE GENERAL SPECIFICATION.
14. SUBJECT TO THE APPROVAL OF THE ENGINEER, OTHER MATERIALS CAN ALSO BE USED AS COVERS / GRATINGS.

REF.	REVISION	SIGNATURE	DATE
–	FORMER DRG. NO. C2405J.	Original Signed	03.2015

STANDARD CATCHPIT DETAILS

(SHEET 5 OF 5)

CEDD CIVIL ENGINEERING AND DEVELOPMENT DEPARTMENT

SCALE AS SHOWN	DRAWING NO.
DATE JAN 1991	C2405 /5

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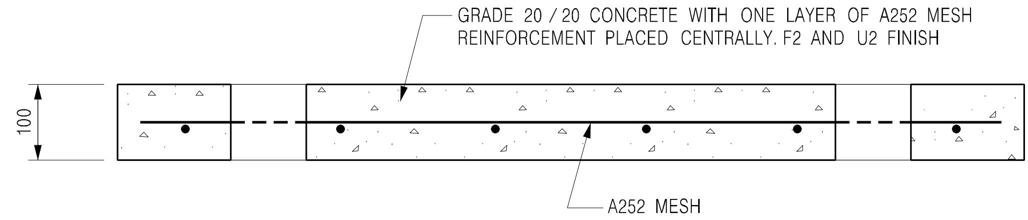
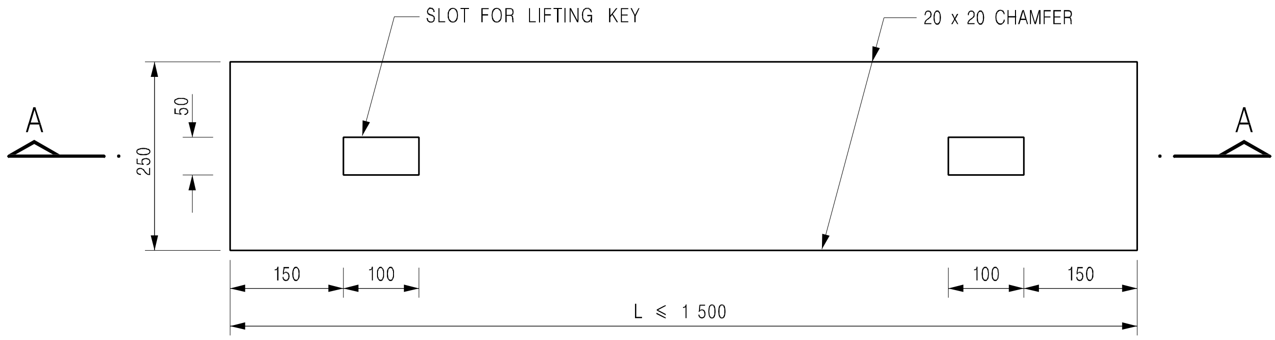
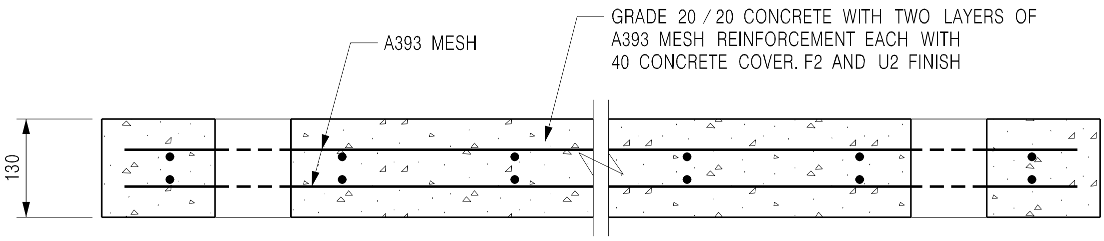


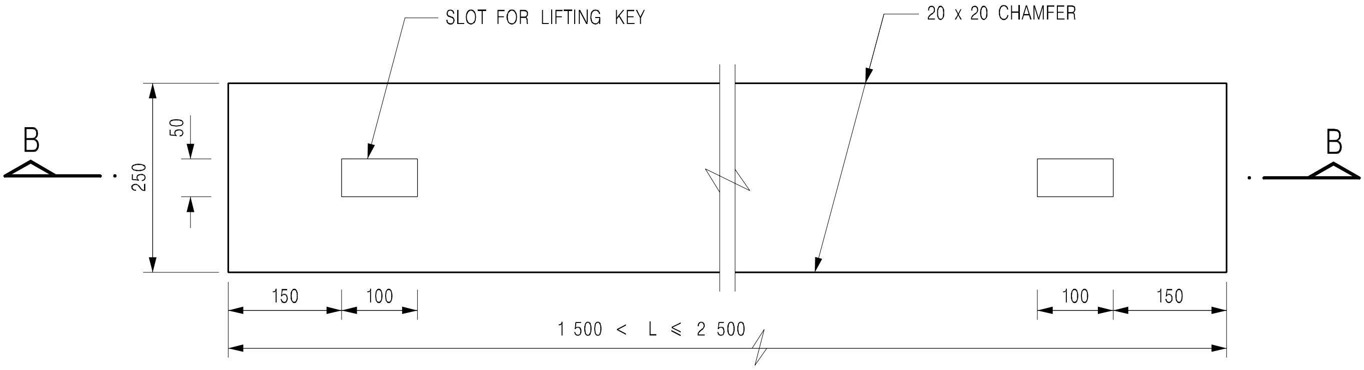
SECTION A – A



PLAN
TYPE 1 – FOR SPAN UP TO 1.5 m



SECTION B – B



PLAN
TYPE 2 – FOR SPANS 1.5 m TO 2.5 m

NOTES:

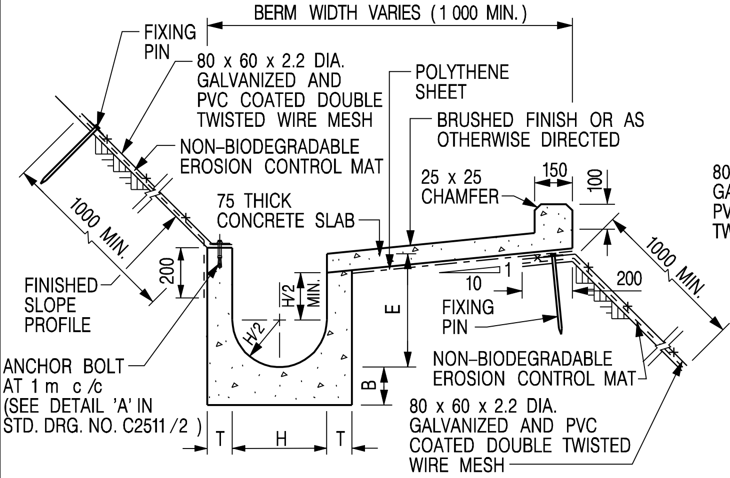
1. ALL DIMENSIONS ARE IN MILLIMETRES.
2. ALL EXTERNAL EDGES OF THE COVERS SHALL BE 20mm CHAMFERED.

REF.	REVISION	SIGNATURE	DATE
B	NAME OF DEPARTMENT AMENDED.	Original Signed	01.2005
A	GENERAL REVISION	Original Signed	12.2002

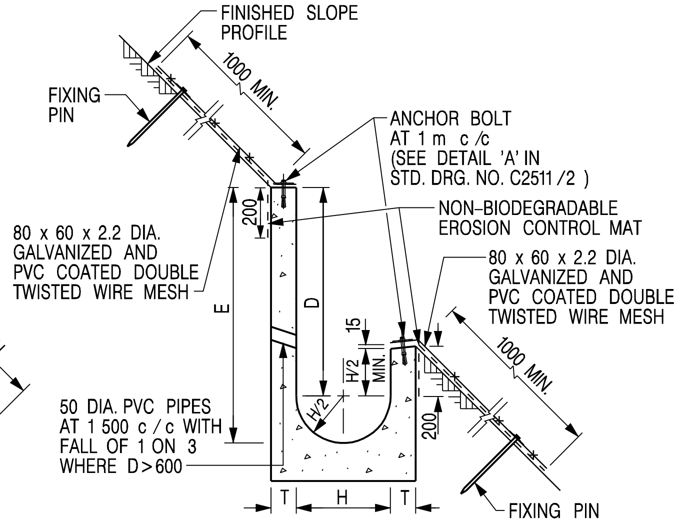
PRECAST CONCRETE COVERS FOR CATCHPIT AND SAND TRAP

CEDD CIVIL ENGINEERING AND DEVELOPMENT DEPARTMENT

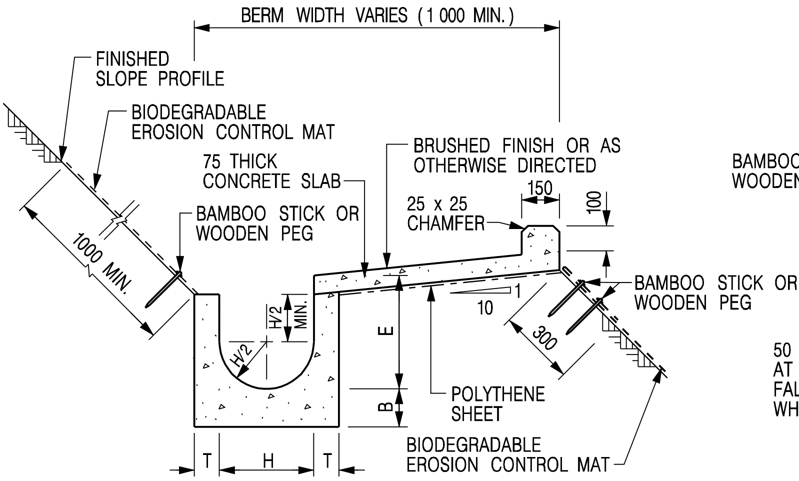
SCALE 1 : 10	DRAWING NO. C2407B
DATE JAN 1991	



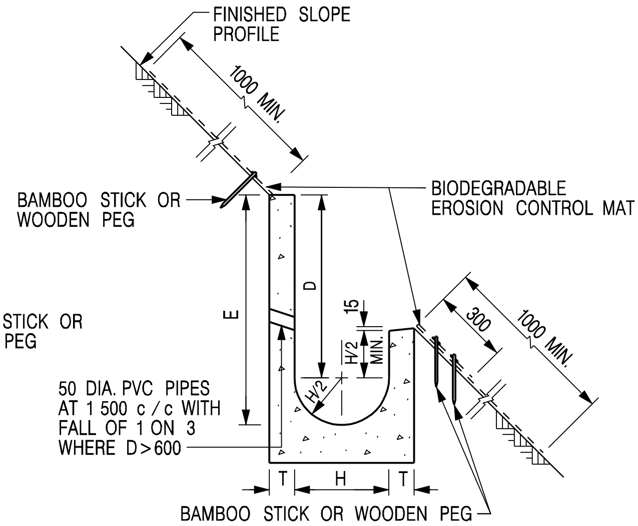
U-CHANNELS CONSTRUCTED ON BERM WITH NON-BIODEGRADABLE EROSION CONTROL MAT



U-CHANNELS NOT CONSTRUCTED ON BERM WITH NON-BIODEGRADABLE EROSION CONTROL MAT



U-CHANNELS CONSTRUCTED ON BERM WITH BIODEGRADABLE EROSION CONTROL MAT



U-CHANNELS NOT CONSTRUCTED ON BERM WITH BIODEGRADABLE EROSION CONTROL MAT

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES.
2. ALL CONCRETE TO BE GRADE 20/20.
3. CONCRETE SURFACE FINISH SHALL BE CLASS U2, F2 OR BRUSHED FINISH AS DIRECTED.
4. SPACING OF EXPANSION JOINT IN CHANNELS, BERM SLABS AND APRONS TO BE 10 METRES MAXIMUM, SEE STD. DRG. NO. C2413 FOR DETAILS.
5. JOINTS FOR CHANNELS, BERM SLABS, APRONS AND WALLS, ETC. TO BE ON THE SAME ALIGNMENT.
6. FOR DIMENSIONS T, H, & B, SEE TABLE BELOW.
7. FOR TYPICAL FIXING PIN DETAILS, SEE STD. DRG. NO. C2511/2.
8. MINIMUM SIZE OF 25 x 50 x 300mm SHALL BE PROVIDED FOR WOODEN PEG.
9. MINIMUM SIZE OF 10mm DIAMETER WITH 200mm LONG SHALL BE PROVIDED FOR BAMBOO STICK.
10. THE FIXING DETAILS OF NON-BIODEGRADABLE AND BIODEGRADABLE EROSION CONTROL MATS ON EXISTING BERM SHALL REFER TO STD. DRG. NO. C2511/1.

NOMINAL SIZE H	T	B	REINFORCEMENT
300	80	100	A252 MESH PLACED CENTRALLY AND T=100 WHEN E>650
375 - 600	100	150	
675 - 900	125	175	A252 MESH PLACED CENTRALLY

REF.	REVISION	SIGNATURE	DATE
I	MINOR AMENDMENT.	Original Signed	07.2018
H	FIXING DETAILS OF BIODEGRADABLE EROSION CONTROL MAT ADDED.	Original Signed	12.2017
G	DIMENSION TABLE AMENDED.	Original Signed	01.2005
F	MINOR AMENDMENT.	Original Signed	01.2004
E	GENERAL REVISION.	Original Signed	12.2002
D	MINOR AMENDMENT.	Original Signed	08.2001
C	150 x 100 UPSTAND ADDED AT BERM.	Original Signed	6.99
B	MINOR AMENDMENT.	Original Signed	3.94
A	MINOR AMENDMENT.	Original Signed	10.92

DETAILS OF HALF-ROUND AND U-CHANNELS (TYPE B - WITH EROSION CONTROL MAT APRON)

CEDD

CIVIL ENGINEERING AND DEVELOPMENT DEPARTMENT

SCALE DIAGRAMMATIC

DATE JAN 1991

DRAWING NO. C2410I

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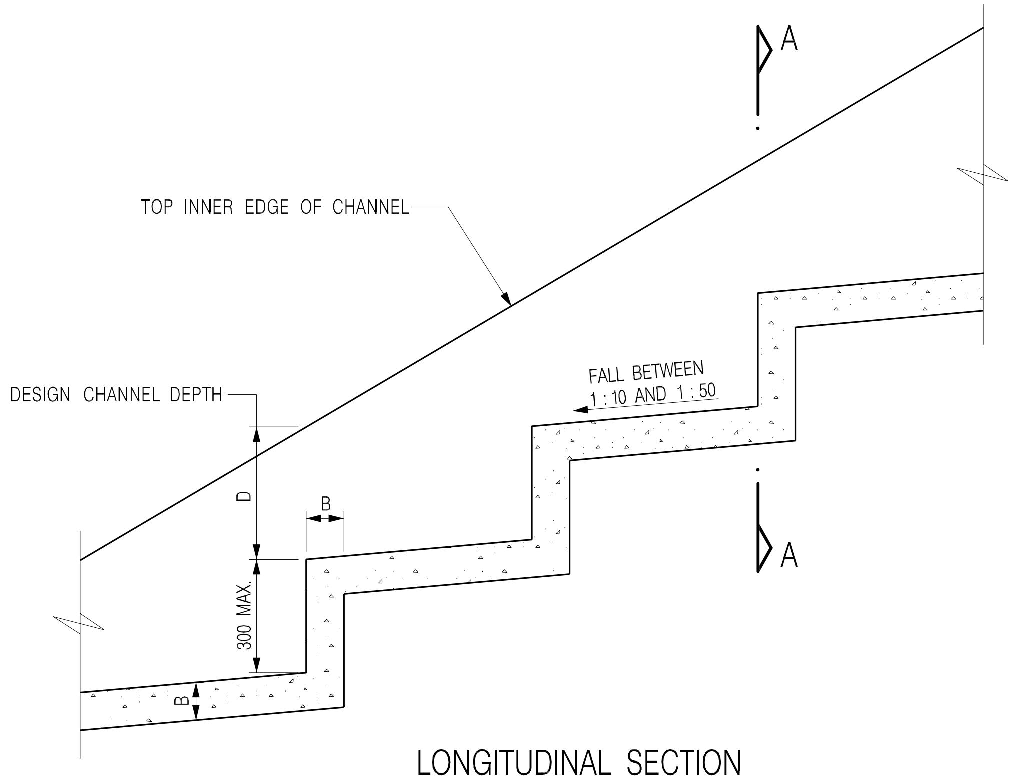
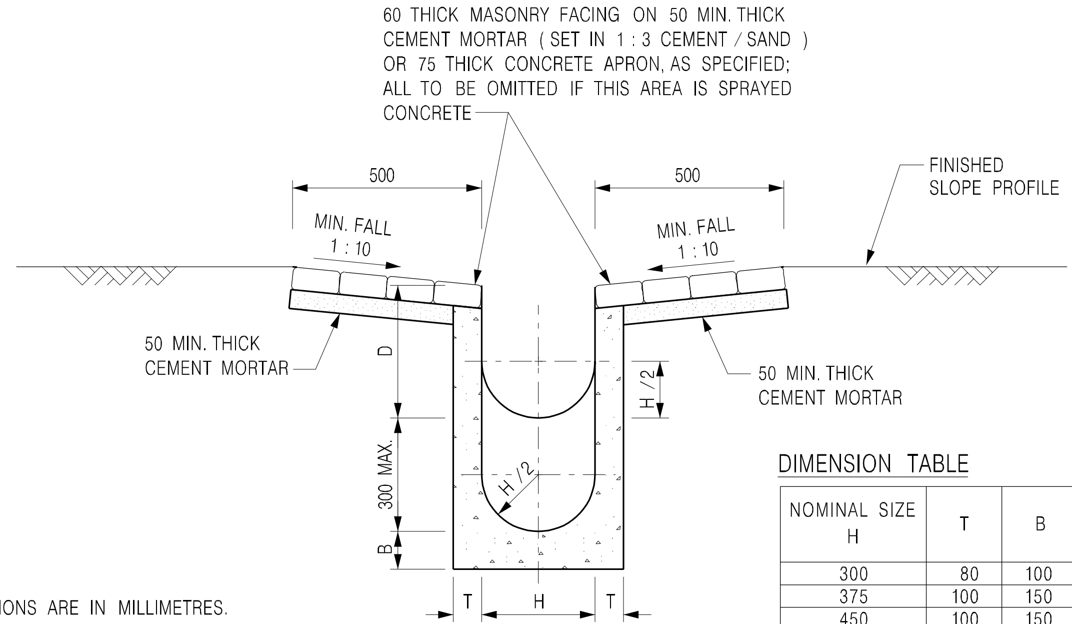


LONGITUDINAL SECTION



SECTION A – A

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES.
2. FOR DIMENSIONS OF CHANNELS SEE TABLE.
3. ALL CONCRETE SHALL BE GRADE 20 / 20.
4. CONCRETE SURFACE FINISH SHALL BE CLASS U2 OR F2 AS APPROPRIATE.
5. EXPANSION JOINTS SHALL BE PROVIDED AT A MAXIMUM SPACING OF 10 METRES WITH DETAILS AS SHOWN ON STD. DRG. NO. C2413.
6. 675 – 900 CHANNELS SHALL BE REINFORCED AS SHOWN ON STD. DRG. NO. C2410.

DIMENSION TABLE

NOMINAL SIZE H	T	B	D
300	80	100	350
375	100	150	540
450	100	150	575
525	100	150	615
600	100	150	650
675	125	175	740
750	125	175	775
900	125	175	850

REF.	REVISION	SIGNATURE	DATE
G	GENERAL REVISION.	Original Signed	08.2006
F	NAME OF DEPARTMENT AMENDED.	Original Signed	01.2005
E	NOTE 6 AMENDED.	Original Signed	01.2004
D	GENERAL REVISION.	Original Signed	12.2002
C	MINOR AMENDMENT.	Original Signed	08.2001
B	MINOR AMENDMENT.	Original Signed	3.94
A	MINOR AMENDMENT.	Original Signed	11.92

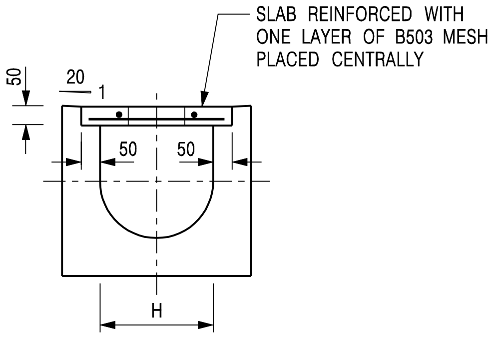
DETAILS OF STEPPED CHANNEL

CEDD CIVIL ENGINEERING AND DEVELOPMENT DEPARTMENT

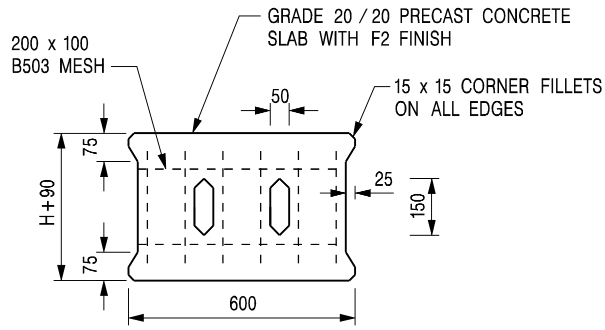
SCALE 1 : 20

DATE JAN 1991

DRAWING NO. C2411G



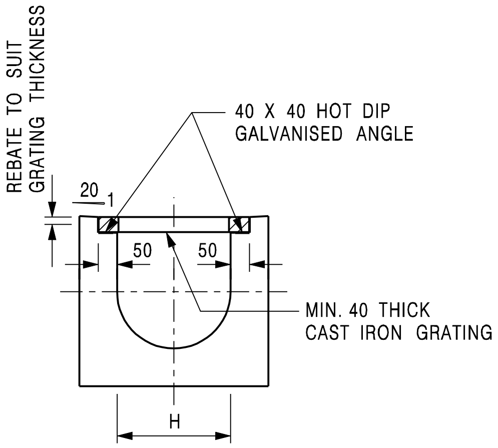
TYPICAL SECTION



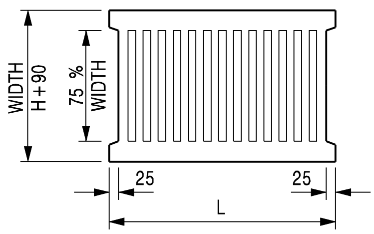
PLAN OF SLAB

U–CHANNELS WITH PRECAST CONCRETE SLABS

(UP TO H OF 525)



TYPICAL SECTION



L = 600mm FOR H ⩽ 375mm
L = 400mm FOR H > 375mm

CAST IRON GRATING

(DIMENSIONS ARE FOR GUIDANCE ONLY, CONTRACTOR MAY SUBMIT EQUIVALENT TYPE)

U–CHANNEL WITH CAST IRON GRATING

(UP TO H OF 525)

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES.
2. H = NOMINAL CHANNEL SIZE.
3. ALL CAST IRON FOR GRATINGS SHALL BE GRADE EN–GJL–150 COMPLYING WITH BS EN 1561.
4. FOR COVERED CHANNELS TO BE HANDED OVER TO HIGHWAYS DEPARTMENT FOR MAINTENANCE, THE GRATING DETAILS SHALL FOLLOW THOSE AS SHOWN ON HyD STD. DRG. NO. H3156.

REF.	REVISION	SIGNATURE	DATE
E	NOTES 3 & 4 AMENDED.	Original Signed	12.2014
D	NOTE 4 ADDED.	Original Signed	06.2008
C	MINOR AMENDMENT. NOTE 3 ADDED.	Original Signed	12.2005
B	NAME OF DEPARTMENT AMENDED.	Original Signed	01.2005
A	CAST IRON GRATING AMENDED.	Original Signed	12.2002

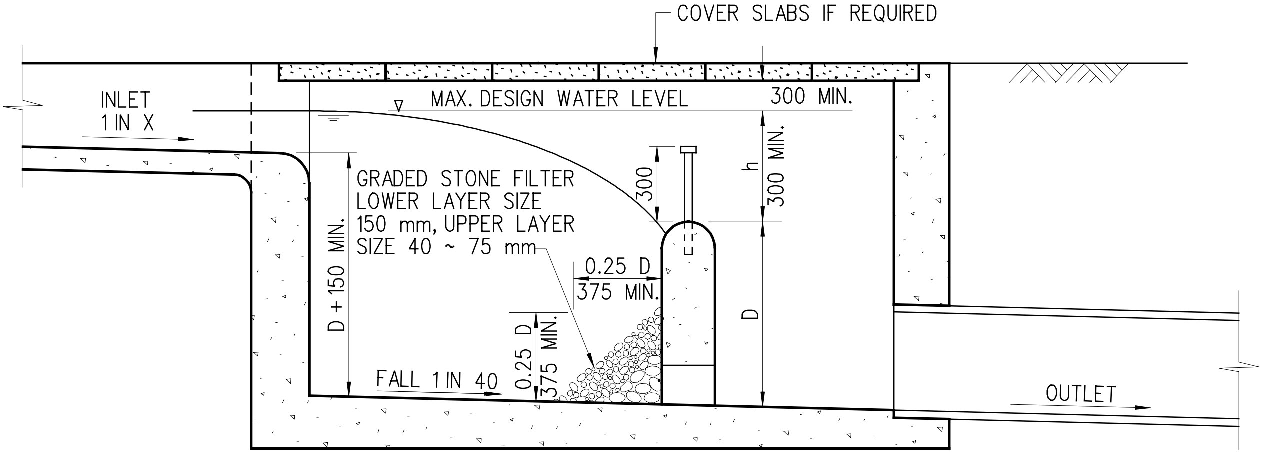
COVER SLAB AND CAST IRON GRATING FOR CHANNELS

CIVIL ENGINEERING AND DEVELOPMENT DEPARTMENT

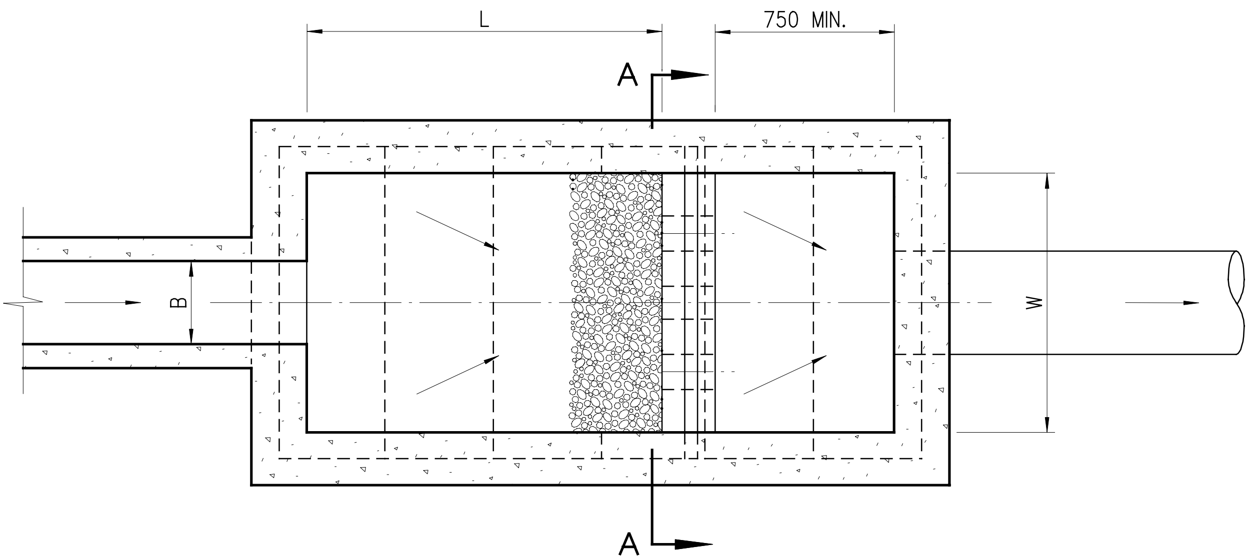
SCALE 1 : 20

DATE JAN 1991

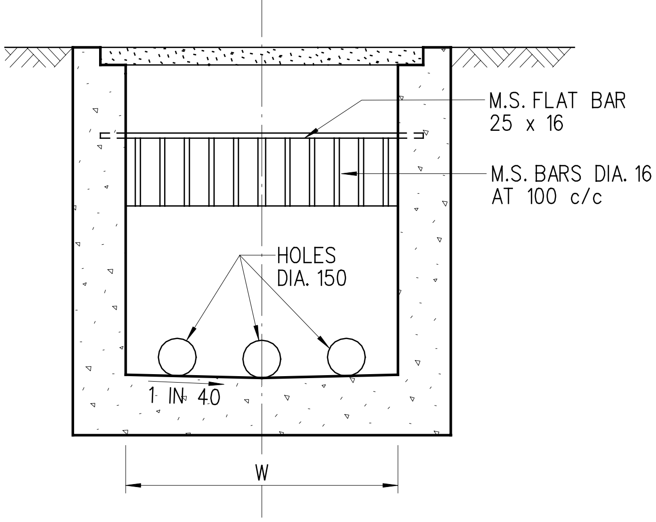
DRAWING NO. C2412E



LONGITUDINAL SECTION



PLAN



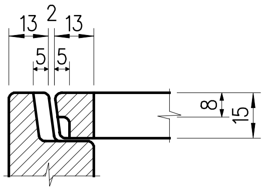
SECTION A-A

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES.
2. NORMALLY FOR DRAINS OF 900 mm DIA. AND BELOW. FOR BIGGER DRAINS AND STEEP TERRAIN, SAND TRAP SHOULD BE SPECIALLY DESIGNED.
3. SIZE
   DEPTH : $D \nless 750$
   WIDTH : $W \geqslant 3B$
   LENGTH : $4.8D^{0.67}\ h^{0.5}\ X^{-0.5} \geqslant 4B$
4. GRADED STONE FILTER SHALL BE CRUSHER RUN GRANITE AGGREGATE.
5. CAPACITY D W L TO BE ACCORDING TO SIZE AND NATURE OF CATCHMENT, PROVIDING DETENTION TIME NOT LESS THAN 5 MINUTES FOR MAX. DESIGN FLOW OF INLET.

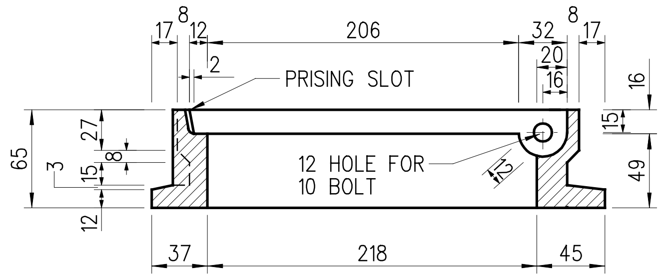
REV.	DESCRIPTION	SIGNATURE	DATE
B	REDRAWN BY CAD	ORIGINAL SIGNED	8.8.2001
A	GENERAL REVIEW	ORIGINAL SIGNED	2.2.2001

SAND TRAP	DRAINAGE SERVICES DEPARTMENT	
	REFERENCE	DRAWING No. DS 1025B
	SCALE DIAGRAMMATIC	

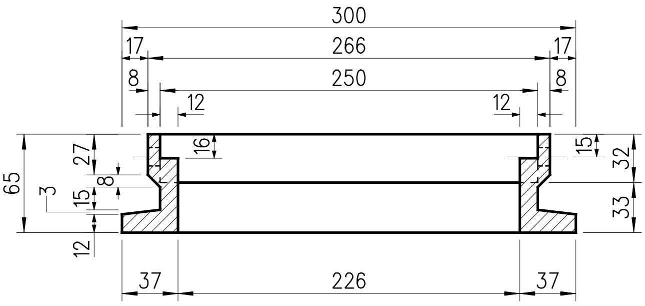


SECTION THROUGH PRISING SLOT

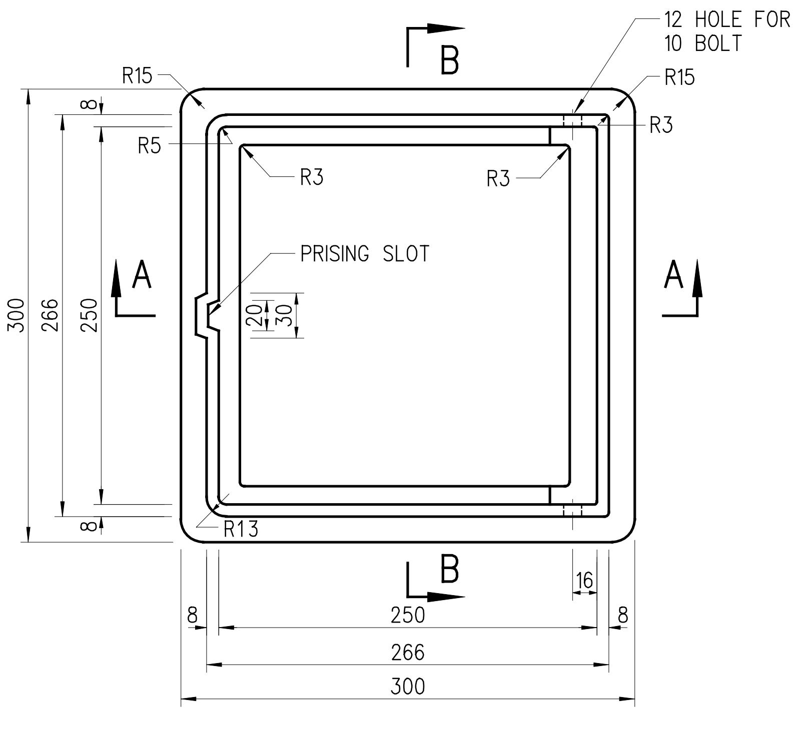
SCALE 1 : 2



SECTION A-A



SECTION B-B



PLAN OF FRAME

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES.
2. ALL CORNERS ARE TO BE ROUNDED TO APPROXIMATELY 2 RADIUS.
3. CAST IRON IS TO CONFORM WITH GRADE 10 BS 1452.

REV.	DESCRIPTION	SIGNATURE	DATE
B	REDRAWN BY CAD	ORIGINAL SIGNED	8.8.2001
A	GENERAL REVIEW	ORIGINAL SIGNED	2.2.2001

GRATED COVER AND FRAME

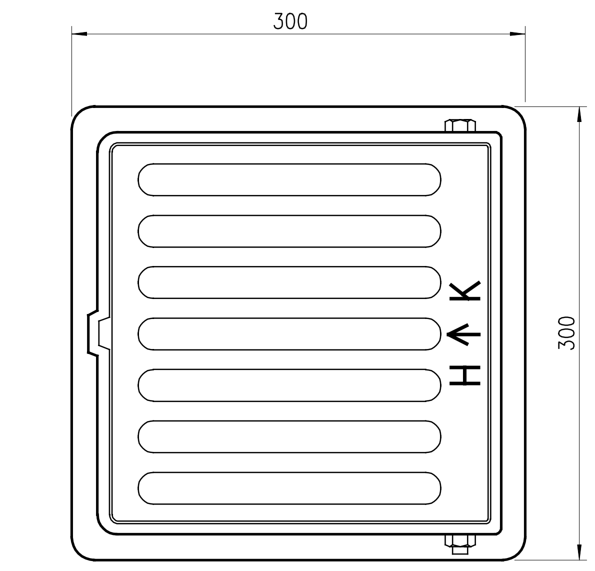
DRAINAGE SERVICES DEPARTMENT

REFERENCE

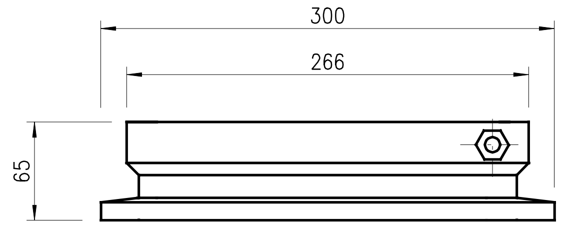
SCALE 1 : 5 OR AS SHOWN

DRAWING No. DS 1045B

(SHEET 1 OF 2)

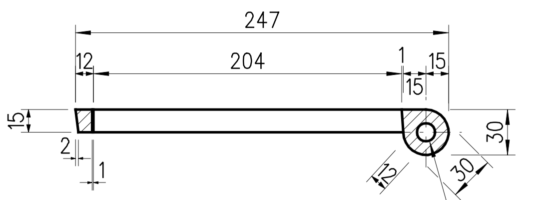


PLAN

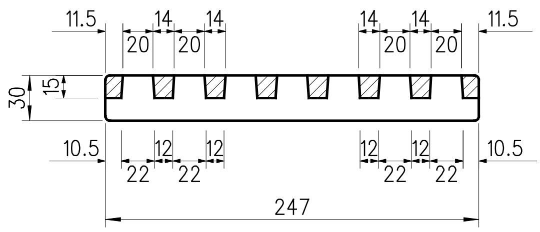


ELEVATION

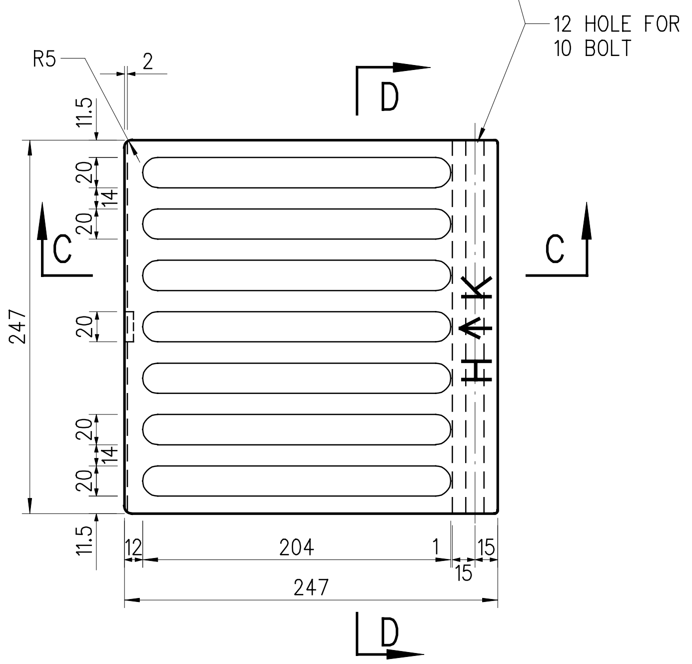
COMPLETE ASSEMBLY



SECTION C-C



SECTION D-D



PLAN OF GRATED COVER

REV.	DESCRIPTION	SIGNATURE	DATE
B	REDRAWN BY CAD	ORIGINAL SIGNED	8.8.2001
A	GENERAL REVIEW	ORIGINAL SIGNED	2.2.2001

GRATED COVER AND FRAME	DRAINAGE SERVICES DEPARTMENT	
	REFERENCE	DRAWING No. DS 1045B (SHEET 2 OF 2)
	SCALE 1 : 5	