ARUP

Appendix A

Drainage Impact Assessment

Application for Permission Under Section 16 of the Town Planning Ordinance (Cap. 131) for Proposed Comprehensive Development including Flats, Retail and Community Facilities and Minor Relaxation of Plot Ratio and Building Height Restriction in "Comprehensive Development Area" Zone at Various Lots in S.D.4 and Adjoining Government Land, Kau Wa Keng, Kwai Chung

Drainage Impact Assessment

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1 Introduction

1.1 Background

1.1.1.1 Arup Hong Kong Limited was commissioned to conduct a Drainage Impact Assessment (DIA) in support of the Section 16 Planning Application for Proposed Comprehensive Development including Flats, Retail and Community Facilities and Minor Relaxation of Plot Ratio and Building Height Restriction in "Comprehensive Development Area" Zone at Various Lots in S.D.4 and Adjoining Government Land, Kau Wa Keng, Kwai Chung (the Application Site).

1.1.1.2 The Application Site, with an area of about 48,313.167 m^2, is located at the Kau Wa Keng valley floor abutting Lai King Hill Road with high accessibility to public transport. It falls within the "CDA" zone on the Approved Kwai Chung Outline Zoning Plan (OZP) No. S/KC/32.

1.2 Purpose of this Report

1.2.1.1 The purpose of this Drainage Impact Assessment (DIA) is to review the sewerage impact on the overall drainage network based on preferred option and developments in the vicinity, assess whether there is adequate capacity for the planned development, and propose mitigation measures (if any).

1.3 Structure of this Report

1.3.1.1 This DIA report will include the following:

Section 1 – **Introduction**, presents the project background, the purpose and structure of the report;

Section 2 – **Project Description**, presents an outline description of the project;

Section 3 – **Outline of Existing and Planned Drainage System**, describes the existing and planned drainage systems near the project area;

Section 4 – **Hydraulic Assessment Methodology for Drainage System**, present the drainage system assessment methodologies;

Section 5 – **Stormwater Flow Estimation, Potential Drainage Impacts and Mitigation Measures**, contains the proposed drainage flow, potential drainage impacts and corresponding mitigation measures;

Section 6 – Conclusion provides a conclusion to this DIA report.

2 Proposed Development

2.1 Proposed Master Layout Plan

2.1.1 The Master Layout Plan is given in **Appendix A**. The Proposed Scheme will be developed by 4 phases, namely Phase 1A (P1A), Phase 1B (P1B), Remaining Phase A (RPA) and Remaining Phase B (RPB). For ease of reference, a table showing the key development parameters of the Proposed Scheme is shown in the table below.

Table 2.1 – Site Area of the Proposed Development Phases

Development Phase	Site Area (ha)
P1A	1.36
P1B	1.01
PRA	0.79
PRB	1.67
Total	4.83

2.1.2 The proposed development is planned to be completed by year 2032.

3 Outline of Existing and Planned Drainage System

3.1 Review of Existing Drainage System

3.1.1 The existing drainage system in the vicinity of the proposed site location for the development options has been reproduced with reference to the GeoInfo Map[1] and presented in **Appendix B1**.

3.1.2 Kau Wa Keng areas locate to the north of Lai King Hill Road, which include the study area of this project, are currently rural residential and cultivated areas with small village houses and squatters, the surface runoff from the study area and the catchments is collected by two unregistered engineered channels in the east and west of the site, and natural streams in the central part of the site.

3.1.3 The surface runoff is then discharged to a 2-cell 2750×4300 drainage box culvert across Lai Yan Court directly from the west (discharge point 1, DP1), and a 2-cell 2750×2750 drainage box culvert along Lai King Hill Road via two 750mm drain (discharge point 2, DP2) and a 1800mm drain (discharge point 3, DP3) from the centre and the east. The two box culverts join at a 4-cell 3300×3300 drainage box culvert that discharges to Victoria Harbour near Kwai Chung Container Terminal 7.

3.1.4 Kau Wa Keng area is considered prone to flooding and several flooding complaints had been made in recent years. In addition, according to the information provided by DSD, the two unregistered engineered channels do no fulfill the 10-year flood protection standard under the hydraulic assessment corresponding DMP review study. Therefore, no drainage diversion proposed under this assessment will involve discharging additional stormwater into existing unregistered engineered channels.

3.2 Review of Planned Drainage System

3.2.1 According to information provided by DSD, there is a drainage improvement works (DIW) under Drainage Master Plan Review (DMP Review) study for Tuen Mun, Tsuen Wan and Kwai Tsing. The drainage performance should be greatly improved after the proposed DIW. However, the said DIW is preliminary and further study is in progress and yet to be confirmed. It is assumed that the DIW is not

[1] GeoInfo Map is a geospatial information service provided by the Hong Kong Special Administrative Region (HKSAR) Government to the general public.

implemented until the completion of the proposed development in this DIA, for conservative purpose.

4 Assessment Methodology for Drainage System

4.1 Technical Guidelines

4.1.1 This DIA has been carried out in accordance with DSD's Stormwater Drainage Manual – Planning, Design and Management (5th Edition, January 2018) (SDM 2018), as well as SDM Corrigendum No. 1/2022 (SDM 2022) and SDM Corrigendum No. 1/2024 (SDM 2024).

4.2 Methodology for Peak Flow Estimation

Flood Protection Standards

4.2.1 According to Section 3.1 of this report and section 6.6 of SDM 2018, the existing drainage systems that the proposed development will discharge to is urban drainage trunk systems. In accordance with Table 10 of DSD's SDM, 200 years return period of flood protection standard will be assessed under this DIA.

Surface Runoff Estimation

4.2.2 For the purpose of surface runoff calculation, runoff coefficients of 0.9 and 0.35 have been adopted for the exiting paved and unpaved areas respectively. For the proposed CDA development, runoff coefficients of 0.8 and 0.35 have been adopted for the paved area with green roof, road pervious pavement, and unpaved areas respectively.

4.2.3 For existing catchments, the paved and unpaved areas are determined by digital topographic map and aerial photos. For the proposed CDA development, it is assumed that 20% of the area is unpaved or covered pervious pavement.

4.2.4 Peak surface runoff is calculated using the Rational Method in accordance with Section 7.5.2 of SDM 2018 and assuming uniform intensity rainfall.

$$Q = 0.278CiA$$

where Q – surface runoff (m^3/s)

i – rainfall intensity (mm/hr)

A – catchment area (km^2)

C – runoff coefficient (-)

Rainfall Intensity

4.2.5 According to Section 4.3.3 of the SDM 2024, the rainfall intensity i can be estimated using Intensity-Duration-Frequency (IDF) relation that can be expressed by the following equation:

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

where a = 508.8, b = 3.46 and c = 0.322 according to Table 3a of the SDM 2024;

t_d in min should make reference to time of concentration.

Time of Concentration

4.2.6 The time of concentration (tc) for various types of catchments shall be calculated and specified for different scenarios in the drainage design.

$$t_c = t_o + t_f$$

4.2.7 Urban Catchment – The time of concentration (t_c) used for the duration of the design storm for urbanised catchment areas has been determined by inlet time (t_o) plus the time of flow (t_f) in the drain.

4.2.8 Natural Catchment – Time of entry or time of flow in the rural hinterland has been calculated using the Brandsby-William's Equation (minimum of 3 minutes assumed).

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

Where: t_o - time of concentration (min)

L - distance (on plan) measured on the line of natural flow between the summit and the point under consideration (m)

A - catchment area (m^2)

H - average catchment slope (m/100m), measured along the line of natural flow, from the summit of catchment to the point under consideration

Climate Change

4.2.9 According to Table 28 of the SDM 2022, an additional 11.1% rainfall intensity will be considered in the proposed development under this study to incorporated climate change effects in mid-century. Climate change factor of mid-century is determined after considering the project timeline and the project scale. The proposed development is planned to be completed by year 2032.

4.2.10 According to Appendix 2 of the SDM 2022, 0% of rainfall increase will be considered because the design allowance for rainfall increase has been included in Table 28 of SDM2022.

4.2.11 It is recommended to allow provision for progressive upgrading for meeting end 21st century requirements.

4.3 Methodology for Drainage Capacity Estimation

Pipe Roughness

4.3.1 Manning Equation is used to estimate the hydraulic capacity. In this hydraulic assessment, the Manning coefficients (n) adopted representing the roughness of the inner surface are as follows:

- $n = 0.016\ s/m^{1/3}$ (for existing drainage box culverts, assume fair concrete-line channels)

5 Drainage Flow Estimation, Potential Drainage Impacts and Mitigation Measures

5.1 Proposed Assessment Scenarios and Corresponding Drainage Network

5.1.1 Three assessment scenarios namely Scenario 1, Scenario 2 and Scenario 3 are considered in this assessment. Scenario 1 is the baseline scenario while Scenarios 2 and 3 are the scenarios with CDA development under phase 1 development (i.e. Phase 1A and Phase 1B as shown in Appendix A) and full development, respectively. The drainage catchments that partially overlap with the study area are shown in **Appendices C and D** for the baseline and proposed scenarios. The upstream catchments will not be affected by the proposed CDA development and thus not included in this assessment.

5.1.2 In Scenario 1 (baseline scenario, refer to **Appendix C**), catchment 1 to 4 are discharged to DP1, DP2, DP3 and DP3, respectively.

5.1.3 In Scenario 2 (phase 1 development scenario, refer to **Appendix D1**), the area within the boundary fence of the phase 1 development of the CDA will has its own private drainage system which will connect to the existing drainage box culvert at DP2 via new connection pipes. The unpaved area of the proposed development is assumed to be 20% of the total area. The remaining part of the original catchment 1, i.e., catchment 1A, will still be discharged to DP1. The remaining part of the original catchment 3 and 4, i.e., catchment 3A and 4A, will still be discharged to DP3. The remaining part of the original catchment 2 will be further divided to catchment 2A and 2B. Stormwater of catchment 2A and 2B will be discharged to DP2 through the drainage system within the phase 1 development by providing drainage diversions from the catchments to catchpits at the boundary of phase 1 development (details to be provided in the detailed design stage). The drainage diversion will be on government land although it is outside the phase 1 development. The existing engineered channels and the proposed drainage diversion will be outside the fence wall of the phase 1 development and the maintenance authority of the government will have free access from outside of private estates to carry out maintenance works.

5.1.4 In Scenario 3 (fully developed CDA scenario, refer to **Appendix D2**), the area within the boundary fence of the CDA will has its own private drainage system which will connect to the existing drainage box culvert at DP2 via new connection pipes. Part of catchments 1A, 3A, 4A and the entire catchment 2B in Scenario 2 will be included in the CDA. The unpaved area of the proposed development is assumed to be 20% of the total area. The remaining part of the original catchment 1, i.e., catchment 1A1, will become smaller than catchment 1A in Scenario 2, and still be discharged to DP1. The original engineered channel in the west of the study area will be demolished and replaced by a drainage box culvert along the side boundary with same capacity as its downstream 2-cell 2750×4300 box culvert. The site area and drainage arrangement for catchment 2A Scenario 2 will remain the same. The remaining part of the original catchments 3 and 4, i.e., catchment 3A1 and 4A1, will become smaller than catchment 3A and 4A in Scenario 2, and still be discharged to DP3. The original engineered channel in the east of the study area will be demolished and replaced by a drainage box culvert boundary with same capacity as its downstream 2-cell 2750×2750 box culvert along the side boundary. The re-provided drainage box culverts will be outside the fence wall of the CDA and the maintenance authority of the government will have free access from outside of private estates to carry out maintenance works.

5.1.5 The concept of sustainable development and blue green infrastructure will be incorporated as much as possible to further reduce the peak flow of surface runoff from the site. Details will be available in the detailed design stage.

5.2 Estimation of Stormwater Flow under Different Assessment Scenarios

5.2.1 Calculation of the peak stormwater flow at DP1-3 from catchments 1-4 under different scenarios is given in **Appendix E**. **Table 5.1 to 5.3** below gives the key information required for impact assessment. Climate change effects has been incorporated in the flow estimate for the proposed development.

Table 5.2 – Summary of Peak Storm Water Flow in Scenario 1

Catchment	Total Area (ha)	Peak Flow, Q (m^3/s)	Flow to DP1	Flow to DP2	Flow to DP3
1	3.94	1.31	1.31	0.00	0.00
2	3.29	1.27	0.00	1.27	0.00
3	3.65	1.27	0.00	0.00	1.27
4	3.13	1.59	0.00	0.00	1.59
	Total	**5.44**	**1.31**	**1.27**	**2.86**

Table 5.2 – Summary of Peak Storm Water Flow in Scenario 2

Catchment	Total Area (ha)	Peak Flow, Q (m^3/s)	Flow to DP1	Flow to DP2	Flow to DP3
1A	3.68	1.22	1.22	0.00	0.00
2A	0.99	0.41	0.00	0.41	0.00
2B	0.45	0.23	0.00	0.23	0.00
2C	0.10	0.07	0.07	0.00	0.00
3A	3.57	1.22	0.00	0.00	1.22
4A	2.85	1.47	0.00	0.00	1.47
CDA - P1	2.37	1.51	0.00	1.51	0.00
	Total	**6.14**	**1.29**	**2.16**	**2.69**

Table 5.3 – Summary of Peak Storm Water Flow in Scenario 3

Catchment	Total Area (ha)	Peak Flow, Q (m^3/s)	Flow to DP1	Flow to DP2	Flow to DP3
1A1	2.83	0.91	0.91	0.00	0.00
2A	0.99	0.41	0.41	0.00	0.00
3A1	2.58	0.71	0.00	0.00	0.71
4A1	2.77	1.43	0.00	0.00	1.43
CDA	4.83	3.06	0.00	3.06	0.00
	Total	**6.52**	**1.32**	**3.06**	**2.14**

5.2.2 In case of 200 year return period, the peak flow discharges to existing 2-cell 2750×4300 drainage box culvert (i.e. via DP1) will change by -0.02m^3/s and 0.01m^3/s in Scenario 2 and 3, respectively. The peak flow discharges to existing 2-cell 2750×2750 drainage box culvert (i.e. via DP2 and 3) will increase by 0.71m^3/s and 1.07m^3/s in Scenario 2 and 3, respectively. The total peak flow discharges downstream box culverts will increase by 0.69m^3/s and 1.08m^3/s in Scenario 2 and 3. In Scenario 2, the surface runoff discharged to the 2 existing unregistered channels in the east and west decrease and the drainage performance will be improved. In Scenario 3, the proposed box culverts will be with the same capacities as their downstream existing box culverts and the performance of the drainage system in the corresponding villages will be further improved. These are the worst-case scenario without implementing the drainage improvement works in the upstream. As discussed in Para. 3.2.1, the drainage performance will be greatly improvement with surface runoff from further upstream being diverted.

5.3 Potential Drainage Impacts and Mitigation Measures

Impact Assessment for Downstream Drainage System

5.3.1 Impact assessments have been done for the existing 2-cell 2750×4300 drainage box culvert across Lai Yan Court and the existing 2-cell 2750×2750 drainage box culvert along Lai King Hill Road. Detailed calculation has been included in **Appendix F**.

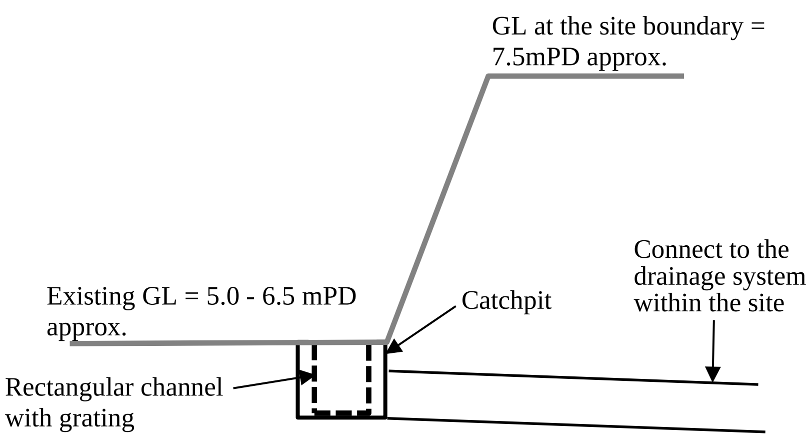
5.3.2 For the 2-cell 2750×4300 drainage box culvert, the critical scenario is Scenario 3, in which the peak will increase by 0.01m^3/s in the case of 200 year return period. The additional peak stormwater flow will occupy only 0.01% of the hydraulic capacity of the box culvert. Therefore, no adverse impact is anticipated.

5.3.3 For the 2-cell 2750×2750 drainage box culvert, the critical scenario is Scenario 3, in which the peak will increase by 1.07m^3/s in the case of 200 year return period. The additional peak stormwater flow will occupy only 2.67% of the hydraulic capacity of the box culvert. Therefore, no adverse impact is anticipated.

Provision of Additional Drainage Channel in Scenario 2

5.3.4 In Scenario 2, rectangular channels with grating will be provided at the boundary of catchments 2A and 2B to convey surface runoff from the catchments to the drainage system within the site. The sizes of the channels are 500×850 and 500×600 or equivalent, for catchments 2A and 2B respectively. Detailed calculation has been included in **Appendix F**. A typical section of the proposed rectangular channels is shown in **Figure 5.1**.

Figure 5.1 – Typical Section of the Proposed Rectangular Channel



Efforts to Enhance the Performance of Local Drainage System

5.3.5 It is understood that the existing western and eastern channels do not have sufficient capacity to convey the stormwater from the nearby areas and further upstream areas to the downstream box culverts. According to the hydraulic models under the latest DMP Review Study, overflow will occur during 10-200 year events under the existing scenario. Large extent in the south part of the applicant's private site (current ground level is 3-4mPD approximately) is subject to flooding during rainfall and high tide events. It is understood that the flooding issues will be resolved after completion of the DIW mentioned in Section 3.2.1. The proposed development will resolve the flooding issues at the site of the proposed development. However, if there is a programme mismatch between the proposed DIW and the proposed development, the severity of flooding in nearby area could increase due to losing benefits from existing site as a flood plain.

5.3.6 In Scenario 3 (**Appendix D2** refers), drainage box culverts with capacity equivalent to the downstream box culverts will be provided along the site boundary to reduce the possibility of overflow, and all the areas surrounding the proposed development are with higher ground levels compared to the proposed development except for catchment 2A. Since a rectangular channel collecting the surface runoff and connecting to the drainage system within the site will be provided to catchment 2A, no excessive flood risk in catchment 2A is expected. Therefore, in Scenario 3, no excessive flood risk in nearby areas of the site is expected in associated with the proposed development.

5.3.7 In Scenario 2 (**Appendix D1** refers), since that most of the areas surrounding the proposed development are with lower ground levels compared to the proposed development, there is a possibility that the severity of the flooding in the nearby areas increases due to losing benefits from existing site as a flood plain, in the period between the commencement of the proposed development and the completion of the proposed DIW, if there is a programme mismatch. The applicant would like to take the development opportunity to bring shared benefits to the local community by providing expedient measures to carter for the potential flooding issues.

5.3.8 It is proposed to provide flood walls along the existing bank lines of the western and eastern channel to reduce the flood risks in the nearby areas in Scenario 2. The flood wall will consist with a concrete parapet in the lower part and a metal railing in the upper part, with total height of 1.1m. The estimated height of the proposed concrete parapet for the western channel will range from 400mm to 700mm, and the estimated height of the proposed concrete parapet for the eastern channel will range from 500mm to 900mm, by making reference to both simulation results of 200A and B cases under the hydraulic model for existing scenario with updated design parameters according to SDM 2022 and SDM 2024. Flap valves will also be provided to the drainage outfalls of pipes/channels from the local low-laying areas to the channels to avoid back water effects. Since that the potential overflow is mainly due to the large amount of surface runoff in the upstream catchments, there will be a time difference between the occurrence of the peak surface runoff in the local low-laying areas and the occurrence of maximum water level in the nearby channel sections and providing the flood wall could reducing the flood risks without compromising the efficiency of local stormwater discharge. Details of the estimation for height of concrete parapets and time of concentration have been included in **Appendix G**. The updated hydraulic model is included in **Appendix H.** Moreover, different adaptation and resilience measures can be applied on site by the applicant, to block ingress/egress along the river during potential flooding events without affecting the functions of existing houses/footpaths in dry days. Examples of these measures are provided in **Appendix I**. Detailed assessment and design using hydraulic modelling will be provided in the detail design stage.

6 Conclusion

6.1.1 A DIA study has been undertaken for the proposed development.

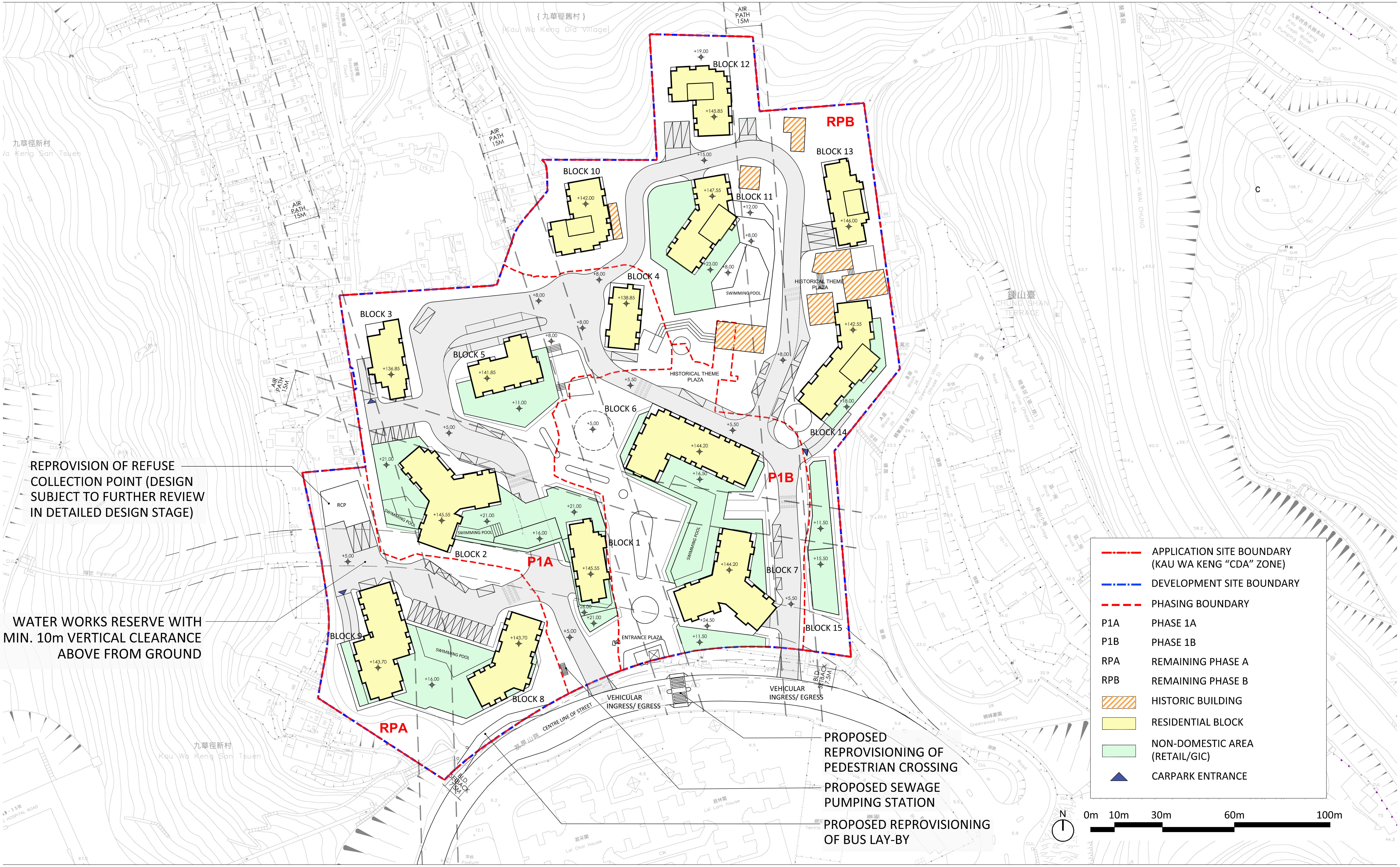
6.1.2 In case of 200 year return period, the total additional peak stormwater flow discharges to downstream box culverts is $1.07m^3/s$ when the CDA is fully developed. No adverse drainage impact from the proposed CDA to the existing drainage system is anticipated. Expedient measures are proposed to enhance the performance of the local drainage system.

Appendix A

Master Layout Plan

MASTER LAYOUT PLAN (DOMESTIC PR:6 NON-DOMESTIC PR:0.5)

1:500@A0 1:1000@A2



PROPOSED COMPREHENSIVE DEVELOPMENT INCLUDING FLATS, RETAIL AND COMMUNITY FACILITIES AND MINOR RELAXATION OF PLOT RATIO AND BUILDING HEIGHT RESTRICTION IN "COMPREHENSIVE DEVELOPMENT AREA" ZONE
AT VARIOUS LOTS IN S.D.4 AND ADJOINING GOVERNMENT LAND, KAU WA KENG, KWAI CHUNG
21 FEBRUARY 2025

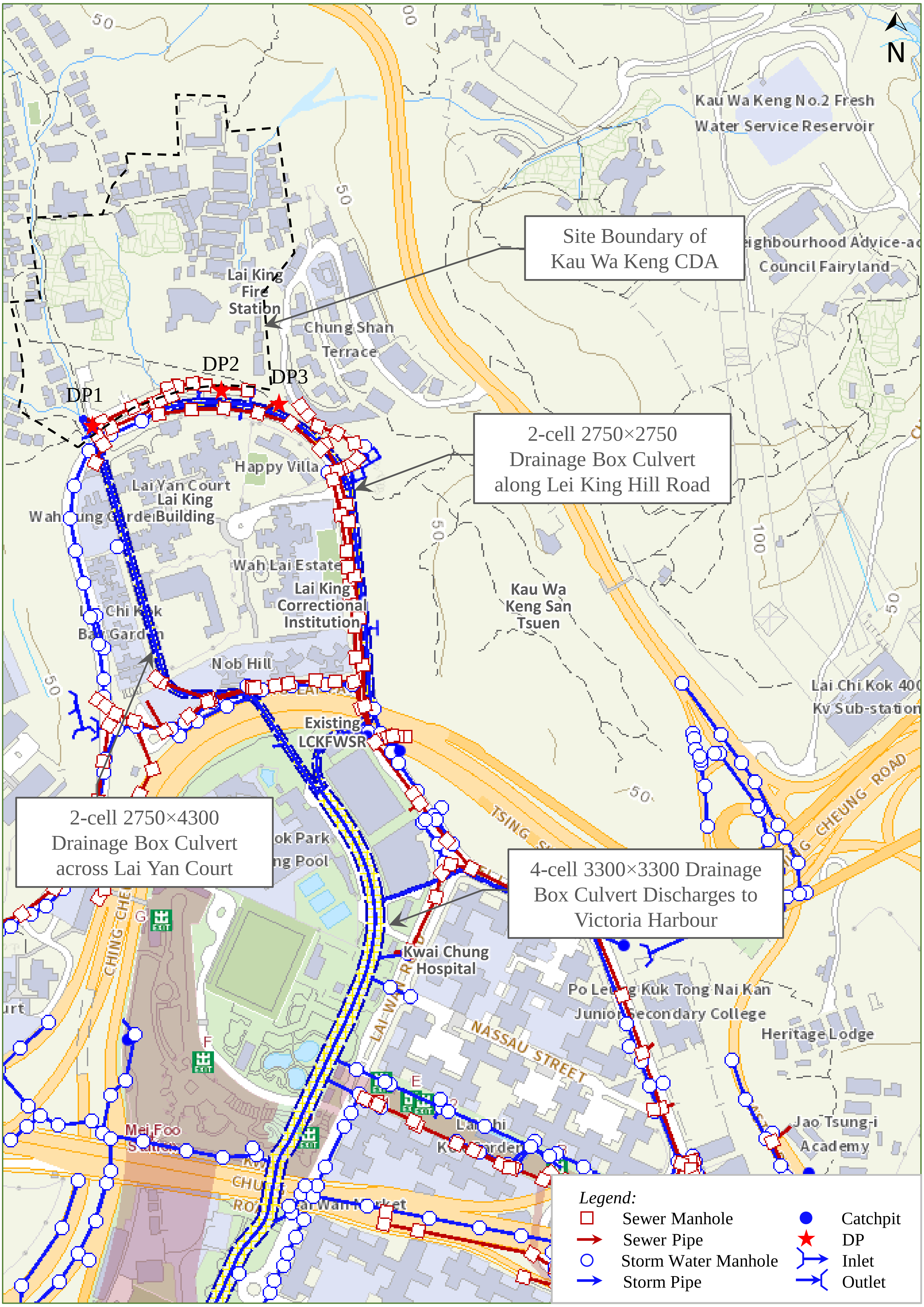
DRAWING NO.: MLP-SK01-R9

LU TANG LAI ARCHITECTS LTD.
呂鄧黎建築師有限公司

Appendix B

Existing Drainage Systems

Appendix B – Layout of Existing Drainage & Sewerage Systems

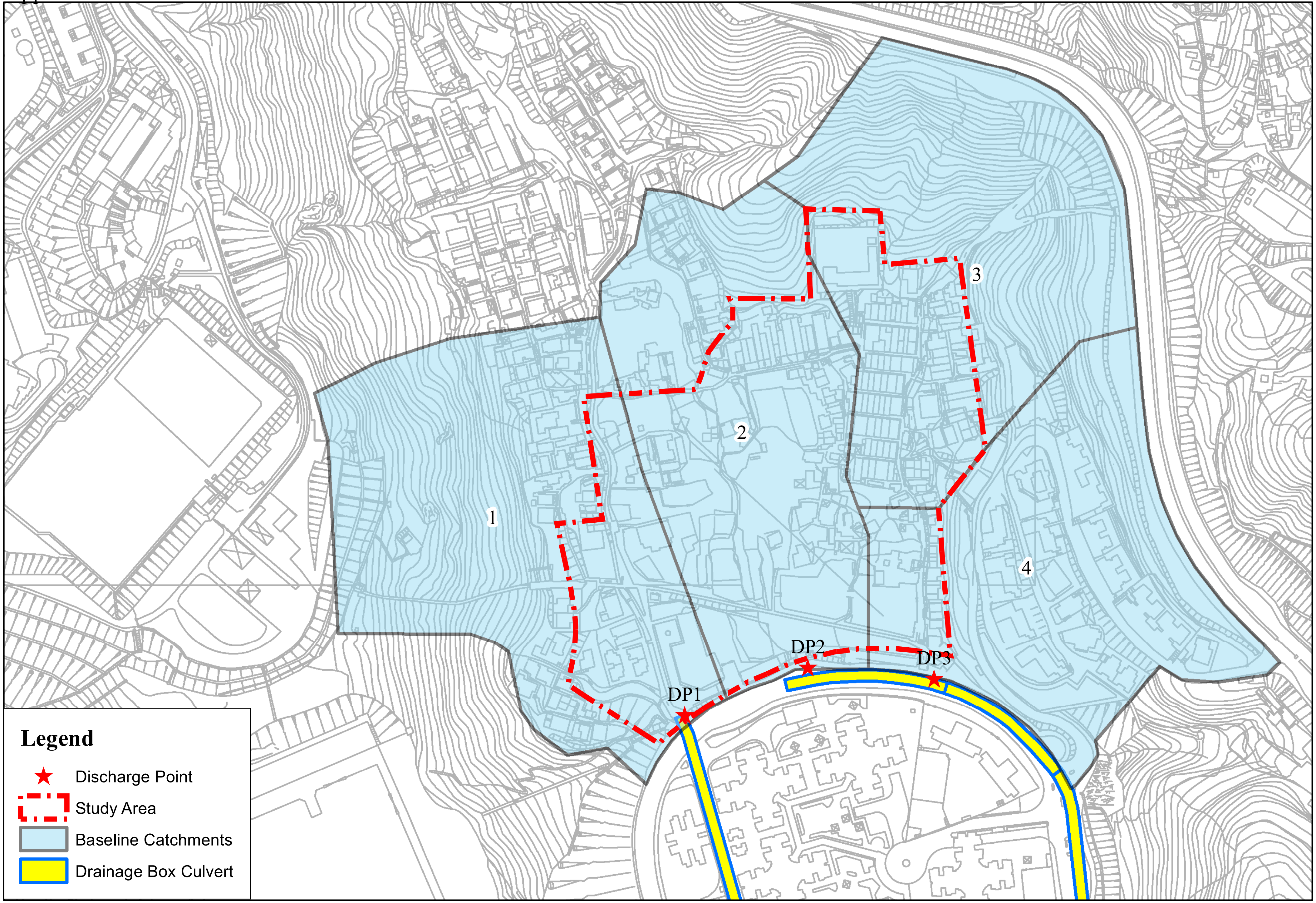


Note: the site boundaries are indicative only, and would be updated if more information is available

Appendix C

Catchments under the Baseline Scenario

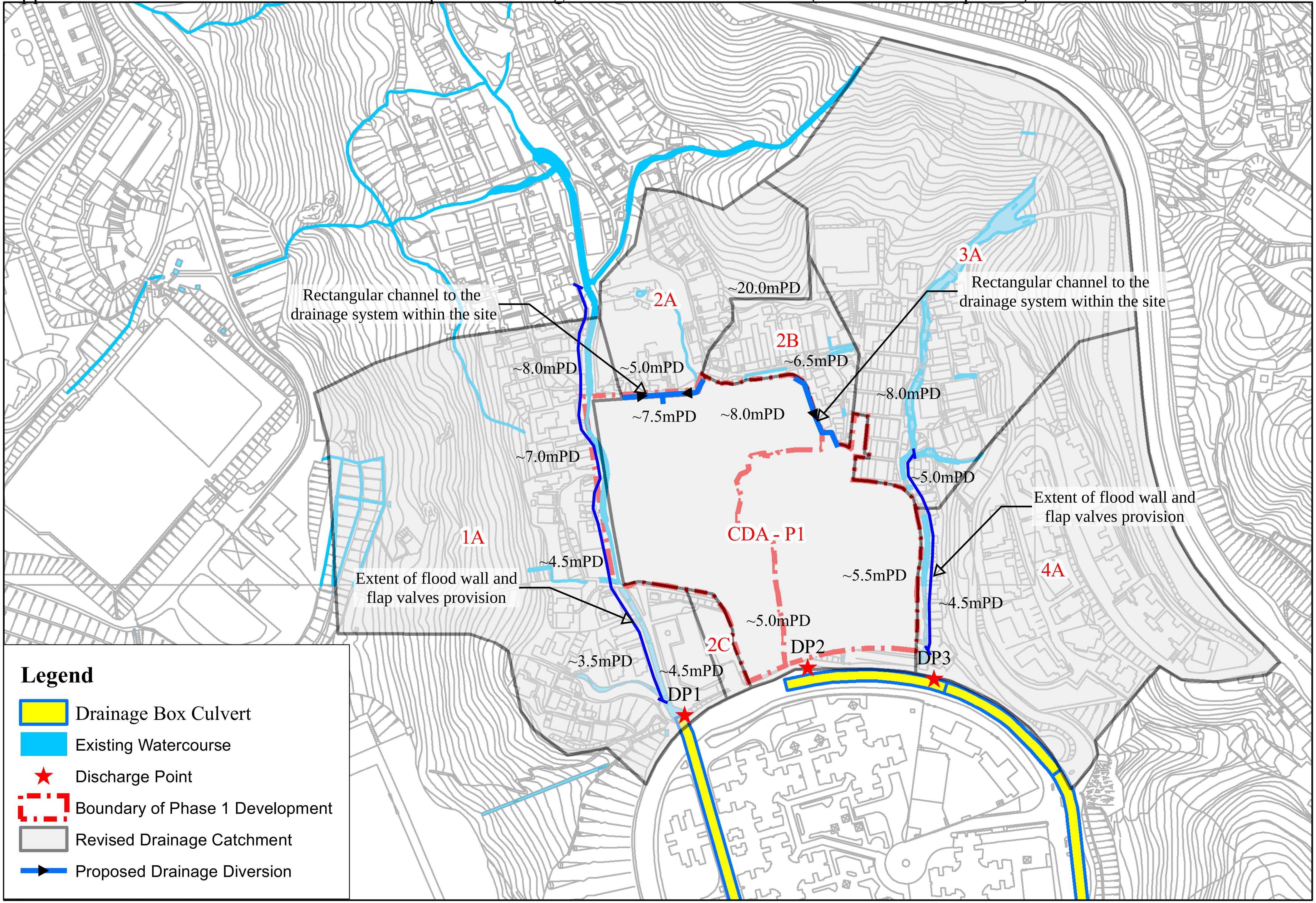
Appendix C - Relevant Catchments in the Baseline Scenario



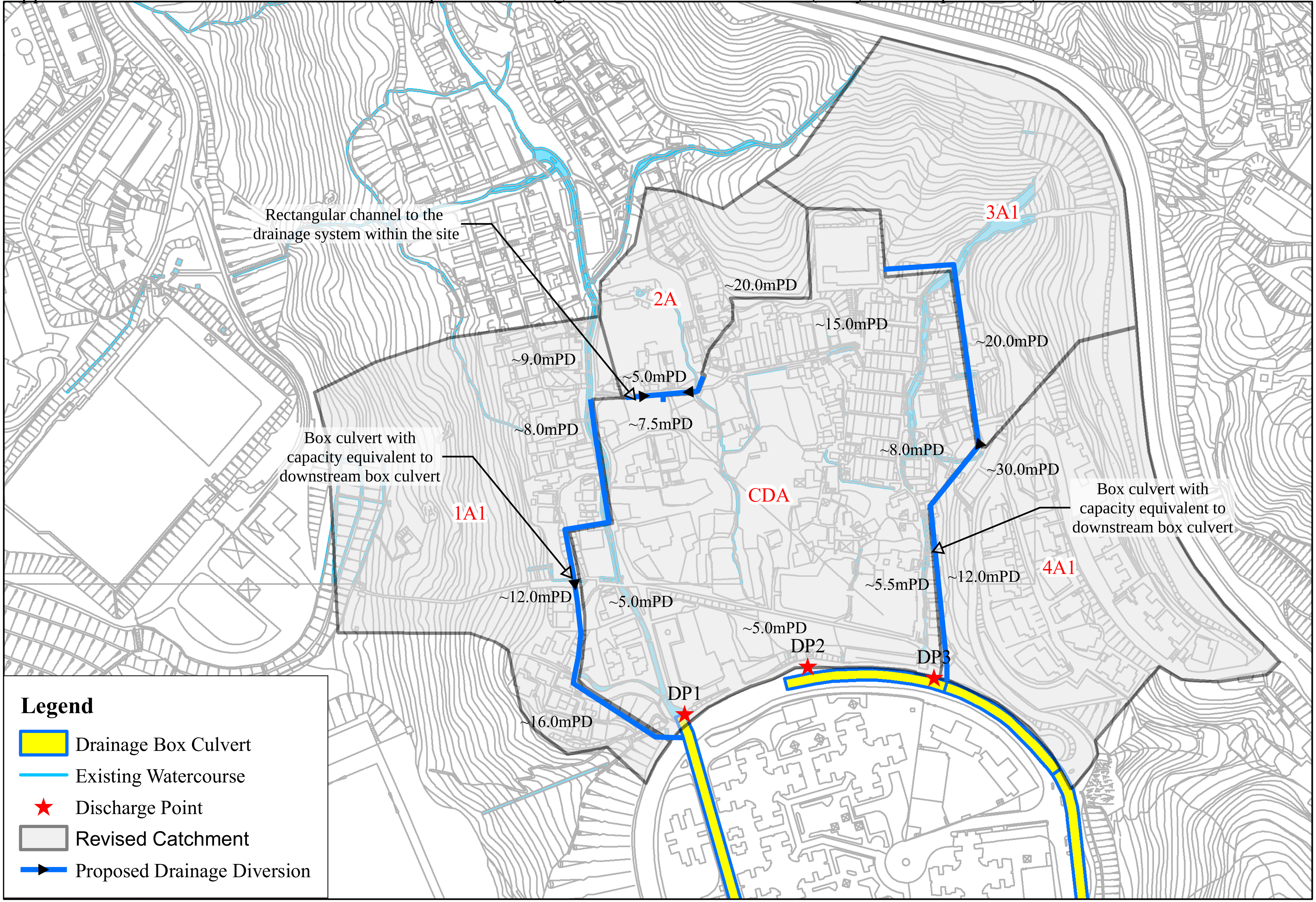
Appendix D

Catchments and Proposed Drainage Diversion under the Proposed Scenario

Appendix D1 - Relevant Catchments and Proposed Drainage Diversion in Scenario 2 (Phase 1 Development)



Appendix D2 - Relevant Catchments and Proposed Drainage Diversion in Scenario 3 (Fully Developed CDA)



Appendix E

Estimation of Additional Stormwater Flows

Appendix E - Srormwater Flow Estimation

Peak Runoff ,Q = 0.278CiA

C = 0.9 for existing paved area.

C = 0.8 for paved area in the development with green roof, road pervious pavement.

C = 0.35 for all unpaved area.

Rainfall Intensity, $i = a / (T_c + b)^c$

DSD SDM 2024 Table 3a

Return Period (yr)	200	*a*	508.8	*b*	3.46	*c*	0.322

Part 1 - Scenario 1 (Baseline)

Catchment	Total Area (ha)	Paved Area (ha)	Unpaved Area (ha)	Time of Conc., t_c (min)	Rainfall Intensity, i (mm/hr)	Peak Flow, Q (m^3/s)	Peak Flow to DP1	Peak Flow to DP2	Peak Flow to DP3
1	3.94	1.14	2.80	7.57	198.63	1.31	1.31	0.00	0.00
2	3.29	1.55	1.75	8.56	192.05	1.27	0.00	1.27	0.00
3	3.65	1.28	2.37	8.08	195.13	1.27	0.00	0.00	1.27
4	3.13	1.91	1.22	4.01	231.43	1.59	0.00	0.00	1.59
					Total	**5.44**	**1.31**	**1.27**	**2.86**

Part 2 - Scenario 2 (Phase 1 Development)

Catchment	Total Area (ha)	Paved Area (ha)	Unpaved Area (ha)	Time of Conc., t_c (min)	Rainfall Intensity, i (mm/hr)	Peak Flow, Q (m^3/s)	Peak Flow to DP1	Peak Flow to DP2	Peak Flow to DP3
1A	3.68	1.07	2.61	7.62	198.26	1.22	1.22	0.00	0.00
2A	0.99	0.47	0.53	6.27	208.56	0.41	0.00	0.41	0.00
2B	0.45	0.34	0.11	6.17	209.39	0.23	0.00	0.23	0.00
2C	0.10	0.09	0.00	1.65	269.28	0.07	0.07	0.00	0.00
3A	3.57	1.18	2.39	8.10	195.03	1.22	0.00	0.00	1.22
4A	2.85	1.79	1.05	4.04	230.97	1.47	0.00	0.00	1.47
CDA - P1*	2.37	1.90	0.47	2.07	289.91	1.51	0.00	1.51	0.00
					Total	**6.14**	**1.29**	**2.16**	**2.69**

* An additional 11.1% rainfall intensity is considered to include climate change effects.

Peak flow to the unregistered engineered channels in the west changes by **-0.02** m^3/s

Peak flow to the unregistered engineered channels in the east changes by **-0.17** m^3/s

Peak flow to the 2-cell 2750*4300 box culvert increases by **-0.02** m^3/s

Peak flow to the 2-cell 2750*2750 box culvert increases by **0.71** m^3/s in Scenario 2

Part 3 - Scenario 3 (Fully Developed CDA)

Catchment	Total Area (ha)	Paved Area (ha)	Unpaved Area (ha)	Time of Conc., t_c (min)	Rainfall Intensity, i (mm/hr)	Peak Flow, Q (m^3/s)	Peak Flow to DP1	Peak Flow to DP2	Peak Flow to DP3
1A1	2.83	0.65	2.18	6.58	206.01	0.91	0.91	0.00	0.00
2A	0.99	0.47	0.53	6.27	208.56	0.41	0.41	0.00	0.00
3A1	2.58	0.39	2.19	8.32	193.57	0.71	0.00	0.00	0.71
4A1	2.77	1.75	1.03	4.06	230.83	1.43	0.00	0.00	1.43
CDA*	4.83	3.87	0.97	2.22	284.88	3.06	0.00	3.06	0.00
					Total	**6.52**	**1.32**	**3.06**	**2.14**

* An additional 10.4% rainfall intensity is considered to include climate change effects.

Peak flow to the 2-cell 2750*4300 box culvert increases by **0.01** m^3/s

Peak flow to the 2-cell 2750*2750 box culvert increases by **1.07** m^3/s in Scenario 3

<u>Critical Scenario</u>

Peak flow to the 2-cell 2750*4300 box culvert increases by **0.01** m^3/s in Scenario 3

Peak flow to the 2-cell 2750*2750 box culvert increases by **1.07** m^3/s in Scenario 3

Appendix F

Calculation for Impact Assessment

Appendix F - Calculation for Potential Drianage Impacts

Manning Equation is used to estimate the performace of the existing/planned sewers

$$\bar{V} = \frac{R^{1/6}}{n}\sqrt{RS_f}$$

where *R (hydraulic radius) = A/P;*
n (Manning coefficient) = 0.015 for fair vitrified sewers;
S_f (friction gradient) = sewer gradient for normal flows.

Impact Assessment for Sewers to the Downstream Box Culverts

Box Culvert	Width (m)	Height (m)	Length (m)	Box Culvert Gradient	Hydaulic Radius R (m)	Velocity at Full Bore (m/s)	Full Bore Capacity for 2 Cells (m^3/s)	Additional Peak Flow in Critical Scenario (m^3/s)	% Full Bore Capacity	Remarks
2750*4300*2	2.75	4.3	29.22	0.002	1.0418502	2.873	67.94	0.01	0.01%	No adverse impact
2750*2750*2	2.75	2.75	31.62	0.002	0.9166667	2.638	39.89	1.07	2.67%	No adverse impact

Povision of Rectangular Dainage Channels Between the Site and Catchment 2A and 2B in Scenario 2

Location	Width (m)	Height (m)	Effective Height (m)	Hydaulic Radius R (m)	Design Gradient	Velocity at Full Bore (m/s)	Full Bore Capacity (m^3/s)	Peak Flow from the Catchment (m^3/s)	% Full Bore Capacity
Catchment 2A	0.5	0.85	0.65	0.180556	0.005	1.412	0.46	0.41	89.59%
Catchment 2B	0.5	0.6	0.4	0.153846	0.005	1.269	0.25	0.23	92.13%

Appendix G

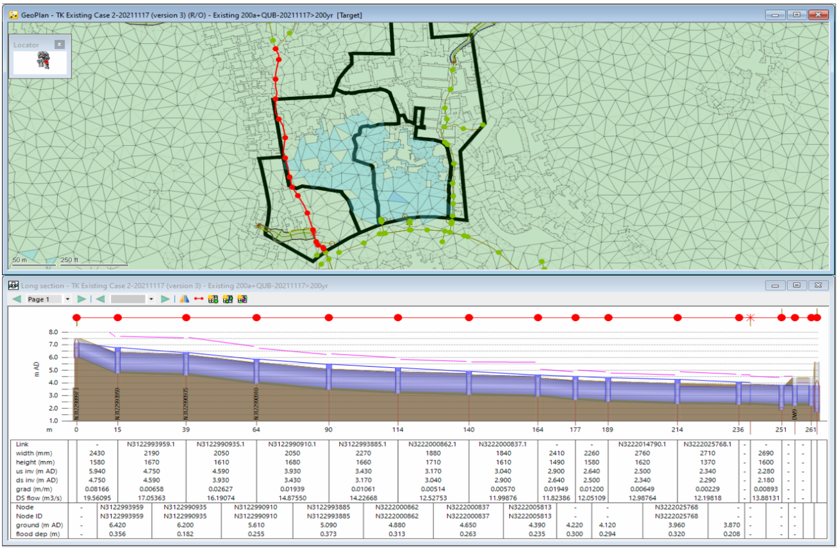
Estimates for the Proposed Parapet Walls in Scenario 2

Appendix G - Enhancement of Existing Local Drainage System

Parameters Used in the Hydraulic Modelling

1.Model zones refer to the original model 1. HKO Headquarters; 2. Tai Mo Shan
2.Storm constants for HKO Headquarters refer to SDM 2024, storm constants for Tai Mo Shan refer to SDM2018
3.Tidal data refer to SDM 2022 @ North Point/Quarry Bay, with 10-year = 3.2mPD and 200-year = 4.19mPD.

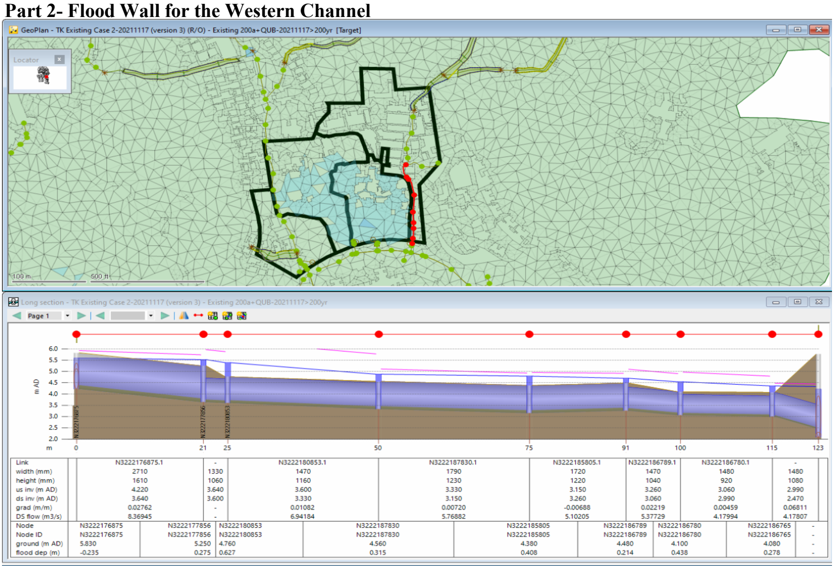
Part 1 - Flood Wall for the Western Channel



Node ID in the Model (from DS to US)	Max Flood Depth for 200A (m)	Max Flood Depth for 200B (m)	Max Flood Depth (mm)	Height of Concrete Parapet* (mm)	Height of Metal Railing (mm)	Total Height (mm)
N3222042725	-0.402	0.275	275	500	600	1100
DW9	-0.390	0.267	267	500	600	1100
N3222032743	0.386	0.860	860	1100	0	1100
N3222031747	0.484	0.886	886	1100	0	1100
N3222025768	0.555	0.865	865	1100	0	1100
N3222014790	0.530	0.791	791	1000	100	1100
N3222008800	0.512	0.727	727	1000	100	1100
N3222005813	0.411	0.579	579	900	200	1100
N3222000837	0.371	0.447	447	700	400	1100
N3222000862	0.375	0.393	393	600	500	1100
N3122993885	0.399	0.394	399	600	500	1100
N3122990910	0.296	0.239	296	500	600	1100
N3122990935	0.225	0.085	225	500	600	1100
N3122993959	0.412	0.173	412	700	400	1100
N3122989973	-0.327	-0.570	-327	0	1100	1100

* Freeborad of 200 to 300mm is considered.

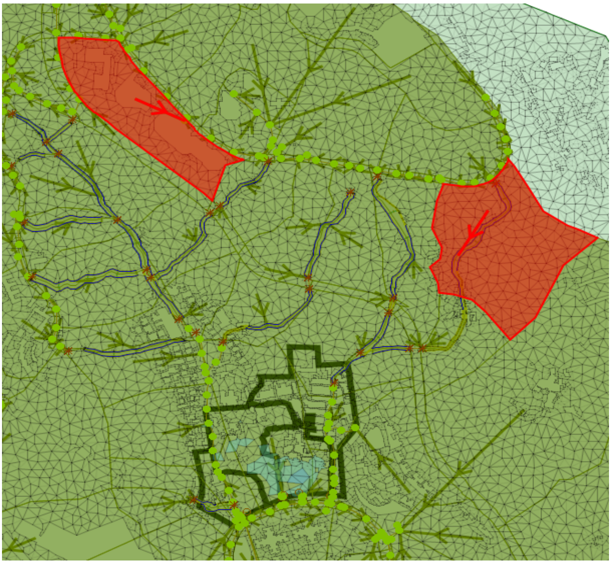
Part 2- Flood Wall for the Western Channel



Node ID in the Model (from DS to US)	Max Flood Depth for 200A (m)	Max Flood Depth for 200B (m)	Max Flood Depth (mm)	Height of Concrete Parapet* (mm)	Height of Metal Railing (mm)	Total Height (mm)
SDH4000983	-1.257	-0.904	-904	0	1100	1100
N3222186765	0.437	0.629	629	900	200	1100
N3222186780	0.575	0.672	672	900	200	1100
N3222186789	0.368	0.435	435	700	400	1100
N3222185805	0.559	0.606	606	900	200	1100
N3222187830	0.451	0.472	472	700	400	1100
N3222180853	0.724	0.625	724	1000	100	1100
N3222177856	0.385	0.235	385	600	500	1100
N3222176875	-0.117	-0.297	-117	0	1100	1100

* Freeborad of 200 to 300mm is consodered.

Part 3 - Time of Concentration for Upstream Catchments
(Examples using Upstream Catchmentz with Max. Areas)



Catment No.	Discharge to	Area (m^2)	L (m)	ΔH (m)	H (m in 100m)	to	tf	tc
TK_461	Western Channel	28,815	275.00	30.00	10.91	8.83	10.17	19.00
TK_4378-1	Eastern Channel	42,593	390.00	125.00	32.05	9.71	5.27	14.98

Typical difference in tc for the western channel# = 11.38 min

Typical difference in tc for the eastern channel^ = 10.93 min

Comparsion between catchment Nos. TK_461 and 1A

^ Comparsion between catchment Nos. TK_4378-1 and 4A

Appendix H

Updated Hydraulic Models (Digital Only)

Appendix I

Examples of Measures for Ingress/Egress

Appendix I

Different adaptation and resilience measures can be applied on site by the applicant, to block ingress/egress along the river during potential flooding events without affecting the functions of existing houses/footpaths in dry days. Examples of these adaptation and resilience measures are shown as follows for reference. Detail design will be provided in later stages.

1. Flap valves/ duckbill check valve to prevent backflow

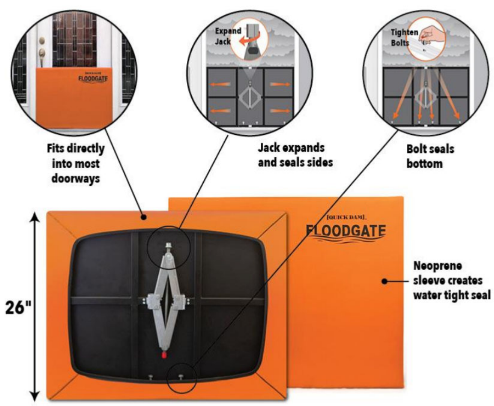

2. Demountable flood barriers at all types of ingress / egress

3. Watertight window to replace existing window

4. Flood gate at larger ingress / egress

5. Temporary deployable flood walls or barriers surrounding premises

6. Temporary doorway barrier at doors



7. Small temporary pump pits can be provided at local low-lying area