APPENDIX 7

SEWERAGE AND DRAINAGE IMPACT ASSESSMENT

SECTION 16 PLANNING APPLICATION

PROPOSED MINOR RELAXATION OF BUILDING HEIGHT RESTRICTION FOR PERMITTED SOCIAL WELFARE FACILITY (RESIDENTIAL CARE HOME FOR THE ELDERLY) AND PROPOSED HOUSE USE WITH CONSERVATION PROPOSAL AT LOT NOS. 1695 S.E SS.1 RP, 1695 S.F SS.1 AND 1695 S.H RP (PART) IN D.D. 120 AND ADJOINING GOVERNMENT LAND, TAI KEI LENG, YUEN LONG

SEWERAGE AND DRAINAGE IMPACT ASSESSMENT

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Ref No: RT21220-SDIA-02

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Project:	SECTION 16 PLANNING APPLICATION PROPOSED MINOR RELAXATION OF BUILDING HEIGHT RESTRICTION FOR PERMITTED SOCIAL WELFARE FACILITY (RESIDENTIAL CARE HOME FOR THE ELDERLY) AND PROPOSED HOUSE USE WITH CONSERVATION PROPOSAL AT LOT NOS. 1695 S.E SS.1 RP, 1695 S.F SS.1 AND 1695 S.H RP (PART) IN D.D. 120 AND ADJOINING GOVERNMENT LAND, TAI KEI LENG, YUEN LONG SEWERAGE AND DRAINAGE IMPACT ASSESSMENT
Report No.:	RT21220-SDIA-02

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Disclaimer

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1 INTRODUCTION

1.1 PROJECT BACKGROUND

BeeXergy Consulting Limited was appointed by the DeSPACE (International) Limited to conduct a sewerage and drainage impact assessment for the Section 16 planning application under the Town Planning Ordinance (Cap 131) of the proposed heritage conservation of Siu Lo Cum Elderly Care Home development due to the proposed minor relaxation of building height restriction from 3 storeys to 6 storeys.

1.2 PROJECT LOCATION

The site is located at Yuen Long to the west of the Tia Tong Road surrounded by various land uses such as industrial and institutional facilities. **Figure 1** shows the project site location and its surrounding area.

Figure 1 Site Location Plan of the Project Area

1.3 PROPOSED LAND USE

The site is proposed for use and the master layout plan is provided in **Appendix A**. The site area, of approximately 1,877m^2, is expected to comprise of a 6-storey Elderly Care Home with 241 beds (or within a range of 220 – 260) in total and a heritage conservation building Siu Lo located at the northwest of the proposed Site. The anticipated year of construction completion and occupation is 2025. The proposed site is currently zoned as "Government, Institution or Community (1)" ("G/IC(1)") under the Approved Yuen Long Outline Zoning Plan (OZP) No. S/YL/25.

2 SEWERAGE IMPACT ASSESSMENT

2.1 SCOPE OF WORKS

The objective of this Sewerage Impact Assessment (SIA) is to assess whether the capacity of the sewerage networking is sufficient to cope with the peak sewage flow arising from the proposed Development during its operation stage and to recommend appropriate mitigation measures to alleviate unacceptable sewerage impact, if any.

2.2 EXISTING AND PROPOSED SEWERAGE NETWORK

According to the drainage record plans, the sewage generated from the proposed Site is expected to be conveyed to the nearest public manhole FMH1009673 located east to the site via the proposed sewage pipeline consisting of a minimum size of 200mm diameter of an estimated length of 8.5m from the proposed terminal manhole S1. The Applicant will be responsible for the construction of all inter-connecting sewage pipework within the project site as well as any other proposed upgrade work in the vicinity. The sewage will be further conveyed to the downstream along Tai Tong Road, leading to Ping Shun Street Sewage Pumping Station and eventually discharged to the San Wai Sewage Treatment Works for treatment.

In consideration of the surrounding environment of the proposed Site, potential backflow problems are found underneath the junction of Tai Tong Road and Ma Tong Road in between section FMH1032444 to FMH1008899 (manhole involved namely FMH1032445, FMH1009570, FMH1009569, FMH1008905, FMH1008906, FMH1008900) due to either lack of manhole invert level details or higher invert level than the upstream. It is necessary to consider upgrade of the aforementioned section, therefore, new sewerage connection from manhole FMH1032444 to FMH1008899 by a new 375mm diameter sewer is recommended.

Appendix C shows the location and alignment of the proposed new manhole and sewerage connection. The following assessment will be based on the scenario of the proposed (mitigated) drainage plan.

2.3 ASSESSMENT CRITERIA, METHODOLOGY AND ASSUMPTIONS

In order to assess the acceptability of the sewerage impact arising from the operation of the proposed Development, the sewage generation has been estimated based on the assumptions shown in **Table 2.1**.

Table 2.1: Parameters for Estimating Wastewater Generation and Hydraulic Capacity

Parameter	Value	Justification
Population		
Elderly Home Guest	260 persons	According to the planning statement, there will be a total of 241 beds (or within a range of 220 – 260) in total, 300 persons is adopted for conservative approach.
Number of Employee in Elderly Home	30 persons	Information provided by the project applicant.
Unit Flow Factors		
Elderly Home Guest	0.27 m^3/day	'Modern Village / R2 Private Development' based on EPD's GESF Table T-1.
Employee in Elderly Home	0.28 m^3/day	'Commercial Employee + J11 Community, Social & Personal Services' based on EPD's GESF Table T-2.
Industrial Employee	2.08 m^3/day	'Industrial Employee + J1 Manufacturing in Yuen Long' based on EPD's GESF Table T-3.
Patrol Station Employee	0.18 m^3/day	'Commercial Employee + J3 Transport, Storage & Communication' based on EPD's GESF Table T-2.
Institutional Employee	0.28 m^3/day	'Commercial Employee + J11 Community, Social & Personal Services' based on EPD's GESF Table T-2.
School Student	0.04 m^3/day	'School Student' based on EPD's GESF Table T-2.
School Employee	0.28 m^3/day	'Commercial Employee + J11 Community, Social & Personal Services' based on EPD's GESF Table T-2.
Catchment Inflow Factor		
P_{CIF}	1.00	Catchment Inflow Factor = 1 for vicinity located in 'Yuen Long' based on EPD's GESF Table T-4.

Peaking Factor		
P	8	Peaking factor = 8 for contributing population <1,000 for sewer (including storm water allowance) based on EPD's GESF Table T-5.
Roughness Values (k_s)		
Existing Pipes	6mm	Conservative value of 'Old tuberculated water mains with Moderate degree of attack in a poor condition' was adopted based on the Sewerage Manual (Part 1) Table 5
Proposed New Pipes	0.6mm	Conservative value of 'Rusty wrought iron pipe in a normal condition' was adopted based on the Sewerage Manual (Part 1) Table 5

With reference to Sewerage Manual (Part 1)[1] issued by the DSD in May 2013, the Colebrook-White Equation will be used to analyse the flow conditions. Equation (i) for circular pipes flowing full will be adopted to estimate the sewage flow for the proposed Development. The Colebrook-White Equation is shown in **Figure 2** below.

(i) for circular pipes flowing full,

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

where
V = mean velocity (m/s)
g = gravitational acceleration (m/s2)
R = hydraulic radius (m)
D = internal pipe diameter (m)
ks = hydraulic pipeline roughness (m)
v = kinematic viscosity of fluid (m2/s)
s = hydraulic gradient (energy loss per unit length due to friction)

Figure 2 Colebrook – White Equation

[1] http://www.dsd.gov.hk/EN/Files/Technical_Manual/technical_manuals/Sewerage_Manual_1_Eurocodes.pdf

2.4 ASSESSMENT RESULTS & DISCUSSION

Detailed calculations of sewage generation and hydraulic capacity are provided in **Appendix D** and **Appendix E** respectively. The estimated cumulative peak discharge of all downstream sewerage of the proposed Site account for no more than 60% of the hydraulic capacity of the concerned sewer. No exceedance of hydraulic capacity for all cumulative peak discharge is anticipated under the proposed sewerage network with upgraded pipework.

2.5 ASSESSMENT SUMMARY

To summarize, there will be one sewer discharge point from the project site to the inlet of proposed sewer terminal manhole which will then be connected to the public sewer manhole along Tai Ting Road. In view of the proposed development and the vicinity, the following proposed new or upgraded pipe works are recommended:

- Proposed new sewer terminal manhole S1 connecting to FMH1009673 existing sewer manhole by a new P.E. pipe with 200mm dia.
- Proposed new sewer connection from manhole FMH10032444 to FMH1008900 and FMH1008900 to FMH1008899 by new 375mm dia. sewer.

According to the estimated sewage generation calculations, it is anticipated that the proposed sewerage will have sufficient capacity to cater for sewage generated from the proposed Site. No adverse sewerage impact associated with the proposed Development is anticipated.

Detailed alignment and design of the connecting sewer will be subject to detailed design of the Project. The Applicant shall be responsible for appointing a qualified engineer for properly design and construct of the connecting sewers, likely at the design stage of Project. Agreement and approval from relevant government departments, including DSD, shall be obtained in due course.

3 DRAINAGE IMPACT ASSESSMENT

3.1 SCOPE OF WORKS

The objectives of this Drainage Impact Assessment (DIA) is to assess whether the proposed Development may cause adverse impacts on drainage and flooding. These impacts will be identified and mitigation measures will be proposed in order to demonstrate that the proposed Development will not cause an unacceptable increase in the risk of flooding in areas upstream of, adjacent to or downstream of the development.

Existing drainage record plans from the Drainage Services Department were obtained for this DIA.

3.2 SITE LOCATION AND TOPOGRAPHY

The topographic levels of the Application site is approximately + 5.9mPD. The site is gradually sloping downwards from south to north direction from + 5.9mPD to + 5.4mPD. The site is currently used as a temporary open public car park and comprises a grade 3 historic building (including its main building and annex block) I.e., Siu Lo. The site condition is mainly paved with concrete.

3.3 DRAINAGE ANALYSIS

3.3.1 ASSUMPTIONS AND METHODOLOGY

Peak instantaneous runoff before and after the proposed Development was calculated based on the Rational Method. The recommended physical parameters, including runoff coefficient (C) and storm constants for different return periods, are as per the *Stormwater Drainage Manual*.

The Rational Method has been adopted for hydraulic analysis and the peak runoff is given by the following expression:

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

where:

Q_p = peak runoff in m^3/s

C = runoff coefficient

i = rainfall intensity in mm/hr

A = catchment area in km^2

Rainfall intensity is calculated using the following expression:

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

where:

i = rainfall intensity in mm/hr

t_d = duration in minutes (td≤240)

a, b, c = storm constants given in Table 3 of SDM

For a single catchment, duration (t_d) can be assumed to be the time of concentration (t_c) which is calculated as follows:

$$t_c = t_0 + t_r$$

where:

t_c = time of concentration

t_0 = inlet time (time taken for flow from the most remote point to reach the most upstream point of the urban drainage system)

Generally, t_0 is much smaller than t_f. As shown in Equation 2, t_d is the divisor. Therefore, larger t_d will result in smaller rain intensity (i) as well as a smaller Q_p. For the worst-case scenario, t_r is assumed to be negligible and so:

$$t_d = t_c = t_0$$

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

where:

A = catchment area (m^2)

H = average slope (m per 100m), measure along the line of natural flow, from the summit of the catchment to the point under consideration

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

The capacities of the drainage pipes have been calculated using the Colebrook-White Equation, assuming full bore flow with no surcharge, as follows, incorporate 10% sedimentation in the calculation of drainage flow capacity in accordance with the *Stormwater Drainage Manual:*

$$V = -\sqrt{32gRs} \times \log(\frac{k_s}{14.8R} + \frac{1.25v}{R\sqrt{32gRs}})$$

where:

V = mean velocity (m/s)

g = gravitation acceleration (m/s^2)

R = hydraulic radius (m)

k_s = hydraulic pipeline roughness (m)

V = kinematic viscosity of fluid (m^2/s)

S = hydraulic gradient (energy loss per unit length due to friction)

3.4 ASSESSMENT ASSUMPTIONS

3.4.1 PROJECT SITE

For the proposed Development, the Site will be occupied by the proposed residential care home building with concrete paved floor. Soft landscape will be also provided at flat roof top and areas around the proposed Development subject to the detailed design stage. For the worst-case scenario, it is assumed that the proposed Development will be 100% paved. As such the Site before development and after development will be the same and is summarized in ***Table 3.1***.

Table 3.1: Surface Characteristics and Runoff Coefficients of the Site

Scenario of Project	Area (m^2)	Surface Characteristics
Before Development	1,877	100% paved
After Development	1,877	100% paved

3.4.2 CUMULATIVE RUNOFF (SURROUNDING CATCHMENTS)

As the existing drainage system collects runoff from the Site and also the surrounding catchments, runoff from surrounding catchments shall been taken into account. Surrounding catchments and proposed Site catchment that contributed to the cumulative runoff have been identified as Catchments A1 to A12 and Catchment S respectively. The area of catchments is presented shown in ***Appendix F***.

With reference to the *Stormwater Drainage Manual*, the runoff coefficients of paved surface are 0.95. The paving conditions and runoff coefficients of related catchments are summarized in ***Table 3.2***.

Table 3.2: Surface Characteristics and Runoff Coefficients of Surrounding Catchments

Catchment	Area (m^2)	Surface Characteristics	Runoff Coefficient for paved area
Proposed Site (S)	1,877	100% paved	0.95
Catchment A1	4,113	100% paved	0.95
Catchment A2	3,091	100% paved	0.95
Catchment A3	1,820	100% paved	0.95
Catchment A4	5,993	100% paved	0.95
Catchment A5	3,321	100% paved	0.95
Catchment A6	1,701	100% paved	0.95
Catchment A7	2,864	100% paved	0.95
Catchment A8	2,629	100% paved	0.95
Catchment A9	1,264	100% paved	0.95
Catchment A10	1,782	100% paved	0.95
Catchment A11	3,074	100% paved	0.95
Catchment A12	2,068	100% paved	0.95

3.5 ESTIMATED EXISTING AND FUTURE RUNOFF

3.5.1 PEAK RUNOFF FROM THE SITE

Based on the assumptions described in ***Section 3.2***, the runoff from the Site before and after the development was estimated based on the return periods of 50 years.

As shown in ***Table 3.3*** the estimated peak runoff generated from the Site Catchment (S) is 0.122 m^3/s. There will be no difference of peak flows of runoff after the completion of the proposed Development under the assessed return periods of 50 years. Detailed calculations are provided in ***Appendix H***.

Table 3.3: Estimated Peak Runoff of the proposed Site

Return Period	Estimated Peak Runoff		
	Before Development	After Development	% Change
50 Years	0.122	0.122	± 0%

3.6 PROPOSED DRAINAGE LAYOUT AND RESULTS

The runoff of the Site catchment (S) will be collected by the proposed terminal manhole SMH01 and discharge to manhole SMH1010931 through the proposed 1 no. of twin 300mm diameter stormwater drain. In view of the clearance between the proposed twin 300mm dia. stormwater drain and the existing 375mm dia. sewer is less than the standard requirement of 300mm, the Applicant will be responsible to implement proposed protection works to the existing sewer, such as provision of concrete surround, to avoid damaging the sewer during the course of construction and backfill works. The Applicant is also responsible to conduct CCTV inspection of the existing 375mm dia. sewer before and after completion of the proposed drainage works and submit the reports to DSD office. Should any damage of the existing 375mm dia. sewer due to the Proposed Development, the Applicant would be responsible for the cost of all necessary repair works, compensation and any other consequences arising therefrom. The design of the proposed drainage is provided in **Appendix F**. The design of the internal drainage system within the Proposed Development will be carried out in the detailed design stage.

Flow capacities of the existing stormwater drains at the downstream of manholes have been assessed with the consideration of total peak flow of stormwater generated from the proposed Development and other surrounding catchments. Detailed calculation of the drainage assessment is provided in **Appendix G**.

Based on the calculation in Appendix G, the estimated peak runoff from the existing is less than 100% capacity of the stormwater drains, and it is anticipated that the proposed drainage system will have sufficient capacity to cater for the surface runoff at the proposed Development.

4 CONCLUSION

The potential sewerage impact due to the application site has been quantitatively addressed. Based on the estimated sewage flow for the Project Site presented in **Appendix D**, the total peak sewage flow projected for the proposed development is about 0.0073 m3/sec.

All sewage generated from the proposed development will be conveyed to the public sewerage

system via the proposed sewer terminal manhole. The sewage generation calculations on the proposed sewerage system have indicated that the proposed sewer terminal manhole (S1) in the proposed Site and other proposed upgraded pipe works will have sufficient capacity to cater for sewage discharged from the proposed Site and surrounding catchments.

The maximum estimated peak flow from the proposed Site and all cumulative catchment areas will account for less than 100% of the flow capacity of the upgraded sewerage system. Hence, it is concluded that no adverse sewerage impacts arising from the development is anticipated.

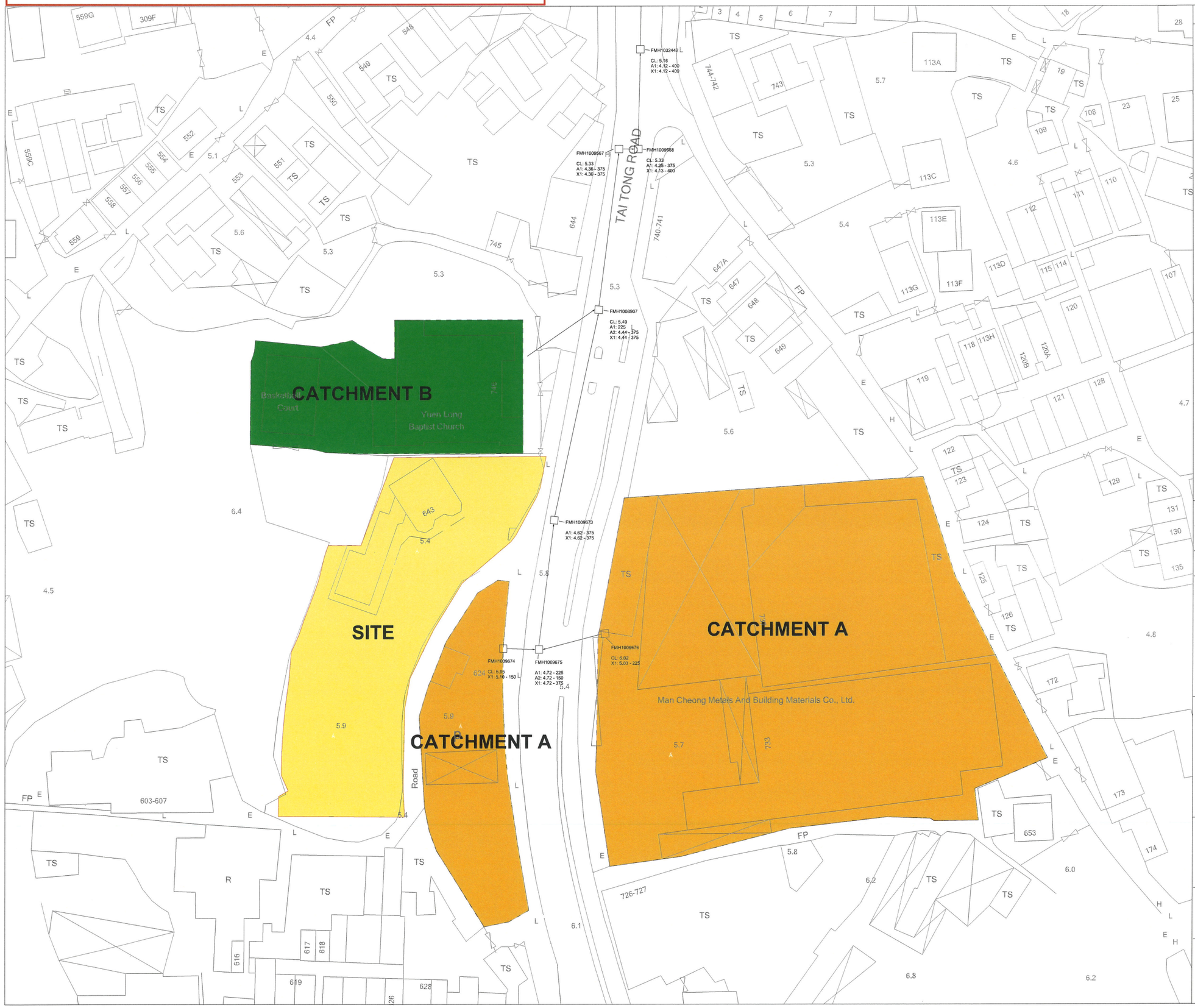
Potential drainage impacts that may arise from the Site after construction of the proposed Development have been assessed.

The peak runoff before and after the development of the proposed Site were estimated using the Rational Method, based on the catchment surface characteristics for the existing environment and the proposed Development. Under the future paving condition, a 100% paving condition of the proposed Site is assessed in this DIA for the worst case scenario and no change on the estimated peak runoff is anticipated after the development.

Flow capacity of the stormwater was calculated using Colebrook-White Equation, while flow capacity of the watercourse was calculated using Manning's Equation. The maximum estimated peak flow of 0.122m^3/s (including runoff calculated based on a return period of 50 years with climate change effect) from the Site. The runoff from the proposed Site (S) will be collected by the proposed terminal manhole SMH01 and discharge to manhole SMH1010931 through the proposed 1 no. of twin 300mm diameter stormwater drain. In addition, flow capacities of the existing stormwater drains at the downstream of manholes have been assessed with the consideration of total peak flow of stormwater generated from the proposed Site and other surrounding catchments. All cumulative catchment areas will account for less than 100% of the flow capacity. Thus, the existing stormwater system will have sufficient capacity to receive stormwater runoff from the proposed Site.

Thus, no adverse sewerage and drainage impact to the existing drainage system is anticipated after the development of the Site.

APPENDIX B EXISTING SEWERAGE PLAN



LEGEND:

- PROPOSED SITE
- CATCHMENT TAKEN INTO ACCOUNT
- EXISTING MANHOLE
- EXISTING SEWERAGE

	Prepared	Checked	Approved
Initial	BW	CC	YS
Date	11/2021	11/2021	11/2021

DrawingTitle

EXISTING SEWERAGE PLAN NO.1

Drawing No.	Rev.
SIA - 1001	0

Scale:

A4 - 1:1000

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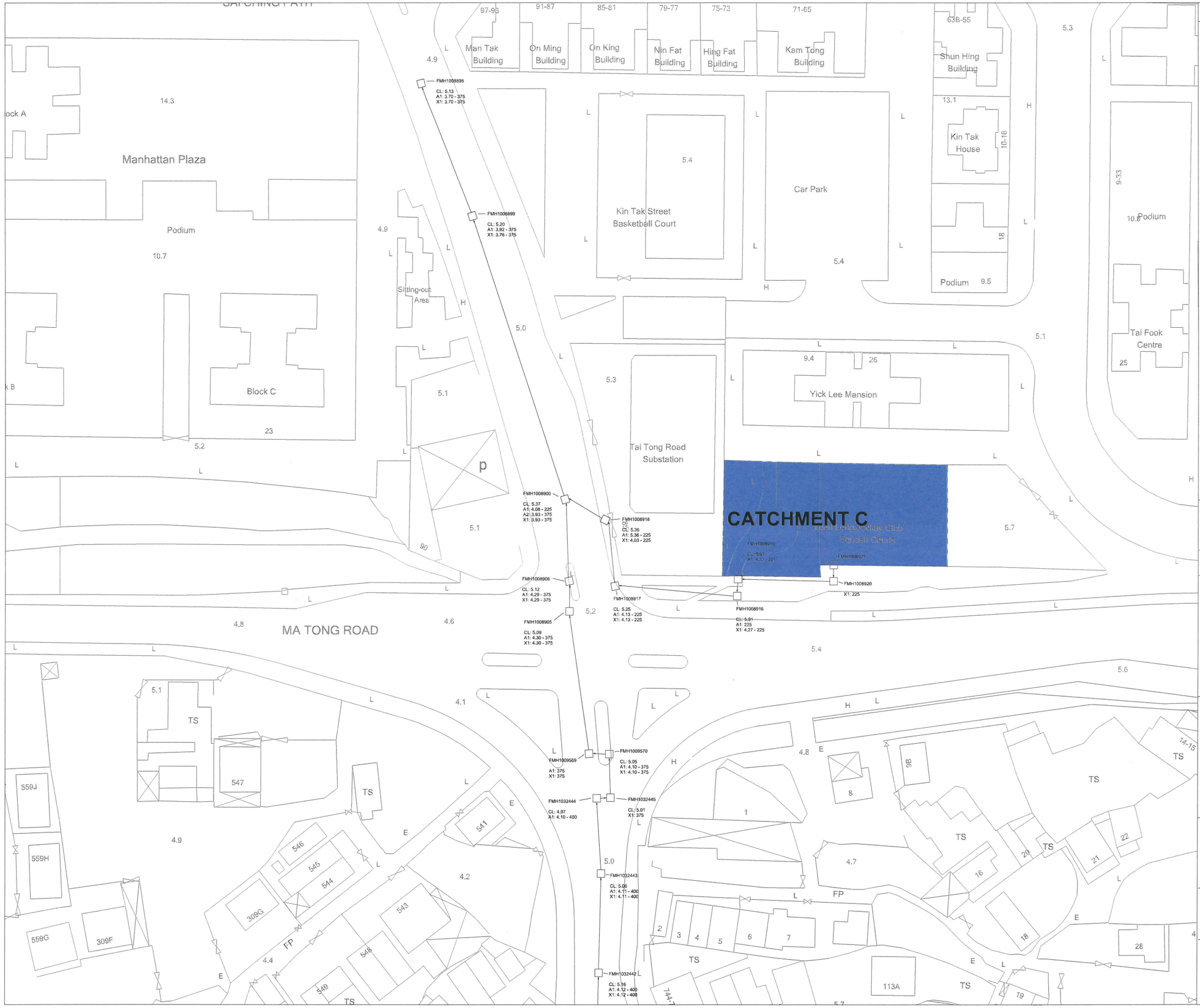

LEGEND:

- PROPOSED SITE
- CATCHMENT TAKEN INTO ACCOUNT
- EXISTING MANHOLE
- EXISTING SEWERAGE

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Initial	BW	CC	YS
Date	11/2021	11/2021	11/2021

DrawingTitle

EXISTING SEWERAGE PLAN NO.2

Drawing No.	Rev.
SIA - 1002	0

Scale:

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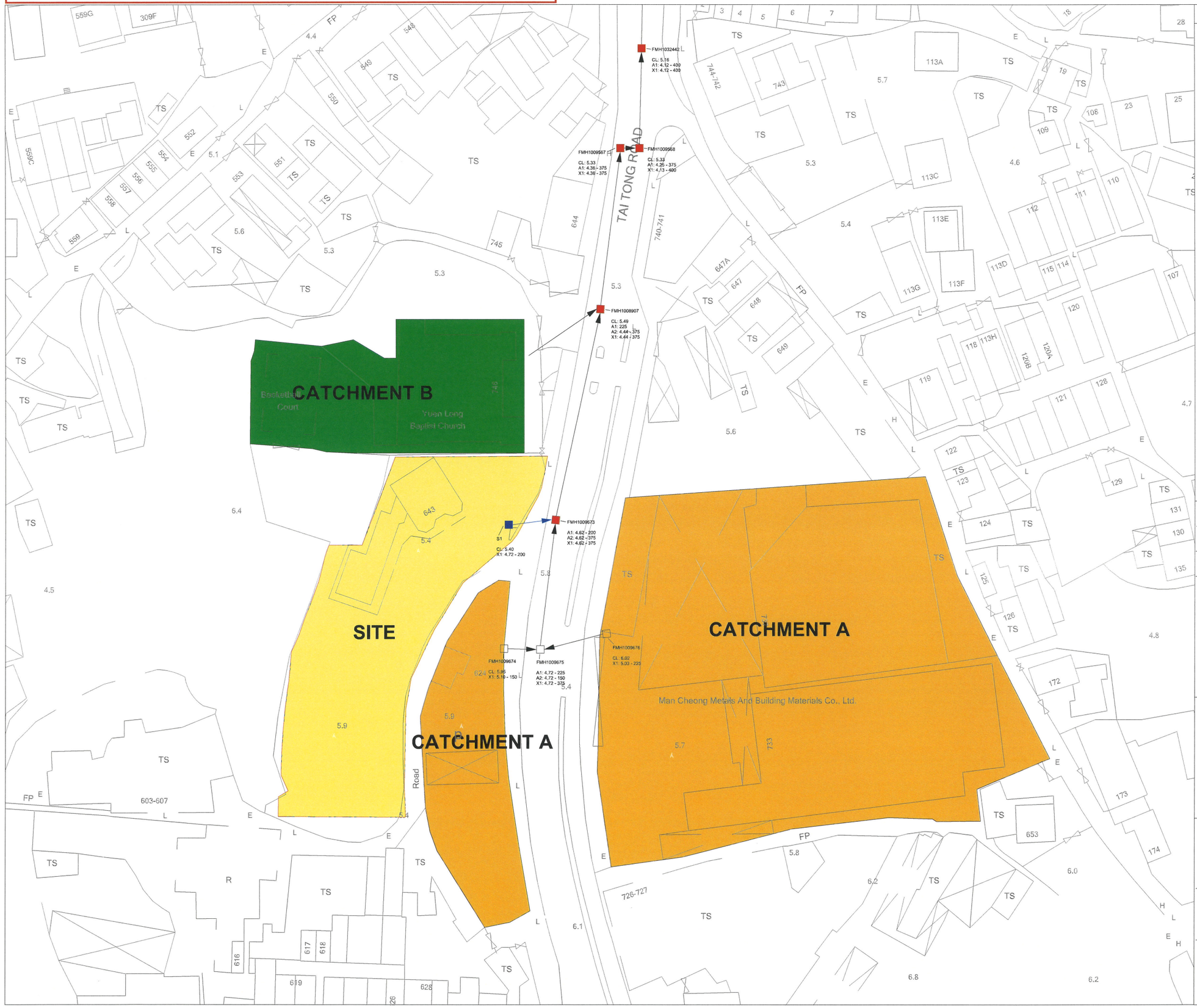
APPENDIX C PROPOSED SEWERAGE PLAN



LEGEND:

- PROPOSED SITE
- CATCHMENT TAKEN INTO ACCOUNT
- EXISTING MANHOLE TAKEN INTO ACCOUNT
- EXISTING SEWERAGE
- PROPOSED TERMINAL MANHOLE
- PROPOSED SEWERAGE

	Prepared	Checked	Approved
Initial	BW	CC	YS
Date	11/2021	11/2021	11/2021

DrawingTitle

PROPOSED SEWERAGE PLAN NO.1

Drawing No.	Rev.
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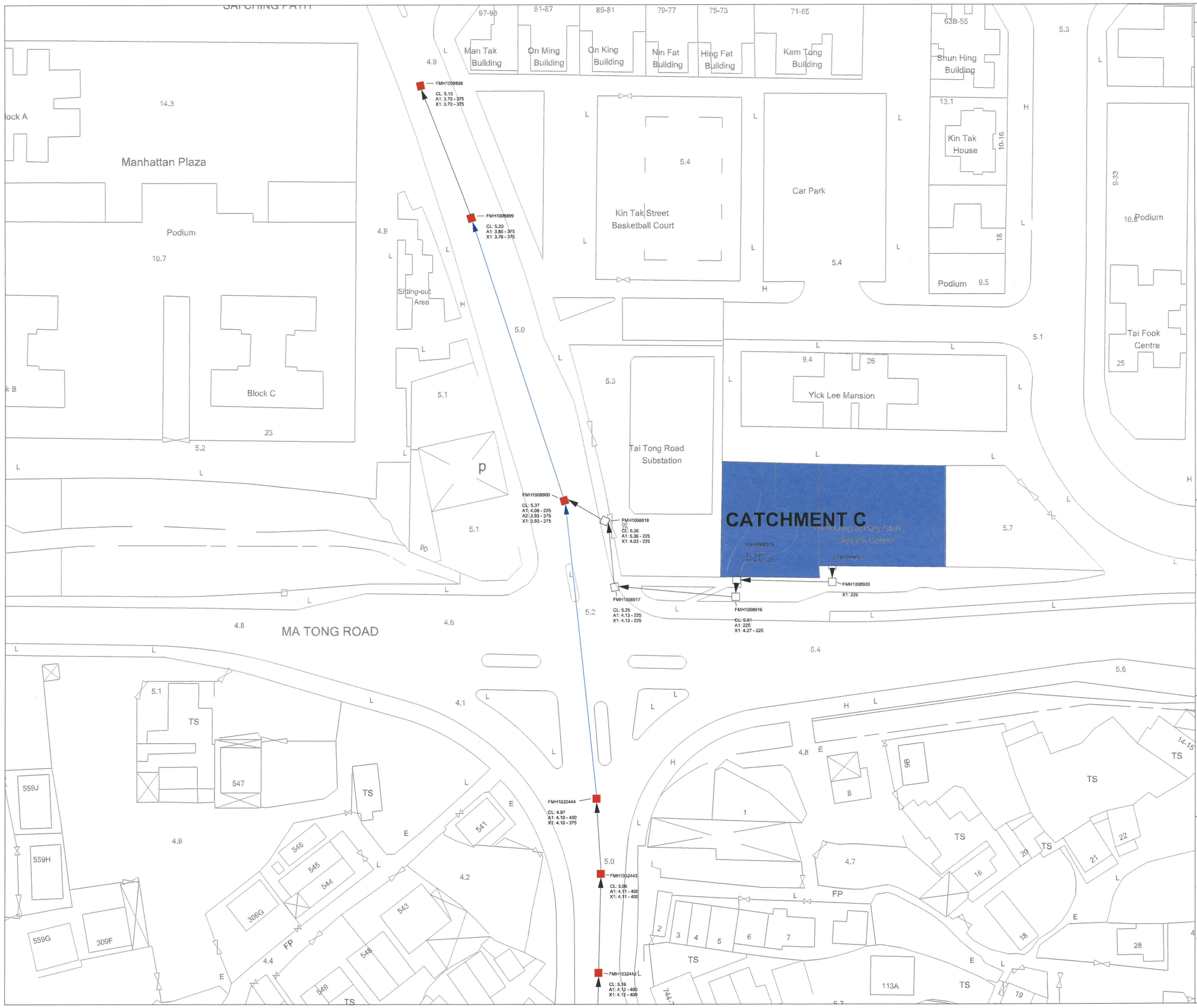

LEGEND:

- PROPOSED SITE
- CATCHMENT TAKEN INTO ACCOUNT
- EXISTING MANHOLE TAKEN INTO ACCOUNT
- EXISTING SEWERAGE
- PROPOSED SEWERAGE

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Initial	BW	CC	YS
Date	11/2021	11/2021	11/2021

DrawingTitle

PROPOSED SEWERAGE PLAN NO.2

Drawing No.	Rev.
SIA - 1004	0

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APPENDIX D CALCULATION OF SEWAGE FLOW

Development	GFA (m2)	Occupancy Density (person/m2)	Estimated Population	Unit Flow Factor (m3/day)	Estimated Average Dry Weather Flow (m3/day)	Catement Inflow Factor	Contributing Population	Peaking Factor	Estimated Peak Flow (L/sec)	Estimated Peak Flow (m3/sec)	Remarks
A) Proposed Development											
Elderly Home Guest	5400	-	260	0.27	70.20	1	710	8	6.500	0.00650	UFF: 0.27 m3/day for 'Modern Village/R2 Private Development' based on EPD's GESF Table T-1 Population: No. of guests in accordance with the planning statement
Elderly Home Employee		-	30	0.28	8.40				0.778	0.00078	UFF: 0.28 m3/day for 'Commercial Employee' and 'Commercial activities of J11 Community, Social & Personal Services' based on EPD's GESF Table T-2 Population: Information from project applicant
B) Catchment A											
Man Cheong Metals and Building Materials Co. Ltd. (萬昌五金建材有限公司)	1130	2.3	26	2.08	54.08	1	419	8	5.007	0.00501	UFF: 2.08 m3/day for 'Industrial employee' and 'Industrial activities of J1 Manufacturing in Yuen Long' based on EPD's GESF Table T-3 Occupancy Density: 2.3 workers/100m2 GFA for 'Manufacturing' based on PlanD's CIFSUS Figure 9
Caltex Patrol Station	100	3.8	4	0.18	0.72				0.067	0.00007	UFF: 0.18 m3/day for 'Commercial Employee' and 'Commercial activities of J3 Trnasport, Storage & Communication' based on EPD's GESF Table T-2 Occupancy Density: 3.8 workers/100m2 GFA for 'Transport' based on PlanD's CIFSUS Figure 9
MCM Construction Materilas Spply Company Limited (萬斯美有限公司)	1230	2.3	28	2.08	58.24				5.393	0.00539	UFF: 2.08 m3/day for 'Industrial employee' and 'Industrial activities of J1 Manufacturing in Yuen Long' based on EPD's GESF Table T-3 Occupancy Density: 2.3 workers/100m2 GFA for 'Manufacturing' based on PlanD's CIFSUS Figure 9
C) Catchment B											
Religious Institution (Church)	5579	-	50	0.28	14.00	1	869	8	1.296	0.00130	UFF: 0.28 m3/day for 'Commercial Employee' and 'Commercial activities of J11 Community, Social & Personal Services' based on EPD's GESF Table T-2 Population: 50 staff based on RNTPC Paper No. A/YL/252A para. 1.4
Composite School Employee		-	63	0.28	17.64				1.633	0.00163	UFF: 0.28 m3/day for 'Commercial Employee' and 'Commercial activities of J11 Community, Social & Personal Services' based on EPD's GESF Table T-2 Population: 32 teaching staff and 8 management/supporting staff for the kindergarten, 6 trainers and 12 trainees for the 4/F special education area, 3 teaching staff and 2 supporting staff for 5/F cooking class area based on RNTPC Paper No. A/YL/252A para. 1.4
Composite School Student		-	283	0.04	11.32				1.048	0.00105	UFF: 0.04 m3/day for 'School Student' based in EPD's GESF Table T-2 Population: Student-teacher ratio of 8.1:1 based on Education Bureau Statistics (https://www.edb.gov.hk/en/about-edb/publications-stat/figures/index.html) for 32 teaching staff in the kindergarden, 12 SEN students for the 4/Fspecial education area, 12 students for the 5/F cooking class area based on RNTPC Paper No. A/YL/252A para. 1.4
D) Catchment C											
Yuen Long Jocky Club Squash Courts	1500	3.3	50	0.28	14.00	1	923	8	1.296	0.00130	UFF: 0.28 m3/day for 'Commercial Employee' and 'Commercial activities of J11 Community, Social & Personal Services' based on EPD's GESF Table T-2 Occupancy Density: 3.3 workers/100m2 GFA for 'Community, Social & Personal Services' based on PlanD's CIFSUS Figure 9
ESSO Tai Tong Petrol Station	100	3.8	4	0.18	0.72				0.067	0.00007	UFF: 0.18 m3/day for 'Commercial Employee' and 'Commercial activities of J3 Trnasport, Storage & Communication' based on EPD's GESF Table T-2 Occupancy Density: 3.8 workers/100m2 GFA for 'Transport' based on PlanD's CIFSUS Figure 9
								Sub-Total of A)	**7.28**	**0.00728**	
								Sub-Total of A+B)	**17.74**	**0.01774**	
								Sub-Total of A+B+C)	**21.72**	**0.02172**	
								Sub-Total of A+B+C+D)	**23.09**	**0.02309**	

APPENDIX E CALCULATION OF SEWAGE FLOW CAPACITY

Manhole Reference	Manhole Reference	Pipe Dia.	Pipe Length	Invert Level 1	Invert Level 2	g	k_s	s	v	V	A	Q	Estimated Capacity	Peak Flow	Capacity	Compliance	Remarks
		mm	m	mPD	mPD	m/s^2	m		m^2/s	m/s	m^2	m^3/s	L/s	L/s	%		
S1	FMH1009673	200	8.5	4.72	4.62	9.81	0.0006	0.01176	0.000001306	1.311	0.031	0.0412	41.20	7.28	17.7%	Yes	Proposed Site; Proposed new terminal manhole and 200mm sewer
FMH1009673	FMH1008907	375	42.0	4.62	4.44	9.81	0.0060	0.00429	0.000001306	0.838	0.110	0.0925	92.52	17.74	19.2%	Yes	Proposed Site + Catchment A
FMH1008907	FMH1009567	375	32.5	4.44	4.36	9.81	0.0060	0.00246	0.000001306	0.634	0.110	0.0701	70.07	21.72	31.0%	Yes	Proposed Site + Catchment A + Catchment B
FMH1009567	FMH1009568	375	3.0	4.36	4.25	9.81	0.0060	0.03667	0.000001306	2.454	0.110	0.2710	271.00	21.72	8.0%	Yes	
FMH1009568	FMH1032442	400	20.0	4.13	4.12	9.81	0.0060	0.00050	0.000001306	0.298	0.126	0.0374	37.44	21.72	58.0%	Yes	
FMH1032442	FMH1032443	400	19.0	4.12	4.11	9.81	0.0060	0.00053	0.000001306	0.306	0.126	0.0384	38.42	21.72	56.5%	Yes	
FMH1032443	FMH1032444	400	15.0	4.11	4.10	9.81	0.0060	0.00067	0.000001306	0.344	0.126	0.0433	43.26	21.72	50.2%	Yes	
FMH1032444	FMH1008900	375	57.0	4.10	3.93	9.81	0.0006	0.00298	0.000001306	0.980	0.110	0.1082	108.24	21.72	20.1%	Yes	Proposed 375mm new sewer
FMH1008900	FMH1008899	375	58.8	3.93	3.85	9.81	0.0006	0.00136	0.000001306	0.657	0.110	0.0726	72.57	23.09	31.8%	Yes	Proposed Site + Catchment A + Catchment B + Catchment C; Proposed 375mm new sewer
FMH1008899	FMH1008898	375	27.5	3.76	3.70	9.81	0.0060	0.00218	0.000001306	0.597	0.110	0.0660	65.96	23.09	35.0%	Yes	

Remarks:

(1) g=gravitational acceleration; k_s=equivalent sand roughness; s=gradient; v=kinematic viscosity of water; V=mean velocity

(2) The mean velocity (V) is claculated by the Colebrook-White Equation for circular pipes:

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

where

V = mean velocity (m/s)
g = gravitational acceration (m/s2)
D = internal pipe diameter (m)
s = slope
ks = roughness coefficient(m)
v = kinematic viscosity of fluid (m2/s)

(3) The value of k_s = 6mm is used for the calculation of existing pipe for conservative approach and 0.6mm for proposed new metal pipe in normal condition based on DSD's "Sewerage Manual" Table 5: Recommended roughness values

(4) Peak flow (Q) is calculated by Q = V x A

APPENDIX F SURROUNDING CATCHMENTS PLAN

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LEGEND:

- PROPOSED SITE
- CATCHMENT TAKEN INTO ACCOUNT

	Prepared	Checked	Approved
Initial	BW	CC	YS
Date	11/ 2021	11/ 2021	11/ 2021

DrawingTitle

LOCATION OF CATCHMENT

Drawing No.	Rev.
DIA - 1001	0

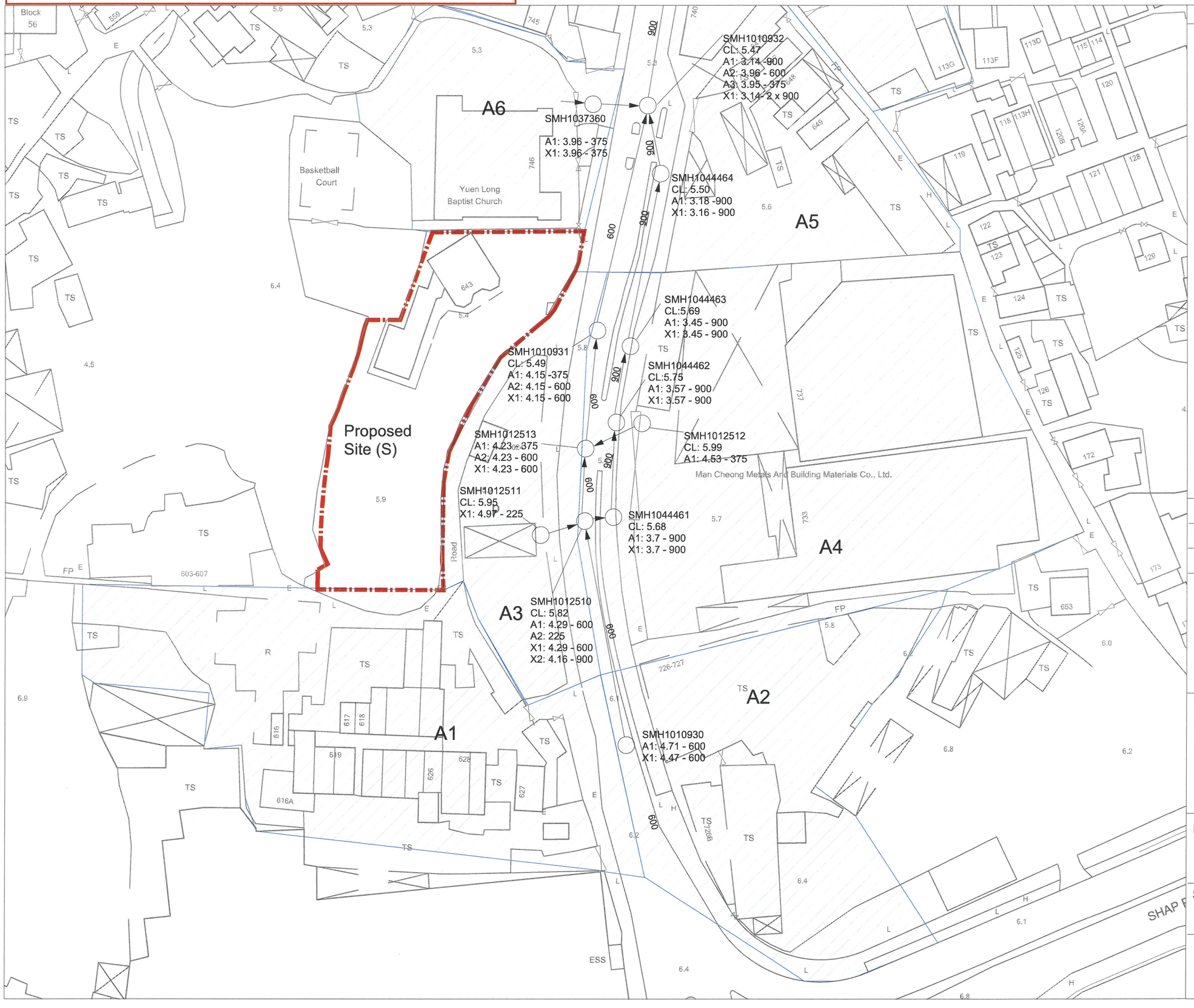
Scale:

A3 - 1:2000

BXG

BeeXergy Consulting Limited

APPENDIX G EXISTING DRAINAGE PLAN



LEGEND:

- PROPOSED SITE
- CATCHMENT TAKEN INTO ACCOUNT
- EXISTING DRAINAGE
- EXISTING CATCHPIT (SCH)
- EXISTING MANHOLE (SMH)
- uc — EXISTING U CHANNEL
- 300 — EXISTING PIPE DIAMTER

	Prepared	Checked	Approved
Initial	BW	CC	YS
Date	11/ 2021	11/ 2021	11/ 2021

DrawingTitle

DRAINAGE PLAN No. 1

Drawing No.	Rev.
DIA - 1002	0

Scale:

A3 - 1:1000

BXG

BeeXergy Consulting Limited

LEGEND:

- PROPOSED SITE
- CATCHMENT TAKEN INTO ACCOUNT
- EXISTING DRAINAGE
- EXISTING CATCHPIT (SCH)
- EXISTING MANHOLE (SMH)
- uc — EXISTING U CHANNEL
- 300 — EXISTING PIPE DIAMTER

SMH1010938
CL: 5.43
A1: 2.77 - 1200
X1: 2.77 - 1200

SMH1010937
A1: 2.78 - 1200
X1: 2.78 - 1200

SMH1010951
CL: 5.02
A1: 2.80 - 2 x 900
A2: 2.80 - 300
X1: 2.79 - 1200

SMH1044465
CL: 5.04
A1: 2.86 - 900
A2: 2.89 - 900
X1: 2.89 - 900

SMH1012234
A1: 2.83 - 400
X1: 2.83 - 300

STH101957
X1: 2.88 - 400

SCH1028586
A1: 4.14 - 600
X1: 600

SMH1010950
CL: 5.01
A1: 600
A2: 2.89 - 900
X1: 2.89 - 900

SMH1012232
A1: 4.23 - 300
X1: 4.23 - 300

SMH1010949
CL: 5.25
A1: 3.06 -2 x 900
X1: 3.05 - 900
X2: 3.05 - 900

SMH1037360
CL: 5.24
X1: 4.31 - 300

SMH1010932
CL: 5.47
A1: 3.14 -900
A2: 3.96 - 600
A3: 3.95 - 375
X1: 3.14 -2 x 900

	Prepared	Checked	Approved
Initial	BW	CC	YS
Date	11/ 2021	11/ 2021	11/ 2021

DrawingTitle
DRAINAGE PLAN No. 2

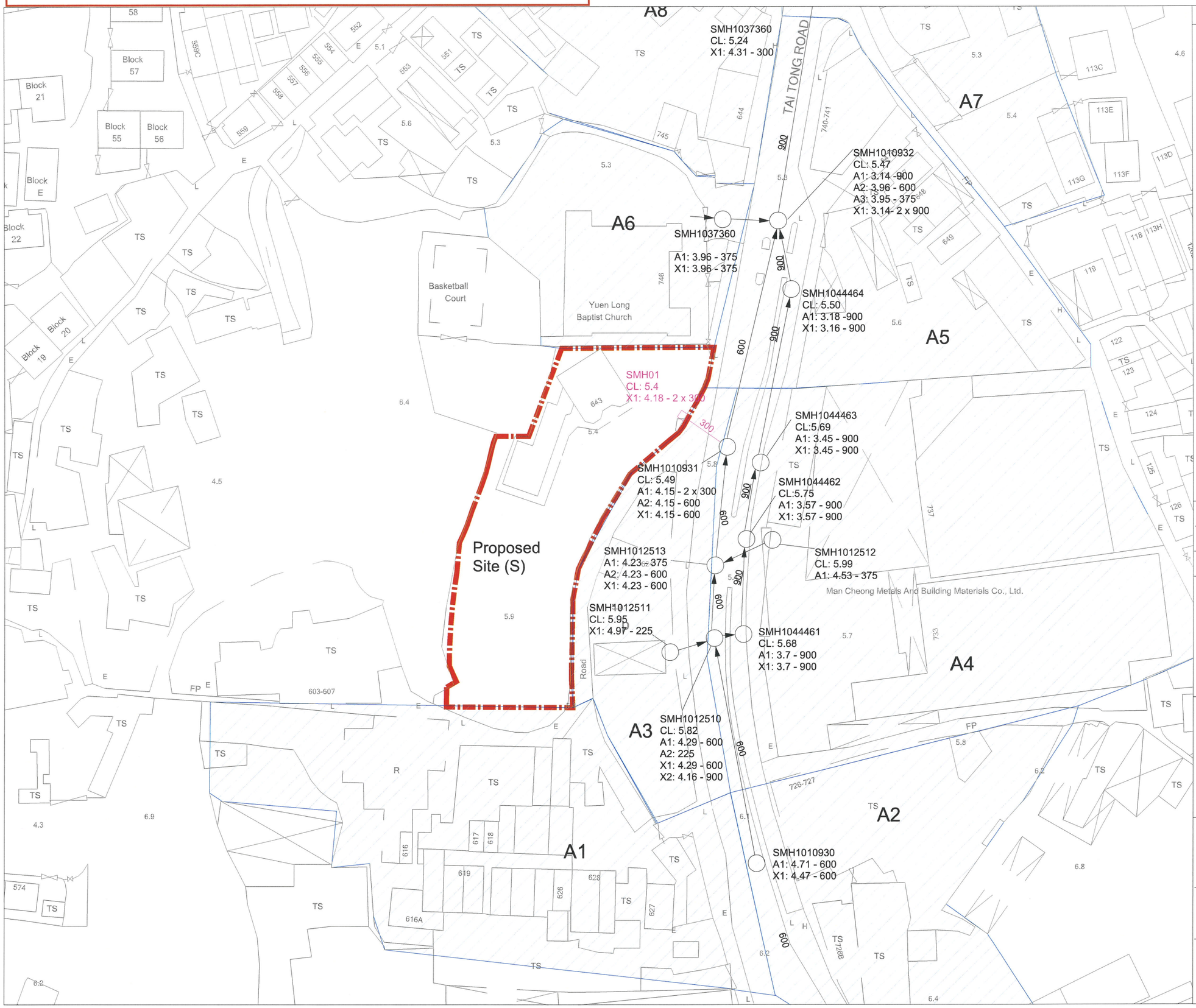
Drawing No.
DIA - 1003

Rev.
0

Scale:
A3 - 1:1000

BXG
BeeXergy Consulting Limited

APPENDIX H PORPOSED DEAINAGE SYSTEM



LEGEND:

- PROPOSED SITE
- CATCHMENT TAKEN INTO ACCOUNT
- PROPOSED TERMINAL MANHOLE
- EXISTING DRAINAGE
- EXISTING CATCHPIT (SCH)
- EXISTING MANHOLE (SMH)
- uc EXISTING U CHANNEL
- 300 EXISTING PIPE DIAMTER
- 300 PROPOSED TWIN PIPE DIAMTER

	Prepared	Checked	Approved
Initial	BW	CC	YS
Date	05/ 2022	05/ 2022	05/ 2022

DrawingTitle

DRAINAGE RECORD PLAN

Drawing No.	Rev.
DIA - 1004	0

Scale:

A3 - 1:500

BXG

BeeXergy Consulting Limited

APPENDIX I RUNOFF CALCULATION

Calculation of Runoff for Return Period of 50 Years

Catchment ID	Paved Catchment Area (km^2)	Average slope (H), m/100m	Flow path length (L), m	Inlet time (t_0), min	Duration (t_d), min	Storm Constants			Runoff intensity (i), mm/hr	Runoff coefficient for paved area (C_p)	C x A	Peak runoff (Q_p) m^3/s
						a	b	c				
Before the Proposed Development												
Catchment S	0.001877	0.63	79.0	5.89	5.89	451.3	2.46	0.337	245.20	0.95	0.00178	0.122
Catchment A1	0.004113	0.53	131.0	9.35	9.35	451.3	2.46	0.337	218.22	0.95	0.00391	0.237
Catchment A2	0.003091	0.14	74.0	7.15	7.15	451.3	2.46	0.337	233.87	0.95	0.00294	0.191
Catchment A3	0.001820	1.85	27.0	1.63	1.63	451.3	2.46	0.337	311.91	0.95	0.00173	0.150
Catchment A4	0.005993	0.29	102.0	7.90	7.90	451.3	2.46	0.337	228.06	0.95	0.00569	0.361
Catchment A5	0.003321	0.44	68.6	5.20	5.20	451.3	2.46	0.337	252.41	0.95	0.00315	0.221
Catchment A6	0.001701	0.19	51.4	4.90	4.90	451.3	2.46	0.337	255.86	0.95	0.00162	0.115
Catchment A7	0.002864	0.41	97.5	7.60	7.60	451.3	2.46	0.337	230.28	0.95	0.00272	0.174
Catchment A8	0.002629	0.51	19.8	1.49	1.49	451.3	2.46	0.337	315.49	0.95	0.00250	0.219
Catchment A9	0.001264	0.26	38.0	3.51	3.51	451.3	2.46	0.337	274.51	0.95	0.00120	0.092
Catchment A10	0.001782	0.45	66.5	5.34	5.34	451.3	2.46	0.337	250.97	0.95	0.00169	0.118
Catchment A11	0.003074	0.43	23.4	1.80	1.80	451.3	2.46	0.337	307.73	0.95	0.00292	0.250
Catchment A12	0.002068	0.35	28.2	2.34	2.34	451.3	2.46	0.337	295.48	0.95	0.00196	0.161

Remark:

(i) Rainfall Increase due to climate Change = 111.1% (1.111)

APPENDIX J CALCULATION OF DRAINAGE CAPACITY

Calculation of Drainage Capacity for Return Period of 50 Years

SECTION		Pipe	Catchment	Length	Level (Out)	Level (In)	d	r	A_w	P_w	R	s	k_s	V	Q_c	Total Runoff in 50 Years	% of capacity	Remark
From	To			m	mPD	mPD	m	m	m^2	m	m	-	mm	m/s	m^3/s	m^3/s	%	
SMH1010930	SMH1012510	1 x 600mm circular pipe	A1+A2	42.00	4.47	4.29	0.6	0.3	0.283	1.885	0.15	0.0042857	0.6	1.5900	0.450	0.428	95%	OK
SMH1012511	SMH1012510	1 x 600mm circular pipe	A3	5.90	4.97	4.29	0.6	0.3	0.283	1.885	0.15	0.1152542	0.6	8.2992	2.347	0.150	6%	OK
SMH1012510	SMH1012513	1 x 600mm circular pipe	(A1+A2+A3)/2	11.10	4.29	4.23	0.6	0.3	0.283	1.885	0.15	0.0054054	0.6	1.7872	0.505	0.289	57%	OK
SMH1012510	SMH1044461	1 x 900mm circular pipe	(A1+A2+A3)/2	2.50	4.16	3.7	0.9	0.45	0.636	2.827	0.23	0.1840000	0.6	13.4850	8.579	0.289	3%	OK
SMH1012512	SSMH1012513	1 x 375mm circular pipe	A4	9.00	4.53	4.23	0.375	0.1875	0.110	1.178	0.09	0.0333333	0.6	3.3188	0.367	0.361	98%	OK
SMH01	SMH1010931	2 x 300mm circular twin pipe	S	7.80	4.19	4.15	0.3	0.15	0.071	0.942	0.08	0.0051282	0.6	1.1224	0.159	0.122	77%	OK
SMH1012513	SMH1010931	1 x 600mm circular pipe	(A1+A2+A3)/2+A4	20.26	4.23	4.15	0.6	0.3	0.707	1.885	0.38	0.0039487	0.6	2.6910	1.902	0.650	34%	OK
SMH1010931	SMH1010932	1 x 600mm circular pipe	(A1+A2+A3)/2+A4+S	42.70	4.15	3.96	0.6	0.3	0.707	1.885	0.38	0.0044496	0.6	2.8574	2.020	0.771	38%	OK
SMH1044461	SMH1044462	1 x 900mm circular pipe	(A1+A2+A3)/2	15.40	3.7	3.57	0.9	0.45	1.590	2.827	0.56	0.0084416	0.6	5.0441	8.022	0.289	4%	OK
SMH1044462	SMH1044463	1 x 900mm circular pipe	(A1+A2+A3)/2	12.30	3.57	3.45	0.9	0.45	1.590	2.827	0.56	0.0097561	0.6	5.4236	8.626	0.289	3%	OK
SMH1044463	SMH1044464	1 x 900mm circular pipe	(A1+A2+A3)/2	31.30	3.45	3.18	0.9	0.45	1.590	2.827	0.56	0.0086262	0.6	5.0991	8.110	0.289	4%	OK
SMH1044464	SMH1010932	1 x 900mm circular pipe	(A1+A2+A3)/2	10.36	3.16	3.14	0.9	0.45	1.590	2.827	0.56	0.0019305	0.6	2.4054	3.826	0.289	8%	OK
SMH1037360	SMH1010932	1 x 375mm circular pipe	A6	7.62	3.96	3.95	0.375	0.1875	0.276	1.178	0.23	0.0013123	0.6	1.1562	0.319	0.115	36%	OK
SMH1010932	SMH1010949	2 x 900mm circular twin pipe	A1+A2+A3+A4+S+A5+A6	49.50	3.14	3.06	0.9	0.45	0.636	2.827	0.23	0.0016162	0.6	1.2523	1.593	1.397	88%	OK
SMH1010949	SMH1010950	1 x 900mm circular pipe	(A1+A2+A3+A4+S+A5+A6+A7+A8)/2	37.19	3.05	2.89	0.9	0.45	0.636	2.827	0.23	0.0043022	0.6	2.0510	1.305	0.895	69%	OK
SMH1010949	SMH1044465	1 x 900mm circular pipe	(A1+A2+A3+A4+S+A5+A6+A7+A8)/2	41.70	3.05	2.86	0.9	0.45	0.636	2.827	0.23	0.0045564	0.6	2.1111	1.343	0.895	67%	OK
UC 600	SCH1028586	1 x 600mm U-channel	A9	19.80	4.2	4.14	0.6	0.3	0.321	1.542	0.21	0.0030303	0.6	1.6391	0.527	0.092	17%	OK
SCH1028586	SMH1010950	1 x 600mm circular pipe	A9	3.15	4.14	2.89	0.6	0.3	0.283	1.885	0.15	0.3968254	0.6	15.4109	4.357	0.092	2%	OK
SMH1010950	SMH1044465	1 x 900mm circular pipe	(A1+A2+A3+A4+S+A5+A6+A7)/2+A8+A9	1.46	2.89	2.86	0.9	0.45	0.636	2.827	0.23	0.0205479	0.6	4.4976	2.861	0.987	34%	OK
STH1001957	SMH1012234	1 x 400mm circular pipe	A10	8.93	2.97	2.93	0.4	0.2	0.126	1.257	0.10	0.0044793	0.6	1.2591	0.158	0.118	75%	OK
SMH1012234	SMH1010951	1 x 300mm circular pipe	A10	9.97	2.93	2.80	0.3	0.15	0.071	0.942	0.08	0.0130391	0.6	1.7972	0.127	0.118	93%	OK
SMH1044465	SMJ1010951	1 x 900mm circular pipe	A1+A2+A3+A4+S+A5+A6+A7+A8+A9+A10	6.93	2.89	2.8	0.9	0.45	1.590	2.827	0.56	0.0129870	0.6	6.2595	19.911	2.000	10%	OK
SMJ1010951	SMH1010937	1 x 120mm circular pipe	A1+A2+A3+A4+S+A5+A6+A7+A8+A9+A10	48.60	2.79	2.78	1.2	0.6	2.827	3.770	0.75	0.0002058	0.6	0.9267	2.620	2.000	76%	OK
SMH1010937	SMH1010938	1 x 120mm circular pipe	A1+A2+A3+A4+S+A5+A6+A7+A8+A9+A10+A11+A12	19.10	2.78	2.77	1.20	0.6	2.827	3.770	0.75	0.0005236	0.6	1.4853	4.200	2.411	57%	OK

Legend

d = pipe diameter, m

r = pipe radius (m) = 0.5d

A_w = wetted area (m^2) = p r^2 (circular) ; $pr^2/2+2r^2$ (U-channel)

P_w = wetted perimeter (m) = 2pr (circular) ; 2pr/2 (U-channel)

R = Hydraulic radius (m) = A_w / P_w

s = Slope of the total energy line

k_s = equivalent sand roughness, mm

V = Velocity of flow calculated based on Colebrook White Equation, m/s

Q_c = Flow Capacity (10% sedimentation incorporated), m^3/s

Q_p = Estimated total peak flow from the Site during peak season, m^3/s