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WEST ISLAND LINE CONTRACT 715
NOISE PERFORMANCE TEST PROPOSAL

Report No.: 13313-22

For

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1. Introduction

Wilson Acoustics Limited (WAL) is commissioned by Eiffage Rail Tak Yue Joint Venture (ERTY-JV) to conduct groundborne noise performance test for the commissioning of West Island Line for MTR Corporation Ltd. (MTR Corporation).

The West Island Line (WIL) is an extension of existing Island Land. It is ~3km underground railway with 3 stations namely Kennedy Town Station, University Station and Sai Ying Pun Station. Environmental Impact Assessment (EIA-153/2008) has been conducted and approved with conditions on 23 Dec 2008.

According to the Environmental Permit (EP) Conditions 4.1.5, *"Six months prior to the operation of the Project, the Permit Holder shall submit to the Director for approval six (6) sets of hard copy and an electronic copy of noise performance test proposal. The noise performance test proposal shall include key sensitive receivers, including domestic premises, to illustrate that the operation of the Project meets the operational ground borne noise criteria in the Approved EIA Report. Before submission to the Director, the noise performance test proposal shall be certified by the ET Leader and verified by the IEC as conforming to the information and recommendations contained in the Approved EIA Report."*

This document presents the performance test proposal in accordance with EP Conditions for agreement with EPD.

2. Ground-borne Noise (GBN) Criteria

With reference to the TM for Assessment of Noise from Places other than Domestic Premises, Public Places or Construction Sites (TM) issued under Noise Control Ordinance (NCO), the criteria for noise transmitted primarily through the structural elements of the building should be 10dB(A) less than the relevant acceptable noise level (ANL). The same criteria are applied to all residential buildings, schools, clinics, hospitals, temples and churches.

The operational GBN criteria for different sensitive use are tabulated in Table 2.1 below.

Table 2.1 Operational Ground-borne Noise Criteria

GBNSR Description	GBN Criteria, $L_{eq,30mins}$, dB(A)	
	Day & Evening (0700 to 2300 hrs)	Night (2300 to 0700 hrs)
Churches, School-Classrooms and Temples	55	No sensitive use
Domestic premises, Clinics and Hospitals	55	45

3. Proposed Testing Locations

Prior to the operation phase of the Project, a commissioning test would be conducted to ensure compliance of the operational ground-borne noise levels with the EIAO-TM noise criteria (Table 4.2 of the approved EIA report refers). Details of the test requirements are provided in a stand-alone EM&A Manual.

In accordance with the EM&A Manual, in order to ensure no adverse impact generate from the operation of train, it is recommended the ET should perform a noise commissioning test at selected key noise sensitive receivers including at least but not limited to the GBNSRs for construction GBN monitoring.

In this proposal, the same locations are proposed for both construction and operational GBN test. The selection of GBNSRs is to cover the potentially worst affected locations in different geologies. The principle is that for adjacent GBNSRs with similar ground condition, the potentially worst affected GBNSR as predicted in the approved EIA report would be selected where possible.

The NSRs and preliminary site survey result on background noise level are summarized in **Table 3.1** and location map is shown in **Appendix A**. Geological profiles are provided in **Appendix B**. **Appendix C** provides preliminary site survey photos and plan drawings of the proposed test locations.

Table 3.1 Proposed Operational GBN Testing Locations and Background

Location No.	Ref. NSR No.	NSR Name	Usage	Geology	Distance to Track (m)		Prelim. Background Noise Reading, dB(A)
					Hori.	Vert.	
L1	2	Hongway Garden	Residential	Mixed	0	28	48
L2	3	Kian Nan Mansion, 81-85 Bonham Strand West	Residential	Mixed	0	30	54[3]
L3	-	106 Des Voeux Road West or 104 Des Voeux Road West[1]	Residential	Rock	15	32	58[3]
L4	-	Chinese Rhenish Church (Lai Yin Church) at Bonham Road	Church	Rock	0	68	33
L5	-	Main Building of the University of Hong Kong	Educational Institute	Rock	0	84	54[4]
L6	-	Hon Wah Middle School at Ching Lin Terrace[2]	Educational Institute	Rock	0	51	45
L7	5	Po Shu Lau, 35-43 Sands Street	Residential	Rock	0	42	47

Remark:

(1) Either location is suitable for measurement, it depends on the in-situ situation when conducting measurement.

(2) Hon Wah Middle School has been moved to Siu Sai Wan. The building is currently under renovation for future use of HKU (Education Institute).

(3) The preliminary surveys on the background noise level at each NSRs were conducted at daytime. The background noise levels of L2 and L3 were mainly affected by traffic noise through the main gate of the buildings, it is expected to be much lower at night time.
(4) The preliminary surveys on the background noise level was conducted at daytime, 1/F staircase inside the building.

To obtain the worst case GBN, the measurement will be conducted at the locations at lowest level that are accessible and with similar indoor noise environment. From **Table 3.1**, preliminary daytime background noise levels of L2 and L3 are 54dB(A) and 58dB(A) respectively, which are considered to be relatively high. To minimize the intrusive noise, the measurement is proposed to be scheduled at mid-night as shown in **Table 4.2**.

4. Measurement Plan

4.1 Measurement Instrument & Setup

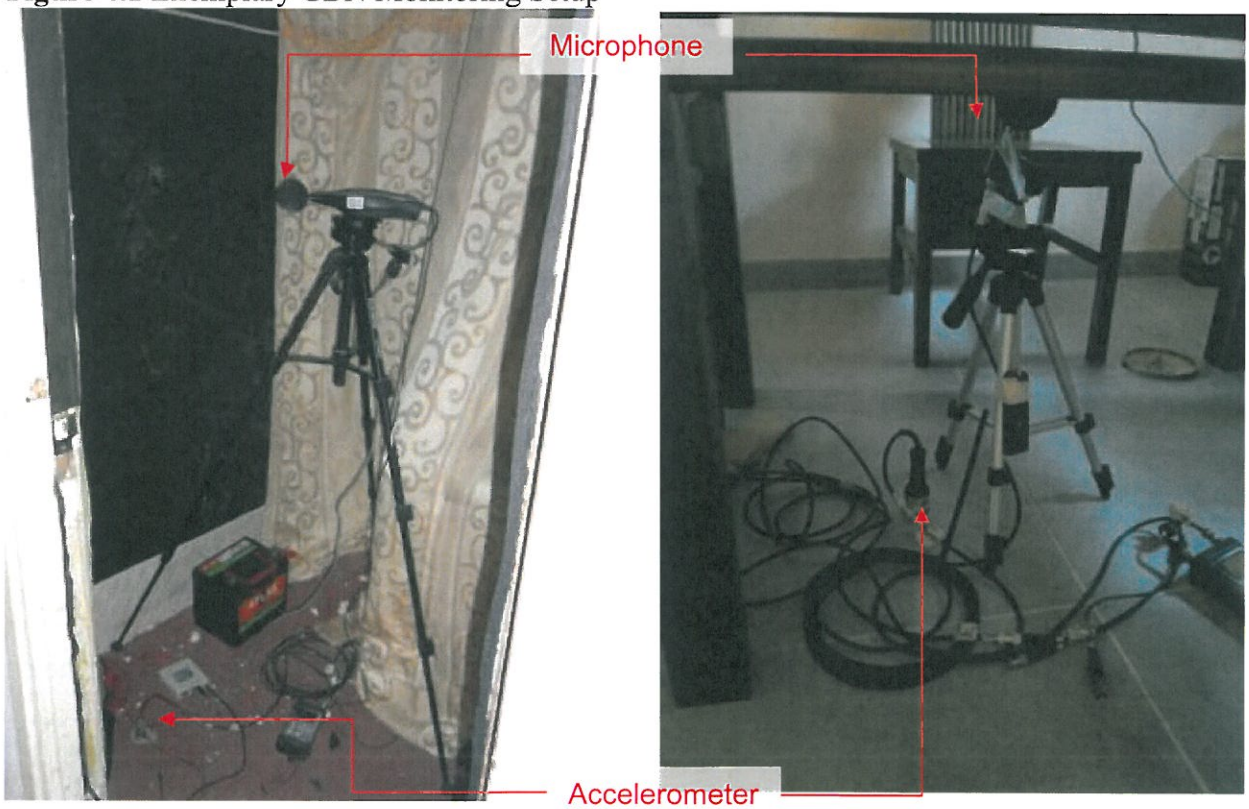
There are total 7 sets of measurement equipment would be deployed simultaneously at all NSRs during the test. Regarding EM&A section 2, the sound level meters to be deployed comply with the International Electrotechnical Commission Publications 651:1979 (Type 1) and 804:1985 (Type 1) specifications. Prior to and following the noise measurement the accuracy of the sound level meter would be checked using an acoustic calibrator. Measurements may be accepted as valid only if the calibration levels from before and after the noise measurement agree to within 1.0dB.

Table 4.1 Proposed Measurement Instruments

Instrument	**Model No.**	**Qty.**
Sound & Vibration Analyzer	SVAN 958 or equivalent	7
Microphone	B&K 378B02 or equivalent	7
Acoustic Calibrator	Svantek SV30A	2
Accelerometer	PCB 393A03	7
Vibration Calibrator	IMI 699A02	1

A microphone would be placed at 1.2m above floor level with windows closed. Vibration sensor would be placed on floor. Actual measurement location and height of microphone may be varied subjected to room environment and requirement of house owner. In case the groundborne noise is below background noise, the vibration sensors would be used to project the groundborne noise contribution from train operation. Exemplary setup is shown below.

Figure 4.1 Exemplary GBN Monitoring Setup



4.2 Train Type for GBN Test

M-stock non-service trains will be deployed for operational GBN test.

M, K and C-stock trains would run on WIL. C-stock and K-stock trains adopt the disc-brake which is less prone to formation of wheel-flat, while M-stock trains adopt the tread-brake such that the wheel condition is in general worse than the C-stock trains and K-stock trains.

Vibration level due to service train operation can provide a direct comparison of vibration characteristic of different train types. Measurements were conducted at two different locations for the comparison of C-stock and M-stock, and the comparison of K-stock and M-stock. Measurements were conducted under exactly the same track conditions and same ground geology. Therefore comparing the vibration levels of service trains would provide good verification.

The first measurement location is on the ground directly above the plain track at 4850m of uptrack of Kwun Tong Line (KTL) inside the Morse Park, Kowloon, where is located between Lok Fu station and Wong Tai Sin Station. Comparison of C-stock and M-stock train was measured at this location. The second measurement location is at Tseung Kwan O line (TKL), the sensors were installed on the ground above the plain track at 350m of downtrack of near Po Lam Station. Comparison of K-stock and M-stock train was measured at this location.

As shown in **Figure 4.2 to 4.5**, passby vibration level of M-stock at plain track is 1 to 3dB greater than C-stock and K-stock. The projected GBN level is around 3dB(A) lower. Hence C-stock and K-stock have lower ground-borne noise impact than M-stock under the same track condition.

4.3 Train Loading

Non-service empty train would be deployed for GBN measurement. Train load has little effect on vibration on audible frequency range as suggested in various literatures (ref: *"Track-Based Control Measures for Ground Vibration – The Influence of Quasi-Static Loads and Dynamic Excitation"*, and *"Ground Vibration Induced by Railway Traffic – The Influence of Vehicle Parameters"*, Noise and Vibration Mitigation for Rail Transit System, NNFM 118, Springer 2012).

Measurement data of trains running along existing operating lines of MTR Corporation also indicates that train load has insignificant effect. **Figure 4.6 and 4.7** show averaged M-stock train passby vibration and the projected GBN near Heng Fa Chuen Station of Island Line. Red solid line and green solid line represent the spectra averaged from at least 30 train passbys during peak hours (i.e. loaded trains) and non-peak hours (i.e. less loaded trains) respectively. Red dash lines and green dash lines are the spectra +/- standard deviation respectively. Taken into account the variations, there is no significant difference for vibration level during peak and non-peak hours, despite the difference in train loading. There would also be no significant difference for their groundborne noise levels.

Figure 4.2 Ground Vibration Level at 350m downtrack of Tseung Kwan O line

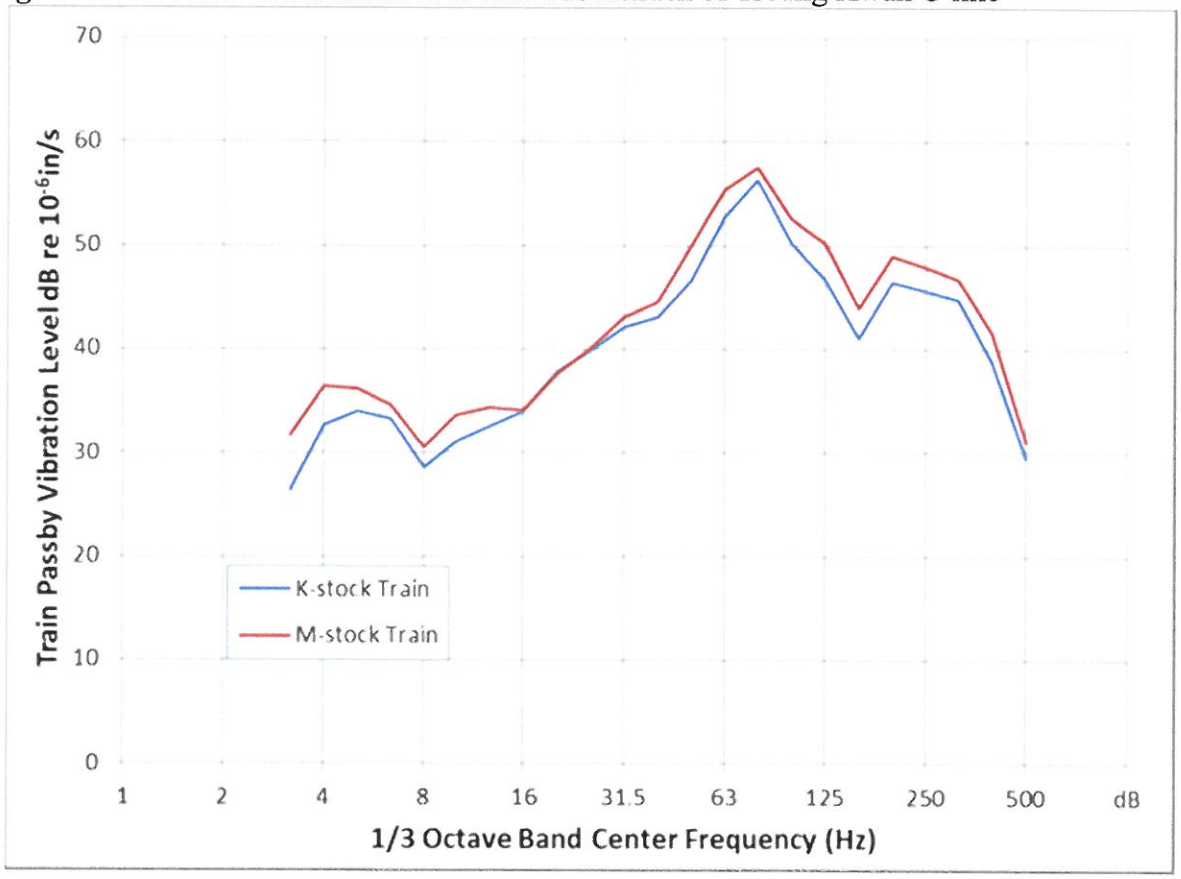


Figure 4.3 Projected GBN at 350m downtrack of Tseung Kwan O line

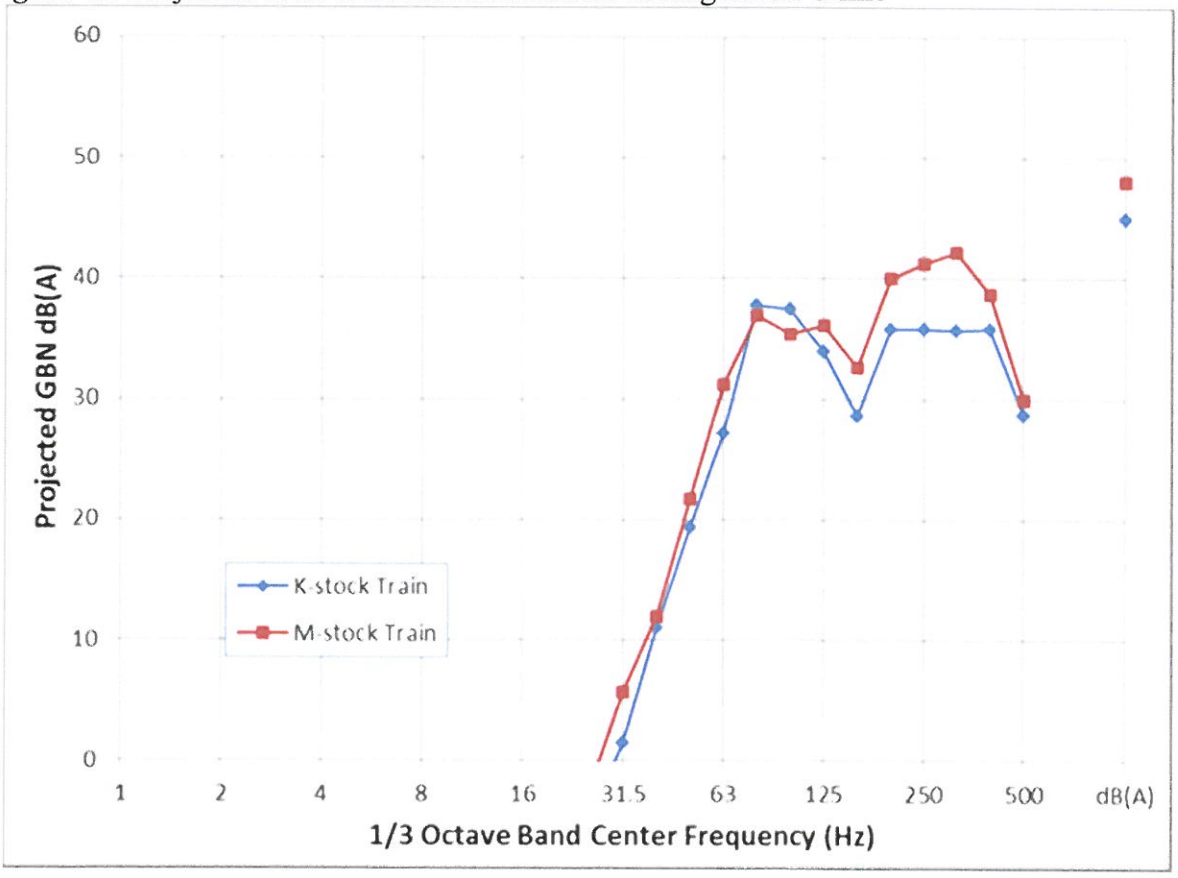


Figure 4.4 Ground Velocity Level at 4850m up-track of Kwun Tong line

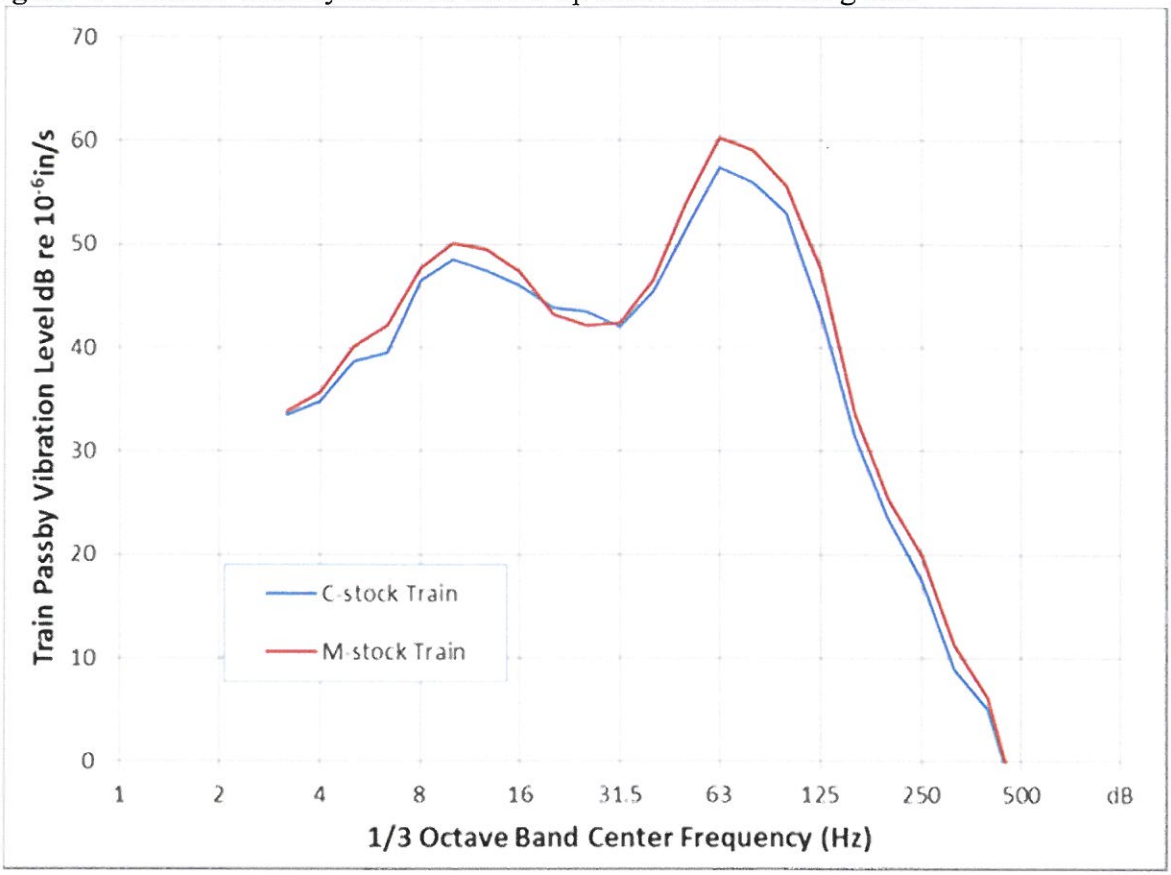


Figure 4.5 Projected GBN at 4850m up-track of Kwun Tong line

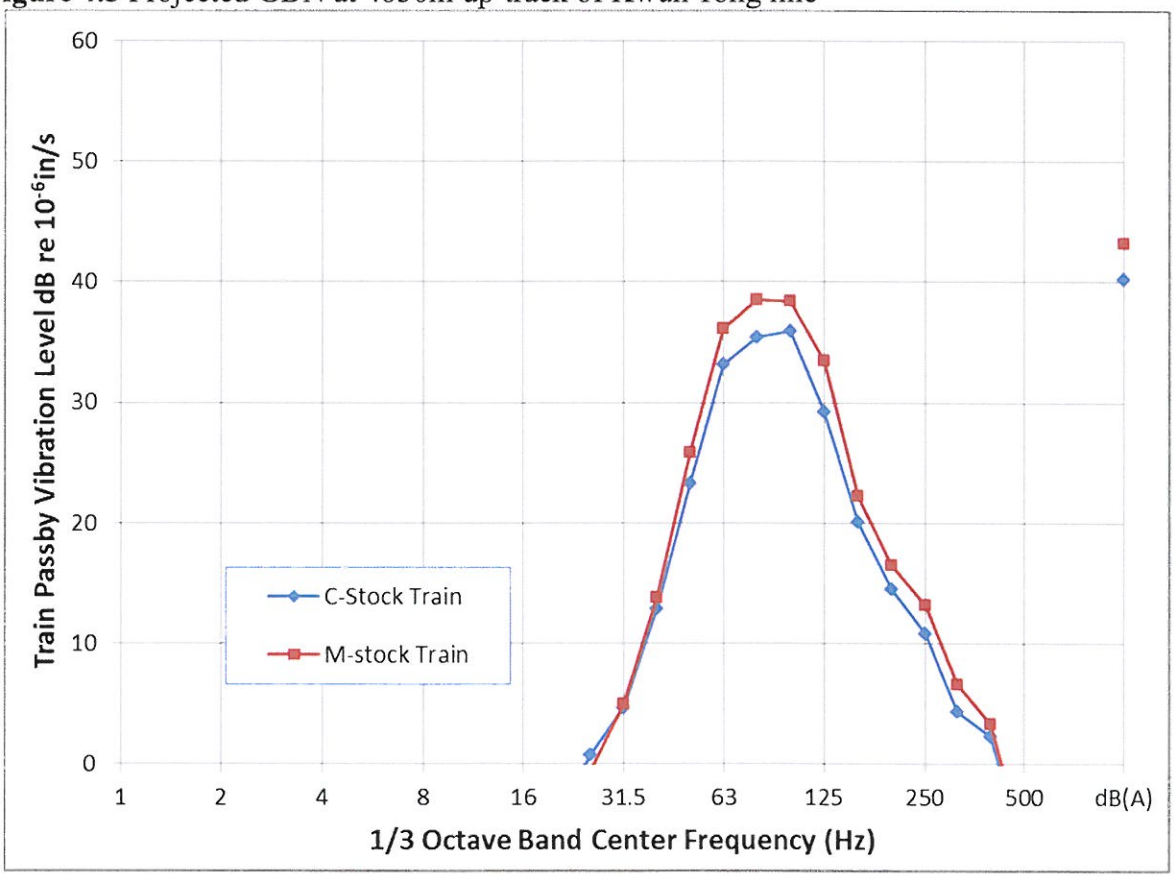


Figure 4.6 Train Passby Vibration Level of M-stock during Peak and Non-peak Hours

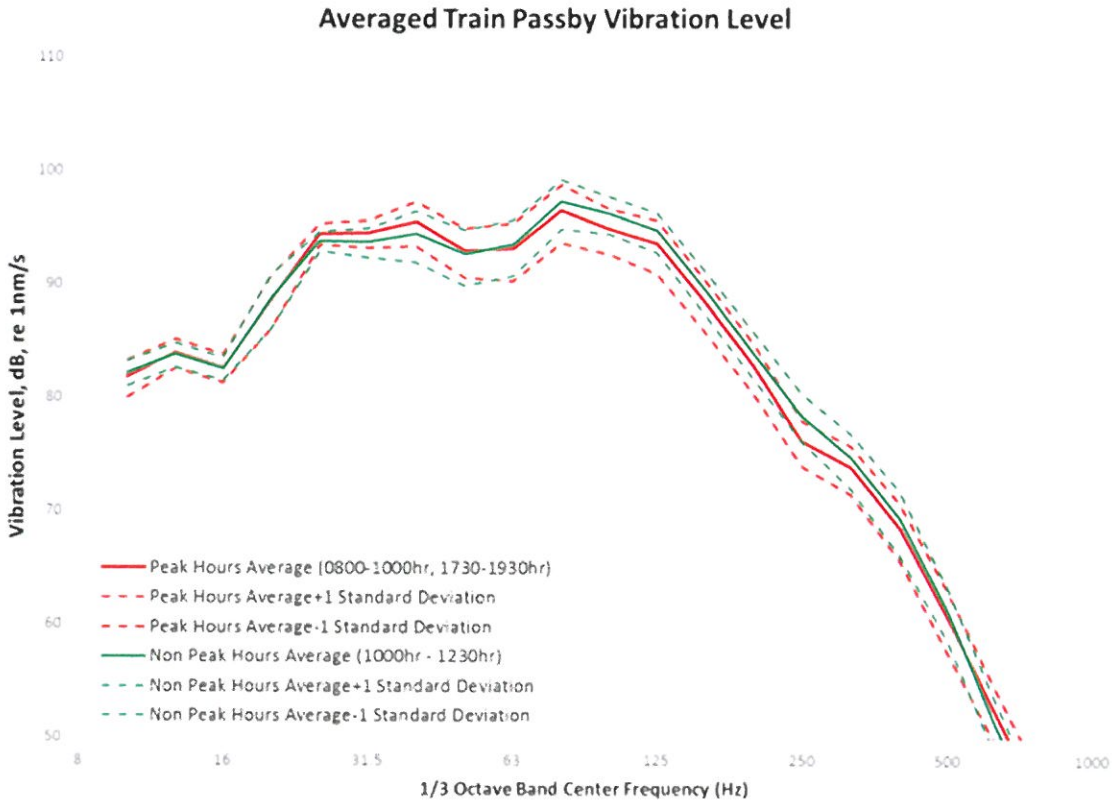
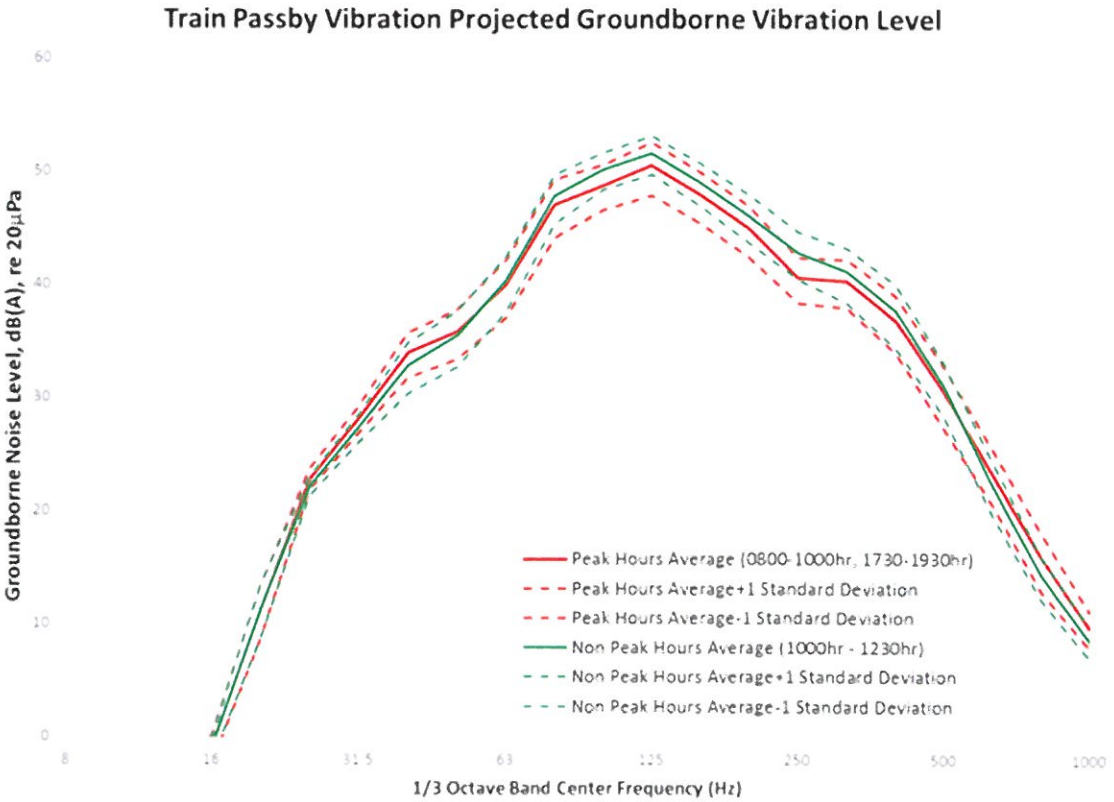


Figure 4.7 Projected GBN of M-stock during Peak and Non-peak Hours



4.4 Tentative Measurement Schedule

Operational GBN performance test is proposed to be conducted 3-4 months prior to the operation of the project. Tentatively the tests would be conducted in late June-mid July subject to availability of possession of tracks after non-traffic hours without affecting daily services of existing lines and scheduling of signalling tests to prepare for line opening.

For each NSR locations, GBN would be measured for train operation in both Eastbound (EB) and Westbound (WB) to assess the cumulative impact. One non-services M-stock would be arranged for the operational test. M-stock trains are regularly maintained by Operations Division of MTR Corporation. For the current performance test, M-stock trains would be free of wheel-flats representing typical operational condition, and run at design operational speed according to the speed profile. Three passbys would be measured at EB and WB respectively. Among the three readings, the maximum Leq,passby will be adopted for the conservative assessment. Further tests will also be conducted for verification if the variations of the results are significant or the results are close to the noise criteria.

Tentative testing schedule is proposed below, subject to the operation arrangement of M-stock test train.

Table 4.2 Tentative Measurement Schedule

Time	Activity
2200 – 0200	Setup at all of the proposed measurement location.
0200 – 0400	Train operation at EB and WB, 3 passbys each.

4.5 Measurement Parameters

Train passby noise and vibration would be logged at 1 second interval including L_{eq} and L_{max}. While noise spectra from 20-500Hz would be extracted to study whether noise environment is affected by train generated structure-borne noise, background adjusted L_{Aeq} in the full audible frequency range would be used to compare with the noise criteria in TM.

A over 60s averaged background noise level would be extracted from the measurement data 180s ahead of each passby. Data analysis process will follow the procedure that descripted in **Section 5**.

5. Assessment Procedures

- A pre-test noise survey would be conducted to find a quietest accessible measurement location within the specified NSRs, as addressed in Section 3.

- In case the background noise already exceed the statutory requirement, background noise measurement will be conducted for minimum 10 minutes to project minimum Leq,30min. A maximum of -3dB(A) background correction would be allowed to avoid over correction and for conservative results. In case the corrected measured noise (BG-3dB(A)) still exceeds statutory requirement, a portable noise enclosure will be employed to insulate extraneous background noise and measure the train induced GBN.

- Based on the recorded vibration level and train running schedule provided by MTR Corporation, extract the train passby data for further analysis.

- Background noise level is determined from averaging the noise level over 60 seconds from the measurement data 180s ahead of each passby.

- Determine the background corrected noise level during train passby. This applies to the entire audible frequency ranging from 20 to 20000Hz.

  Train passby duration would be determined from vibration sensors placed at the monitoring point, and make reference to train running schedule provided by MTR Corporation. Vibration above background indicates train passage. The duration is taken as train length divided by design operational speed.

$$L_{eq,passby} = 10 \times log\left(10^{Leq,during\ passby/10} - 10^{Leq,background/10}\right)$$

  Where $L_{eq,during\ passby}$ is the noise level during train passby
  $L_{eq,background}$ is the background noise level
  $L_{eq,passby}$ is the background corrected noise level

- Obtain the train operation headway during worst case 30 minute operation. Determine the Sound Exposure Level arising from Eastbound and Westbound train operation in 30 minutes.

$$SEL_{EB} = L_{eq,passby,EB} + 10 \times log(T_{EB}) + 10 \times log(N_{EB})$$
$$SEL_{WB} = L_{eq,passby,WB} + 10 \times log(T_{WB}) + 10 \times log(N_{EB})$$

  Where T is the train passby duration and N is number of passby is 30 minutes
  Subscript EB denotes Eastbound and WB denotes Westbound.

- Determine $L_{eq,30min}$ and compare with statuary requirements.

$$L_{eq,30min} = 10 \times log\left(10^{SEL_{EB}/10} + 10^{SEL_{WB}/10}\right) - 10 \times log(1800)$$

Appendix A

Proposed Testing Locations

Figure A1. Proposed Testing Locations

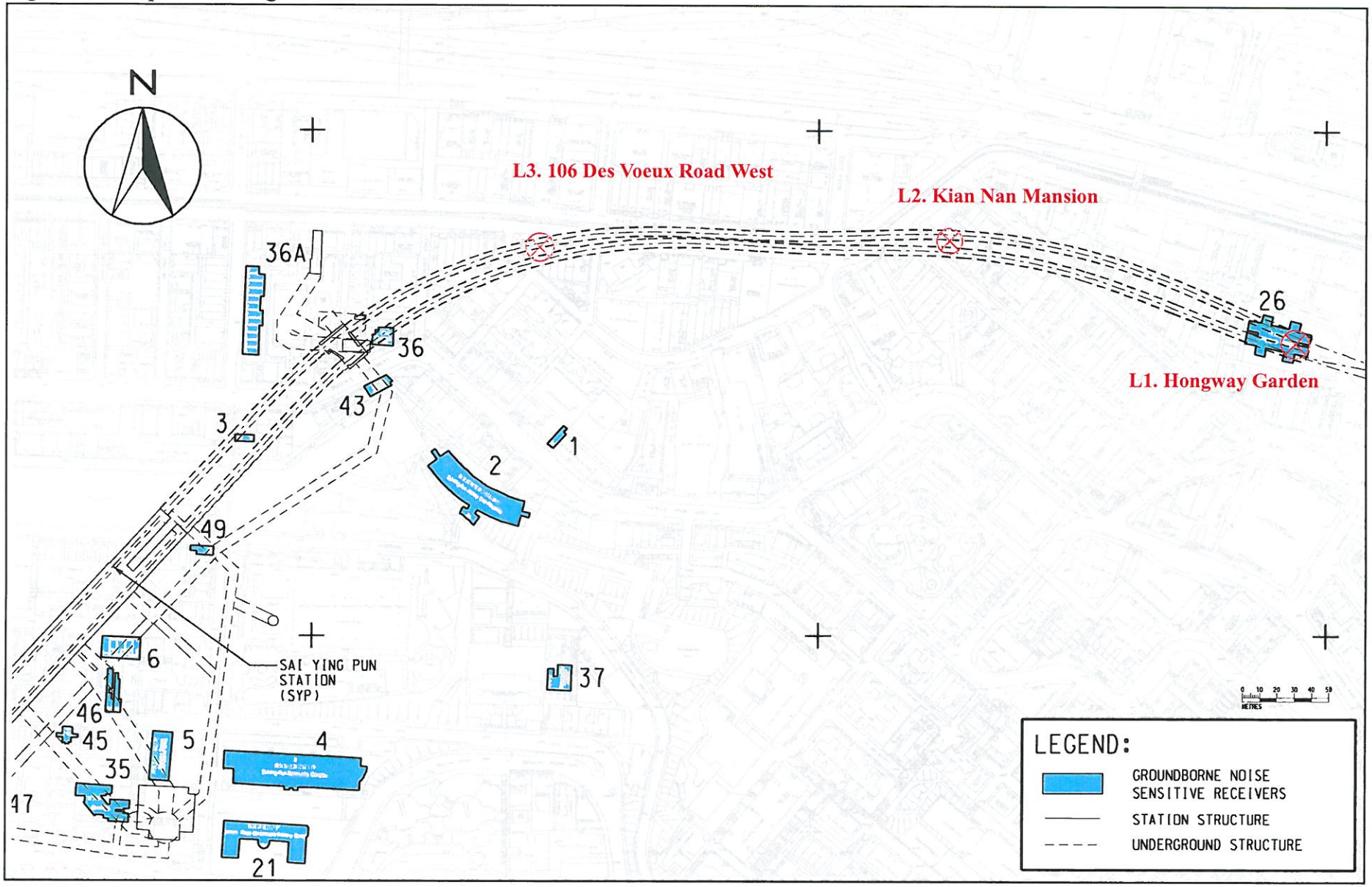


Figure A2. Proposed Testing Locations

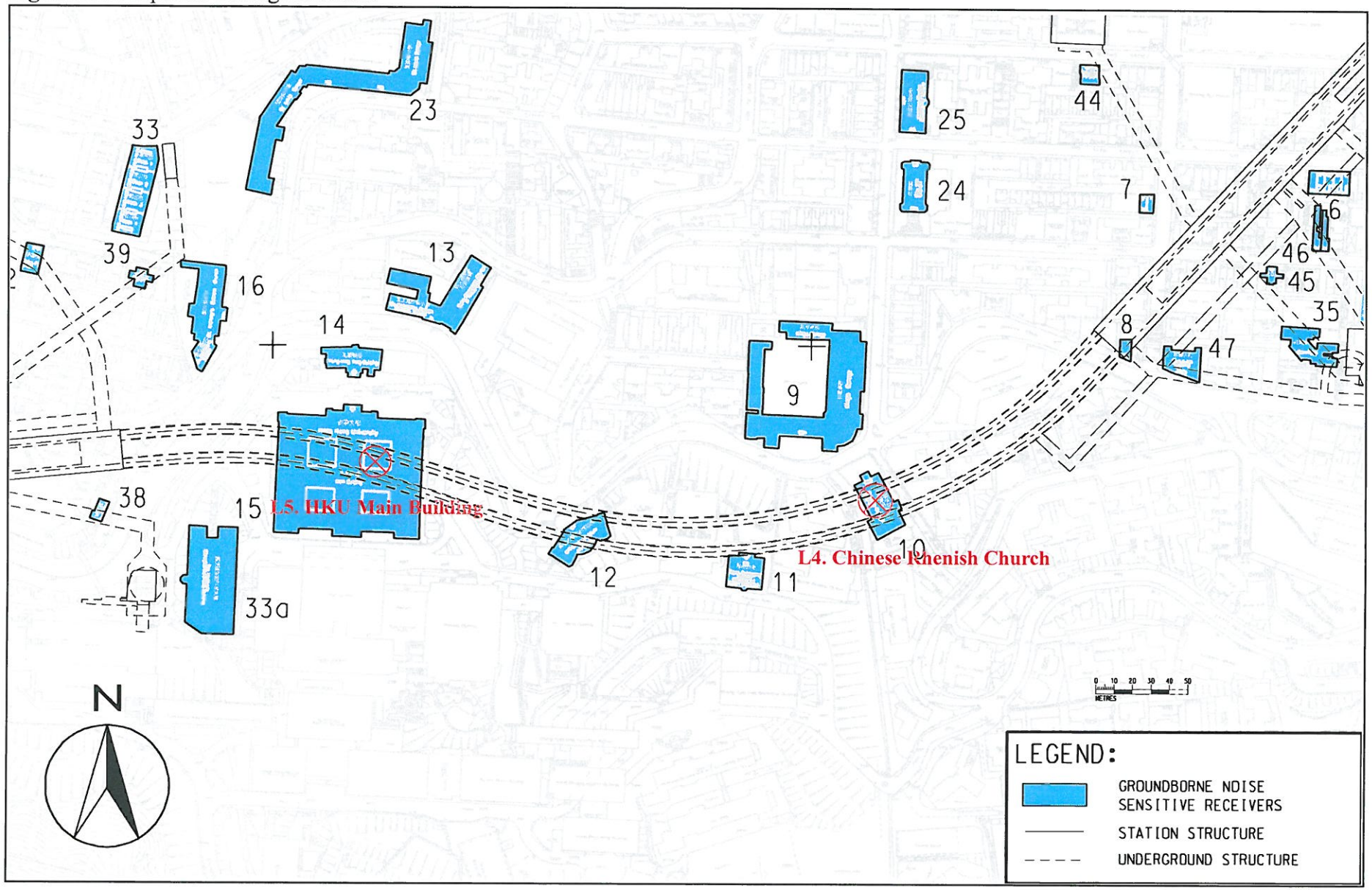
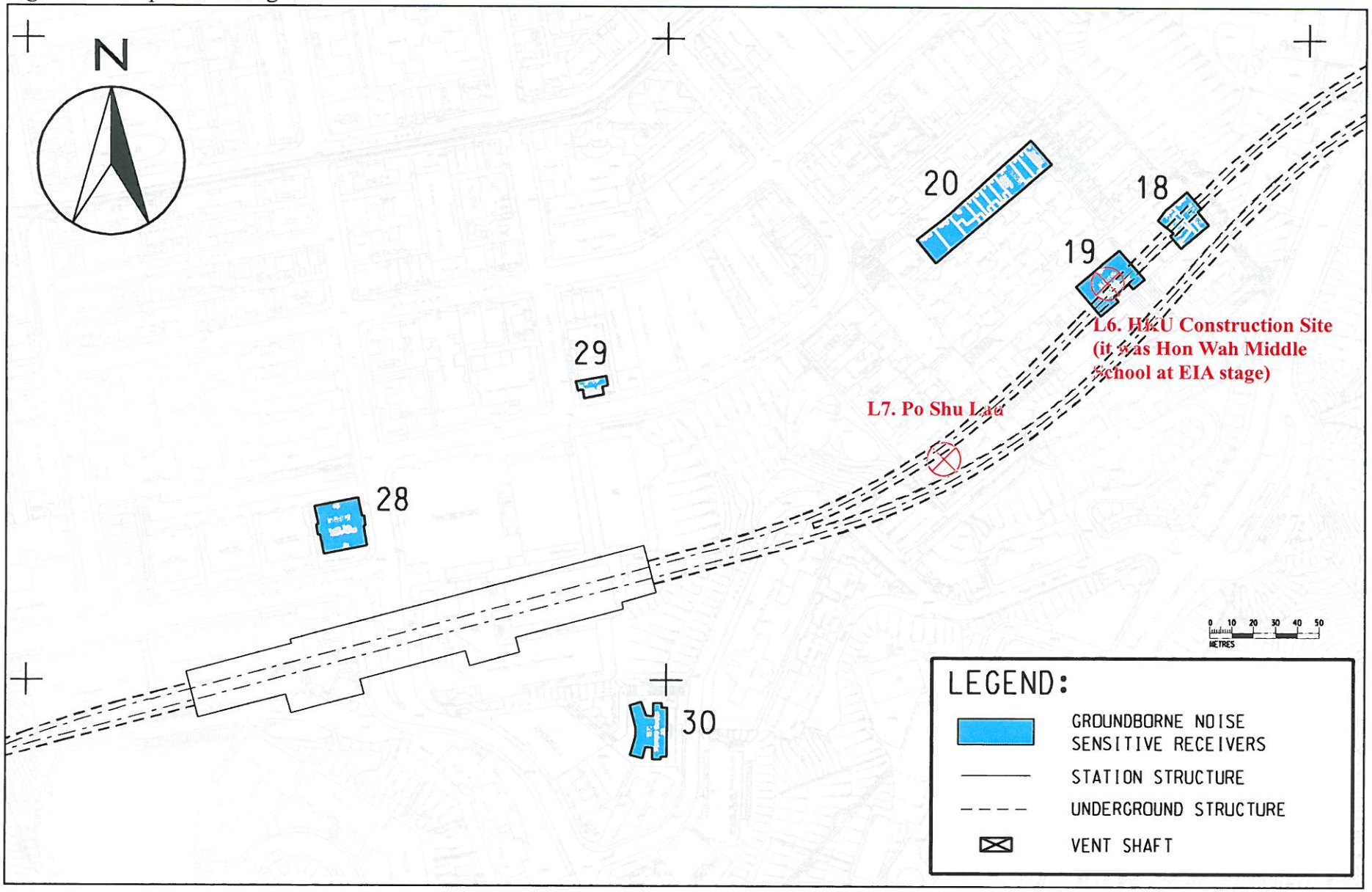


Figure A3. Proposed Testing Locations



Appendix B

Alignment and Geological Profile

Figure B1. Alignment and Geological Profile Westbound Sheet 1

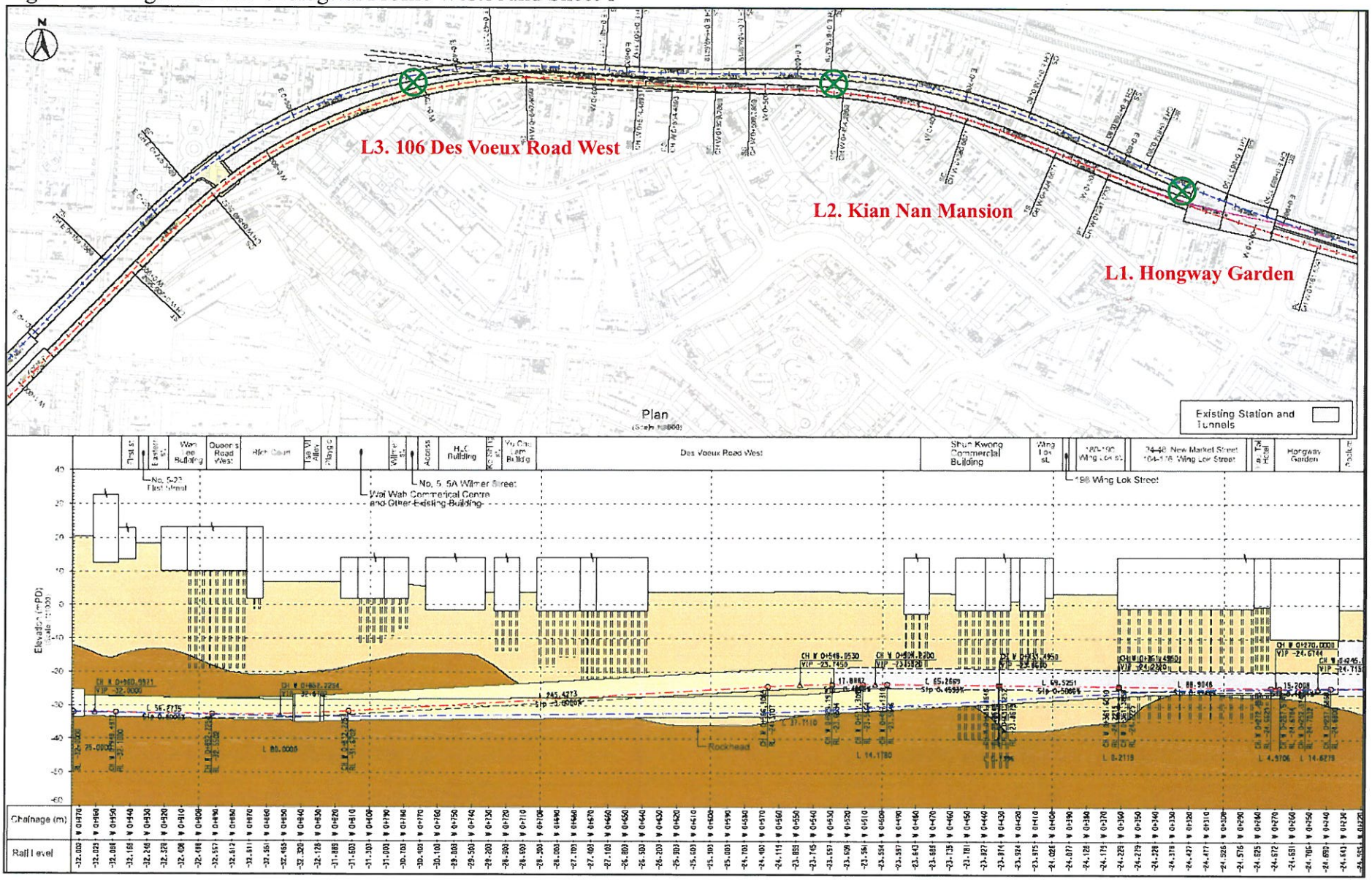


Figure B2. Alignment and Geological Profile Eastbound Sheet 1

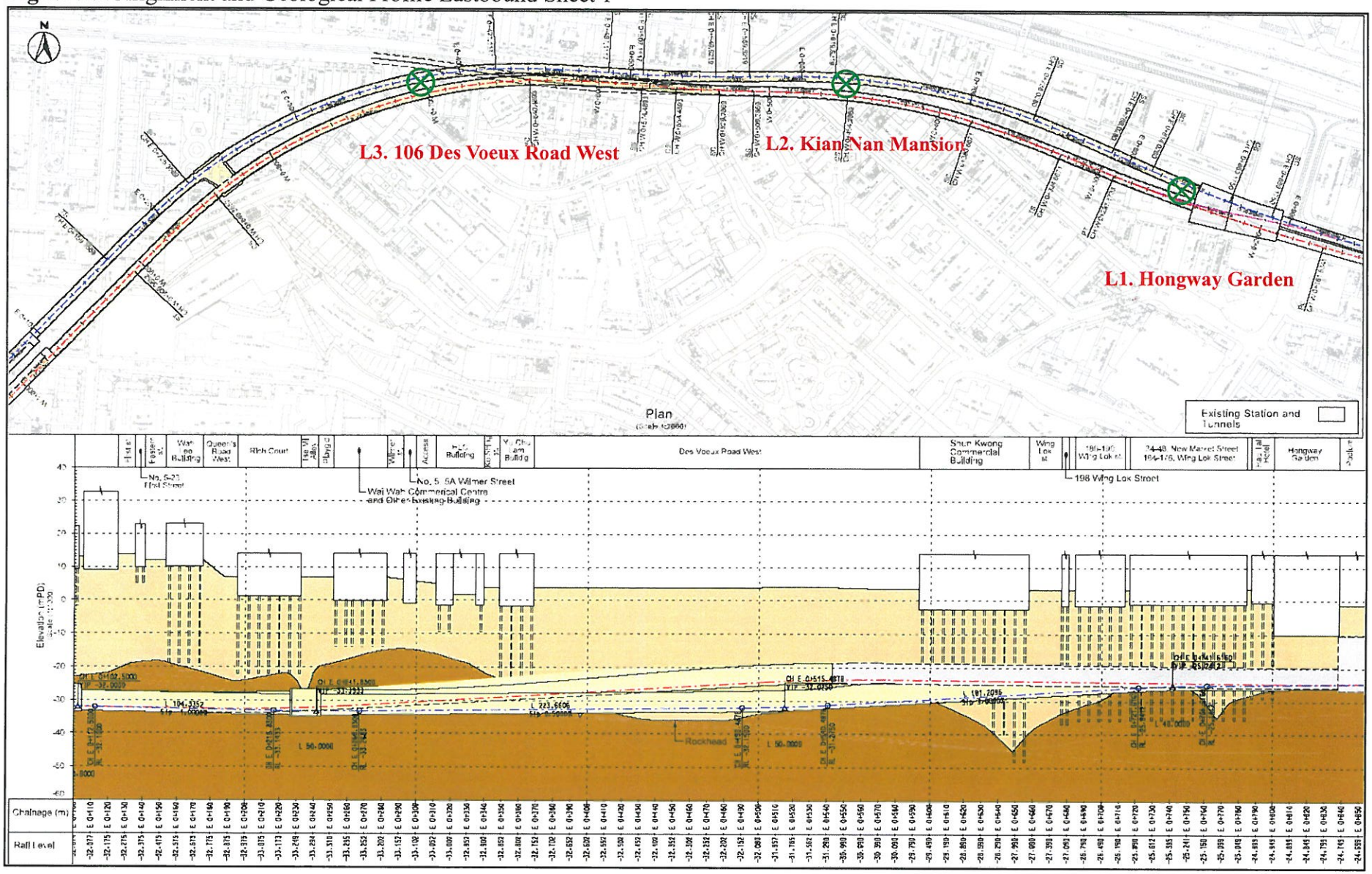


Figure B3. Alignment and Geological Profile Westbound Sheet 2

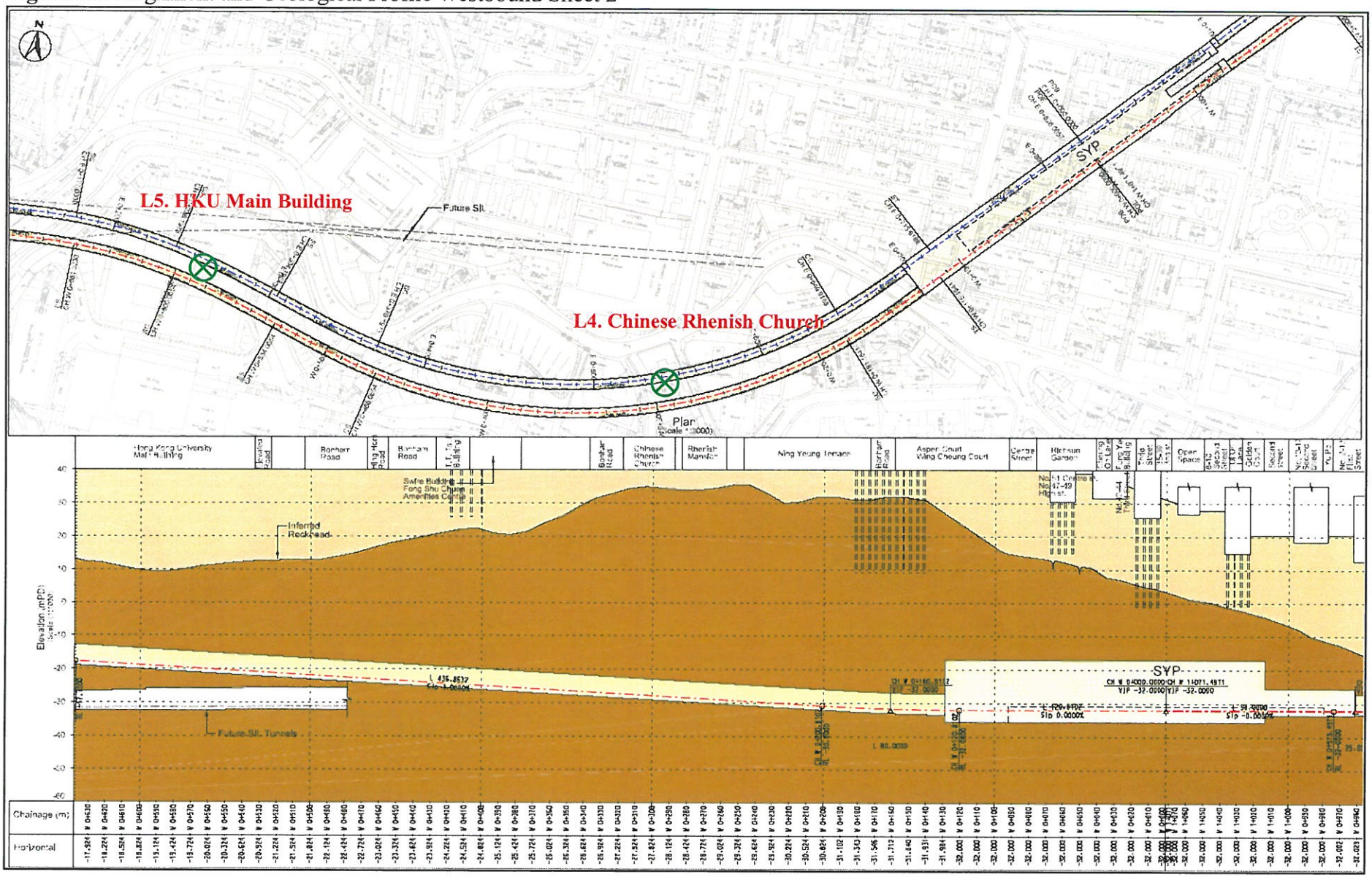


Figure B4. Alignment and Geological Profile Eastbound Sheet 2

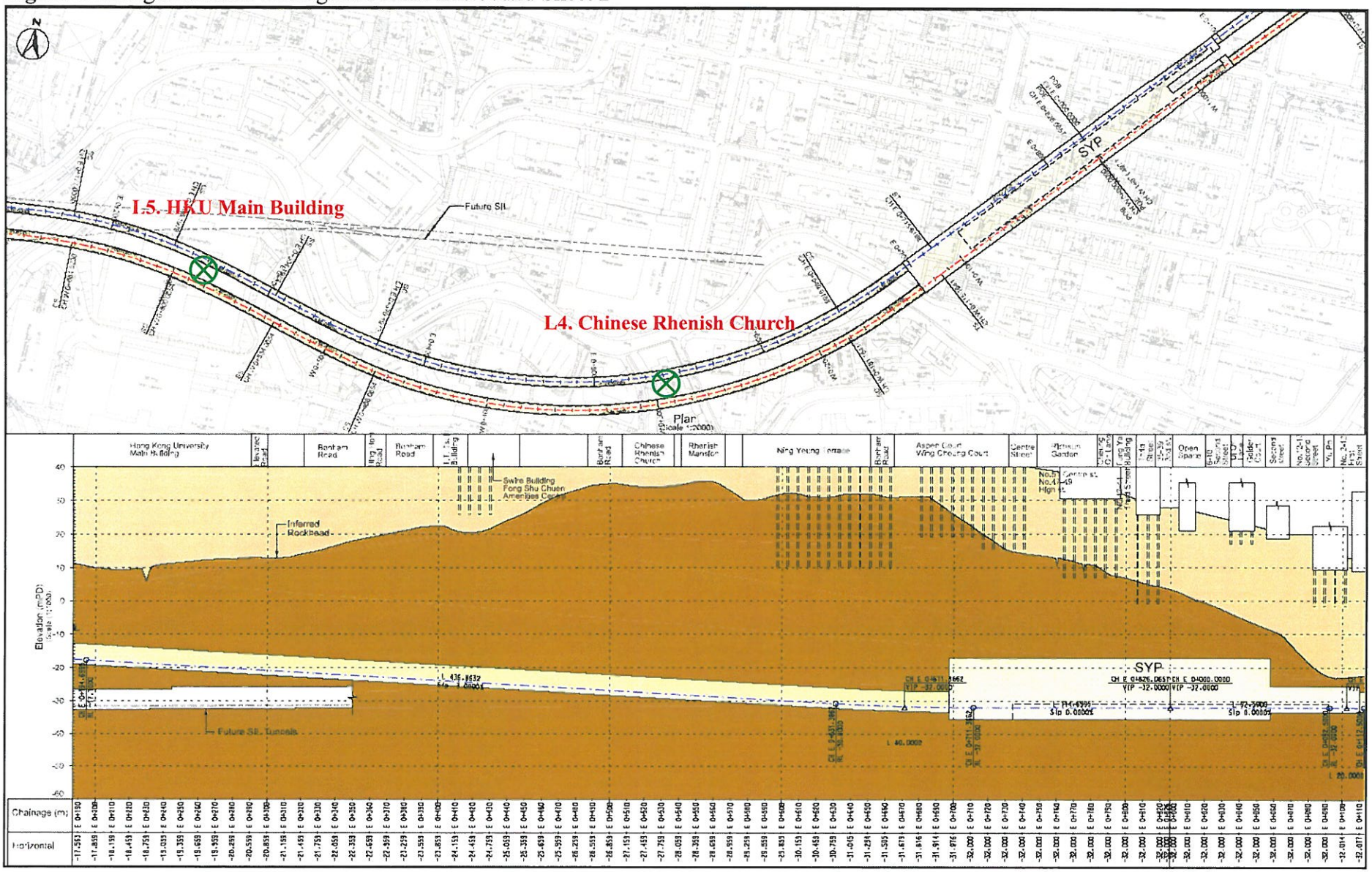


Figure B5. Alignment and Geological Profile Westbound Sheet 3

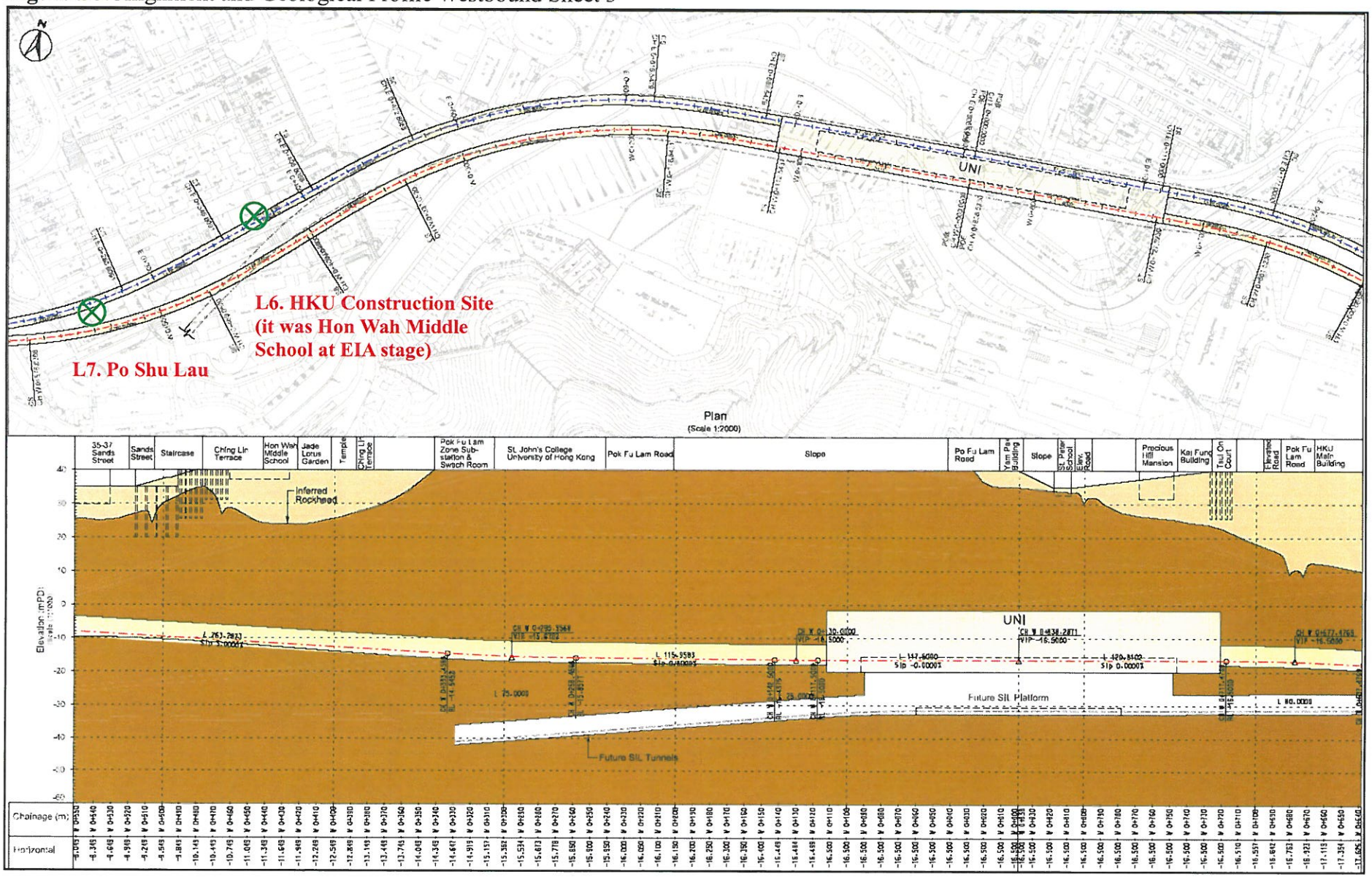


Figure B6. Alignment and Geological Profile Eastbound Sheet 3

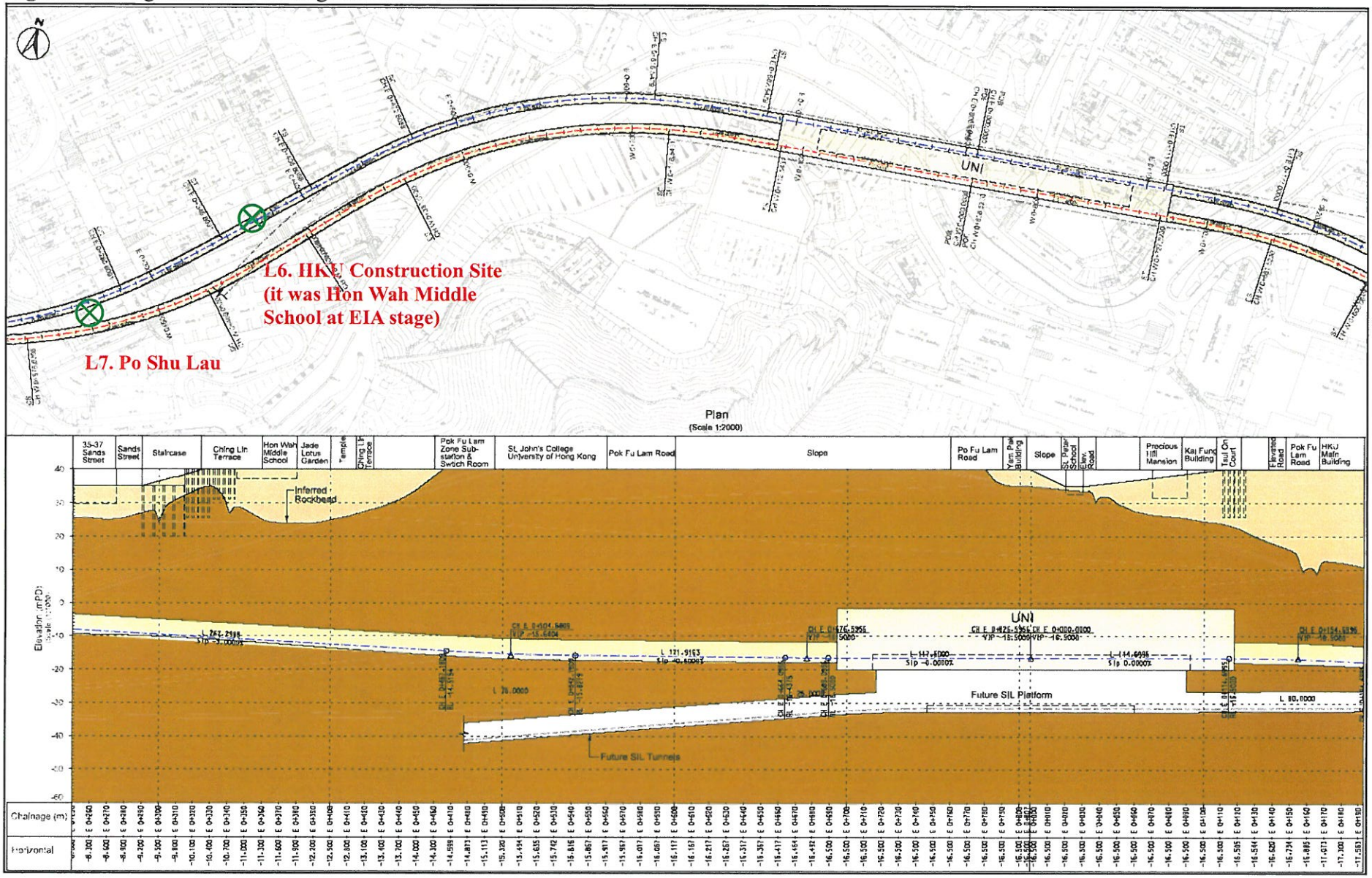


Figure B7. Alignment and Geological Profile Westbound & Eastbound Sheet 4

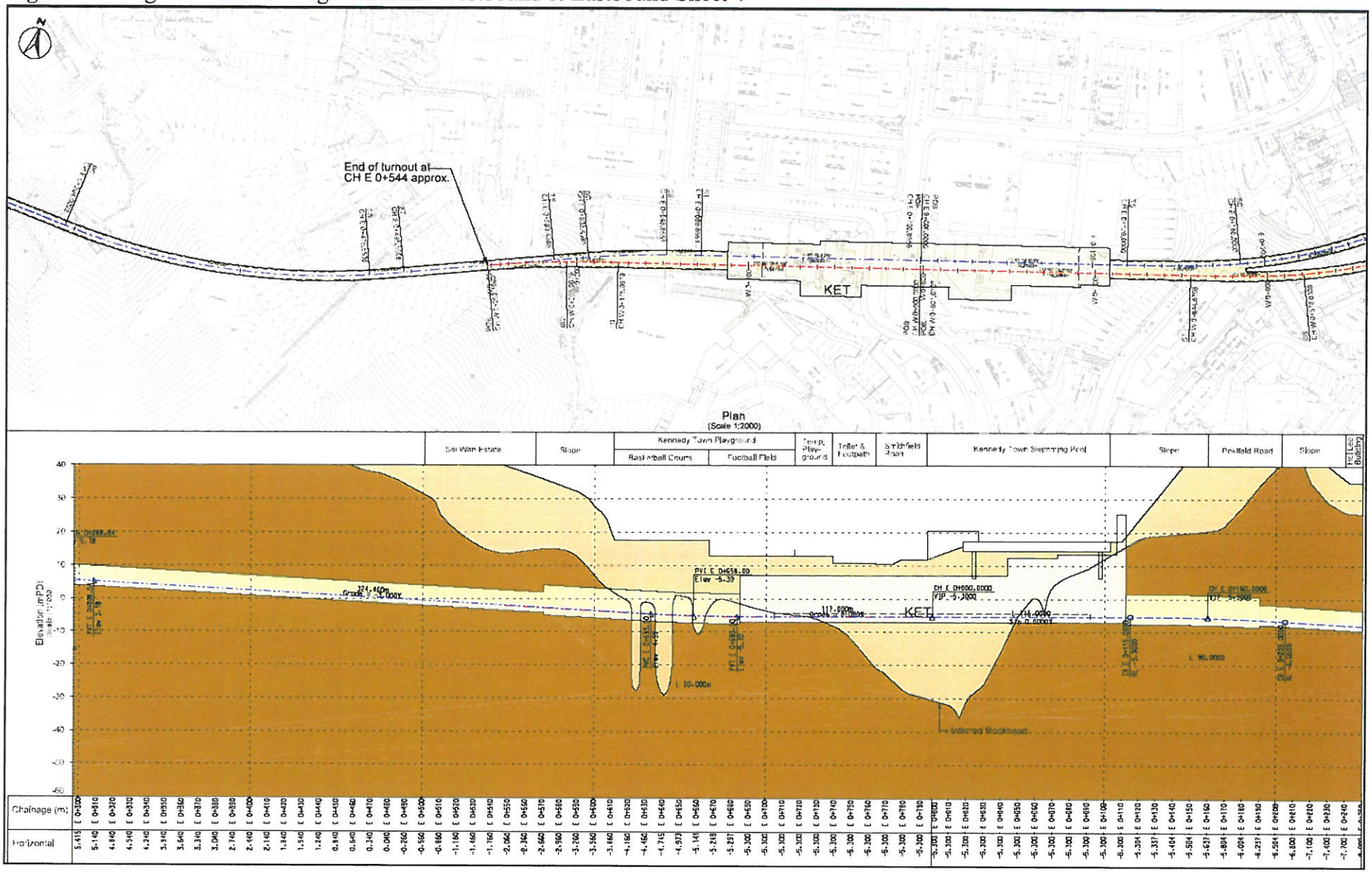
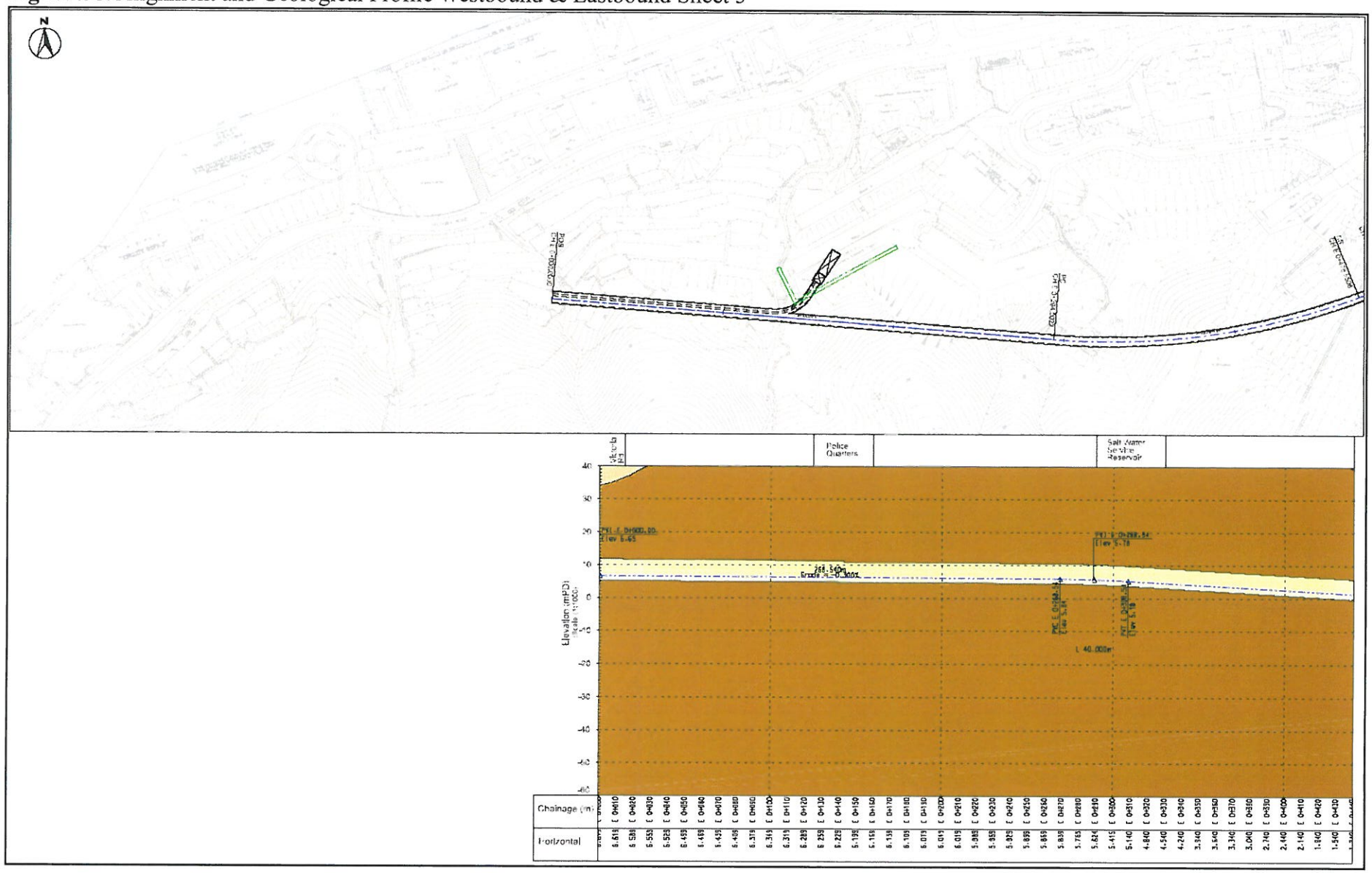


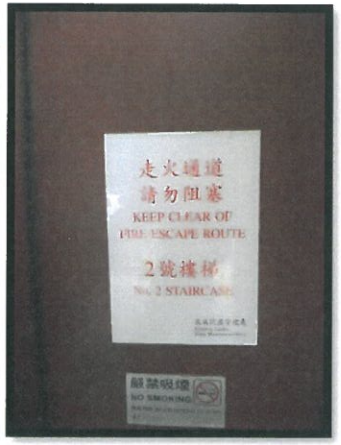
Figure B8. Alignment and Geological Profile Westbound & Eastbound Sheet 5

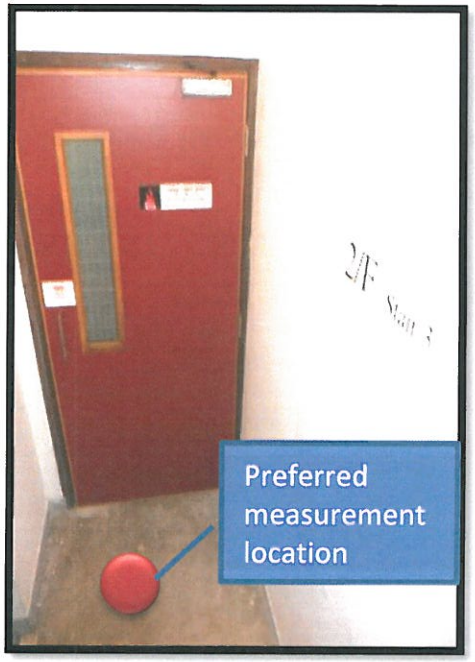


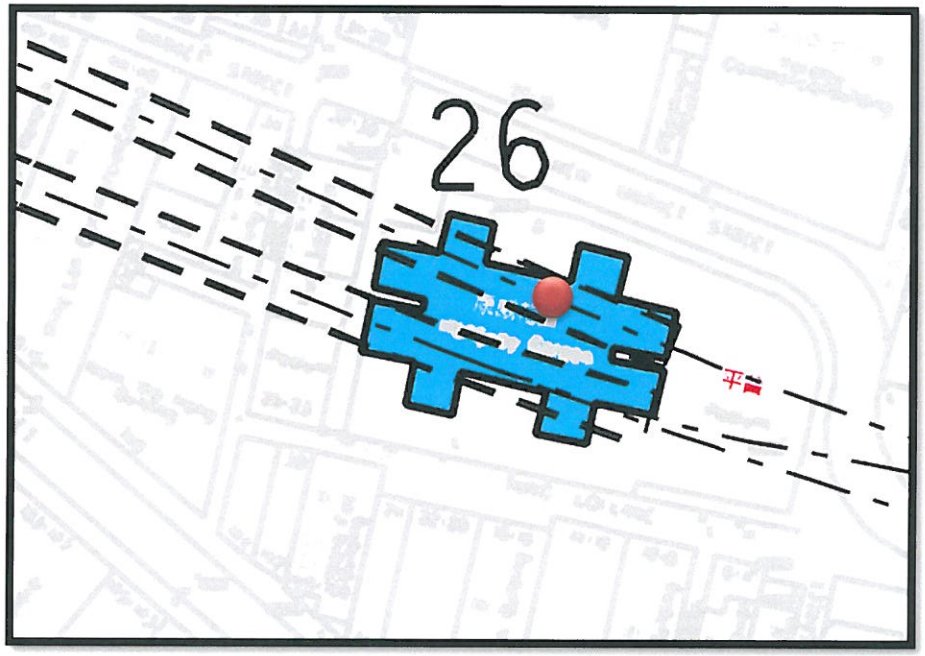
Appendix C

Site Survey Photos and Plan Drawings

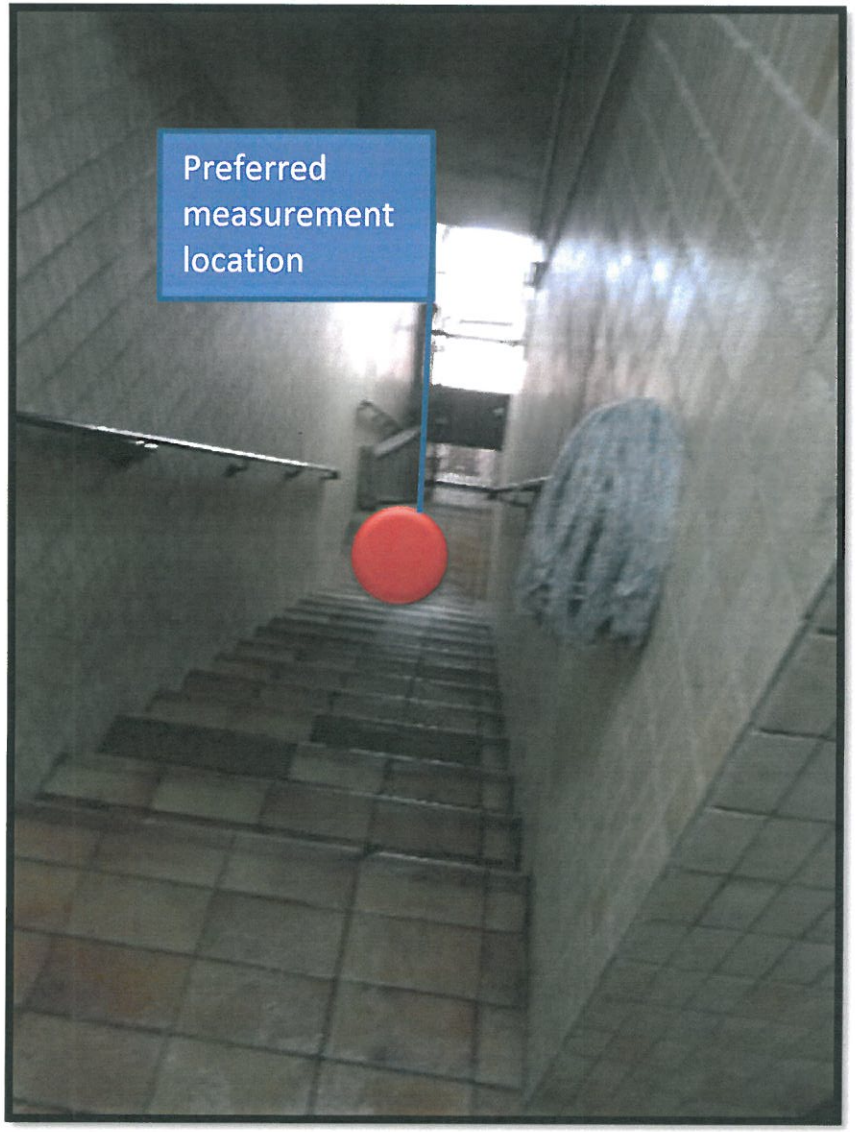
Appendix C1. Proposed Location L1 Site Surv ey Photos and Plan Drawings

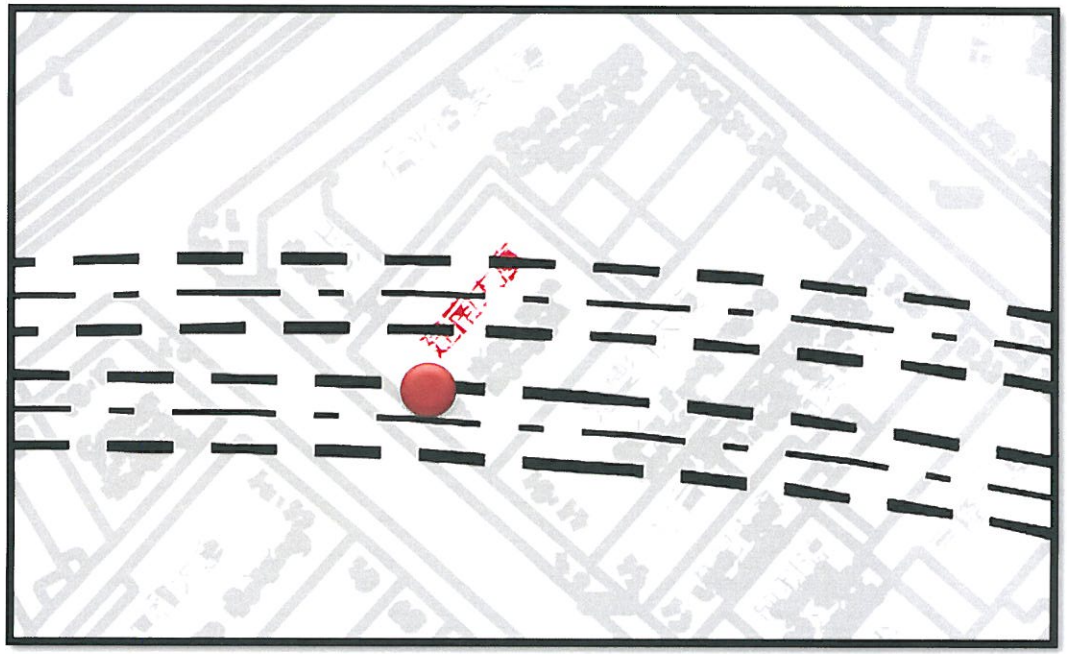




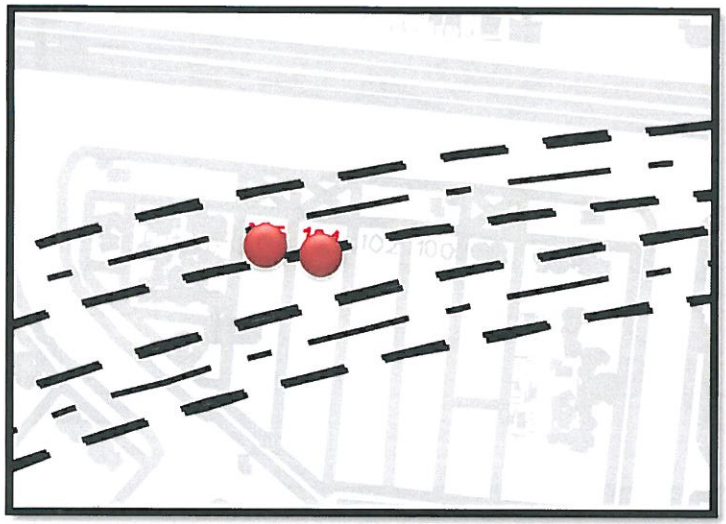


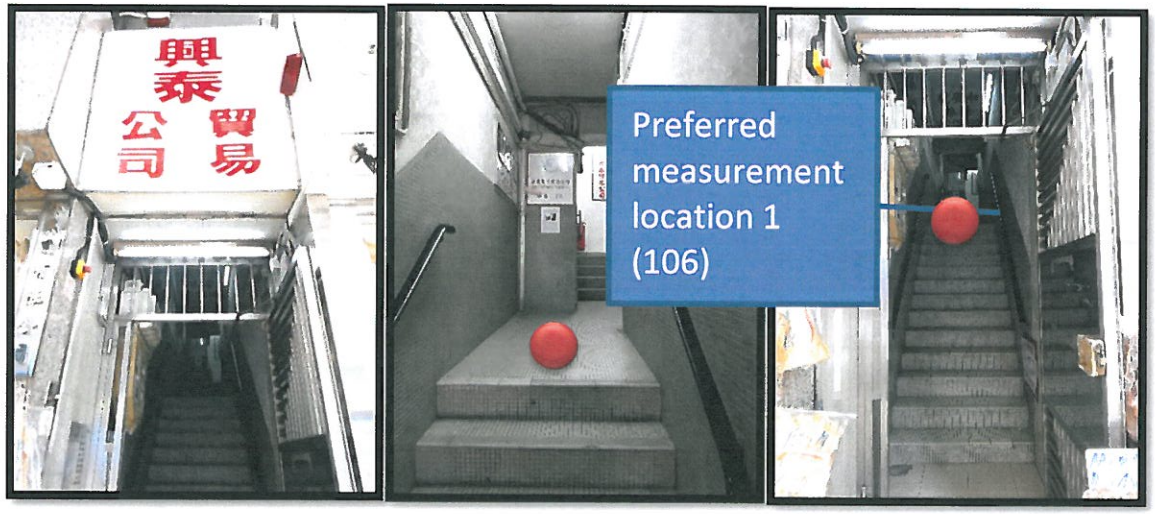
Appendix C2. Proposed Location L2 Site Survey Photos and Plan Drawings

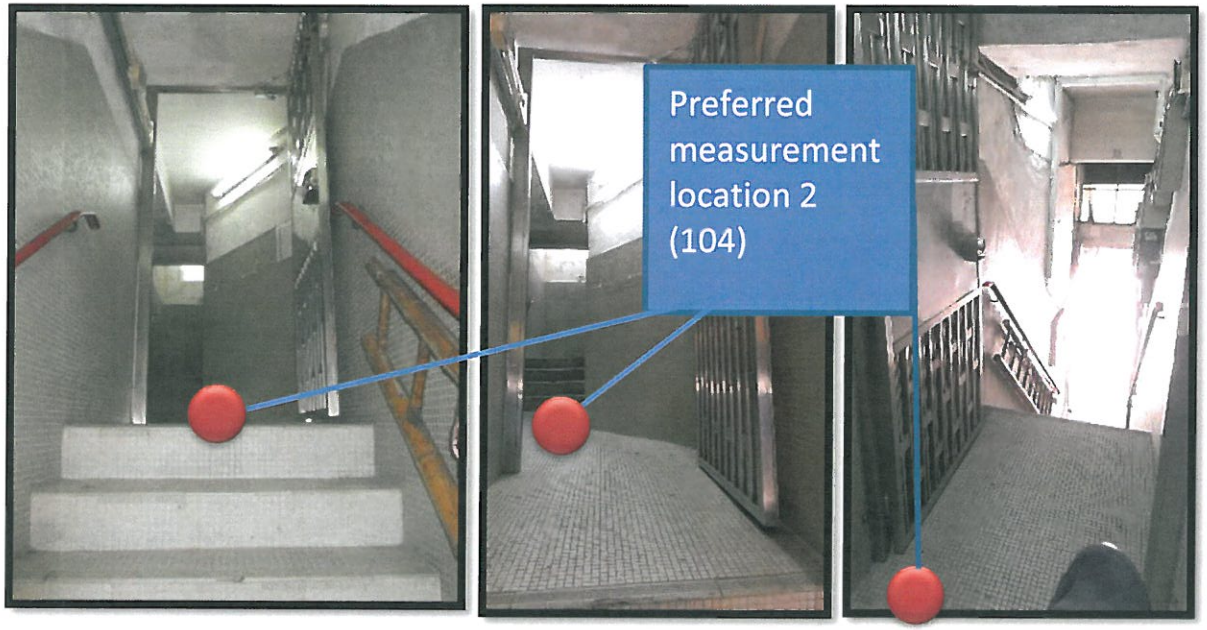




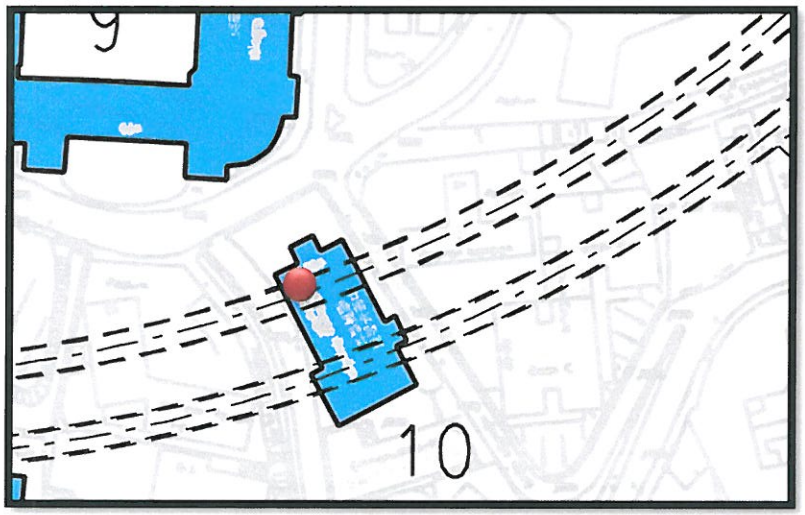
Appendix C3. Proposed Location L3 Site Survey Photos and Plan Drawings



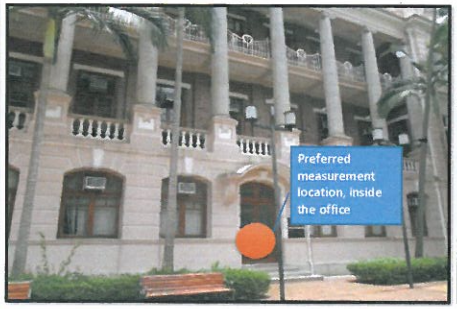

興泰貿易公司
Preferred measurement location 1 (106)

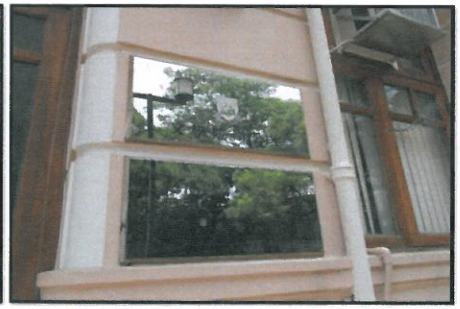

Preferred measurement location 2 (104)

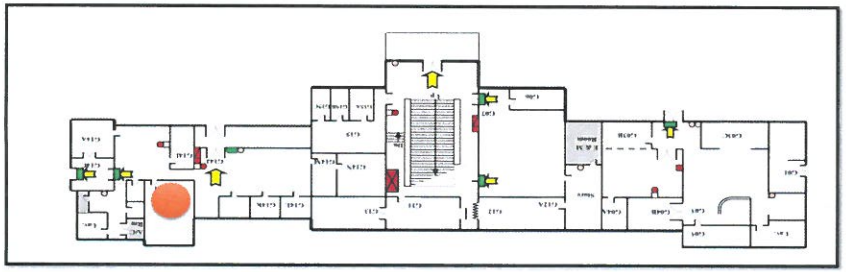
Appendix C4. Proposed Location L4 Site Survey Photos and Plan Drawings

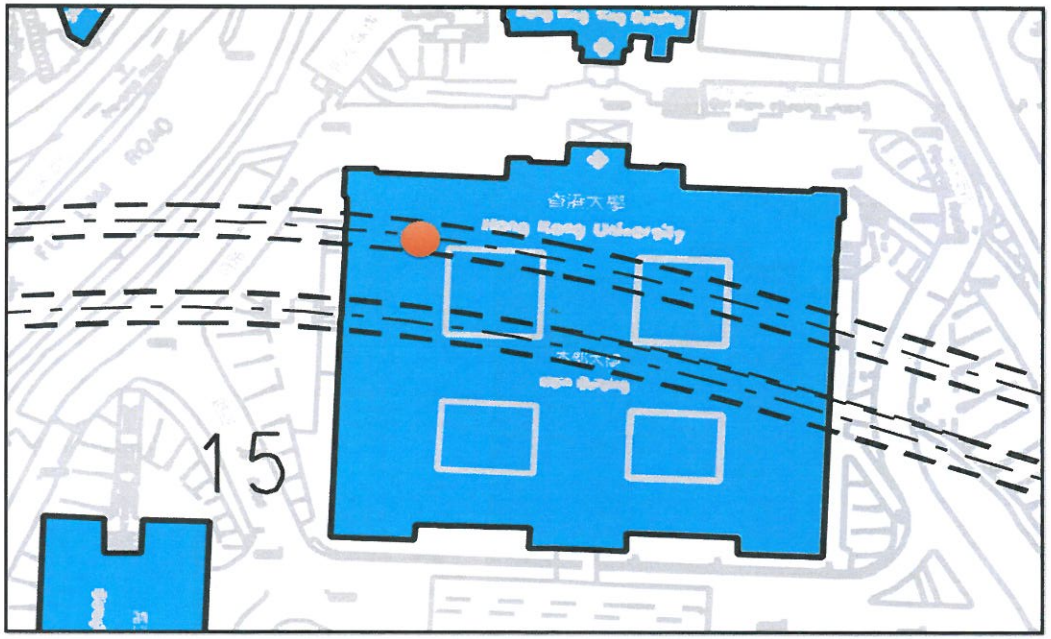


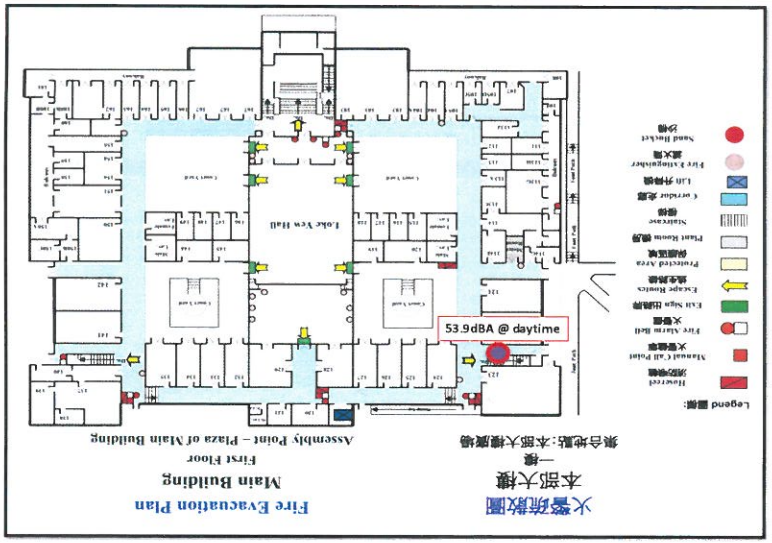
Appendix C5. Proposed Location L5 Site Survey Photos and Plan Drawings



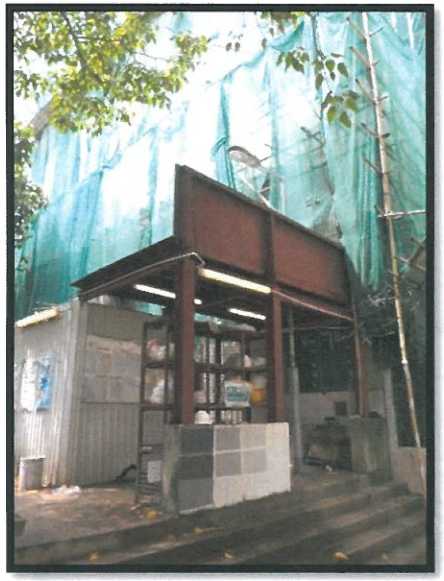


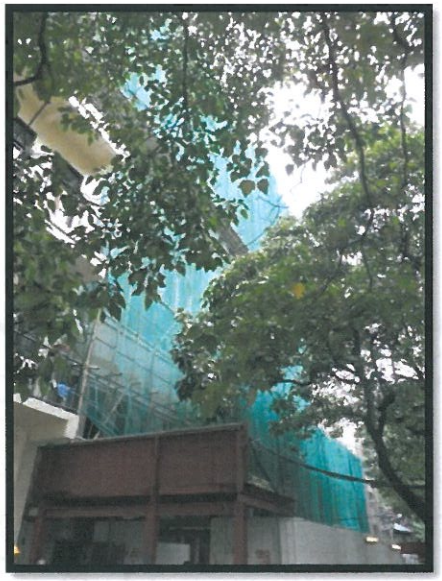


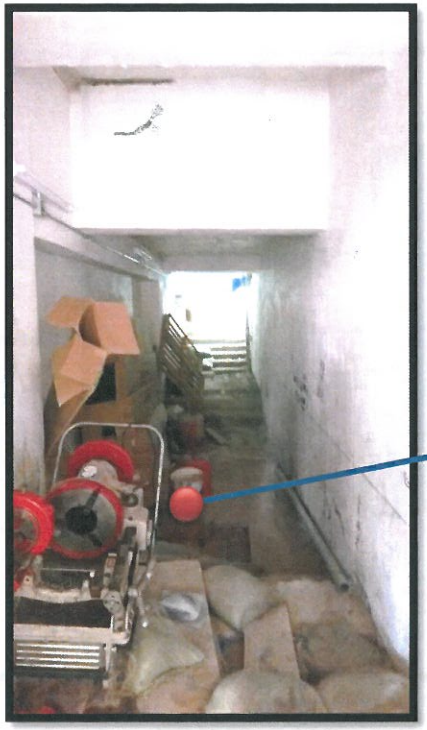




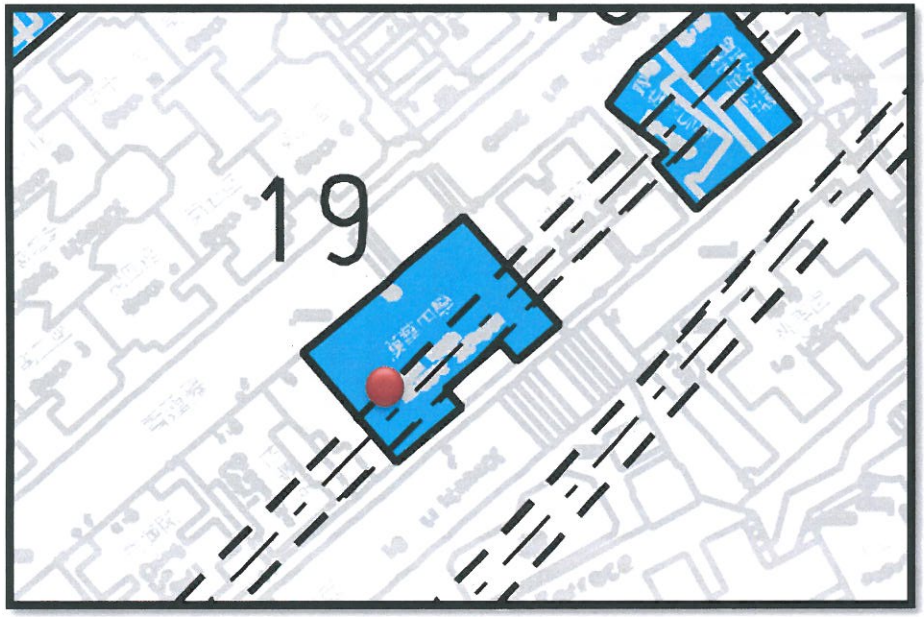
Appendix C6. Proposed Location L6 Site Survey Photos and Plan Drawings







Preferred measurement location, inside the building



Appendix C7. Proposed Location L7 Site Survey Photos and Plan Drawings