10. GROUNDBORNE NOISE IMPACT

Introduction

10.1 Potential ground-borne noise impacts likely arising from the construction and operation of the Project have been evaluated and assessed in this section.

Environmental Legislation, Standards and Guidelines

Construction Phase

10.2 Construction ground-borne noise is under the control of the Noise Control Ordinance (NCO), the Environmental Impact Assessment Ordinance (EIAO), and their subsidiary Technical Memorandum.

10.3 Noise arising from the general construction works of the Project during normal daytime hours (0700-1900 except general holidays and Sunday) is governed by the EIAO-TM. With reference to the Technical Memorandum for the Assessment of Noise from Places Other Than Domestic Premises, Public Places or Construction Sites (IND-TM) under the NCO, the criteria for noise transmitted primarily through the structural elements of the building or buildings are expected to be 10dB(A) less than the relevant acceptable noise level (ANL). These criteria apply to all residential buildings, schools, clinics, hospitals, temples and churches.

10.4 In the restricted hours (i.e. between 1900 and 0700 on a normal working day or at any time on a general holiday and Sunday), the construction noise is controlled by the Technical Memorandum on Noise from Construction Work other than Percussive Piling (GW-TM). Similarly, the ground-borne noise criteria is limited to 10dB(A) below the respective ANL. A Construction Noise Permit (CNP) is required for construction activities involving the use of PME carried out in restricted hours.

10.5 The construction ground-borne noise criteria for the identified ground-borne noise sensitive receivers (NSR) are tabulated in **Table 10.1** below.

Table 10.1 Construction Ground-borne Noise Criteria

NSR/Assessment Description	Ground-borne Noise Criteria, $L_{eq\ 30\ min}$ dB(A) [a]		
	Daytime (0700-1900 hrs) (except General Holidays & Sunday)	Daytime during general holidays and Sundays and all days during Evening (1900 to 2300 hrs)	Night (2300 to 0700 hrs)
Domestic premises, hotels and service apartments	65	55	40
Schools [b]	60/55 [c]	55	[b]
The Hong Kong Academy for Performing Arts (HKAPA) [d]	60/55 [c]	55	[b]

Note:
[a] Ground-borne noise is deemed not to be affected by external factors. Thus, an Area Sensitivity Rating of B is used to determine the appropriate criteria during restricted hours.
[b] No sensitive use/activity during this period.
[c] A 5dB(A) reduction to the ground-borne noise criteria is recommended for schools during the examination period.
[d] HKAPA is currently used as performing arts centre and provides professional education, training and research facilities in the performing arts, theatre and entertainment arts, film and television. With a similar nature of education, tutoring, communication and rehearsal in both performing arts centre and education institution, a criterion for educational use is considered appropriate for HKAPA.

10.6 The administrative and procedural control of all blasting operations in Hong Kong is vested in the Mines Division of the Civil Engineering and Development Department (CEDD). The Dangerous Goods (General) Regulations, Chapter 295 also stipulates that no person shall carry out blasting unless he possesses a valid mine blasting certificate to be issued by the Mines Division of CEDD. The Superintendent of Mines will review the application on a case-by-case basis before issuing the Mine Blasting Certificate.

Operation Phase

10.7 With reference to the IND-TM, the criteria for noise transmitted primarily through the structural elements of the building or buildings is 10dB(A) less than the relevant acceptable ANL. The same criteria are applied to all residential buildings, schools, clinics, hospitals, temples and churches. The criteria applied for assessment of ground-borne noise are summarised in **Table 10.2** below.

Table 10.2 Operation Ground-borne Noise Criteria

Type of NSR	Ground-borne Noise Criteria, ($L_{eq\ 30\ min}$ dB(A))	
	Day & Evening (0700 to 2300 hrs)	Night (2300 to 0700 hrs)
Domestic premises (including hotels and service apartments)	55	45
Churches, Schools and Clinics	55	[a]
HKAPA	55 [b]	[a]

Note:
[a] No sensitive use/activity during this period.
[b] HKAPA is currently used as performing arts centre and provides professional education, training and research facilities in the performing arts, theatre and entertainment arts, film and television. With a similar nature of education, tutoring, communication and rehearsal in both performing arts centre and education institution, a criterion for educational use is considered appropriate for HKAPA.

Description of the Existing Environment

10.8 The Project runs from the south of the proposed Hung Hom Station (HUH) across the Victoria Harbour to the Causeway Bay Typhoon Shelter (CBTS), Exhibition Station (EXH) and then to Admiralty Station (ADM).

10.9 The Project area in Hung Hom is located in well developed urban areas. The surrounding land uses mainly comprise a mixture of commercial, Government/Institution/Community and residential uses. Dominant noise sources identified were the traffic noise from Hong Chong Road, Chatham Road South, Chatham Road North, Cheong Tung Road South, Cross Harbour Tunnel, etc.

Identification of Ground-borne Noise Sensitive Receivers

10.10 The SCL (HUH – ADM) runs from the north of the North Ventilation Building, Plant Rooms and Emergency Access (NOV) at Hung Hom side, across the Victoria Harbour to the new EXH and ADM. To evaluate the ground-borne noise impacts from the Project during construction and operation phases, representative existing and planned/committed NSRs within 300m from the Project (i.e. Study Area), were identified in accordance with Section 3 of Annex 13 of the EIAO-TM, observations from site visits and relevant land use plans such as Outline Zoning Plans.

Construction Phase

10.11 Potential ground-borne noise impacts during construction phase of the Project would arise mainly from the PME for rock breaking/drilling works (such as hydraulic breaker, rock drill, pile rig, etc) and tunnel boring machine (TBM).

10.12 Under the assumption of worst-case scenario, representative NSRs were identified for the assessment of construction ground-borne noise impact due to the TBM operation and the use of PME for rock breaking/drilling works. The identified representative NSRs are presented in **Table 10.3** and shown in **Figure Nos. NEX2213/C/331/ENS/M52/001** to **NEX2213/C/331/ENS/M52/004**.

Table 10.3 Representative Noise Sensitive Receivers for Construction Ground-borne Noise Assessment

NSR ID	Description	Uses	Horizontal Distance to the Work Site(s) (m)	Nearest Site
Kowloon Side				
HH9	Harbourfront Horizon	Service Apartment	220	Hung Hom Landfall
Hong Kong Side				
CH2	Hoi Kung Court	Residential	60	South Ventilation Shafts, Plant Rooms and Emergency Access (SOV), TBM Launching Shaft
			48	Tunnel Construction by TBM
CH3	Elizabeth House, Block C	Residential	60	Tunnel Construction by TBM
EX2	Renaissance Harbour View Hotel	Hotel	30	Tunnel Construction by Cut & Cover Method
EX3	Grand Hyatt Hotel	Hotel	30	Tunnel Construction by Cut & Cover Method
EX4	HKAPA	Educational	40	Tunnel Construction by TBM
AD4	Island Shangri-La Hotel	Hotel	Immediately above work site(s)	Tunnel Construction by Drill and Blast

Operation Phase

10.13 Representative NSRs for the assessment of operational ground-borne noise impact have been identified and are presented in **Table 10.4** and their locations are illustrated in **Figure Nos. NEX2213/C/331/ENS/M52/101** to **NEX2213/C/331/ENS/M52/103**.

Table 10.4 Representative Noise Sensitive Receivers for Operational Ground-borne Noise Assessment

NSR ID	Description	Land Use	No. of storey	Area Sensitive Rating
Kowloon Side				
HH9b	Harbourfront Horizon	Service Apartment	22	B [a]
Hong Kong Side				
CH2	Hoi Kung Court	Residential	19	B [a]
CH3	Elizabeth House, Block C	Residential	21	B [a]
EX2	Renaissance Harbour View Hotel	Hotel	42	B [a]
EX3	Grand Hyatt Hotel	Hotel	34	B [a]
EX4	HKAPA	Educational	8	B [a]
AD4	Island Shangri-La Hotel	Hotel	56	B [a]

Note:
[a] Ground-borne noise is deemed not to be affected by external factors. Thus, an Area Sensitivity Rating of B is used to determine the appropriate criteria during restricted hours.

Ground-borne Noise Sources

Construction Phase

10.14 Potential ground-borne noise impact during construction phase would arise mainly from drill and blast, and TBM operation for tunnelling works, as well as PME used for rock breaking/drilling including breakers, drill rigs and pipe pile rigs. Drill-and-blast activities would only cause short term noise impact and would not have significant contribution on the averaged noise level $L_{eq\ 30min}$.

10.15 Since the Project would be constructed concurrently with SCL (MKK – HUH) at Hung Hom, potential cumulative ground-borne noise impact from SCL (MKK-HUH) would be assessed.

10.16 According to the approved WDII and CWB EIA Report, the ground-borne noise impact on NSR (including Hoi Kung Court i.e. CH2) due to rock breaking activity would be minimal, taking into account the buffer distance of more than 150m. Hence, cumulative construction ground-borne noise impact from the WDII/CWB project is not expected.

10.17 Based on the latest construction programme for South Island Line (East) (SIL(E)), the construction of the ADM and the Hong Kong Park Ventilation Building (HKB) (foundation works and adits) under SIL (E) would not be undertaken concurrently with the Project. Therefore, cumulative construction ground-borne noise impact from SIL(E) is not expected.

Operation Phase

10.18 When trains operate in tunnels that are located in close proximity to occupied structures, there is a possibility that vibrations associated with train passbys can be transmitted through the ground and structure and be radiated as noise in the occupied spaces within the structure. The transmitted noise through structures may have potential impact on the NSRs.

10.19 Cumulative ground-borne noise impact from SIL(E) and the Project at Admiralty would be expected and therefore was considered in the assessment.

10.20 The proposed SCL alignment will come within 300m of the following existing rail lines in Hong Kong Island side:

- Passing under the Tsuen Wan Line in Admiralty; and
- Passing under the Island Line in Admiralty.

10.21 The cumulative ground-borne noise impact from the operation of these existing rail lines and the Project was also addressed.

Ground-borne Noise Prediction Methodology

Construction Phase

10.22 The methodology used to determine ground-borne noise levels in the Project is recommended by the U.S. Department of Transportation and Federal Transit Administration[1]. This projection methodology has been previously used for Ground-borne Noise & Vibration Assessment in the approved Kowloon Southern Link (KSL) EIA Report[2].

10.23 The main components of the proposed prediction model for ground-borne noise are:

- Vibration source level from operation of hydraulic breakers, drill rigs, piling rigs, hand-held breakers and TBM;
- Vibration propagation through the ground to the structure foundation;
- Vibration reduction due to the soil/structure interface;
- Vibration propagation through the building and into occupied areas; and
- Conversion from floor and wall vibration to noise.

10.24 The vibration level $L_{v,rms}$ at a distance R from the source is related to the vibration source level at a reference distance R_o. The conversion from vibration levels to ground-borne noise levels is determined by the following factors:

---

[1] U.S. Department of Transportation "High-Speed Ground Transportation Noise and Vibration Impact Assessment", 1998

[2] KCRC, KSL GSA 5100 Environmental Impact Assessment & Associated Services Environmental Impact Assessment Report, January 2005. (Register No. AEIAR-083/2005)

$C_{dist:}$	Distance attenuation
$C_{damping}$:	Soil damping loss across the geological media
$C_{building}$:	Coupling loss into building foundation
C_{floor}:	Coupling loss per floor
C_{noise}:	Conversion factor from floor vibration levels to noise levels
C_{multi}:	Noise level increase due to multiple sources
C_{cum}:	Cumulative effect due to neighbouring sites

10.25 The predicted ground-borne noise level L_p inside the noise sensitive rooms is given by the following equation.

$$L_p = L_{v,rms} + C_{dist} + C_{damping} + C_{building} + C_{floor} + C_{noise} + C_{multi} + C_{cum}$$

Reference Vibration Source ($L_{v,rms}$)

10.26 For the assessment of ground-borne noise due to hydraulic breaker, rock drill and pile rig, reference was made to the assessment approach, source terms and transmission factors adopted in the approved KSL EIA Report. The reference source levels adopted for the assessment are given in **Table 10.5**.

Table 10.5 Reference Vibration Levels of Powered Mechanical Equipment

Plant	Vibration (rms) at reference distance of 5.5m from source [a]	Vibration (ppv) at distance 2m from source
Hydraulic Breaker	0.298 mm/s	-
Handheld Breaker	0.279 mm/s	-
Drill Rig	0.536 mm/s	-
Pile Rig	-	19.3 mm/s

Remark: [a] Extracted from KSL GSA 5100 Environmental Impact Assessment & Associated Services - Environmental Impact Assessment Report, Register No.: EIA-098/2004.

10.27 The expected source vibration of the TBM is extracted from the approved KSL EIA Report. The geology encountered during the KSL EIA study consists predominately of granite, which is similar to the geology expected to be encountered in the study area. The KSL source vibration measurements are therefore considered the most appropriate available information for the purpose of assessing TBM ground-borne noise. The reference vibration levels for the TBM are illustrated in **Appendix 10.1**.

Soil Damping Factor ($C_{damping}$)

10.28 The assessment of ground borne noise damping due to soil causing the vibration amplitude to decay in inverse correlation to the propagation distance. The decay relationship is based on the equation set out in the Transportation Noise Reference Book[3].

$$V(R) = V(R_o) \times e^{-2\pi f \, \eta \, R/2c}.$$

10.29 The velocity amplitude (V) is dependent on the frequency (f) in Hz, the soil loss factor (η), the wave speed c in m/s and the distance (R) from the source to the NSR. The properties of the soil material expected to be encountered are shown in **Table 10.6** below.

Table 10.6 Wave Propagation Properties of Soil

Soil Type	Longitudinal Wave Speed c, m/s	Loss Factor, η	Density, g/cm^3
Soil	1500	0.5	1.7
Rock	3500	0.01	2.65

10.30 No damping attenuation was applied for propagation in rocks. All NSRs were assumed to have a piling foundation on rockhead.

[3] P. M. Nelson. Transportation Noise Reference Book. 1987.

Coupling Loss into Building Structures ($C_{building}$)

10.31 The coupling loss into building structures represents the change in the incident ground-surface vibration due to the presence of the piled building foundation. The empirical values with reference to the "Transportation Noise Reference Book", 1987 are given in **Table 10.7** below. In addition, a coupling loss correction of -18 dB from bedrock to pile should be adopted. However, the correction from bedrock to pile depends on actual site condition and correction of zero dB is assumed for conservative approach.

Table 10.7 Loss factor for Coupling into Building Foundation

Frequency	Octave Band Frequencies, Hz					
	16	31.5	63	125	250	500
Loss factor for coupling into building foundation, dB	-7	-7	-10	-13	-14	-14

Coupling Loss per Floor (C_{floor})

10.32 The coupling loss per floor represents the floor-to-floor vibration transmission attenuation. For multi-storey buildings, a coupling loss of 2 dB reduction per floor was assumed for a conservative assessment to account for any possible amplification due to resonance effects.

Conversion from Floor Vibration to Noise Levels (C_{noise})

10.33 A -27dB correction was assumed for conversion of vibration to noise (re. 20μPa). This is in line with the previous approved EIA reports.

Multiply Source Factor (C_{multi})

10.34 This represents the increase in noise level due to multiple noise sources. The ground-borne noise levels from construction plant were summed logarithmically in accordance with standard acoustic principles to obtain the total ground-borne noise level at the area of interest.

Cumulative Effect (C_{cum})

10.35 The cumulative effect of construction ground-borne noise from other nearby concurrent sources, if any, was also included.

Conversion to A-weighted Noise

10.36 For calculation of ground-borne noise impacts from TBM, a 20dB(A) reduction was adopted for conversion to A-weighted noise. This conversion factor was obtained from the "Transit Noise and Vibration Impact Assessment"[4].

Operation Phase

10.37 The operational ground-borne noise impact assessment was conducted in accordance with the procedures outlined in Federal Transit Administration (FTA) Guidance Manual for detailed vibration analysis. This methodology was adopted in the approved West Island Line (WIL) EIA Report[5]. The ground-borne noise levels at the representative NSRs have been calculated based on the following equation:

$$L = FDL + TIL + TOC + TCF + LSR + BCF + BVR + CTN + SAF$$

where

L Train passby noise level, in dB
FDL force density level, in dB re 1 lb/in$^{1/2}$
TIL trackform attenuation or insertion loss, relative level

[4] U.S. Department of Transportation, Transit Noise and Vibration Impact Assessment, May 2006.

[5] MTR Corporation Limited. West Island Line Environmental Impact Assessment, Final EIA Report, October 2008. (Register No. AEIAR-126/2008)

TOC	turnout and crossover factor
TCF	vibration coupling between the tunnel and the ground for soil based tunnels, relative level
LSR	line source transfer mobility, in dB re 1 (uin/s)/(lb/ft^0.5)
BCF	adjustment to account for building coupling loss, in dB
BVR	building vibration amplification within the structure, in dB
CTN	conversion from vibration to noise within the building, in dB
SAF	safety factor to account for wheel/rail condition and uncertainties in ground conditions, in dB

Force Density Levels (FDL)

10.38 The vibration source levels (force density levels, FDL) for the existing SP1900 EMU were obtained from passby measurements on the up track through Pat Heung Depot in previous rail projects. The deterioration in rail and rolling stock condition has already been taken into account in FDL obtained by measurements under rough rail condition. In accordance with the approved KSL EIA Report, comparisions of FDL obtained from the SP1900 EMU to other Hong Kong transit trains, including old East Rail EMU, as well as several other heavy rail EMUs in operation in the United States, indicated that the SP1900 FDL was 5 dB to 10 dB higher than the maximum FDL for the other trains. The FDL adopted in the assessment was based on previous approved EIA as shown in **Appendix 10.2**.

10.39 The maximum operating train speed at the tunnel section across Victoria Harbour where there are no NSRs in the vicinity will be up to 120kph while the speeds for the tunnel section in the inland of Hong Kong Island are 60kph and 80kph at the overrun and other sections respectively. Speed correction was applied to the FDL using the following empirical relationship:

$$\Delta FDL = 20 \times \log\left(\frac{\mathrm{V}}{\mathrm{V_{ref}}}\right)$$

Trackform Alternatives or Insertion Loss (TIL)

10.40 Trackform attenuation has two components: the magnitude of the attenuation and the frequency above which attenuation occurs (resonance frequency of the trackform). Generally, more compliant trackform support and more massive elements in the trackform will result in a greater magnitude of attenuation occurring at lower frequencies. Thus, floating slab trackform (FST) will produce significantly more attenuation at lower frequencies than a resilient baseplate. However, greater compliance in the trackform support results in greater mobility of the rail, which requires careful examination of changes in rail geometry under loading, and consideration of associated fatigue and component life expectancy. In addition, larger trackform elements will take up more space in tunnels and may cause spatial incompatibilities that are difficult to be overcome in the design. The TIL for existing MTR trackforms in previous approved EIA were adopted where appropriate.

10.41 The ground-borne noise levels at NSRs were calculated initially with direct fixation track without trackform insertion loss for the whole alignment, except a section of alignment to the north ADM using Type 2 trackform (see below). If noise exceedances were predicted, low noise trackforms including low stiffness fasteners, floating slab track, etc would be considered. The attenuation provided by different low noise trackforms was included in the calculation to determine the appropriate trackforms for meeting the criteria. The type of vibration mitigating trackform is often grouped into three categories listed below:

- Type 1: A medium attenuation baseplate or booted dual sleepers based on a bonded or non-bonded compression style baseplate with a resilient elastomeric element having static stiffness of about 25 kN/mm, to be fitted atop the concrete sleepers or atop the invert;
- Type 2: A high attenuation baseplate or booted dual sleepers including:
  i. a bonded “Egg” style baseplate with a resilient elastomeric element having static stiffness in the range of 7 kN/mm to 14 kN/mm, to be fitted atop concrete sleepers or on the invert;
  ii. the Pandrol Vanguard baseplate having static stiffness on the order of 3kN/mm to 5kN/mm; or
  iii. resiliently supported sleepers whose resilient support pad is manufactured from natural rubber and has a static stiffness in the order of 8kN/mm to 12 kN/mm - an alternative for tangent, or near-tangent track only;

- Type 3: A floating mini slab trackform (FST) with a loaded resonance frequency of approximately 16Hz.

Tunnel Coupling Factor (TCF)

10.42 Generally heavier transit structures are likely to lower the vibration levels. With reference to FTA Manual, vibrations induced by trains in Cut and Cover (CC) tunnels and Stations are 3dB and 5dB less than that in bored tunnels constructed through soil. For bored tunnels in soil, the TCF depends on the soil properties. Due to lack of comprehensive data on different soil strata, TCF is conservatively assumed to be 0dB. Thus, the TCF used is 0dB, -3dB and -5dB for bored tunnel, CC tunnel and stations respectively. No TCF is applied to tunnel structures bored through rock.

Turnout and Crossover Factor (TOC)

10.43 At points and crossings, where the wheel transitions from one rail to another, the sudden loading/unloading of the leading and trailing rails results in increased broad band vibration levels over that of plain line continuous rail. While it is not possible to machine grind the rails through either the points or crossings, surface deterioration is often be evident. For standard level turnouts and crossings receiving average maintenance, the FTA Manual recommends a correction of 10dB. For modern inclined turnouts in good condition, where impact loads are lessened, a correction of 5dB is considered appropriate. These corrections have been adopted in this study.

Line Source Response (LSR)

10.44 The LSR determines the vibration levels or attenuation in the ground as a function of distance caused by an incoherent line source of unit force point impacts, with line source (train) orientated along the alignment. Therefore, the basic quantity required for the determination of the LSR is the vibration response caused by a unit point source impact, which is defined as the Point Source Response (PSR). Given that the PSR are located along the alignment, the LSR will follow directly by incoherent integration of the PSR values over the train length. However, the determination of the LSR from force point impacts in numerous boreholes along the alignment over the length of the alignment is neither practical nor affordable. Thus, idealised assumptions of transverse isotropy and layer-wise homogeneity are invoked, which allow PSR obtained from a single borehole to be taken as representative along the alignment near a building receiver and used in the calculation of LSR.

10.45 Soil mobility has already been measured in Hong Kong at a number of locations, including KSL and WIL. The selection of borehole data is based on tunnel depth and rockhead level (i.e. whether the tunnel is borned in rock or soil strata). The geological profiles of the Project are illustrated in **Appendix 3.1** and relevant borehole information is listed in **Table 10.8** below. In the ground-borne noise assessment, these soil mobility data were referenced. The most relevant measured results (taking into account the ground type) were used for the calculations. Typical PSRs for the different geology expected to be encountered have been identified and are presented in **Appendix 10.3**. Nevertheless, MTR Corporation Limited will further review the LSR values and mitigation during the construction stage after tunnel boring.

Table 10.8 Typical PSR Adopted for the Representative Noise Sensitive Receivers

Selected NSR				Reference Borehole		
NSR No.	**Rock(R) / Soil-borne(S)**	**Track Depth [m]**	**Rockhead Depth [m]**	**Borehole No.**	**Borehole Depth [m]**	**Rockhead Depth [m]**
HH9b – Harbourfront Horizon	S	11	21	WIL D095	10.4	23
CH2 - Hoi Kung Court	R	17 & 25	~12	WIL D012	41.4	30
CH3 - Elizabeth House	South: S	South: 15	~25-35	WIL D012	18	30
	North: R	North: 28		WIL D103	21	19
EX2 - Renaissance Harbour View Hotel	S	20 & 27	~35	WIL D012	18	30

Selected NSR				Reference Borehole		
NSR No.	**Rock(R) / Soil-borne(S)**	**Track Depth [m]**	**Rockhead Depth [m]**	**Borehole No.**	**Borehole Depth [m]**	**Rockhead Depth [m]**
EX3 - Grand Hyatt Hotel	S	27 & 34	~50	WIL D012	18	30
EX4 - HKAPA	R	33 & 35	20-34	WIL D012	41.4	30
AD4 – Island Shangri-La Hotel	R	48 & 49	25-30	WIL D012	41.4	30

10.46 The PSR is numerically interpolated between setbacks to create a contoured surface in frequency and distance. The LSR is then determined by a numerical incoherent integration of the PSR along the length of the train centred on the receiver for each individual 1/3 octave bands.

$$LSR(s,d,f) = 10\log\left[\int_{-l/2}^{l/2}\left[10^{PSR\left[\sqrt{d^2+s^2+y^2},\, f\right]/20}\right]^2 dy\right]$$

where s = perpendicular setback
d = depth to top of rail
l = train length

Building Coupling Factor (BCF)

10.47 The recommended BCF established within FTA Manual was adopted for this Project. In general, larger and heavier structures have greater vibration attenuation than smaller and lighter structures. Receivers in this study are divided into 5 types according to the structure type and assigned different BCF attenuation ratings as below:

- Type 0 – Large Masonry with spread footings
- Type 1 – 2-4 storeys medium sized structures
- Type 2 – 1-2 storeys complexes
- Type 3 – Single family detached residences
- Type 4 – Large Masonry Building On Piles

10.48 The BCF for different structures takes into account the greater vibration attenuation in larger and heavier structures than smaller and lighter structure and they are presented in **Appendix 10.4**. The extent of the attenuation is governed by the difference in mechanical impedance between the soil and the foundation, with impedance being determined by differences in mass and stiffness within the soil and foundation. As both the tunnel structure and building pilings are founded on rock and there is no impedance contrast between the rock and the foundation, the BCF for the Project is considered to be zero.

Building Vibration Response (BVR)

10.49 The BVR is generally determined by two factors as described below:

- Resonance amplification due to floor, wall and ceiling spans: With reference to the FTA Manual, a 6 dB correction was adopted to account for structural resonances of typical reinforced concrete buildings. The spectral correction is provided in **Appendix 10.5**.
- Floor-to-floor attenuation: A floor-to-floor attenuation of 2 dB reduction per floor was assumed. Where there is a multi-floor occupancy, only the structural borne noise impact on the lowest occupied floor was considered.

Conversion to Noise (CTN)

10.50 A +2 dB correction for conversion of vibration (re: 10^{-6} in/s) in room walls, floors and ceiling to noise (re: 20 micro Pa) was assumed in this study.

Safety Factor (SAF)

10.51 To tackle the problem of differences in overall predicted and measured A-weighted noise levels, a safety factor was applied in the model. As a conservative approach, a 10 dB safety factor was adopted to account for uncertainty and variation in ground characteristics.

Level of Uncertainty

10.52 The predictions of ground-borne noise impacts were based on the methodologies described in the FTA Guidance Manual. The methodology which had previously been applied in other EIA studies is generally accepted for use in assessing ground-borne noise impacts against EIAO-TM and IND-TM noise criteria. In carrying out the assessment, realistic worst case assumptions have been made in order to provide a conservative assessment of noise impacts. The construction ground-borne noise impact was assessed based on conservative estimates for the types of plant and methods of working. For operational ground-borne noise assessment, the soil mobility data was made reference to previous measurements for other EIA studies having similar rockhead level and borehole depth.

10.53 There would be some limitations such as the accuracy of the predictive base data for future conditions e.g. plant inventory for the proposed construction works and uncertainty in the soil mobility for future operation. Uncertainties in the assessment of impacts have been considered when drawing conclusions from the assessment. For operational ground-borne noise assessment, 10dB overall safety factor was incorporated to account for prediction uncertainty. Also the proposed mitigation measures should be reviewed when more specific data are available at later stage (e.g. after tunnel boring).

Assessment Results

Construction Phase

10.54 Ground-borne noise levels at the representative NSRs associated with the construction of the Project using TBM and PME for rock breaking/drilling works were predicted, and are summarized in **Table 10.9** below. For the worst case scenario, it was assumed in the calculation that all the PME would be operated simultaneously. Detailed calculations and assumptions for each representative NSR are provided in **Appendix 10.6**.

Table 10.9 Predicted Construction Ground-borne Noise Impact

NSR No.	Description	Predicted Ground-borne Noise Levels $L_{eq(30mins)}$, dB(A)		Overall Predicted Ground-borne Noise Levels $L_{eq(30mins)}$, dB(A)	Criteria, $L_{eq(30mins)}$ dB(A)	Criteria Achieved ?
		TBM	PME			
HH9	Harbourfront Horizon	N/A	41-49	41-49	65	Yes
CH2	Hoi Kung Court	46	63	63	65	Yes
CH3	Elizabeth House, Block C	32	N/A	32	65	Yes
EX2	Renaissance Harbour View Hotel	N/A	52	52	65	Yes
EX3	Grand Hyatt Hotel	N/A	52	52	65	Yes
EX4	HKAPA	52	N/A	52	60/55	Yes

NSR No.	Description	Predicted Ground-borne Noise Levels $L_{eq(30mins)}$, dB(A)		Overall Predicted Ground-borne Noise Levels $L_{eq(30mins)}$, dB(A)	Criteria, $L_{eq(30mins)}$ dB(A)	Criteria Achieved ?
		TBM	PME			
AD4	Island Shangri-La Hotel	N/A	55	55	65	Yes

Note:
N/A – Not applicable

10.55 As shown in **Table 10.9**, the predicted construction ground-borne noise levels at all representative NSRs is expected to comply with the day time noise criteria. Adverse construction ground-borne noise impact due to the use of TBM and PME during day time period is not envisaged.

10.56 In case of any construction activities being conducted during restricted hours (i.e. between 1900 and 0700 on a normal working day or at any time on a general holiday and Sunday), it is the Contractor's responsibility to ensure compliance with the Noise Control Ordinance (NCO) and the relevant technical memoranda. The Contractor will be required to submit a CNP application to the Noise Control Authority and abide by any conditions stated in the CNP, should one be issued.

10.57 The Project would be constructed concurrently with SCL (MKK – HUH) at Hung Hom Landfall. Potential cumulative construction ground-borne noise impact from the Project and SCL (MKK – HUH) was therefore assessed. Detailed calculations are provided in **Appendix 10.7** and the results are summarized in **Table 10.10** below. The results indicate that the cumulative construction ground-borne noise levels at the NSR would comply with the noise criteria.

Table 10.10 Cumulative Construction Ground-borne Noise Impact from Concurrent Project

NSR No.	Description	Cumulative Construction Ground-borne Noise Levels, dB(A)	Criteria, dB(A) ($L_{eq(30mins)}$ unless specified) Daytime (0700-1900 hrs) (except General Holidays & Sunday)	Criteria Achieved?
HH9	Harbourfront Horizon	43-49	65	Yes

Operation Phase

10.58 The operational ground-borne noise levels from the Project at the representative NSRs were assessed based on direct fixation track with a section of alignment to the north ADM using Type 2 trackform for a length the provision of these trackform, the Lmax levels at HKAPA were predicted to be below 25dB(A). **Table 10.11** summarises the predicted operational ground-borne noise levels. Detailed calculation and assumptions and results in terms of Leq (30mins), Leq (24hr) and Lmax are provided in **Appendix 10.8**. All input parameters e.g. train speed and frequency had covered all scenario including the normal and worst case. The lowest affected floor is considered as the worst affected receivers for each NSR. As indicated in **Table 10.11**, the predicted operational ground-borne noise levels at all the representative NSRs would comply with the noise criteria.

Table 10.11 Predicted Operational Ground-borne Noise Impact

NSR No.	Description	Predicted Ground-borne Noise Levels[a], $L_{eq(30mins)}$ dB(A)		Ground-borne Noise Criteria, $L_{eq(30mins)}$ dB(A)		Criteria Achieved ?
		Day & Evening	Night	Day & Evening	Night	
HH9b	Harbourfront Horizon	<20	<20	55	45	Yes
CH2	Hoi Kung Court	38	37	55	45	Yes
CH3	Elizabeth House, Block C	<20	<20	55	45	Yes

NSR No.	Description	Predicted Ground-borne Noise Levels[a], $L_{eq(30mins)}$ dB(A)		Ground-borne Noise Criteria, $L_{eq(30mins)}$ dB(A)		Criteria Achieved ?
		Day & Evening	Night	Day & Evening	Night	
EX2	Renaissance Harbour View Hotel	<20	<20	55	45	Yes
EX3	Grand Hyatt Hotel	<20	<20	55	45	Yes
EX4	HKAPA	<20	<20	55	N/A	Yes
AD4	Island Shangri-La Hotel	20	<20	55	45	Yes

Note:
[a] The prediction is based on train frequency at peak hours as follow:
- 30 trains per hour per direction during daytime/evening (0700-2300).
- 24 trains per hour per direction at night (2300-0700).

N/A Not applicable

10.59 Cumulative ground-borne noise impact from the SIL(E) and the Project at Admiralty would be expected. The cumulative ground-borne noise impact from SIL(E) was assessed by using the operational ground-borne noise levels predicted in the approved SIL(E) EIA Report[6]. **Table 10.12** summarises the cumulative operational ground-borne noise levels at NSR AD4 that is the worst-affected NSR in the vicinity of the interfacing area. As shown in **Table 10.12**, the cumulative operational ground-borne noise levels at NSR AD4 would be well below the night-time noise criterion by more than 20 dB(A). No adverse cumulative operational ground-borne noise impact from SIL(E) is therefore anticipated.

Table 10.12 Cumulative Operational Ground-borne Noise Impact from SIL(E)

NSR No.	Description	Predicted Ground-borne Noise Levels, dB(A)		Cumulative Ground-borne Noise Levels, dB(A)	Criteria, dB(A) ($L_{eq(30mins)}$ unless specified)	Criteria Achieved?
		The Project	SIL(E)[*]			
AD4	Island Shangri-La Hotel	<20	16	20	45 (worst-case with night-time operation)	Yes

Note:
[*] Operational ground-borne noise levels at AD4 from SIL(E) is based on the approved SIL(E) EIA Report (Register No. AEIAR-155/2010).

10.60 With regard to the cumulative impact with the existing rail lines, NSR AD4 is also the nearest NSR to Island Line. As shown in the above table, the predicted ground-borne noise levels at NSR AD4 would be at least 20 dB(A) below the night-time noise criterion. In addition, Island Line trains will slow down and stop at the existing Admiralty Station resulting in insignificant contributions to the cumulative impact. As such, adverse cumulative ground-borne noise impact from the existing Island Line is not expected.

10.61 The nearest representative NSR to the existing Tsuen Wan Line is EX4. As shown in **Table 10.11**, the predicted ground-borne noise levels from the Project during day and evening time is only 27 dB(A) that is 28dB(A) below the noise criterion. Hence, cumulative ground-borne noise impact from the existing Tsuen Wan Line would be unlikely to be a concern for the Project.

10.62 During abnormal or emergency operations of the Project, the train service will be interrupted or stopped that will result in the train frequency during that period being lower than the scheduled

[6] MTR Corporation Limited. South Island Line (East) Environmental Impact Assessment, EIA Report, August 2010. (Register No. AEIAR-155/2010)

timetable. Hence, adverse ground-borne noise impact arising from the abnormal or emergency operations is not expected.

Recommended Mitigation Measure

Construction Phase

10.63 As presented above, the predicted construction ground-borne noise levels at all identified representative NSRs would comply with the noise criteria and therefore no mitigation measure is deemed necessary.

Operation Phase

10.64 The predicted operational ground-borne noise at all identified representative NSRs would comply with the noise criteria. Mitigation measure is therefore deemed not necessary.

10.65 The prediction of ground-borne noise impact relied on a number of conservative assumptions, however as a further conservative measure, provisions have been made in the design of the tunnel for installation of contingency mitigation measures should they be necessary to minimize the potential ground-borne noise impact on existing NSRs and planned/committed noise sensitive developments that interface with the Project. Implementation of the contingency mitigation measures should be reviewed in connection with continuous liaisons with the relevant parties during the design stage and prior to the installation of the railway tracks. In view of the lack of concrete details and programme of those non-committed developments and extensions at this stage, they will have to take into account this Project in their planning and development stages.

10.66 Based on the size of the tunnel proposed under the Project, the contingency mitigation measures may consist of:

- Medium attenuation baseplates (Type 1) — additional attenuation of about 5 to 10dB(A);
- High attenuation baseplate or booted dual sleepers (Type 2) additional attenuation of about 10 to 15dB(A); or
- Floating mini slab trackform (Type 3) — additional attenuation of about 20 to 30dB(A).

10.67 Nonetheless, these contingency mitigation measures would be reviewed when more specific data are available at later stage (e.g. after tunnel boring during the construction stage).

Evaluation of Residual Impacts

10.68 No adverse residual impact would be expected during both construction and operation phases.

Environmental Monitoring and Audit Requirements

Construction Phase

10.69 The predicted construction ground-borne noise would comply with the noise criteria. Therefore, environmental monitoring is considered not necessary during construction phase.

Operation Phase

10.70 Prior to the operation phase of the Project, a commissioning test will be conducted to ensure compliance of the operational ground-borne noise levels with the adopted noise criteria. Details of the test requirements are provided in a stand-alone EM&A Manual.

Conclusion

10.71 Construction ground-borne noise impacts arising from rock breaking/drilling associated with the operation of TBM and PME (such as hydraulic breaker, drill rig, pile rig, etc) were found to comply with noise criteria. No adverse cumulative construction ground-borne noise impacts were predicted. Therefore, in terms of ground-borne noise impacts, both TBM and Cut & Cover tunnel construction methods are considered to be feasible.

10.72 During operation phase, predictions of ground-borne noise levels at the identified representative NSRs were performed using the methodology recommended by the US Department of Transportation. With suitable trackform, the predicted ground-borne noise criteria at all representative NSRs would comply with the adopted noise criteria. Potential cumulative impact from existing/future rail lines was considered. No adverse cumulative impact is anticipated.

10.73 Although adverse impact of operational ground-borne noise from the Project is not anticipated, provisions have been made in the design of the tunnel for installation of necessary contingency mitigation measures should they be necessary. Such contingency mitigation measures would be reviewed when more specific data are available at later stage (e.g. after tunnel boring).