

Provision of Services to Conduct Environmental Impact Study

Environmental Impact Study (Turf City and Holland Plain)

Study Stage: Final

Volume 4 of 5

Submitted by: AECOM Singapore Pte Ltd Submitted to: Land Transport Authority

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11. Airborne Noise

11.1 Introduction

This section presents the detailed assessment of airborne noise impacts from the construction and operation of the Project to the identified noise ecologically sensitive receptors. Noise from construction and operational activities may be perceivable, especially to receptors in proximity and those having a direct line-of-sight to the noise sources from the Study Area. The key steps for conducting the noise impact assessment are as follows:

- Review baseline noise monitoring data to assess current baseline noise level in the Study Area;
- Identify and classify sensitivity of the receptors surrounding the Study Area;
- Conduct a noise impact assessment to quantitively assess noise impacts during construction and operational phases;
- · Recommend minimum control and mitigation measures to be implemented; and
- Determine the overall significance of the residual noise impacts after the implementation of mitigation measures.

11.2 Methodology and Assumption

The sections below outline the methodology used in the noise impact assessment for construction and operational phases.

11.2.1 Baseline Airborne Noise Study

Baseline noise monitoring is used to establish the existing noise levels in the study area. A site survey was conducted from 5-6 November 2019 for up to 150m around the construction worksite areas/ project footprint areas. A total of nine (9) noise monitoring locations were proposed (at the inception stage), based on the following considerations:

- Identification of NSRs (hospitals, schools, childcare facilities, old age homes, residences, fauna and habitats of high ecological value) nearest to the construction worksite areas/ project footprint boundary of the proposed facility building;
- Other NSRs away from the construction worksite areas/ project footprint were eliminated as these receptors are assumed to be barricaded by the first row of buildings;
- NSRs with areas having ongoing construction were avoided;
- Areas where CCNR EIA has already established noise baseline in the past has been excluded;
- NSRs where the owner denied permission during site walkover was excluded (e.g. past experience with terrace houses/ bungalows, embassies at Swiss valley area, heavy car park area at Grand Stand, etc).
- The closest NSR to the construction worksite areas/ project footprint was selected; and
- For a high rise residential sensitive receptor, ensure monitoring was conducted at different floor heights (e.g., mid-level, top level) to capture the terrain variation and its impact on noise levels.

The noise monitoring locations are detailed in Table 11-1 and shown in Figure 11-1. Noise monitoring was conducted for one week (weekdays and weekends), to capture baseline noise levels over time periods of 12 hours (long term), 1 hour, 15 minutes and 5 minutes (short term) at each location. Thereafter, baseline airborne noise monitoring was supplemented with secondary baseline data obtained from the concurrent study carried out by AECOM in the vicinity, to obtain the baseline noise levels for the purpose of establishing the baseline conditions within the Study Area. The Norsonic 131 Sound Level Meter was used to record the noise levels above. The method and results are detailed in the baseline noise monitoring report shown in Appendix N and further discussed in Section 11.5.

Table 11-1 Proposed Baseline Noise Monitoring Locations

Monitoring Location	Nearest Construction Worksite Area / Project Footprint	Sensitivity of Receptor at Monitoring Location	Justification	Photo of Monitoring Location
N05: Methodist Girls School	CR15 Worksite (Holland Plain)	Priority 1, 2, 3 (dependent on habitat sensitivity)	Representative baseline noise monitoring location within the study area. The baseline noise level was dominated by the operational noise from the school located north-east of the CR15.	
N06: The Sterling Condominium	CR15 Worksite (Holland Plain)	Priority 1, 2, 3 (dependent on habitat sensitivity)	Representative baseline noise monitoring location within the study area. Baseline noise monitoring location located west of CR15 Worksite.	
N07: Landed housing along Hua Guan Avenue	CR15 Worksite (Holland Plain)	Priority 1, 2, 3 (dependent on habitat sensitivity)	The open area along Dunearn Road near the landed housing along Hua Guan Avenue was selected as a representative baseline noise monitoring location within the study area located north-west of the CR15.	

Monitoring Location	Nearest Construction Worksite Area / Project Footprint	Sensitivity of Receptor at Monitoring Location	Justification	Photo of Monitoring Location
N08: Swiss School in Singapore	CR14 Worksite (Turf City)	Priority 1, 2, 3 (dependent on habitat sensitivity)	Representative baseline noise monitoring location within the study area. The baseline noise level is expected to be dominated by the operational noise from the school.	
N09: Within Eng Neo Avenue Forest	CR14 Worksite (Turf City)	Priority 1, 2, 3 (dependent on habitat sensitivity)	Representative baseline noise monitoring location within the study area. Baseline noise monitoring location located east of CR14 Worksite.	
N12: Within Site I	CR14 Worksite (Turf City)	Priority 1, 2, 3 (dependent on habitat sensitivity)	Representative baseline noise monitoring location within the study area Site I. Baseline noise monitoring location located east of CR14 Worksite.	

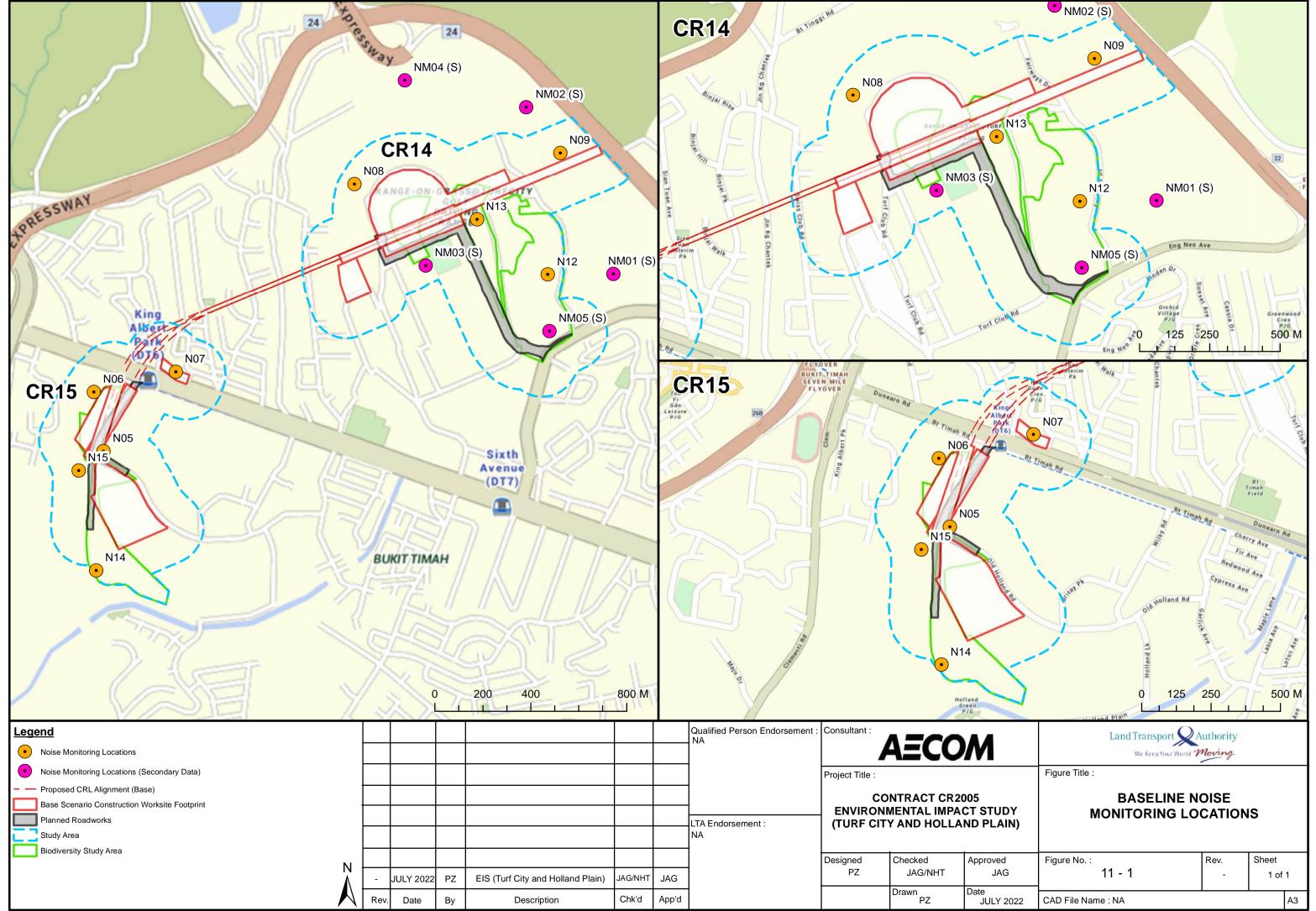
Monitoring Location	Nearest Construction Worksite Area / Project Footprint	Sensitivity of Receptor at Monitoring Location	Justification	Photo of Monitoring Location
N13: Within Site II	CR14 Worksite (Turf City)	Priority 1, 2, 3 (dependent on habitat sensitivity)	Representative baseline noise monitoring location within Site II. Baseline noise monitoring location located east of CR!4 Worksite. Representative baseline noise monitoring location for greenfield area of Site II, Bright Path Pre School and Saddle Club.	
N14: Near Holland Plain and Site V	CR15 Worksite (Holland Plain)	Priority 1, 2, 3 (dependent on habitat sensitivity)	Representative baseline noise monitoring location within Site V. Baseline noise monitoring location located south of CR15 Worksite.	
N15: Near Holland Plain and Site IV	CR15 Worksite (Holland Plain)	Priority 1, 2, 3 (dependent on habitat sensitivity)	Representative baseline noise monitoring location within Site IV. Baseline noise monitoring location located west of CR15 Worksite.	

Monitoring Location	Nearest Construction Worksite Area / Project Footprint	Sensitivity of Receptor at Monitoring Location	Justification	Photo of Monitoring Location
N01(S)*	CR14 Worksite (Turf City)	Priority 1, 2, 3 (dependent on habitat sensitivity)	Representative baseline noise monitoring location is a greenfield site. The selected location represents the environment of the nearby forested areas.	
N02(S)*	CR14 Worksite (Turf City)	Priority 1, 2, 3 (dependent on habitat sensitivity)	Representative baseline noise monitoring location is a greenfield site. The selected location represents the environment of the nearby forested areas.	
N03(S)*	CR14 Worksite (Turf City)	Priority 1, 2, 3 (dependent on habitat sensitivity)	Representative baseline noise monitoring location is a greenfield site within the Site III. The selected location represents the environment of the Site III and located southern part of the Site III.	

Monitoring Location	Nearest Construction Worksite Area / Project Footprint	Sensitivity of Receptor at Monitoring Location	Justification	Photo of Monitoring Location
N04(S)*)	CR14 Worksite (Turf City)	Priority 1, 2, 3 (dependent on habitat sensitivity)	Representative baseline noise monitoring location in the forested area adjacent to The British Club/ Swiss Club is a greenfield site within the Project Site. The selected location represents the environment of the forested areas.	
N05(S)*	CR14 Worksite (Turf City)	Priority 1, 2, 3 (dependent on habitat sensitivity)	Representative baseline noise monitoring location in a greenfield site within the Site I. The selected location represents the environment of the southern part of the Site I forest area.	

Notes:

^{*} Secondary baseline noise monitoring locations from the concurrent study carried out by AECOM in the vicinity



11.2.2 Prediction and Evaluation of Impact Assessment

The airborne noise impact assessment includes the evaluation of construction noise to the sensitive noise receptors respectively.

11.2.2.1 Construction Phase

- For the assessment on the construction phase, the noise levels generated from the equipment used, as detailed in Section 11.3, were predicted using SoundPLAN ver 8.2. A quantitative assessment on the noise sensitive receptors (within the 150m Study area) was carried out and compared with the stipulated Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008. The identified noise sensitive receptors were assessed in accordance with the impact evaluation matrix as shown in Section 6.4.2Based on the impact evaluation, mitigation to reduce airborne noise impacts was recommended for the affected noise sensitive receptors;
- The study on construction noise impact to the noise sensitive receptors focused on three (3) construction scenarios for CR14 worksite and two (2) construction scenarios for CR14 worksite. The three scenarios for CR14 worksite were:
 - Scenario 1: Cut and cover works and associated activities (non TBM/entrance construction work) – Assesses construction noise impacts from the cut and cover worksites to the sensitive receptors;
 - Scenario 2: Tunnel Boring Machine (TBM) works Assesses construction noise impacts from the TBM worksites to the sensitive receptors; and
 - Scenario 3: Construction of station entrances Assesses construction noise impacts from the respective station entrances to the sensitive receptors.
- The two scenarios for CR15 worksite were:
 - Scenario 1: Cut and cover works and associated activities (non TBM/entrance construction work) – Assesses construction noise impacts from the cut and cover worksites to the sensitive receptors; and
 - Scenario 2: Construction of station entrances Assesses construction noise impacts from the respective station entrances to the sensitive receptors.
- Assumptions to the construction noise assessment are as listed below:
 - Within each scenario, works are assumed to be carried out at the same time between the different worksites;
 - The terrain in the study area was typically provided for areas 50-100 m from the site. For the
 areas where topographical elevations were not available, an extrapolation of data from the
 edge of known terrain was undertaken to cover the entire study area;
 - For the grid noise map for ecological sensitive area, a resolution of 40m was adopted;
 - For ecological point receptors or grid elevation estimation for fauna, a test run for 0.5 m and 1.5 m height above ground was conducted and the results found almost similar results, so 1.5 m height above ground which was more conservative was adopted to remain in line with the human receptor criteria as adopted by regulations.

11.2.2.1.1 Rock Breaking and Excavation and Air Overpressure

Where common excavation techniques are not able to break down hard rocks, rock breaking and excavation can be proposed as an effective and efficient method to break down and remove rocks. For the CR14 mitigated worksite, rock breaking and excavation is proposed for breaking Bukit Timah Granite at a depth of 25m below ground.

As a result of rock breaking and excavation, the major side effects on the environment includes air overpressure. When an MIC of any magnitude is detonated, air which acts as a fluid radiates from its specific work location outwards towards the surrounding environment. This radiation of energy compresses the air with diminishing pressure over distance. Air overpressure is usually measured in the form of dB (Lin). Frequency of rock breaking and excavation at CR14 mitigated worksite is assumed to be 1 time per day and 5 times per week for a 6-days work week over a span of 5 months.

During the writing of this report, detailed information was not available, the extant of rock breaking and excavation works is planned to be carried out by an appointed contractor at a later stage. Hence, the approach taken in this section will be to provide a guideline to the criteria as set out in BS5228-2:2009+A1:2014. Based on assumptions made (location, depth, method) and known information (distance to nearest receptors), this assessment will provide an estimate on the maximum amount of MIC (MIC charge mass, kg) that should be permitted in order to keep air overpressure within the stated criteria. Predictive methods in AS 2187.2-2006 MIC – Storage and Use Part 2 will be used to predict air overpressure based on constants recommended within the guideline with formula (1) below:

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$$P = K_a (\frac{R}{q^{\frac{1}{3}}})^a$$
 ----- (1)

Where

P = pressure in kilopascals

Q = MIC charge mass, in kilograms

R = distance from charge, in metres

K_a = site constant (assumed to be 100)

a = site exponent (assumed to be -1.45)

Due to the lack of information for rock breaking and excavation works in Singapore, the site constant was assumed based on AS 2187.2-2006. The site constant K_a is commonly ranging from 10 to 100 for confined explosion hole charges and hence is conservatively assumed to be 100 for the purpose of the calculation. The site exponent, a, is assumed to be -1.45 for confined explosion hole charges. The alternative to confined explosion hole charges would be unconfined surface charges which is usually employed in mine breaking and drilling. The distance from charge to the receptor, R, is measured from the centre of the CR14 mitigated worksite to the nearest boundary of Site I, Site II and Site III is approximately 183m, 12m and 190m respectively.

The criteria adopted from BS5228-2:2009+A1:2014 is 120 dB (Lin). Hence, the sound power level (SPL) at the receptor can be calculated based on the formula (2) below.

$$SPL = 20 log_{10} \left(\frac{Pa}{P_0} \right)$$
 ----- (2)

Where

Pa = pressure in pascals

P_o = reference pressure of 0.00002 pa

SPL = sound pressure level in dB

11.2.2.2 Operational Phase

An airborne noise study at the boundary of facility building will be conducted in a separate study by LTA. Based on the predicted results at the boundary due to the operation of the facility building, CR2005 assessed and evaluated the impacts on the ecological receptors identified within Site I, Site II, Site III, Site IV and Site V in accordance to the impact evaluation matrix as shown in Section 6.4.2 and NEA Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Buildings, 2018.

A qualitative assessment was provided to assess the increase in traffic volume due to the project operations based on the NEA Technical Guideline for Land Traffic Noise Impact Assessment, 2016 [R-54] and assessed in accordance with impact evaluation matrix as shown in Section 6.4.2.

11.2.3 Assessment Criteria

There are currently no guidelines or standards available to assess the noise from construction and operational phases of the project on the respective ecological receptors. The current guidelines and standards available are used to assess the respective noise impact to humans only and will be adopted for this study for the purpose of establishing the criteria and assessing noise impacts to the identified noise ecologically sensitive receptors. The ecological impacts from airborne noise is species dependent hence the assessment will be based on the species identified during site surveys at Site I, Site II, Site III, Site IV and Site V (see Section 11.4 for airborne noise sensitive receptors) in sync with the biodiversity section of this report. It is to be noted that ecological receptor noise impact was assessed against the baseline noise level as the noise criterion.

11.2.3.1 Construction Noise Criteria

In determining the impact of the construction noise to sensitive receptors, the baseline noise level detailed in Section 11.5 will be included in the calculation to derive a background noise correction factor to establish the maximum permitted noise level from the construction activities in accordance with the noise legislation stated in *Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008 [R-52].* It is to be noted that Airborne noise impacts will occur from above ground construction sites only.

The legislative requirements for environmental noise in Singapore contain three parts which specify the applicable noise criteria for construction sites over different time periods. The corresponding maximum permissible noise criteria are provided in Table 11-2 to Table 11-4 for periods of different duration, these are:

L_{Aeq(12 hour)} which refers to equivalent continuous noise level over a period of 12 hours;

L_{Aeq(1 hour)} which refers to equivalent continuous noise level over a period of 1 hour within a 24 hr period; and

LAeq(5 min) which refers to equivalent continuous noise level over a period of 5 minutes within a 24 hrs period.

Table 11-2 Maximum Permissible Noise Levels for Construction Works over a Period of 12 hours

Types of Affected Buildings	Days of	Maximum Permissible L _{Aeq(12 hour)} , dB		
Types of Affected Bulldings	the week	7am – 7pm	7pm – 7am	
(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	All days	60	50	
(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	All days	75	-	
I Buildings (other than those in paragraphs (a) and (b))	All days	75	65	

Table 11-3 Maximum Permissible Noise Levels for Construction Works over a Period of 1 hour

Types of affected	Days of	Maximum Permissible L _{Aeq (1 hour)} (dB)			
buildings	the week	7am – 7pm	7pm – 10pm	10pm – 7am	
Residential buildings located less than 150 m from the construction site where the noise is being emitted	Monday to Saturday	-	65	55	

Table 11-4 Maximum Permissible Noise Levels for Construction Works over a Period of 5 minutes

Types of affected	Days of	Maximum Permissible L _{Aeq (5 mins)} (dB)				
buildings	the week	7am – 7pm	7pm – 10pm	10pm – 7am		
(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	All days	75	55	55		
(b) Residential buildings located less than 150 m from the construction site	Monday to Saturday	90	70	55		
where the noise is being emitted	Sundays & PHs	75	55	55		
(c) Buildings (other than those in paragraphs (a) and (b))	All days	90	70	70		

As per the legislation, if there are other sources of noise affecting the measurement of noise emitted from the construction site, the maximum permissible noise levels for construction sites are supposed to be adjusted by the addition of a correction factor to account for the existing background noise levels in the area. The correction factor corresponds to the difference between the relevant permissible level, and the background noise level and is presented in Table 11-5. The difference in the noise levels are then added to the higher of the two noise levels (background noise/ criteria as appropriate) to give the applicable noise criteria for the specified construction area.

Table 11-5 Construction Noise Correction Factor

Difference between Permissible & Background Noise Levels (dB(A))	Correction Factor to be Added to the Higher of the Two Noise Levels, (dB(A))
Below 2	3
2 to 4	2
4 to 10	1
10 and above	Nil

11.2.3.1.1 Rock Breaking and Excavation and Air Overpressure

BS5228-2:2009+A1:2014 provides a criterion for air overpressure. Routine rock breaking and excavation can regularly generate air overpressure levels at adjacent premises of around 120 dB (Lin). This level corresponds to an excess air pressure which is equivalent to that of a steady wind velocity of 5 m·s-1 (Beaufort force 3, gentle breeze) and is likely to be above the threshold of perception. Although this criterion is usually employed for impacts on humans, it has been adopted for this study on ecological receptors (e.g., fauna within Site III).

11.2.3.1.2 Operational Noise Criteria

In determining the impact of the operational noise to sensitive receptors, the baseline noise level in the study area will be included to derive the corrected boundary noise limits in accordance with NEA Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Buildings, 2018 [R-53]. Traffic noise with the NEA Technical Guideline for Land Traffic Noise Impact Assessment, 2016 [R-54] for noise sensitive and residential building receptors. It is to be noted that ecological receptor noise impact was assessed against the baseline noise level as the noise criterion.

11.2.3.1.3 ACMV Boundary Noise Limits

The NEA Noise Guideline describes a non-industrial building as:

"Any permanent or temporary building or structure used for the purposes of trade, business or commerce and includes any shopping complex, financial institution, office tower, hotel, educational institution, hospital, transport infrastructures, community infrastructure, sport and recreational infrastructure but does not include any factory and residential premises." The noise limits outlined in the NEA Noise Guideline shall, therefore, be used. These noise limits are outlined in Table 11-6. However, noise criteria for biodiversity will follow a "no worse off than baseline approach". The current set of Project-specific noise criteria for ecological receptors based on baseline noise monitoring in Year 2020 is provided in Table 11-6 for reference.

Table 11-6 Boundary Noise Limits by NEA for Human and Project Criteria for Ecological Sensitive Receptors

Types of affected buildings	Boundary Noise Limits (reckoned as the equivalent continuous noise level over 15 minutes), dB(A)				
	Day 7am to 7pm	Evening 7pm to 11pm	Night 11pm to 7 am		
Noise Sensitive Premises such as hospital, home for the aged sick, library, etc.	60	55	50		
Residential Premises	65	60	55		
Others	70	65	60		
Site I	56	51	45		
Site II	53	51	46		
Site III	54	53	47		
Site IV	50	49	49		
Site V	73	74	73		

*Notes:

- 1. Ecological receptor noise impact to be assessed against the baseline noise level as the noise criterion.
- 2. Criteria for ecological receptor is more stringent than human criteria.

3. If there are any noise monitoring works being conducted hereafter, i.e., during actual pre-construction phase (i.e. before actual site clearance) and/or pre-commissioning phase, this Project-specific noise criteria (no worse off than baseline approach) will be updated accordingly and be complied on site.

In accordance with the guideline, noise from the sources under consideration is measured so as to determine the impact over a continuous 15-minute period. Adjustments to the measured noise level are applied to account for the effects of duration, tonality, intermittency and impulsiveness of the noise. The measured, adjusted 15-minute noise level is then assessed in relation to the noise limits.

11.2.3.1.4 Land Traffic Noise Impact Assessment Criteria

NEA's noise requirements are as follows:

- (1) The noise levels at 1 m from the façade of the new residential/noise sensitive building shall not exceed LAeq(1hr) 67 dB; and
- (2) The indoor noise level of the new residential/noise sensitive building under natural ventilation shall not exceed LAeq(1hr) 57 dB.

This traffic noise assessment is typically conducted by a Noise Consultant appointed for the proposed developments for the residential and noise sensitive buildings for the project. This study will only consider traffic noise impact to the ecological receptors qualitatively.

11.3 Potential Sources of Airborne Noise Impacts

This section discusses the potential equipment and activities which could cause noise impacts from the respective construction and operational phases of the project.

11.3.1 Construction Phase

The construction noise impacts generated from the various construction activities depended on the inventory adopted during each activity of the construction programme. The main source of noise was from the Powered Mechanical Equipment (PMEs). The PMEs and the respective sound power levels used in this study are listed in Appendix Y.

Based on the construction programme proposed by CR2005, the CR14 and CR15 worksite followed a cut and cover construction method. For the construction at the facility building worksites of CR14 mitigated scenario, construction programme for a typical facility building was adopted however it is to be noted that rock breaking, and excavation has been proposed at the CR14 worksite, and this study explored air overpressure impacts from rock breaking and excavation. The construction inventory for the respective worksites is shown in Appendix Z.

Based on the construction inventory, the sound power level used in the noise model are shown in Table 11-7 below. The sound power level of concurrent projects for the cumulative impact assessment are also shown in Table 11-7 below. It is to be noted that rock breaking, and excavation and air overpressure was not considered for noise modelling and was only assessed semi-qualitatively due to the instantaneous nature of the noise generated from rock breaking and excavation.

Table 11-7 Effective Sound Power Level

	Effective Sound Power Level L _{wA,} dB from overall construction inventory					
Construction Activity	L _{Aeq (12 hours)}	L _{Aeq (12 hours)}	L _{Aeq (5 min)}	L _{Aeq (5 min)}		
	7am-7pm	7pm-7am	7am-7pm	7pm-7am		
	CR14 Work	site				
1. Clearance for Construction Area	116	-	119	-		
2. Temporary Earth Retaining System	107	105	110	108		
3. Excavation to Work Platform Level	109	99	114	102		
4. Temporary wo–k - Installation of D Wall, Sheet Pile	107	107	108	108		

Effective Sound Power Level L _{wA,} dB from overall construction inventory						
Construction Activity	L _{Aeq (12 hours)}	L _{Aeq} (12 hours)	L _{Aeq (5 min)}	L _{Aeq (5 min)}		
	7am-7pm	7pm-7am	7am-7pm	7pm-7am		
5. Installation of Wallers & Struts/Stage excavation	108	108	110	110		
6. TBM (For Scenario 2)	115	115	115	115		
7. Construction of Permanent Structure	102	102	105	105		
8. Reinstatement of Work & Exiting Road	115	115	116	116		
9. Entrances - Construction of D Wall & Sheet piles (For Scenario 3)	108	-	110	-		
10 Road wo-k - Clearance for Construction Area	116	-	119			
11 Road work - Traffic Deck	118	-	120	-		
	CR15 Work	site				
1. Clearance for Construction Area	116	-	119	-		
2. Temporary Earth Retaining System	107	105	110	108		
3. Excavation to Work Platform Level	109	99	114	102		
Temporary work - Installation of D Wall, Sheet Pile	107	107	108	108		
5. Installation of Wallers & Struts/Stage excavation	108	108	110	110		
6. Construction of Permanent Structure	102	102	105	105		
7. Reinstatement of Work & Exiting Road	115	115	116	116		
8. Entrances - Construction of D Wall & Sheet piles (For Scenario 3)	108	-	110	-		
Road work - Clearance for Construction Area	116	-	119			
10. Road work - Traffic Deck	118	-	120	-		
11. Utility Diversion Work	109	-	110	-		
12. Site Office Construction	95	-	97	-		
13. Construction of Material Storage Area	107	106	109	109		
	Concurrent Projects					
	CR16 Work	site				
Clearance for Construction Area including Tree felling	117	117	120	120		
Levelling (Cut and Fill) to Work Platform Level	109	109	114	114		
3. Soil Nailing	112	111	113	113		
4. Pumping Mains Diversion	112	112	115	115		

	Effective Sound Power Level L _{wA} , dB from overall construction inventory							
Construction Activity	L _{Aeq} (12 hours)	L _{Aeq (12 hours)}	L _{Aeq} (5 min)	L _{Aeq} (5 min)				
	7am-7pm	7pm-7am	7am-7pm	7pm-7am				
5. Pumping Mains Diversion (Open Cut)	111	111	114	114				
6. Utility diversion/Temp Drain diversion	115	105	117	108				
7. Construction of Site Office	95	94	97	97				
	A1-W2 Work	site						
Site Clearance and Site Preparatory Works	117	117	118	118				
2. Piling / D-wall Works	119	119	120	120				
3. Excavation and RC Works	115	115	116	116				
4. Superstructure Construction	116	116	117	117				
Note Worst case noise levels are shown in red.								

As mentioned in Section 11.2.2, three scenarios for CR14 worksite and two scenarios for CR15 worksite were modelled as a result of the varying construction works expected to occur at the worksites. Based on the effective sound power level generated from the worksites shown in Table 11-7, the worst-case noise levels used in the respective scenarios are shown in Table 11-8 below.

Table 11-8 Effective Sound Power Level (Noise Model Input)

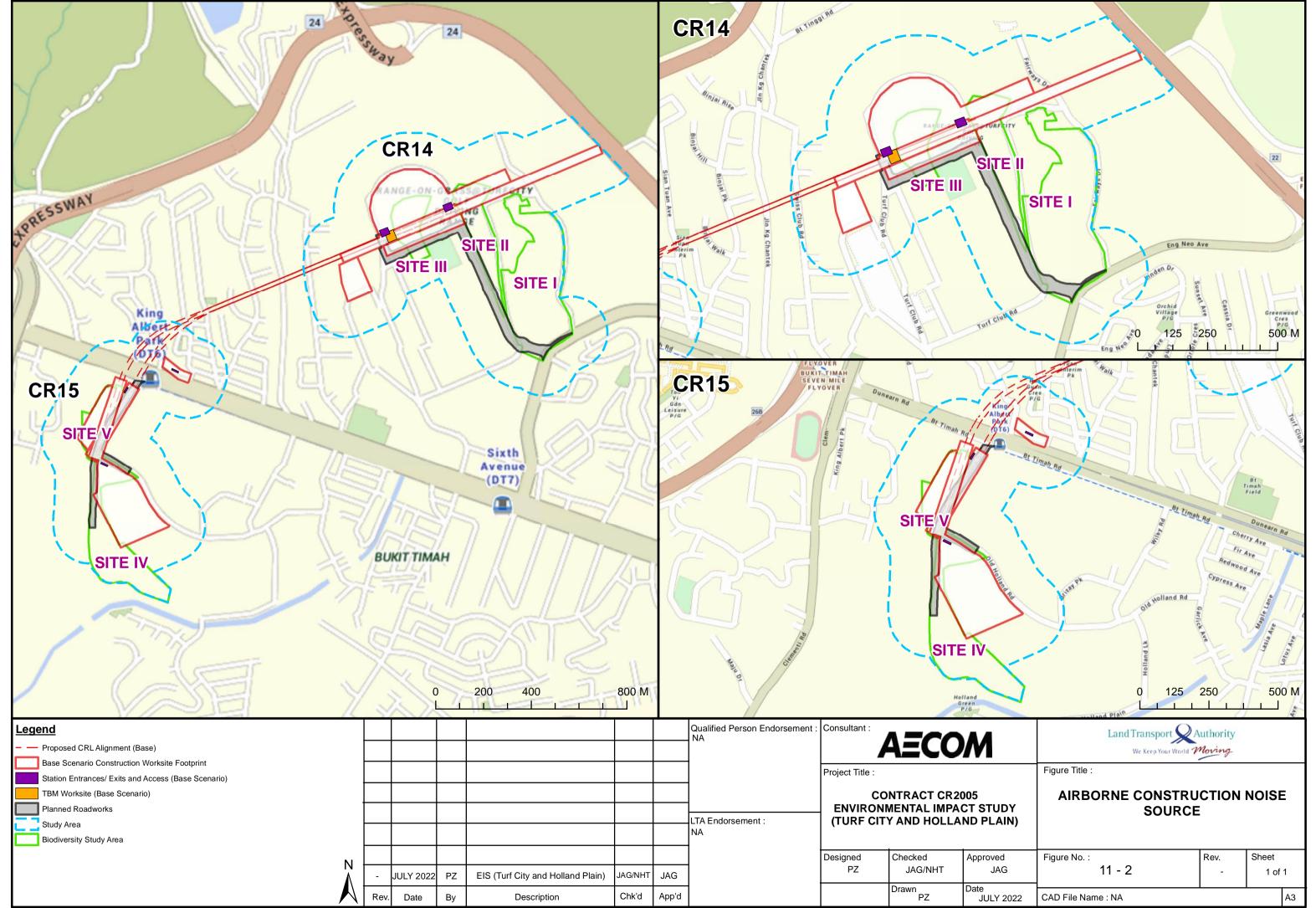
Consulta / Wardenita	Effective S	ound Power Le noise m		sed in the
Scenario / Worksite	L _{Aeq (12 hours)}	L _{Aeq (12 hours)}	L _{Aeq (5 min)}	L _{Aeq (5 min)}
CR	14 Worksite	7pm-ram	7am-7pm	7рт- торт
Scenario 1: Cut and cover works and associated activities				
Clearance for Construction Area & Reinstatement of Work & Exiting Road	116	115	119	116
Road work	118	105	120	108
Scenario 2: TBM (Launching)	115	115	115	115
Scenario 3: Construction of station entrances	108	-	110	-
CR	15 Worksite			
Scenario 1: Cut and cover works and associated activities				
Clearance for Construction Area & Reinstatement of Work & Exiting Road	116	115	119	116
Road work	118	105	120	108
Site Office Construction	95	-	97	-
Construction of Material Storage Area	107	106	109	109
Scenario 2: Construction of station entrances	108	-	110	-

The worksites mentioned in Table 11-8 above are shown in Figure 11-2 below.

The likelihood of the assessment was based on the on the work period and active noise period for machinery. The scenarios as mentioned above were deemed have Certain or Regular likelihood as explained below. The likelihood evaluation for construction activities for the airborne noise assessment is shown in Table 11-9.

Table 11-9 Likelihood Evaluation for Construction Activities for Airborne Noise Assessment

Construction Worksite	Construction Activities	Base Scenario	Mitigated Scenario
	Rock breaking and excavation	Likelihood- Certain Work period = 1 Active noise period for Machinery = 1 1 x1 =1	Likelihood- Certain Work period = 1 Active noise period for Machinery = 1 1 x1 =1
	Scenario–1 - Cut and cover works and associated activities	Likelihood- Certain Work period = 1 Active noise period for Machinery = 1 1 x1 =1	Likelihood- Regular Work period = 0.5 (restricted to daytime) Active noise period for Machinery = 1 0.5 x1 =0.5
CR14	Scenario 2 – TBM Works	Likelihood- Certain Work period = 1 Active noise period for Machinery = 1 1 x1 =1	Likelihood- Certain Work period = 1 Active noise period for Machinery = 1 1 x1 =1
	Scenario 3 – Construction of station entrances	Likelihood- Regular Work period = 0.5 (Day time only) Active noise period for Machinery = 1 0.5 x1 =0.5	Likelihood- Regular Work period = 0.5 (Day time only) Active noise period for Machinery = 1 0.5 x1 = 0.5
	Scenario 1: Cut and cover works and associated activities	Likelihood- Certain Work period = 1 Active noise period for Machinery = 1 1 x1 =1	Likelihood- Regular Work period = 0.5 (restricted to daytime) Active noise period for Machinery = 1 0.5 x1 = 0.5
CR15	Scenario 2 – Construction of station entrances	Likelihood- Regular Work period = 0.5 (Day time only) Active noise period for Machinery = 1 0.5 x1 =0.5	Likelihood- Regular Work period = 0.5 (Day time only) Active noise period for Machinery = 1 0.5 x1 =0.5



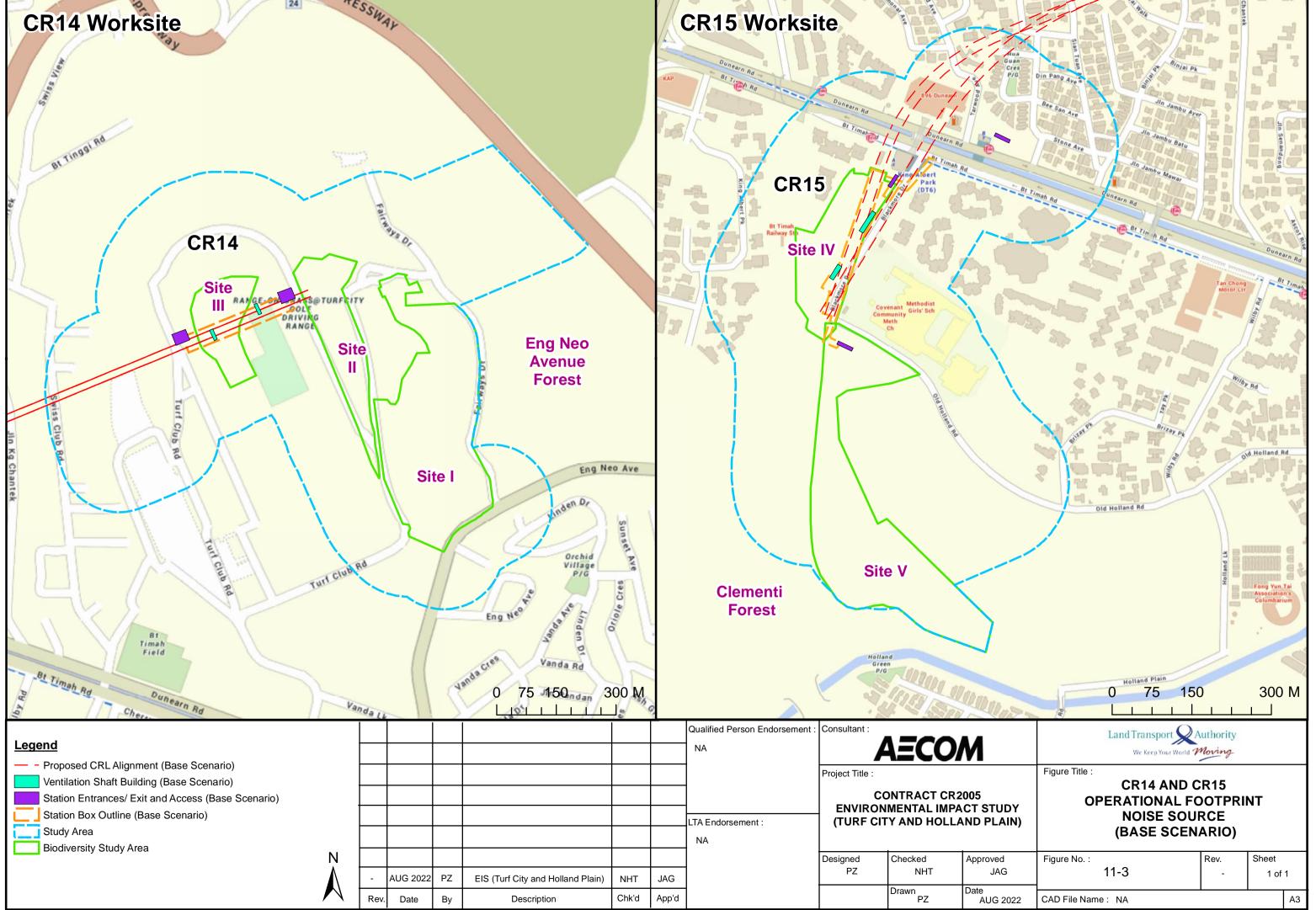
11.3.2 Operational Phase

It is to be noted that the alignment is not considered for this assessment as the rail is underground and will not cause any airborne noise impact. The typical noise sources during operational phase of the project includes the following:

- Traffic noise due to increase in vehicular volume due to the development of the project; and
- Air-conditioning and mechanical ventilation noise from services at the facility buildings.

The traffic increase (if any) could potentially cause disturbance to the ecologically sensitive receptors within the respective Biodiversity Study Area. Traffic noise currently exist with existing roads at the construction worksites. The major roads are namely Bukit Timah Road and Pan Island Expressway (PIE).

Air-conditioning system noise is expected to be present for the duration of the station operating hours, however, mechanical ventilation is expected to persist through the day due to maintenance work within facility buildings and alignment.



11.4 Identification of Airborne Noise Sensitive Receptors

This study focuses on the noise impacts to the Biodiversity Study Area and the respective fauna within the study area for the construction and operational phases. The identified ecological receptors for the construction and operational phases based on the biodiversity studies are categorised below and known habitats (where applicable).

Receptor Sensitivity - Habitat

It is to be noted that the sensitivity of both fauna and habitat are important while identifying sensitivity of noise sensitive receptors. However, during recent nature group engagement held on ²3rd March 2022, for this Project, it was proposed by the members of the nature group to use habitat as the basis of sensitivity assessment for this Project. Therefore, based on the usage of the site, the habitat sensitivity maps were created and used in the assessment. In addition, since there are urban patches of land nearby which may not be suitable to support the presence of fauna, this study will assess these regions as "Not Assessable".

Receptor Importance

For the classification of receptor sensitivity on a species scale for assessment of mitigation measures as a secondary approach, auditory sensitivity of the respective species was used to assign receptor priority. Species that use sound for communication, foraging and breeding are known to have their behaviours disrupted by sound were assigned higher Priority status for auditory sensitivity. Species that are less affected by airborne noise but are of Conservation Significance were assigned second Priority. Species that are less affected by airborne noise and are not of Conservation Significance were assigned lowest Priority.

Species prioritisation of the ecologically sensitive receptors within the Biodiversity Study Area follows the approach listed in order below:

- 1. The actual presence or likely presence (from records) from faunistic field assessment conducted
- 2. The conservation significance or importance of the identified ecological receptors
- 3. The ecological receptor's likely sensitivity to noise impacts

Literature review findings

Based on faunistic field assessment within the Biodiversity Study Area, the full list of ecologically sensitive receptors are shown in Appendix O. Aculeate hymenopterans such as Bees and Wasps are capable of detecting airborne sounds despite not having ears. Due to capability to detect noise, aculeate hymenopterans are deemed to be auditory sensitive [P-88]. However, based on faunistic surveys, no Aculeate hymenopterans of conservation significance was observed. Hence, they are classified as Priority 2 ecologically sensitive receptor.

It is documented that adult odonates appear to be able to hear however sound does not appear to cause significant behavioural change [P-93]. Odonates are consequently regarded as being less auditory sensitive. Hence, they are classified as Priority 2 or 3, dependant on conservation significance.

Lepidoptera such as the butterfly and moth are known to behaviourally respond to low-frequency vibrations and sounds to avoid insect predators and parasites [P-95]. Adult butterflies are known to make use of existing airborne noise in order to avoid predators [P-84]. Hearing dependent night-flying butterflies and moths are sensitive to sounds in order to avoid predation from bats [P-97]. Based on the above, lepidopterans are considered highly auditory. Hence, classified as Priority 1 ecologically sensitive receptor.

Studies have been conducted on the transmission of noise energy across the air to water boundary. Research shows that the transmission of airborne noise energy to the water medium is low due to the difference in acoustic characteristic impedance of air to water by a ratio of 3600 [P-98]. Hence, the aquatic species within water bodies such as decapods, fishes and tadpoles are considered to be Priority 3 ecologically sensitive receptor as it cannot be determined if these species are auditory-sensitive.

Amphibians such as frogs are considered to have highly auditory sensitive as studies have demonstrated that anthropogenic noise is likely to substantially decrease the reproductive success in frogs [P-87]. Hence, amphibians are classified as Priority 1 ecologically sensitive receptor.

Reptiles such as lizards and skinks are considered to be highly auditory sensitive due to studies showing these species exhibiting stress responses when exposed to anthropogenic noise [P-90]. Snakes are unable to hear airborne noise and are not considered noise sensitive but are however sensitive to vibrations [P-85]. Turtles and

terrapins will follow the classification of aquatic species due to the ability to traverse the lands and water [P-86]. Given the wide range of species classified under reptiles, the classification for Reptiles ranges from Priority 1 to Priority 3 ecologically sensitive receptors.

Birds are considered to be highly auditory sensitive as most make use of sound for communication and breeding. Studies have also shown that birds are impacted negatively by anthropogenic noise [P-81]. Hence, birds are classified as Priority 1 ecologically sensitive receptors.

Non-volant mammals such as Rodents are known to display stressed behaviour in response to sounds of heavy machinery which could be common occurrence from construction noise [P-91]. Hence, non-volant mammals are deemed to be highly auditory sensitive and classified as Priority 1 ecologically sensitive receptors.

Anthropogenic noise is known to impacts bats negatively by disrupting foraging patterns [P-96] and are hence classified as highly auditory sensitive. However, based on faunistic surveys, no bats of conservation significance were observed. Hence, they are classified as Priority 2 ecologically sensitive receptor.

Based on faunistic field assessment within the Biodiversity Study Area, the full list of ecologically sensitive receptors are shown in Appendix O.

11.5 Baseline Airborne Noise

11.5.1 Baseline Monitoring Results

Site survey was conducted from 5 - 6 November 2019 and the baseline noise monitoring were conducted between 29 January – 02 March 2020, 13 September – 19 September 2021, 24 September – 30 September 2021 and 23 June – 30 June 2021. It should be noted that baseline noise monitoring was conducted during COVID-19 pandemic. The ambient noise level in this area might be higher during normal conditions.

Table 11-10 and Table 11-11 summarises the $L_{Aeq(12\ hour)}$ and $L_{Aeq(5\ min)}$ baseline results for weekdays and Sundays/public holidays respectively. Table 11-12 summarises the $L_{Aeq(15\ min)}$ baseline results. Refer to Appendix N for the baseline noise monitoring report.

Table 11-10 Summary of Baseline Noise Monitoring Results – Weekdays (For Construction Noise Impact)

Location	Date of Monitoring	LAeq(12	hour), db				LAe	q(5 min)	, dB			
		7am-7pm	7pm-7am	78	am – 7pm	1	7pm – 10pm			•	10pm – 7am	
		Ove	erall	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
N05: Methodist Girls School	24 Feb – 02 Mar 2020	55	49	46	71	53	42	71	51	37	59	43
N06: The Sterling Condominium	24 Feb - 02 Mar 2020	61	57	57	76	60	57	70	59	49	61	55
N07: Landed housing along Hua Guan Avenue	29 Jan – 05 Feb 2020	60	57	57	74	60	57	71	59	48	64	55
N08: Swiss School in Singapore	24 Feb - 02 Mar 2020	54	47	42	69	51	39	69	49	36	55	39
N09: Within Eng Neo Avenue Forest	29 Jan – 05 Feb 2020	56	55	53	68	56	52	73	56	47	64	51
N12: Within Site I	13 Sep – 19 Sep 2021	53	47	43	65	51	42	55	47	39	55	46
N13: Within Site II	13 Sep – 19 Sep 2021	57	49	46	62	52	46	59	50	41	59	46
N14: Within Site V	24 Sep - 30 Sep 2021	52	51	38	69	50	42	57	49	44	73	49
N15: Within Site IV	23 Jun – 30 Jun 2022	74	75	49	86	73	72	78	74	71	94	74
N01(S): Eng Neo Avenue Forest (Southern)*	10 Sep - 16 Sep 2021	53	50	46	60	52	47	59	51	44	56	50
N02(S): Eng Neo Avenue Forest (Northern)*	10 Sep – 16 Sep 2021	62	60	59	73	62	59	71	62	52	65	57
N03(S): Ravine in the centre of the former racetrack*	18 Oct- 24 Oct 2021	56	55	48	74	54	47	74	56	45	67	48
N04(S): Forested area adjacent to The British Club/ Swiss Club*	24 Nov– 30 Nov 2021	54	60	49	75	53	50	83	59	43	80	52
N05(S): Site I (Southern)*	18 Oct- 24 Oct 2021	57	49	49	66	56	49	58	52	37	56	46

Notes:

^{*} Secondary baseline noise monitoring data obtained from the concurrent study carried out by AECOM in the vicinity

Table 11-11 Summary of Baseline Noise Monitoring Results – Sunday/Public Holiday (For Construction Noise Impact)

Location	Date of Monitoring	LAeq(12	hour), db				LAe	q(5 min)	, dB			
		7am-7pm	7pm-7am	78	am – 7pm	1	7pm – 10pm			10pm – 7am		am
		Ove	erall	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
N05: Methodist Girls School	24 Feb – 02 Mar 2020	52	48	45	66	50	44	52	48	39	56	44
N06: The Sterling Condominium	24 Feb - 02 Mar 2020	59	56	55	61	59	57	60	58	48	60	54
N07: Landed housing along Hua Guan Avenue	29 Jan – 05 Feb 2020	59	56	56	61	59	57	59	58	48	60	54
N08: Swiss School in Singapore	24 Feb - 02 Mar 2020	50	40	42	58	48	39	47	41	37	46	38
N09: Within Eng Neo Avenue Forest	29 Jan – 05 Feb 2020	55	53	53	59	55	53	59	55	48	58	51
N12: Within Site I	13 Sep – 19 Sep 2021	62	50	43	74	53	43	56	52	44	50	47
N13: Within Site II	13 Sep – 19 Sep 2021	57	49	45	78	56	47	64	59	49	58	53
N14: Within Site V	24 Sep - 30 Sep 2021	49	52	41	61	47	41	63	48	44	63	49
N15: Within Site IV	23 Jun – 30 Jun 2022	74	73	72	76	73	73	77	74	72	74	73
N01(S): Eng Neo Avenue Forest (Southern)*	10 Sep - 16 Sep 2021	53	50	48	59	53	48	54	51	47	52	51
N02(S): Eng Neo Avenue Forest (Northern)*	10 Sep – 16 Sep 2021	60	59	58	67	60	60	68	62	50	62	55
N03(S): Ravine in the centre of the former racetrack*	18 Oct- 24 Oct 2021	53	47	47	60	52	47	48	47	46	54	47
N04(S): Forested area adjacent to The British Club/ Swiss Club*	24 Nov– 30 Nov 2021	53	68	51	57	53	56	81	65	42	63	51
N05(S): Site I (Southern)*	18 Oct- 24 Oct 2021	57	49	51	63	56	49	55	52	41	55	50

Notes:

^{*} Secondary baseline noise monitoring data obtained from the concurrent study carried out by AECOM in the vicinity

Table 11-12 Summary of Baseline Noise Monitoring Results (For Operational Noise Impact)

Location	Date of Monitoring	LAeq(15 min), dB									
		7	'am – 7pm		7	pm-11pm	1	1	1pm-7ar	n	
		Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	
N05: Methodist Girls School	24 Feb – 02 Mar 2020	47	67	53	44	66	50	38	58	43	
N06: The Sterling Condominium	24 Feb – 02 Mar 2020	55	71	60	57	67	59	49	60	54	
N07: Landed housing along Hua Guan Avenue	29 Jan – 05 Feb 2020	56	69	60	57	67	59	49	62	54	
N08: Swiss School in Singapore	24 Feb – 02 Mar 2020	44	66	51	39	66	47	36	53	39	
N09: Within Eng Neo Avenue Forest	29 Jan – 05 Feb 2020	53	65	56	53	72	56	47	61	51	
N12: Within Site I	13 Sep – 19 Sep 2021	44	73	52	43	56	48	40	54	46	
N13: Within Site II	13 Sep – 19 Sep 2021	45	77	53	45	63	51	42	58	46	
N14: Within Site V	24 Sep – 30 Sep 2021	43	67	50	42	59	49	44	71	49	
N15: Within Site IV	23 Jun – 30 Jun 2022	52	81	73	72	77	74	71	93	73	
N01(S): Eng Neo Avenue Forest (Southern)*	10 Sep – 16 Sep 2021	48	58	53	49	56	51	46	54	50	
N02(S): Eng Neo Avenue Forest (Northern)*	10 Sep – 16 Sep 2021	58	71	61	57	68	61	51	64	56	
N03(S): Ravine in the centre of the former racetrack*	18 Oct- 24 Oct 2021	48	70	54	46	74	53	45	52	47	
N04(S): Forested area adjacent to The British Club/	24 Nov- 30 Nov 2021	51	72	53	51	82	60	44	78	51	
Swiss Club*											
N05(S): Site I (Southern)*	18 Oct- 24 Oct 2021	49	64	56	44	57	51	39	55	45	
Notes:											
* Secondary baseline noise monitoring data obtained from	n the concurrent study carried or	ut by AEC	DM in the v	vicinity							

11.5.2 Corrected Construction Noise Criteria

Based on the baseline noise monitoring results, the overall noise levels for $L_{Aeq(12 \text{ hour})}$ and $L_{Aeq(5 \text{ min})}$ from noise monitoring points were used to calculate the "adjusted maximum permissible noise level" in line with the directions given in Section 11.2.3 to determine the construction noise criteria for this project.

Table 11-13 displays the corrected criteria and the calculations are shown in Appendix Z.

It is to be noted that ecological receptors noise impact in Site I to Site V were assessed against the baseline noise level as the Project-specific noise criteria (no worse off than baseline approach). Since there is no public holiday for ecological receptors, weekday baseline noise levels were used for noise criteria.

Table 11-13 Corrected Construction Noise Criteria- Weekdays

No.			Types Affected Receptors	of	L _{Aeq(12}	hour), dB		LAeq(5 min)	, dB
					7am- 7pm	7pm- 7am	7am- 7pm	7pm- 10pm	10pm- 7am
	(12) Na) Sensitive (Human)	Noise	61		53	75	56		55
N06					64	58	75	60	58
N07					63	58	75	60	58
N08					61	52	75	56	55
N09					62	56	75	59	57
N12					61	52	75	56	56
N13					62	53	75	56	56
N14					61	54	75	56	56
N15					74	75	78	74	74
N01(S)					61	53	75	57	56
N02(S)					65	61	75	63	60
N03(S)					62	56	75	59	56
N04(S)					61	61	75	61	57
N05(S)					62	53	75	57	56
N05					55	49	53	51	43

No.	Types of Affected Receptors	LAeq(12 hour), dB		LAeq(5 min), dB			
		7am- 7pm	7pm- 7am	7am- 7pm	7pm- 10pm	10pm- 7am	
N06	Ecological Sensitive	61	57	60	59	55	
N07	Receptors*	60	57	60	59	55	
N08		54	47	51	49	39	
N09		56	55	56	56	51	
N12		53	47	51	47	46	
N13		57	49	52	50	46	
N14		52	51	50	49	49	
N15		74	75	73	74	74	
N01(S)		53	50	52	51	50	
N02(S)		62	60	62	62	57	
N03(S)		56	55	54	56	48	
N04(S)		54	60	53	59	52	
N05(S)		57	49	56	52	46	

*Notes:

- 1. Ecological receptor noise impact to be assessed against the baseline noise level as the noise criterion.
- 2. Criteria for ecological receptor is more stringent than human criteria.
- 3. If there are any noise monitoring works being conducted hereafter, i.e. during actual pre-construction phase (i.e. before actual site clearance) and/or pre-commissioning phase, this Project-specific noise criteria (no worse off than baseline approach) will be updated accordingly and be complied on site.

11.5.3 Corrected Operational Noise Criteria

Based on the baseline noise monitoring results, the overall noise levels for $L_{Aeq(15 \text{ Min})}$ from noise monitoring points were used to calculate the "adjusted maximum permissible noise level" in line with the directions given in Section 11.2.3 to determine the operational noise criteria for this Project.

Table 11-14 shows the corrected operational noise criteria and the calculations are shown in Appendix Z. It is to be noted that ecological receptors noise impact in Site I to Site V were assessed against the baseline noise level as the Project-specific noise criteria (no worse off than baseline approach).

Table 11-14 Corrected Operational Noise Criteria

No.	Types of Receptors	Affected		LAeq(15 min), dB	
			7am-7pm	7pm-11pm	11pm-7am
(13) Na) Noise Sensitive Premises (Human)	61		56	51	
N06			63	60	55
N07			63	60	55
N08			61	56	50
N09			61	59	54
N12			61	56	51
N13			61	56	51
N14			61	56	53
N15			73	74	73
N01(S)			61	57	53
N02(S)			64	62	57
N03(S)			61	58	52
N04(S)			61	61	54
N05(S)			62	57	51
N05	Ecological Receptors*	Sensitive	53	50	43
N06	Recopiols		60	59	54

No.	Types of Affected Receptors		LAeq(15 min), dB	
		7am-7pm	7pm-11pm	11pm-7am
N07		60	59	54
N08		51	47	39
N09		56	56	51
N12		52	48	46
N13		53	51	46
N14		50	49	49
N15		73	74	73
N01(S)		53	51	50
N02(S)		61	61	56
N03(S)		54	53	47
N04(S)		53	60	51
N05(S)		56	51	45

*Notes:

- 1. Ecological receptor noise impact to be assessed against the baseline noise level as the noise criterion.
- 2. Criteria for ecological receptor is more stringent than human criteria.
- 3. If there are any noise monitoring works being conducted hereafter, i.e. during actual pre-construction phase (i.e. before actual site clearance) and/or pre-commissioning phase, this Project-specific noise criteria (no worse off than baseline approach) will be updated accordingly and be complied on site.

11.6 Minimum Control for Potential Impacts

This section proposes minimum controls or standard practices commonly implemented that have been assumed to be implemented for the purposes of impact assessment.

11.6.1 Construction Noise

Mitigation measures with the principles as stated on Section 6.5 were developed to control construction noise levels that are predicted to exceed the project criteria at the nearest noise sensitive receivers:

- **Elimination/ Avoidance** Where changes to the project design and construction methodology can be made to eliminate or avoid an identified impact (e.g., optimisation or reduction of construction footprint, shift, or elimination of construction site in critical areas, exclusion of noisy construction phases to be conducted at evening/ night period, etc.). If full elimination is not possible, the next level of mitigation is to minimise the identified impact;
- Minimisation (Substitution) Where changes to the project design and construction methodology cannot
 affect impact elimination; compensatory measures can be adopted to mitigate for identified impacts. For e.g.,
 substitution of the noisier Hammer Piler with alternative Silent Piler to reduce impacts to residents. As much
 as possible, alternative quieter equipment will be used for the Project construction.
- Minimisation (Engineering controls) Where changes to the project design and construction cannot affect
 impact avoidance or minimisation via substitution, engineering controls can be adopted to further mitigate for
 identified impacts and possibly an enhancement measure (e.g. use of equipment enclosures wherever
 necessary).
- Minimisation (Administrative controls) Where applicable, enhanced mitigation can be achieved by
 applying administrative controls on top of engineering controls. These controls do not remove environmental
 hazards, but limit or prevent receptor's exposure to hazards, such as proper scheduling of noisier construction
 activities, reducing work on weekends, etc.
- Compensation/ Offset Where possible, measures should be taken to compensate/ offset the impacts in a different part of the development, wherever technically and financially feasible, e.g. rare shrubs or trees that are important to birds and mammals to be planted elsewhere in consultation with NParks, etc.

The following control measures should be observed during the construction stage to reduce the noise levels:

- Construction prohibition period should be followed, as per fourth schedule of Environment Protection and Management regulation;
- Prepare a Construction Noise Management Plan, to establish baseline monitoring prior to site clearance, plan for monitoring during the construction phase, and procedure for complaint handling;
- The contractor shall review the equipment to be used on site and erect localised noise barriers prior to undertaking high noise generating work;
- Machines (such as trucks) that may be in intermittent use shall be shut down between work periods or shall be throttled down to a minimum;
- Only well-maintained plants shall be utilised on-site and plants shall be serviced regularly during the entire construction period;
- The number of PMEs shall be reduced as far as practicable when construction works are carried out at areas close to the noise sensitive receivers:
- Silencers or mufflers on construction equipment shall be utilised and shall be properly maintained during the construction programme;
- Behavioural practices including no shouting, no loud stereos/ radios on site, no dropping of materials from height, no throwing of metal items shall be ensured;
- Construction respite: Restrict high noise generating drilling activities only in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block, if possible;
- Periodic noise monitoring by an independent third party, to establish compliance with requirements and to advise on equipment causing concern, and additional potential mitigation measures;
- Plan the layout of the site by considering using materials and other large structural equipment as noise barriers;
- Plant known to emit noise strongly in one direction shall, wherever possible, be orientated so that the noise is directed away from the nearby NSRs;

- Material stockpiles and other structures shall be effectively utilised, wherever practicable, in screening noise from on-site construction activities;
- Acoustic sheds should be provided at the locations of the noise generating activity such as operation of handheld breaker;
- Construction works at the surface and initial boring to be conducted in the daytime as far as possible;
- The optimisation of worksite to be situated away from Biodiversity Study Area as far as practicable.; and
- Works using machines or vehicles that generate noise should be conducted within the daytime period since the site is next to the Biodiversity Study Area.

11.6.2 Operation Noise

The mechanical ventilation equipment would be designed and sited appropriately during detailed design phases to ensure boundary noise levels are in compliance with the adjusted boundary noise limits derived in Section 11.5.3. Some noise sources might be located close to the boundary and might need special attention for boundary noise limits compliance, and if necessary, would be equipped with additional mitigation measures- to be provided upon assessment of the operation noise.

Minimum controls for the noise emission from the operation of the air-conditioning and mechanical ventilation systems are listed below:

- Use low air-conditioning and mechanical ventilation system equipment;
- Ensure that any exhaust outlet or intake from the mechanical ventilation system is designed to be adequately set back as far as possible from the boundary line of the development;
- Acoustic treatment for equipment to meet noise level limit at site boundary where necessary;
- AC system to be designed with the AHU units placed at appropriate locations as set back from the boundary line of the development as possible; and
- Acoustic enclosures for outdoor equipment.

11.7 Prediction and Evaluation of Airborne Noise Impacts

This section discusses the predicted construction noise impacts and operational noise impacts to the ecologically sensitive receptors from the base scenarios of all the proposed development.

11.7.1 Construction Phase

11.7.1.1 Construction Scenarios 1 to 3

Based on the modelled noise levels in Table 11-8, the ecologically sensitive receptors within the Biodiversity Study Area are exposed to a wide range of noise levels from the Project site dependant on the location of the noise sensitive fauna. Hence, the assessment assumes the worst-case noise impact at the boundary of the Biodiversity Study Area fronting the receptive worksites across the scenarios.

The noise impact on ground level (1.5m) will not be same with higher elevation (10-15m) even in same location, and the response from ecological receptors will vary according to the noise levels as well as type of fauna inhabiting or experiencing the levels. It is to be noted that impacts on higher elevation receptors such as bird species are likely able to find alternative habitats in the surroundings for reasons more than just noise, including increased human presence, light, noise and other activities also. Therefore, the predicted noise levels with construction noise impact more on fauna near the ground level up to 1.5m height, hence, the predicted levels at this height were assessed in more details for Scenario 1 to Scenario 3 (CR14 worksite) is shown in Table 11-15 and for Scenario 1 to Scenario 2 (CR15 worksite) is shown in Table 11-16.

CR14 Worksite

The worst-case noise contours with impact significance (1.5m height) for CR14 worksite during Base Scenario 1 to Scenario 3 are shown in Figure 11-4 to Figure 11-8.

Table 11-15 Summary of Construction Noise Predictions (Base Scenarios) – CR14 Worksite

						High	Certain	Major	3.9
		1			High	High	Certain	Major	2.6
	Site II		75	23					
–1 - Cut and	Site I	1	64	18	High	High	Certain	Major	3.7
cover works	Site II	1	68	22	High	High	Certain	Major	2.4
and associated activities (7pm-7am)	Site III	1	62	6	Medium	Medium	Certain	Major	0.1
2 TDM /7cm	Site I	1	46	-	Negligible	Very Low	Certain	Minor	-
2 – TBM (7am-	Site II	1	52	-	Negligible	Very Low	Certain	Minor	-
7pm)	Site III	1	60	6	Medium	Medium	Certain	Major	0.2
2 – TBM (7pm-	Site I	1	46	-	Negligible	Very Low	Certain	Minor	-
2 – тый (тріп- 7am)	Site II	1	52	6	Medium	Medium	Certain	Major	0.7
raiii)	Site III	1	60	4	Medium	Medium	Certain	Major	Less than 0.1
3 –	Site I	1	45	-	Negligible	Very Low	Regular	Minor	-
Construction of	Site II	1	62	10	High	High	Regular	Major	0.1
station entrances (7am-7pm)	Site III	1	54	-	Negligible	Very Low	Regular	Minor	-
Note * Ecological recept	ors noise impact to be	e assessed agains	t the baseline noise	level as the noise criterio	n.	•	·	·	·

Site I, Site II and Site III

Site I, Site II and Site III are in close proximity (150m from worksite) to the CR14 worksite. Across the three base scenarios, the highest noise level 76dB(A) was predicted for ground level receptors during the cut and cover works and associated activities, with 60dB(A) during TBM work and 62dB(A) during construction of station entrances respectively. This is largely dependent on the proximity of the noisy works.

During the cut and cover works and associated activities, Priority 1 ecologically sensitive habitats at Site I, Site II and Site III will potentially experience the highest exceedance of the noise criterion 23dB(A) (high impact intensity) with high impact consequence. Since the likelihood is calculated as **Certain**, the resulting impact significance is **Major.**

During the TBM works, Priority 1 ecologically sensitive habitat at Site II and Site III will potentially experience the highest exceedance of the noise criterion 6dB(A) (medium impact intensity) with medium impact consequence. Since the likelihood occurring during the entire construction is regarded as **Certain**, and the resulting impact significance is **Major**. But for the priority 1 ecologically sensitive habitat at Site I will potentially experience the no exceedance than the noise criterion and the resulting impact significance is **Minor**.

During the Entrance construction, Priority 1 ecologically sensitive habitat at Site II will potentially experience the highest exceedance of the noise criterion 10dB(A) (high impact intensity) with high impact consequence. Since the likelihood occurring during the entire construction is regarded as **Regular**, the resulting impact significance is **Major**. But for the priority 1 ecologically sensitive habitat at Site I and Site III will potentially experience the no exceedance than the noise criterion and the resulting impact significance is **Minor**.

CR15 Worksite

The worst-case noise contours with impact significance (1.5m height) for CR15 worksite during Base Scenario 1 to Scenario 2 are shown in to Figure 11-9 to Figure 11-11.

Table 11-16 Summary of Construction Noise Impacts (Base Scenario-) - CR15 Worksite

						Medium	Certain	Major	Less than 0.1
-1 - Cut and cover works and associated activities (7pm-	Site IV Site V	1	69	20	Negligible High	Very Low High	Certain Certain	Minor Major	2.1
7am)	Site IV	1	74	1	Low	Low	Regular	Moderate	
Construction of station entrances (7am-7pm)	Site V	1	58	8	High	High	Regular	Major	Less than 0.1

^{*} Ecological receptors noise impact to be assessed against the baseline noise level as the noise criterion.

Site IV and Site V

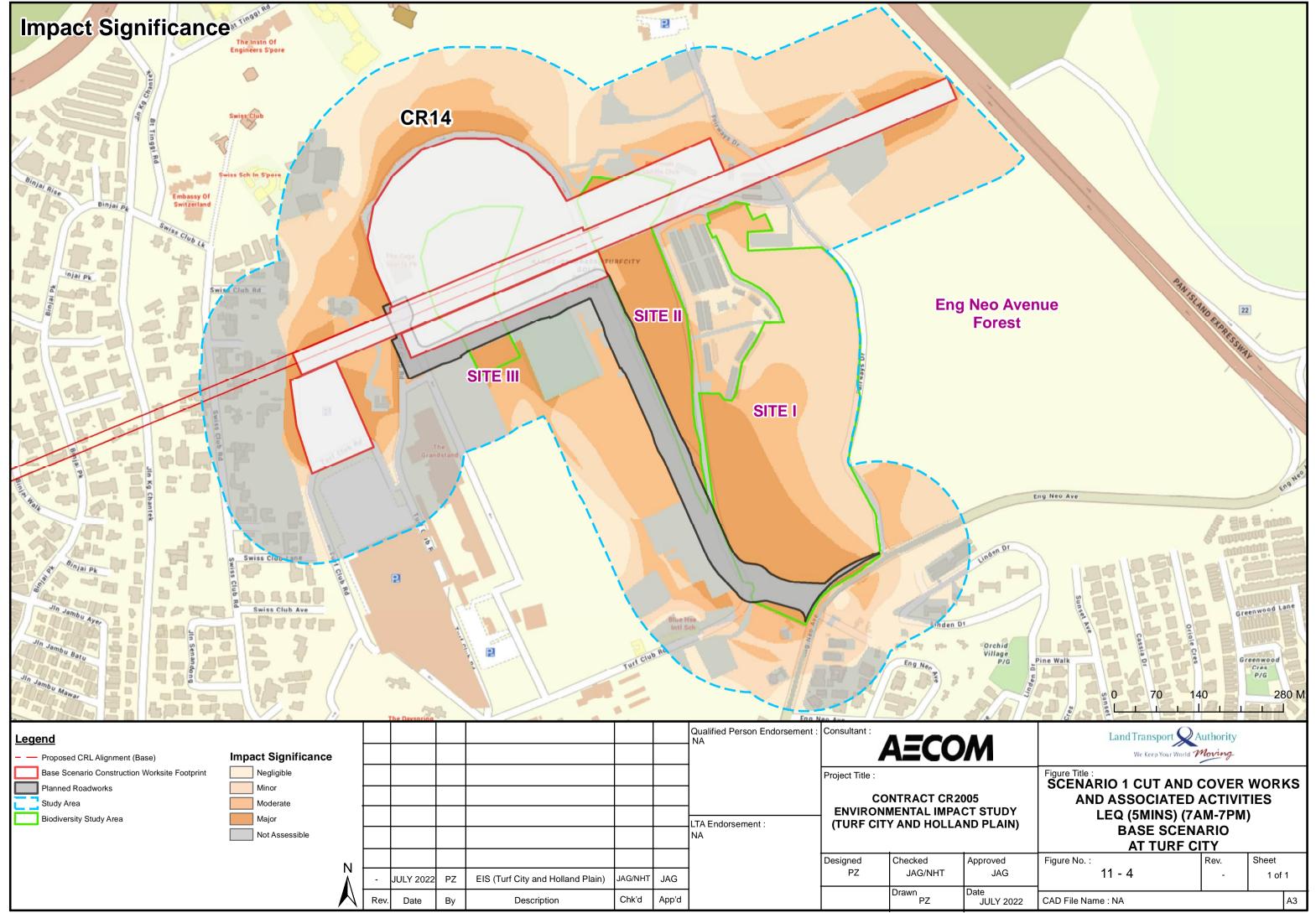
Site IV and Site V are in close proximity (150m from worksite) to the CR15 worksite. Across the two base scenarios, the highest noise level 80dB(A) was predicted for ground level receptors during the cut and cover works and associated activities, with 74dB(A) during TBM work respectively. This is largely dependent on the proximity of the noisy works.

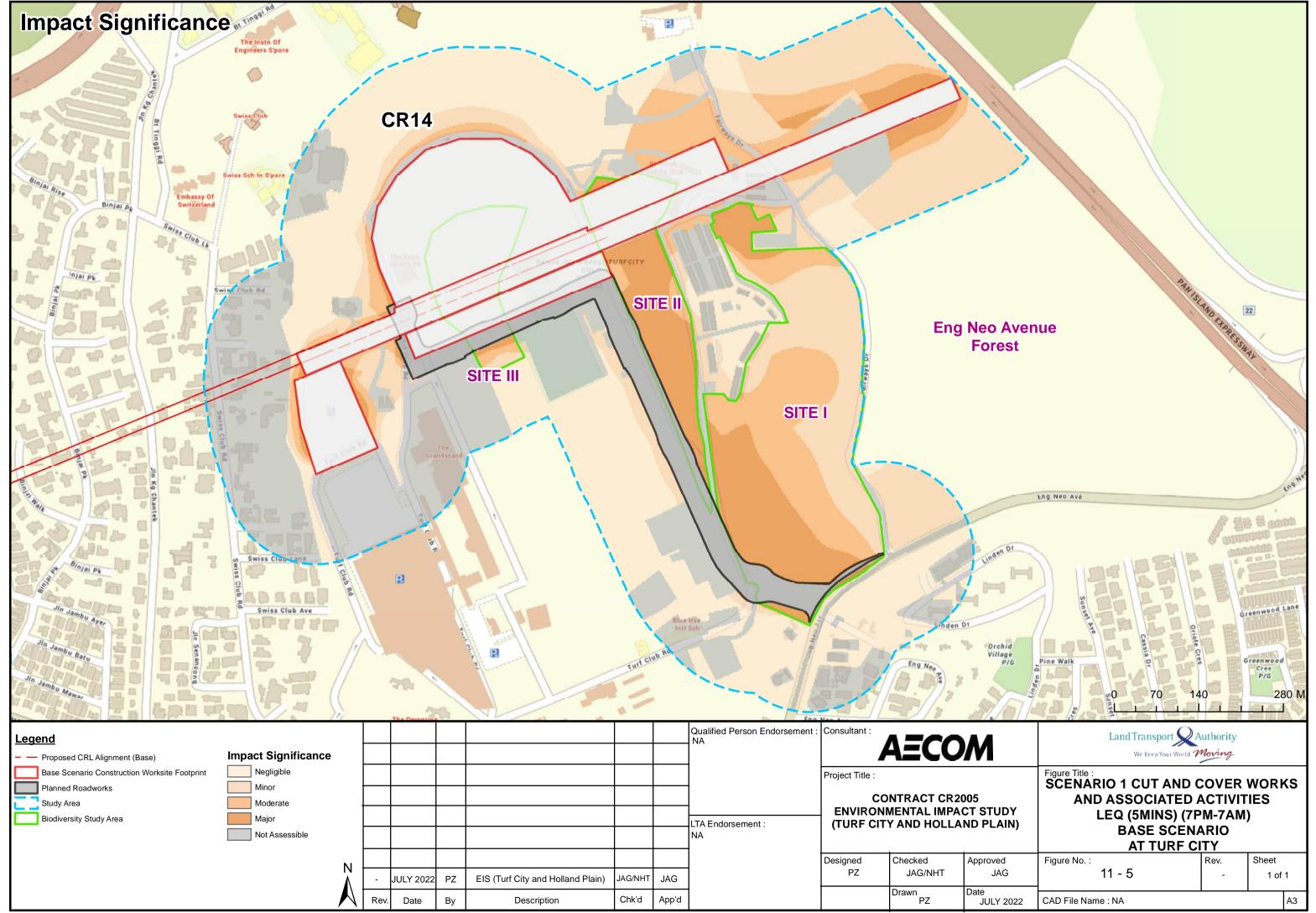
During the cut and cover works and associated activities, Priority 1 ecologically sensitive habitats at Site IV will potentially experience the highest exceedance of the noise criterion 5dB(A) (medium impact intensity) with medium impact consequence. Since the likelihood is calculated as **Certain**, the resulting impact significance is **Major**. Priority 1 ecologically sensitive habitats at Site V will potentially experience the highest exceedance of the noise criterion 30dB(A) (high impact intensity) with high impact consequence. Since the likelihood is calculated as **Certain**, the resulting impact significance is **Major**.

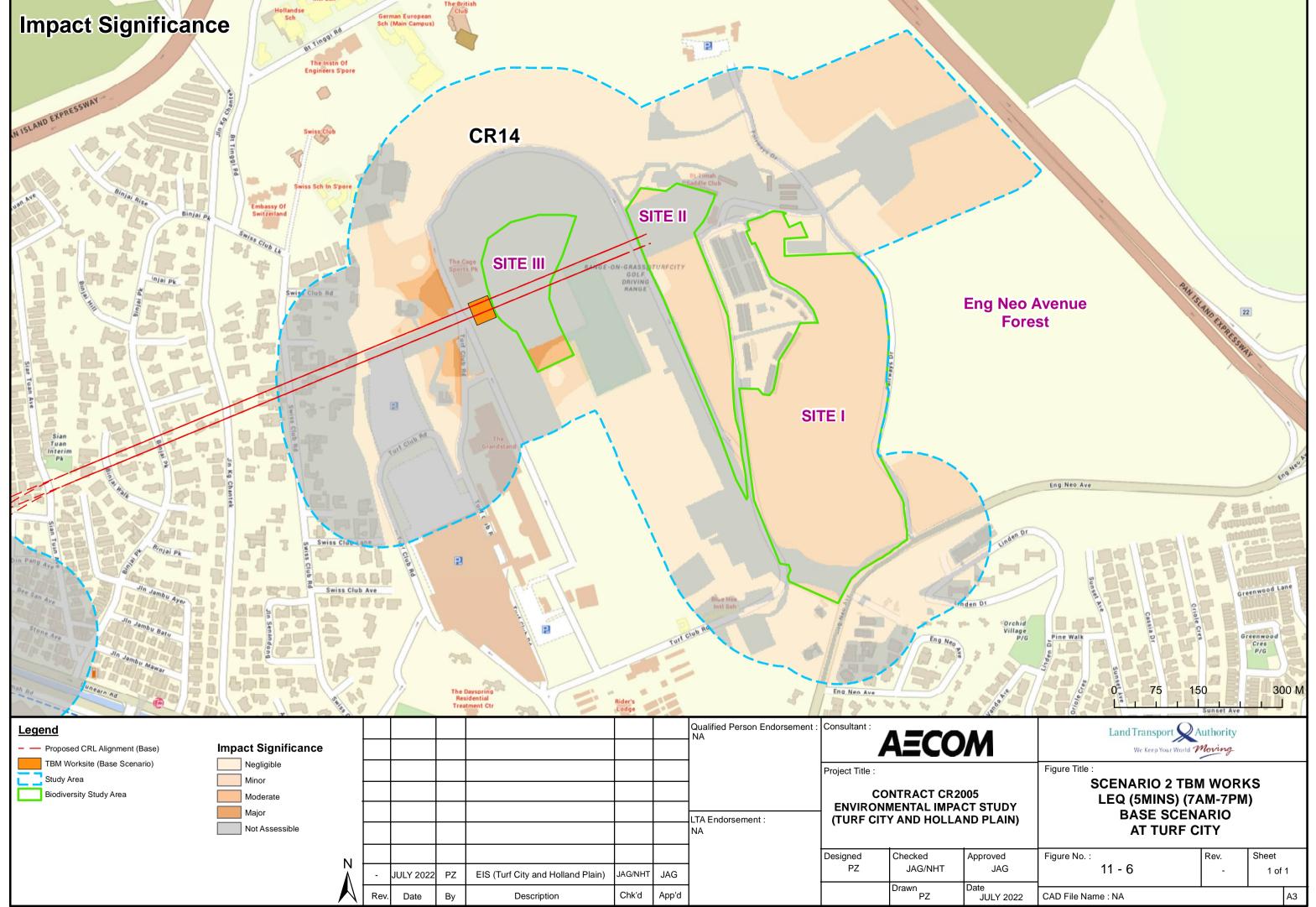
During the Entrance construction, Priority 1 ecologically sensitive habitat at Site V will potentially experience the highest exceedance of the noise criterion 8dB(A) (high impact intensity) with high impact consequence. Since the likelihood occurring during the entire construction is regarded as **Regular**, the resulting impact significance is **Major**. Priority 1 ecologically sensitive habitats at Site IV will potentially experience the highest exceedance of the noise criterion 1dB(A) (low impact intensity) with low impact consequence, and the resulting impact significance is **Moderate**.

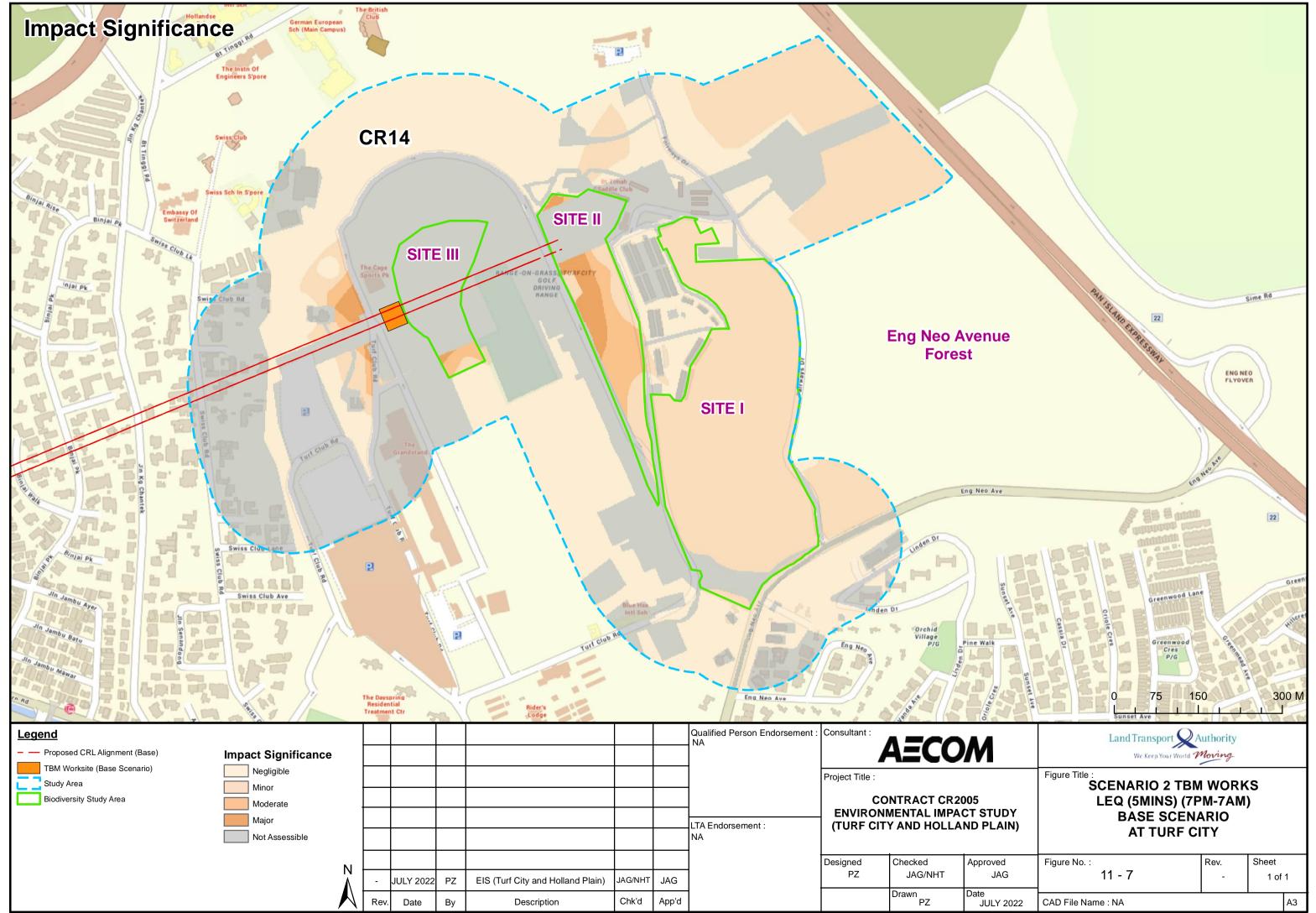
It is to be noted that impacted bird species are likely able to find alternative habitats in the surroundings. However, impacts are expected in the form of disturbances from noise. It can be expected that the fauna which are highly mobile are able to move deeper within Clementi Forest from Site IV and Site V, and Eng Neo Avenue Forest from Site I, Site II and Site III, away from construction noise. As with the previous case close to ground, some species may be able to find refuge in the adjacent Clementi Forest (areas that are not work site). Impacts of disturbances to these species are unclear, but noise disturbances may affect its communication with other individuals. This site in particular has large mammals such as slow loris and langurs inhabiting the site which may be impacted at their arboreal activities and group interaction (for langurs) impacted. It is therefore likely that during the excavation period these mammals and avian species will tend to move farther away from the site.

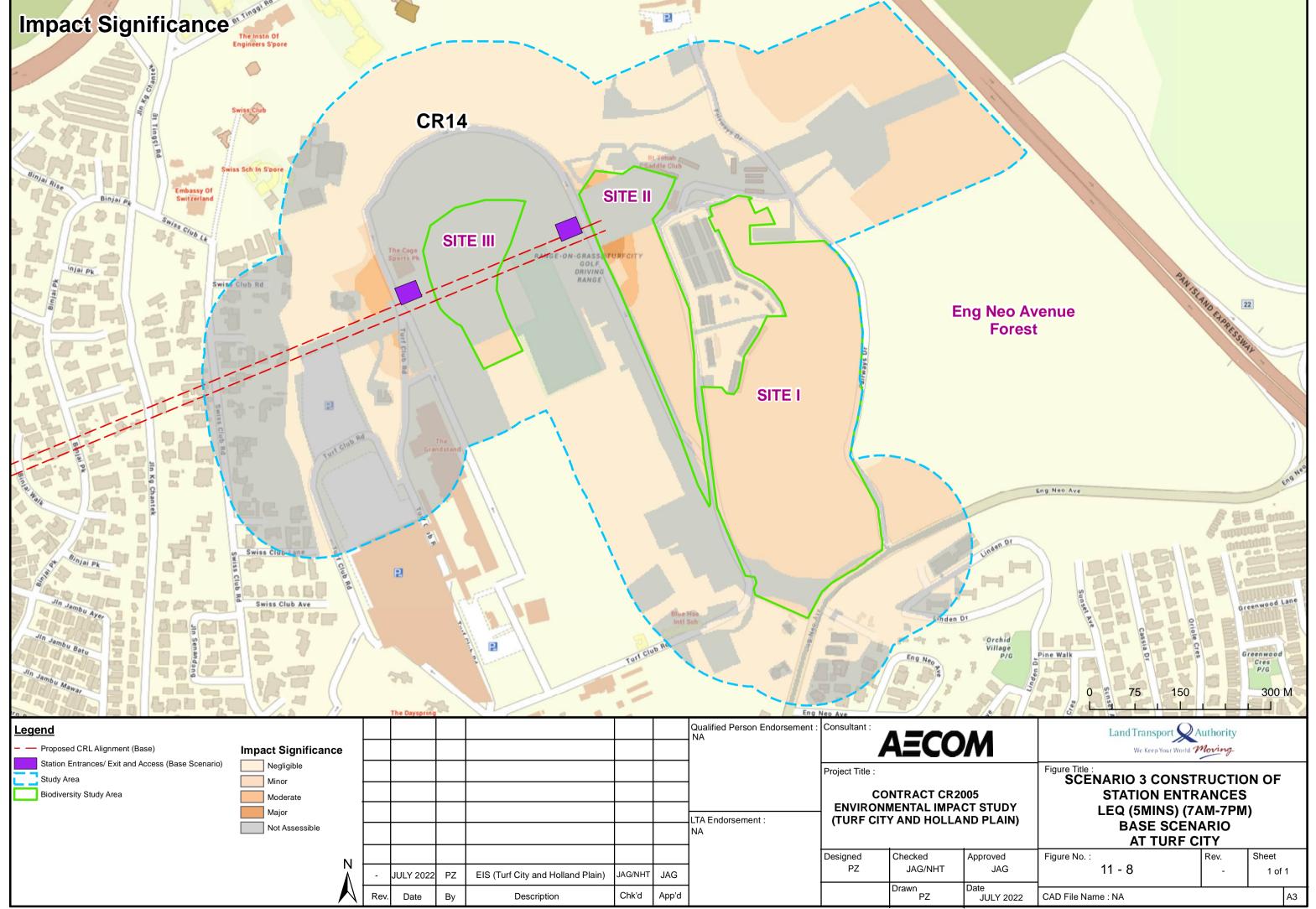
Note that since the intensity of impact is much higher than the criteria, mitigation measures are proposed in Section 11.8 to reduce the noise impact to the ecologically sensitive habitats within the Biodiversity Study Area

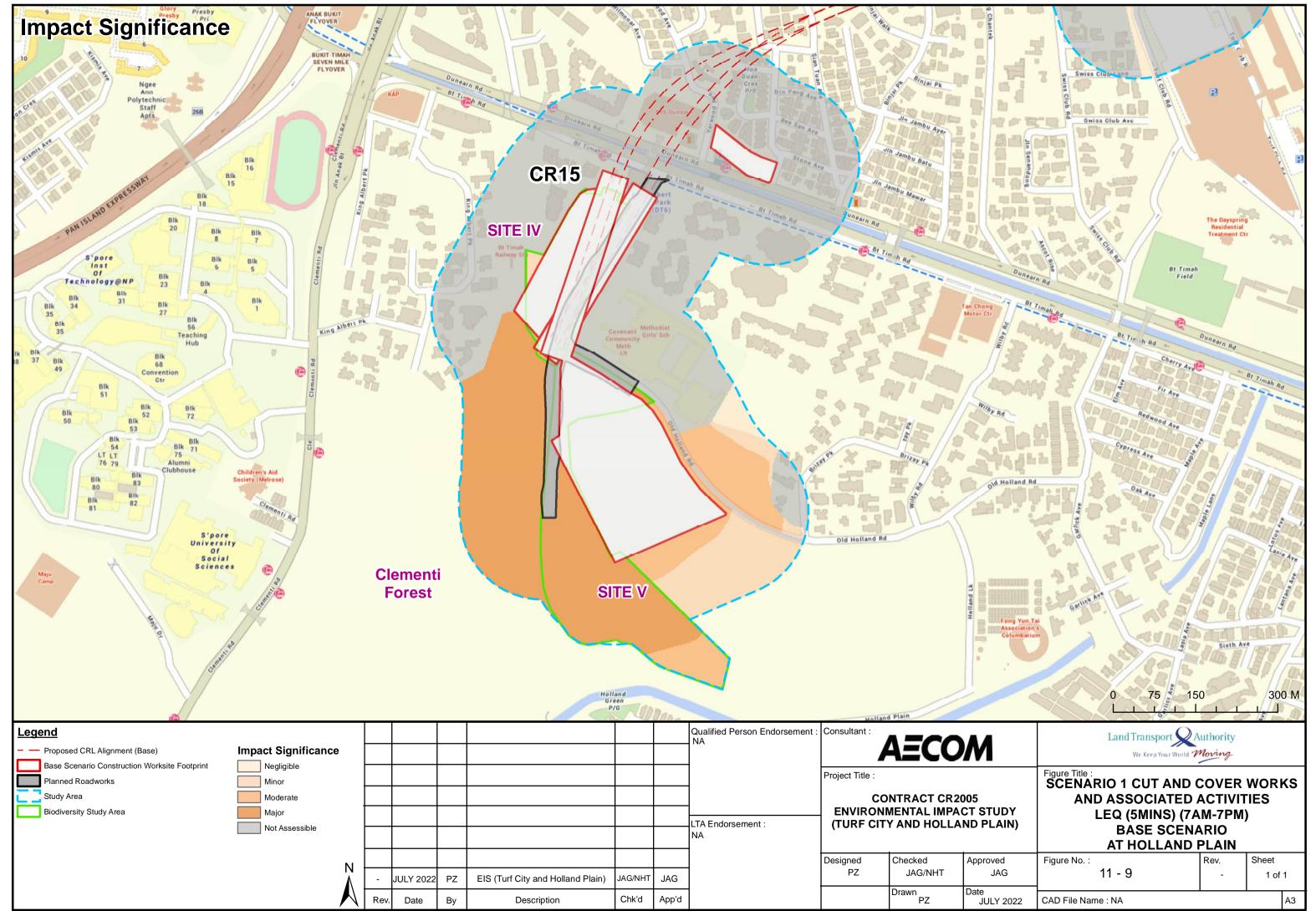


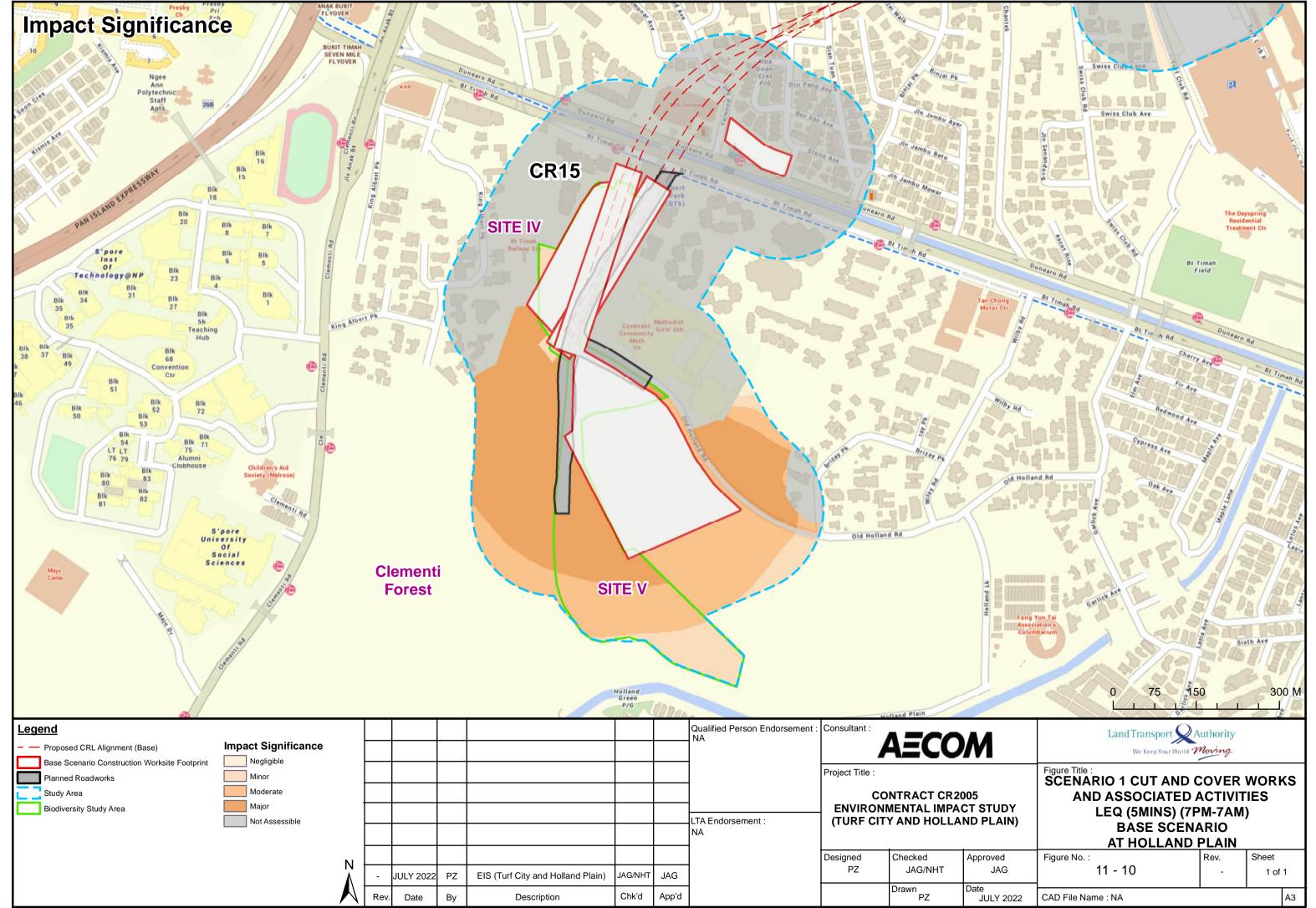


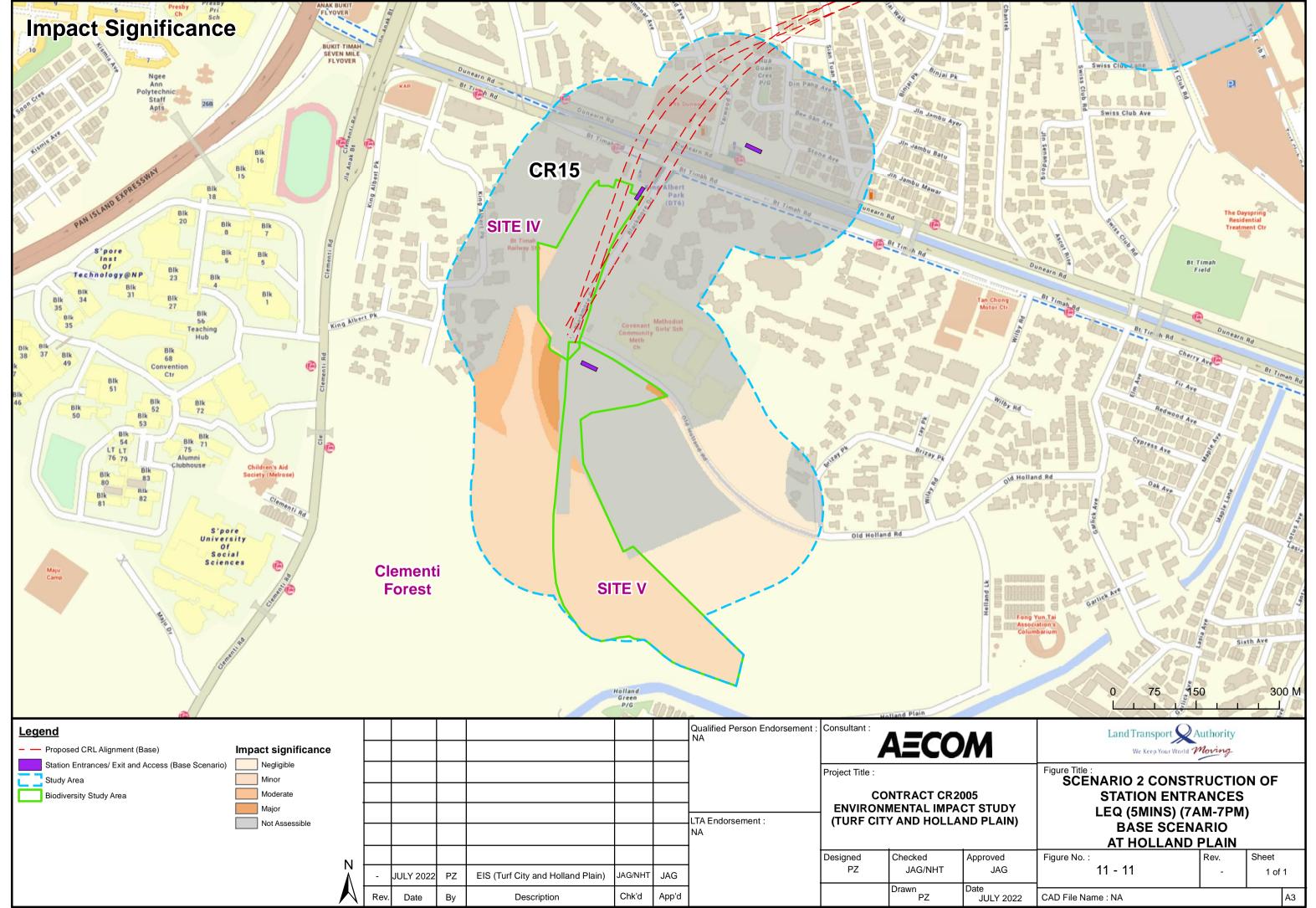












11.7.2 Operational Phase

11.7.2.1 Boundary Noise Limits for ACMV in Non-industrial Building

As mentioned in Section 11.2.2.2, an airborne noise study at the boundary of facility buildings associated will be conducted in a separate study by LTA. The criteria for noise at each location has been provided to the consultant and the noise at boundary is expected to meet the NEA Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Buildings, 2018 and or stringent criteria as per the Table 11-17. Given that the design of this building shall be such as to meet the boundary noise requirements as stated in this report, and the design of the building shall be such as it camouflages in the surroundings; the expected noise impact during operational phase will be **negligible**.

Table 11-17 Project Criteria for Operational Noise Impact Assessment

No.	Types of Receptors	LAeq(15 min), dB							
		7am-7pm	7pm-11pm	11pm-7am					
Site I* (N05(S))		56	51	45					
Site II* (N13)		53	51	46					
Site III* (N03(S))	Noise Sensitive Receptors (Ecological)	54	53	47					
Site IV* (N15)		73	74	73					
Site V* (N14)		50	49	49					

*Notes:

- 1. Ecological receptor noise impact to be assessed against the baseline noise level as the noise criterion.
- 2. Criteria for ecological receptor is more stringent than human criteria.
- 3. If there are any noise monitoring works being conducted hereafter, i.e., during actual pre-construction phase (i.e., before actual site clearance) and/or pre-commissioning phase, this Project-specific noise criteria (no worse off than baseline approach) will be updated accordingly and be complied on site.

11.7.2.2 Traffic Noise

There is a new access road for these CR14 and CR15 MRT stations, the routine traffic near Site I to Site III for CR14 worksite and near Site IV to Site V for CR 15 worksite are expected to be much higher than the recent traffic. Therefore, the noise from the traffic from the new access road shall dominate the noise levels.

At the time of writing of this report, the predicted traffic and road design/ alignment was not confirmed. In absence of specialist traffic study, therefore there shall be no evaluation was conducted from traffic noise in operational noise in this report; however, with current knowledge as above at this stage, the variations can only be speculated as described.

11.8 Recommended Mitigation Measures

11.8.1 Construction Phase

AECOM proposes the following recommendation to reduce the exceedance noise level

11.8.1.1 Elimination/Substitution

CR14 worksite and CR15 worksite weighed a design modification of worksite configuration in base scenario above, and the benefit from the mitigated/ modified scenario is that less biodiversity sensitive areas are impacted in this case due to its reduced footprint

11.8.1.2 Engineering Controls

Due to the proximity of sensitive receptors to the construction boundary, mitigation measures for control of noise at the source are recommended and where possible for example, silent piling is recommended so that cut and cover works, and associated activities related noise levels can further be reduced especially for heights in trees for arboreal dwellers.

The implementation of noise mitigation comes about in two steps:

<u>Step 1</u>: The construction inventory list is analysed to check the equipment (PME) causing high noise levels (higher quantity of PME and longer working periods of PME can cause higher noise levels). The use of equipment with lower noise level shall be prioritised, as this is the most effective way to mitigate the noise level at the source;

Step 2: When Step 1 is not applicable or feasible, noise barriers as detailed in the sections below. The barrier height and placement position of a noise barrier are the prime factors determining its efficiency. Acoustic specification of the noise barrier shall be determined based on the quantitative noise impact assessment to be conducted at later stage. The following factors are to be accounted for, while erecting a barrier:

- The barrier shall be placed as close as possible to either the source or the receiver position, for maximum effectiveness;
- Materials having noise absorptive properties shall be used for the inner side of the noise barrier (facing the site); and
- It is necessary to bend the barriers around the noise source, so as to avoid passage of sound around the ends. Typically, the length of the barrier shall be at least ten times the height of the barrier.
- Noise Barrier of minimum STC 20 are recommended to be erected at all the locations presented in Figure 11-12 in order to mitigate the construction noise to the noise sensitive receptors. These locations are:
 - For CR14 worksite:
 - a. 8m high noise barrier at the construction boundary of CR14 fronting noise sensitive receptors (Site I, Site II and Site III); and
 - b. 5 m high noise barrier at the construction boundary of CR14 road construction worksite fronting noise sensitive receptors (Site I and Site II)
 - For CR15 worksite:
 - 12 m high noise barrier at the construction boundary of CR15 fronting noise sensitive receptors (Site IV, Site V and human receptors).
- Since the impact intensity was high with more than 20 dB(A) exceedance and impact significance was Major, portable noise barrier were highly recommended close to the noisy equipment/ activities.

<u>Step 3:</u> As a last resort in order to manage complaints, or mitigate further if there are intermittent noisy works, Table 11-18 provides information on methods of quietening PME to be adopted as further mitigation. These portable noise enclosures/other modes of source control specified below with reference to standards can then be implemented.

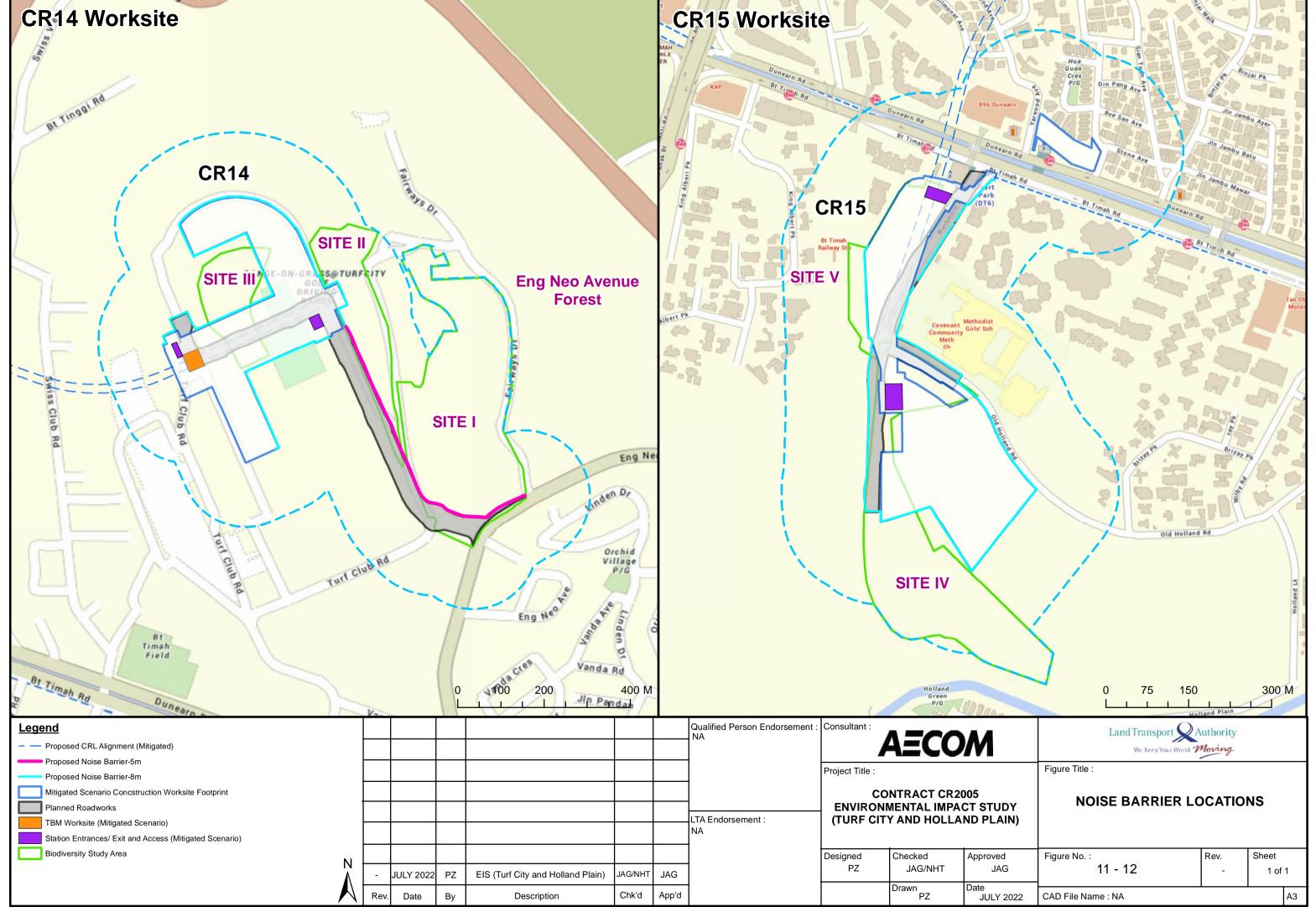
The maximum reduction level in Table 11-18 is achievable when all source control measures stated in this table are adopted. Noise enclosures should be used at the locations of the noise generating equipment at the construction site. Acoustic sheds should be provided at the locations of the noise generating activity such as operation of hand-held breaker.

Table 11-18 Control of Noise Source from Construction Site

Type of Equipment	Equipment	Reductio n Level, dB(A) ¹	Description of Source Control				
			Acoustic dampening of metal casing of body shell; acoustic enclosure or screen between the generator and receptor.				
Compressors & Generators	Generators	-20	The acoustic casing for the generator shall be proprietary product supplied by the generator manufacturer. The screen, if used, shall be as close as possible to the generator and it shall be of a solid construction (minimum STC 20 or surface density > 20kg/m²) with no gaps at the bottom or in-between panels.				
Hacking major structures	Excavator with Rock Breaker	-15	Use of an acoustic shed with adequate ventilation for the machine and bit.				
	Crane	-10					
	Roller	-10					
	Gantry Crane	-10					
	Dump Truck	-10	Manufacturers' enclosure panels to be kept closed. The engines of these vehicles shall not				
Earth-moving Plant	Excavator with Rock Breaker	-10	be exposed and clad with the manufacturers' enclosure to reduce noise break-out. Manufacturer-supplied silencers for the engine exhausts shall be installed and maintained.				
	Excavator	-10					
	Concrete Mix Truck	-10					
	Lorry	-10					
	Paver	-10					
Pumps	All Pumps	-10 to -20	Use of acoustic enclosure				
Piling Rig	Bore Piling Machine	-10	Acoustic dampening of panels and covers; careful alignment of pile and rig; regular cleaning, oiling and greasing of the rig. The screening shall be as close as possible to the pile-driving and extracting activities and shall be of a solid construction (minimum STC 20 or surface density > 20kg/m²) with no gaps at the bottom or in-between panels (in the direction of the receiver cutting line-of-sight between the noise source and the receiver, on three sides as a minimum). A micropile (small diameter pile) may be used for smaller construction footprint for impact on biodiversity, however, this aspect does not impact noise assessment significantly.				

Note:

¹ The noise reduction level makes reference to BS 5228-1:2009 Code of practice for noise and vibration control on construction and open sites – Part 1: Noise



Based on the Singapore Standards Code of Practice for Noise Control at Construction Sites, 2014 (SS602:2014), the typical materials used for noise barriers and acoustic shed/enclosures is given below:

Acoustic Shed / Enclosure:

A typical machine acoustic enclosure covers the machine as fully as possible (with/without ventilation), providing adequate sound insulation that noise energy does not readily pass through it. In addition, it could also have a sound absorbing material lining, to avoid the build-up of sound energy inside. In general, an acoustic enclosure could include:

- Outer cover material made up of brickwork, fibreboard or plasterboard. Thickness of the insulating cover depends on the material used;
- Inner lining of sound absorbing material such as glass fibre, mineral wool, straw slabs, wood wool slabs
 can be used. A thickness of at least 25mm is to be provided in case of high frequency sound, whereas a
 12mm thick lining would suffice for low frequency sound; and
- Perforated sheet coverings can be used to protect the inner lining material, especially if it is glass wool or mineral wool-based lining.

In the case of a more permanent or substantial machine enclosure or acoustic shed, concrete breezeblock and open textured blockwork can be more effective alternatives as these are known to be durable, inexpensive and quick to assemble, and provide a useful degree of sound absorption.

Temporary Water Barrier:

Additionally, in anticipation for high-noise events relating to rock breaking and excavation that may result in a flight-response from fauna species (e.g., wild boars) resulting in potentially road deaths, the Contractor must erect a temporary water barrier (around 1m in height). Refer to Section 12.9.1 for more details regarding the implementation and placement of water barriers.

11.8.1.3 Administrative Controls

The following administrative control measures will be observed during the construction stage to further reduce the noise levels:

- Although most of the construction activities will generate high noise level, but the birds will move out and displace to locations away from worksite eventually when noise levels are too high. Hence, only suggest to avoid site clearance during peak breeding season.
- Machines (such as trucks) that may be in intermittent use will be shut down between work periods or will be throttled down to a minimum;
- Only well-maintained plants will be utilised on-site and plants will be serviced regularly during the entire construction period;
- The number of PMEs will be reduced as far as practicable when construction works are carried out at areas close to the noise sensitive receivers:
- Silencers or mufflers on construction equipment will be utilised and will be properly maintained during the construction programme;
- Behavioural practices including no shouting, no loud stereos/ radios on site, no dropping of materials from height, no throwing of metal items will be ensured;
- Construction respite: Restrict high noise generating drilling activities only in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block, if possible;
- Periodic noise monitoring by an independent third party, to establish compliance with requirements and to advise on equipment causing concern, and additional potential mitigation measures;
- Plan the layout of the site by considering using materials and other large structural equipment as noise barriers;
- Plant known to emit noise strongly in one direction will, wherever possible, be orientated so that the noise
 is directed away from the nearby noise sensitive receptors; and
- Material stockpiles and other structures will be effectively utilised, wherever practicable, in screening noise from on-site construction activities.
- All handheld percussive breakers and air compressors used on site will comply with local legislation and LTA requirements.
- Activities may be scheduled to minimise noise generated at certain areas during periods which may be particularly sensitive to noise,

- Works using machines or vehicles that generate noise should be prohibited in the night and the dawn and no night works after 7pm for all non-safety critical activities since the site is next to the Biodiversity Study Area;
- Appropriate hearing protectors will be used by personnel operation the plant or equipment, the hearing protector must attenuate the exposure of the user to sound pressure levels below 85dB (A). Signage to remind personnel to put on hearing protection will be put up at work areas that emit excessive noise. Choice of hearing protector such as ear plugs (for < 100 dB (A)), earmuffs (for 100 dB (A) to 120 dB (A), ear plugs and ear muffs (for > 120dB (A)) in various noise exposure level.
- Noise awareness briefing will be conducted regularly and highlighted the noise mitigation measures such
 as position of machinery, making use of portable noise barriers and dos and don'ts for use of machinery
 at night.
- Above-ground works not critical for safety reasons to be restricted to weekdays (avoiding works on Sunday and Public holidays); and
- Works will be halted immediately, and mitigation measures adjusted to prevent future occurrence of roadkill incidents upon any observed signs of fauna seen trying to dash onto the road.

In addition to the above measures, an EMMP for noise has been prepared, for management of potential impacts from noise during construction phase. Details of the same are provided in **Section 13**.

11.8.2 Operational Phase

11.8.2.1 Minimum Controls for ACMV Noise

Minimum Controls below should be applied at the detailed design stage of the development by the appointed M&E consultants. An appointed Noise consultant should validate the noise in accordance with NEA's Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Building. In addition, mitigation measures will be provided by the appointed Noise Consultants during the detailed design stage.

- · Use low air-conditioning and mechanical ventilation system equipment;
- Ensure that any exhaust outlet or intake from the mechanical ventilation system is designed to be adequately set back as far as possible from the boundary line of the development;
- Acoustic treatment for equipment to meet noise level limit at site boundary where necessary;
- AC system to be designed with the AHU units placed at appropriate locations as set back from the boundary line of the development as possible; and
- · Acoustic enclosures for outdoor equipment.

11.8.2.2 Minimum Controls for Traffic Noise

Due to the lack of information at this juncture of reporting, assessment, minimum controls and mitigation will be provided by the appointed Noise Consultant during the prelim design stage and in accordance with *Technical Guideline for Land Traffic Noise Impact Assessment*.

11.9 Residual Impacts

11.9.1 Rock Breaking and Excavation Air Overpressure

Rock breaking and excavation events are proposed at the CR14 mitigated worksite with the closest Biodiversity Study Area being Site II. The approximate distance from CR14 worksite to the boundary of the receptor is 12m.

Based on the approach mentioned in Section 11.2.2.1.1, for Priority 1 receptors the air over pressure for 0.7kg is 160 dB at 12m distance from CR14 (Mitigated) worksite based on formula (2).

Table 11-19 Summary of Prediction and Evaluation of Airborne Noise - Rock Breaking and Excavation Impacts CR14 Worksite

Horizontal Distance from CR14 Worksite, m	Ecologically sensitive Study Area	Receptor Priority	Discharge Mass (Up to)	SPL	Impact Intensity	Impact Consequence	Likelihood	Impact Significance
183	Site I	1		127	Low	Very Low	Certain	Minor
12	Site II	1	0.7kg	160	Medium	Medium	Certain	Moderate*
190	Site III	1		126	Low	Very Low	Certain	Minor

Note:

Priority 1 ecologically sensitive habitat will potentially experience low impact intensity with very low impact consequence at Site I and Site III. Since the likelihood of rock breaking and excavation works occurring during the entire construction is regarded as **Certain**, the resulting impact significance is **Minor**. Priority 1 ecologically sensitive habitats at Site I will potentially experience medium impact intensity with medium impact consequence, after applying the mitigation measures refer to Section 12.9.1 and the resulting impact significance is **Moderate**.

11.9.2 Construction Scenario 1 to 3

Residual construction Impact Assessment assumes that the mitigation measures within Section 11.8 are implemented in the construction areas. Based on the residual airborne construction noise prediction, the area of "Major" impact significance is expected to be reduced significantly during post-mitigated scenarios than base scenario. The residual construction noise impact for post-mitigated scenario is shown in Table 11-20 for CR 14 worksite and Table 11-21 for CR15 worksite respectively.

Since the likelihood of the assessment was based on the work period and active noise period for machinery. The likelihood evaluation of Scenario 1- Cut and cover works and associated activities of CR14 worksite and CR15 worksite (refer to Table 11-9) became Regular due to the work period reduce from 24 hr (Base Scenario) to 12 hr (7am-7pm) in the Mitigated Scenario.

^{*} This measure reduces the impact significance, resulting in Minor – Moderate at Site II after applying the mitigation measures refer to Section 12.9.1.

CR2005
AECOM

Table 11-20 Summary of Residual Construction Noise Impacts – CR14 worksite

						High	Regular	Major	1
	Site II	1	75	23	High	High	Regular	Major	1.8
	Site III	1			High	High	Regular	Major	0.4
			71	17					
O TDM	Site I	1	45	-	Negligible	Very Low	Certain	Minor	
2 – TBM (7am-7pm)	Site II	1	51	-	Negligible	Very Low	Certain	Minor	
(7 am-7 pm)	Site III	1	61	7	High	High	Certain	Major	Less than 0.1
O TDM	Site I	1	45	-	Negligible	Low	Certain	Minor	
2 – TBM	Site II	1	51	5	Medium	Medium	Certain	Major	0.2
(7pm-7am)	Site III	1	61	5	Medium	Medium	Certain	Major	Less than 0.1
3 –	Site I	1	45	-	Negligible	Very Low	Regular	Minor	-
Construction	Site II	1	62	10	High	High	Regular	Major	0.1
of station	Site III	1			Low	Low	Regular	Moderate	
entrances			57	3					
(7am-7pm)									
Note		•	•	•	•				

^{*} Ecological receptors noise impact to be assessed against the baseline noise level as the noise criterion.

CR2005

Table 11-21 Summary of Residual Construction Noise Impacts – CR15 worksite

						Very Low	Regular	Minor -				
	Site V	1	69	19	High	High	Regular	Major	0.4			
2 – Construction of	Site IV	1	43	-	Negligible	Very Low	Regular	Minor	-			
station entrances	Site V	1	44	-	Negligible	Very Low	Regular	Minor	-			

Note

^{*} Ecological receptors noise impact to be assessed against the baseline noise level as the noise criterion.

CR14 Worksite

Scenario 1: Due to cut and cover works and associated activities, based on the residual airborne construction noise prediction above, Priority 1 ecologically sensitive habitats at Site I, Site II and Site III will potentially still experience high impact intensity in an albeit, smaller area (20-50% of the unmitigated base scenario), but with high impact consequence for this smaller area. Cut and cover works and associated activities will be beneficial by reducing area of impact significance significantly from 3.9 hectares (Base Scenario 1; Cut and cover works and associated activities) to 1 hectare (Post Mitigated Scenario 1: Cut and cover works and associated activities) to 1.8 hectare (Post Mitigated Scenario 1: Cut and cover works and associated activities) at Site II. Since the likelihood occurring during the entire construction is regarded as Regular, the resulting impact significance is **Major**.

Scenario 2: Due to TBM work, Priority 1 ecologically sensitive habitat at Site III will potentially experience high impact intensity in an albeit smaller area (~50% of the base unmitigated scenario) and therefore, with high impact consequence and at Site II will potentially experience medium impact intensity with medium consequence. TBM work the proposed 5m noise barriers and 8m noise barriers will be beneficial by reducing area of impact significance significantly from 0.7 hectares (Base Scenario 2; TBM work) to 0.2 hectares (Post Mitigated Scenario 2; TBM work) at Site II; and from 0.2 hectares (Base Scenario 2; TBM work) to less than 0.1 hectare (Post Mitigated Scenario 2; TBM work) at Site III. Since the likelihood occurring during the entire construction is regarded as Certain, and the resulting impact significance is **Major** for Site II and Site III. But for Priority 1 ecologically sensitive receptors at Site I will potentially experience no exceedance than the noise criterion, negligible impact intensity and the resulting impact significance is **Minor**.

Scenario 3: Construction of station entrances, Priority 1 ecologically sensitive habitat at Site II will potentially experience high impact intensity. Since the likelihood occurring during the entire construction is regarded as Regular, the resulting impact significance is **Major**. But Priority 1 ecologically sensitive habitat at Site III will potentially experience low impact intensity and the resulting impact significance is **Moderate and** for Priority 1 ecologically sensitive receptors at Site I will potentially experience no exceedance than the noise criterion, negligible impact intensity and the resulting impact significance is **Minor**.

The residual airborne noise contours with impact significance (1.5m high) are shown in Figure 11-13 to Figure 11-16. A summary of construction noise impact at ground level for both Base Scenario and Post Mitigated Scenario are shown in Table 11-22.

Table 11-22 Summary of Construction Noise Impacts (Base and Post Mitigated Scenario Evaluation) CR14 Worksite

Scenario	Ecologically sensitive Study Area	Receptor Priority	or Base Scenario Evaluation Scenario Ecologically Receptor Post I sensitive Priority Study Area										Post Mitiga	t Mitigated Evaluation			
-1 - Cut and cover works and associated activities	Site I	1	High	High	Certain	Major	3.9–1 - Cut and cover works and associated activities (7am-7pm)	Site I	1	18	High	High	Regular	Major	1		
(7am-7pm)	Site II	1	23 High	High	Certain	Major	2.6										
–1 - Cut and cover works	Site I	1	18 High	High	Certain	Major	3.7										
and associated	Site II	1	22 High	High	Certain	Major	2.4		Site III	1	17	High	High	Regular	Major	0.4	
activities (7pm-7am)	Site III	1	6 Medium	Medium	Certain	Major	0.1										
	Site I	1	- Negligible	Very Low	Certain	Minor	-		Site I	1	-	Negligible	Very Low	Certain	Minor		
2 – TBM (7am-7pm)	Site II	1	- Negligible	Very Low	Certain	Minor	-	2 – TBM (7am-7pm)	Site II	1	-	Negligible	Very Low	Certain	Minor		
,	Site III	1	6 Medium	Medium	Certain	Major	0.2	` ,	Site III	1	7	High	High	Certain	Major	Less than 0.1	
2 – TBM	Site I	1	- Negligible	Very Low	Certain	Minor	-	2 – TBM	Site I		-	Negligible	Low	Certain	Minor		
(7pm-7am)	Site II	1	6 Medium	Medium	Certain	Major	0.7	(7pm-7am)	Site II		5	Medium	Medium	Certain	Major	0.2	
-3 - Construction	Site I	1	Negligible	Very Low	Regular	Minor	3 - Construction of station entrances	Site I	1	-	Negligible	Very Low	Regular	Minor	-		
of station entrances	Site II	1	10 High	High	Regular	Major	0.1		Site II	1	10	High	High	Regular	Major	0.1	
	Site III	1	- Negligible	Very Low	Regular	Minor	-		Site III	1	3	Low	Low	Regular	Moderate		

Note
* Ecological receptor noise impact to be assessed against the baseline noise level as the noise criterion.

In any case, the receptors which are at height immediately next to the construction site are likely to have a straight line of sight despite a noise barrier, therefore the benefit of barrier is unlikely to occur for the avian and arboreal species at height. It can be expected that the fauna which are highly mobile are able to move away from construction and it may not be possible to render further mitigation of impacts for their benefit; other than shortening the timespan of noisy construction activities, source selection of low noise machines, and administrative best practice measures. The resulting impact significance for the respective Biodiversity Study Area are shown below:

Base Scenario (CR14 worksite)

Site I: Minor to MajorSite II: Minor to MajorSite III: Minor to Major

Post Mitigated Scenario (CR14 worksite)

Site I: Minor to Major
 Site II: Minor to Major
 Site III: Moderate to Major

It is to be noted that the area of worksite in term of footprint are significantly reduced and that area are not included in the impact significance area (Hectares) for CR14 worksite and CR15 worksite.

Since the residual impact significance is Major, additional portable noise barrier are highly recommended close to the noisy equipment/ activities and no night works after 7pm for all non-safety critical activities since the site is next to the sensitive receptors.

Comparison of Base and Post Mitigated Scenarios of CR14 worksite are presented in Figure 11-19 to Figure 11-23. The area of "Major" impact significance is expected to be reduced significantly and can be seen obviously in the figures.

CR15 Worksite

Scenario 1: Due to cut and cover works and associated activities, based on the residual airborne construction noise prediction above, Priority 1 ecologically sensitive habitats at Site V will potentially experience high impact intensity with high impact consequence. Cut and cover works and associated activities the proposed 8m noise barriers will be benefit by reducing area of impact significantly from 4.6 hectares (Base Scenario 1; Cut and cover works and associated activities) to 0.4 hectare (Post Mitigated Scenario 1: Cut and cover works and associated activities). Since the likelihood occurring during the entire construction is regarded as Regular, the resulting impact significance is **Major**. Priority 1 ecologically sensitive habitat at Site IV will potentially experience the no exceedance than the noise criterion and the resulting impact significance is **Minor**.

Scenario 2: Due to the construction of station entrances, Priority 1 ecologically sensitive habitats at Site IV and Site V will potentially experience the no exceedance than the noise criterion and the resulting impact significance is **Minor**.

The residual airborne noise contours with impact significance (1.5m high) for CR15 worksite are shown in Figure 11-17 to Figure 11-18. A summary of construction noise impact at ground level for both Base Scenario and Post Mitigated Scenario are shown in Table 11-23.

Table 11-23 Summary of Construction Noise Impacts (Base and Post Mitigated Scenario Evaluation) CR15 Worksite

Scenario	Ecologically sensitive Study Area	Receptor Priority	Base Scenario Evaluation						Ecologically sensitive Study Area	y Receptor Priority	Post Mitigated Evaluation					
-1 - Cut and cover works and associated activities (7am-7pm)	Site IV	1	Medium 5	Medium	Certain	Major	Less than 0.1–1 - Cut and cover works and associated activities (7am-7pm)	Site IV	1	_	Negligible	Very Low	Regular	Minor	-	
-1 - Cut and cover works and associated activities (7pm-7am)	Site IV	1	Negligible -	Very Low	Certain	Minor	-		Site V	1	19	High	High	Regular	Major	0.4
-2 - Construction of station entrances	Site IV	1	Low 1	Low	Regular	Moderate	-2 - Construction of station entrances (7am-7pm)	Site IV	1	-	Negligible	Very Low	Regular	Minor	-	
(7am-7pm)	Site V	1	8 High	High	Regular	Major	Less than 0.1		Site V	1	-	Negligible	Very Low	Regular	Minor	-

In any case, the receptors which are at height immediately next to the construction site are likely to have a straight line of sight despite a noise barrier, therefore the benefit of barrier is unlikely to occur for the avian and arboreal species at height. It can be expected that the fauna which are highly mobile are able to move away from construction and it may not be possible to render further mitigation of impacts for their benefit; other than shortening the timespan of noisy construction activities, source selection of low noise machines, and administrative best practice measures. The resulting impact significance for the respective Biodiversity Study Area are shown below:

Base Scenario (CR15 worksite):

Site IV: Minor to Major

Site V: Major

Post Mitigated Scenario (CR15 worksite):

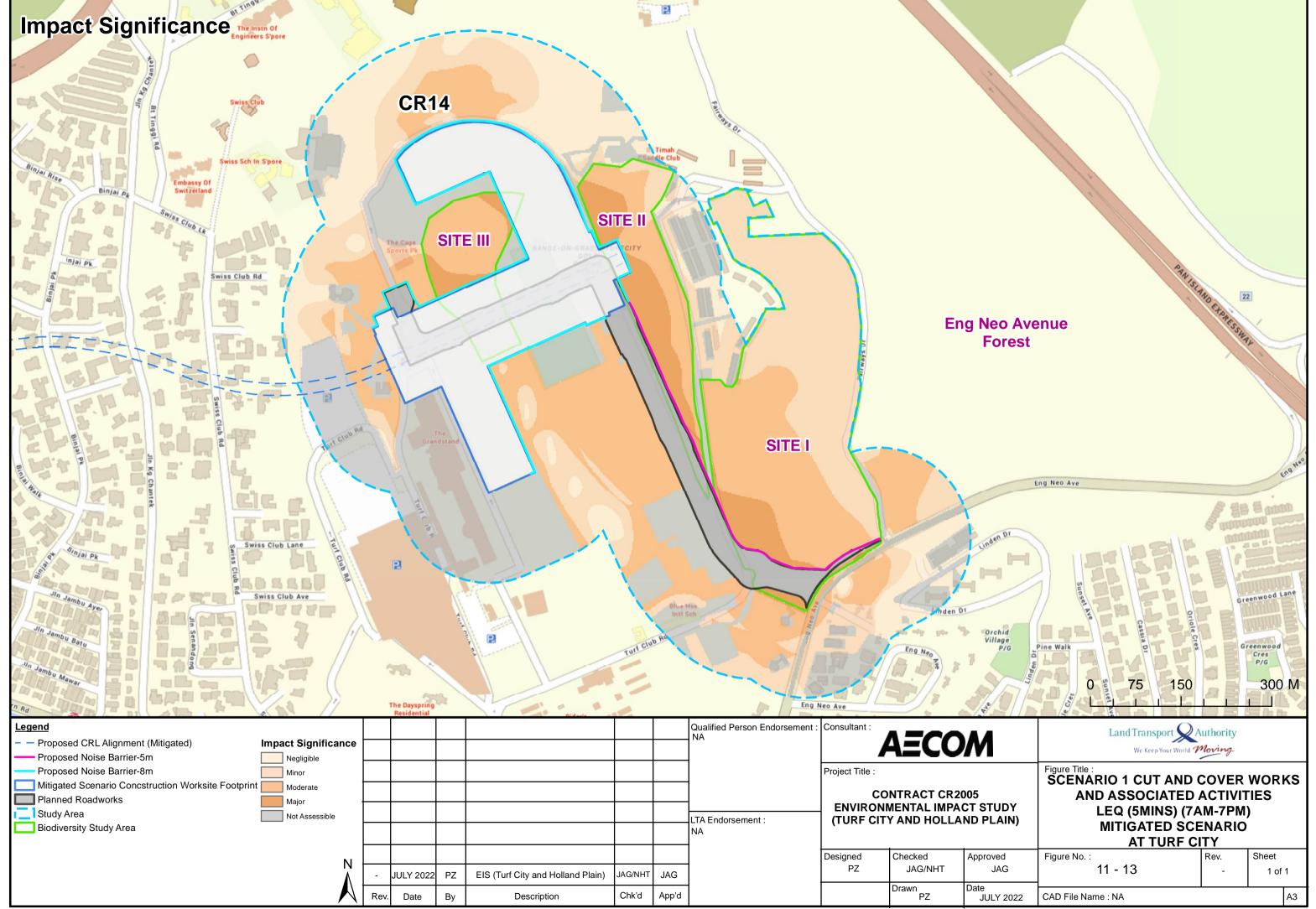
Site IV: Minor Site V: Major

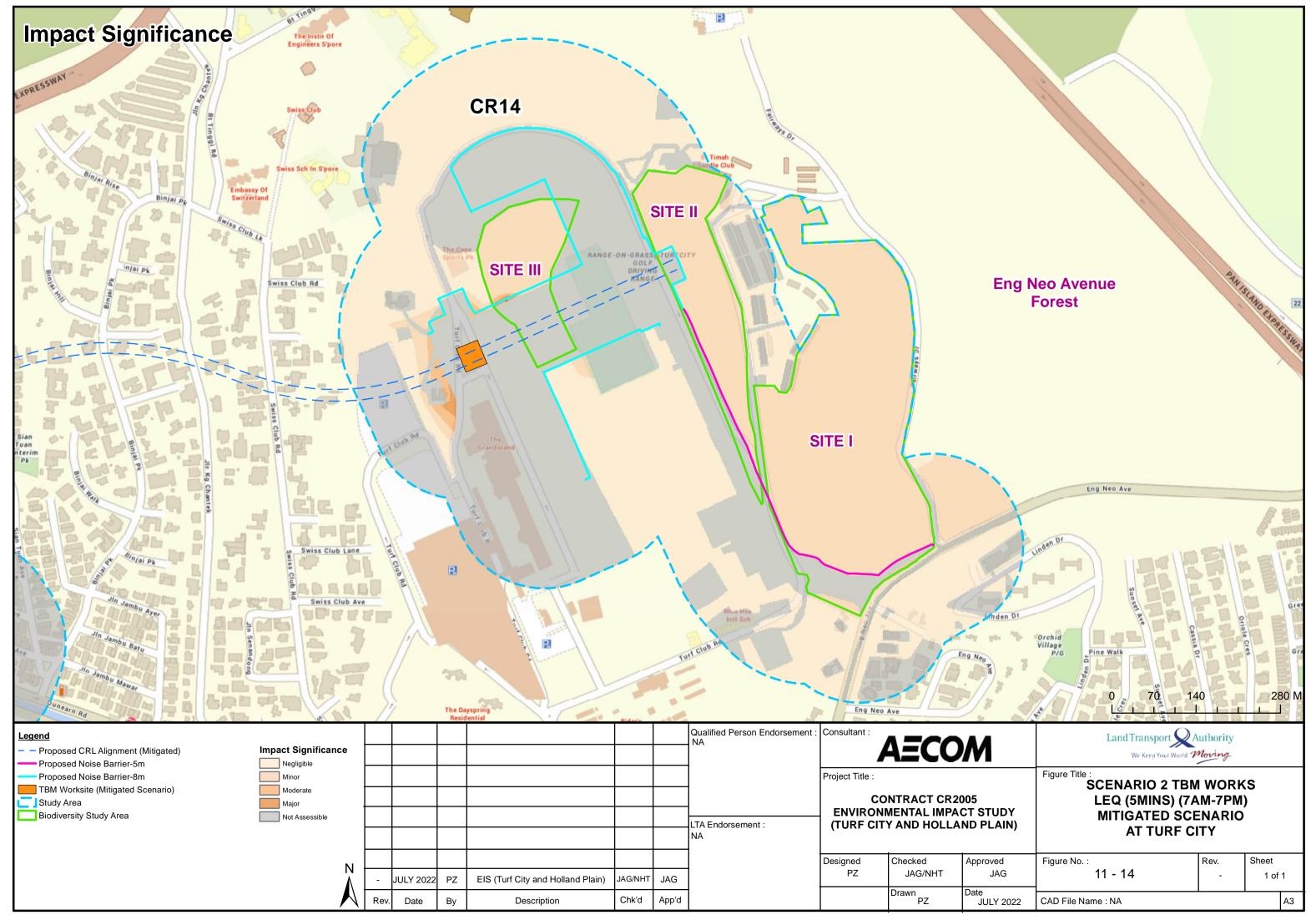
It is to be noted that the footprint of the worksites, which has been significantly reduced in size under the mitigated scenario, have not been included in the impact significance area (Hectares) for the CR14 and CR15 worksites, respectively.

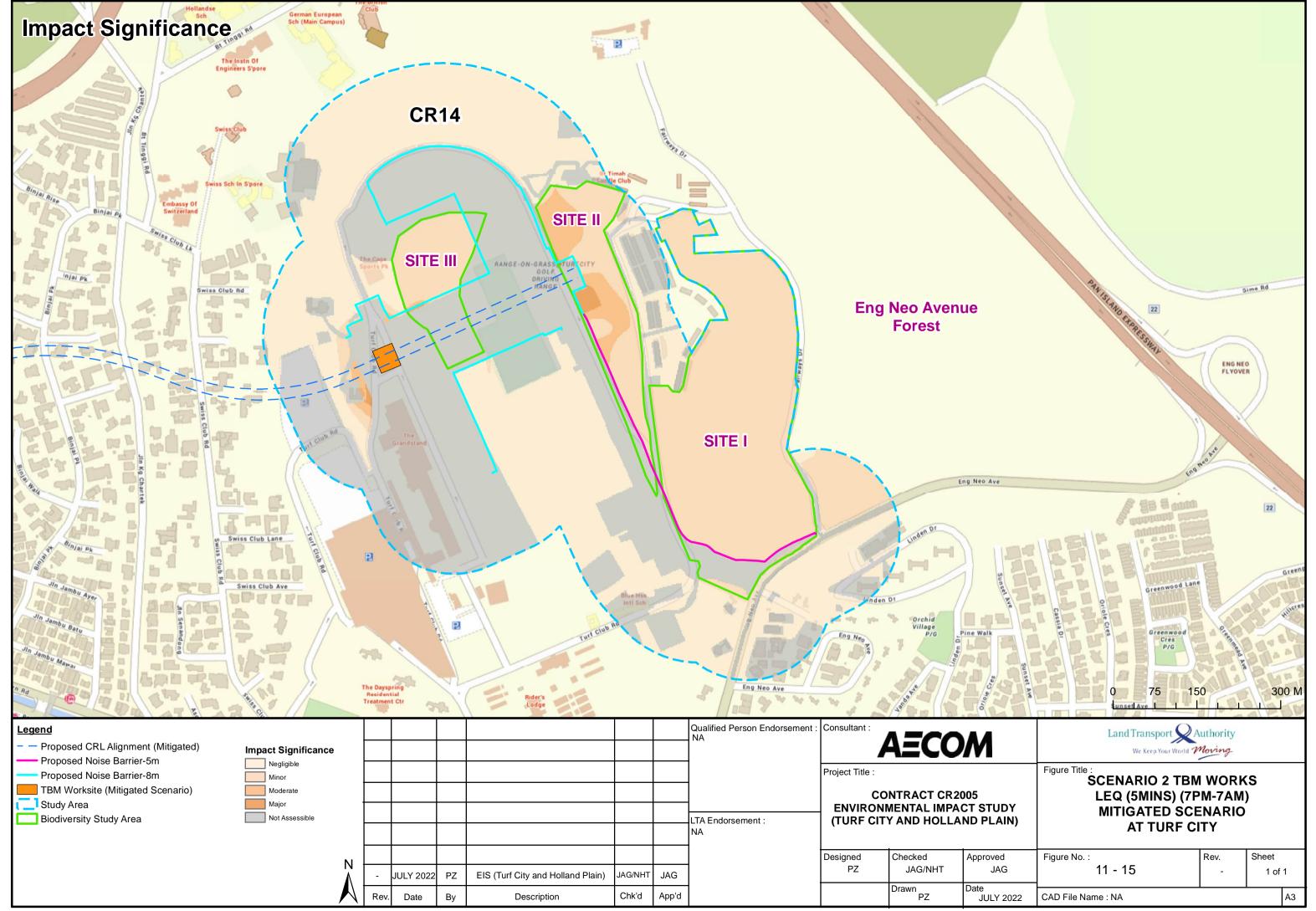
Since the residual impact significance is Major, portable noise barrier are highly recommended close to the noisy equipment/ activities and no night works after 7pm for all non-safety critical activities since the site is next to the sensitive receptors.

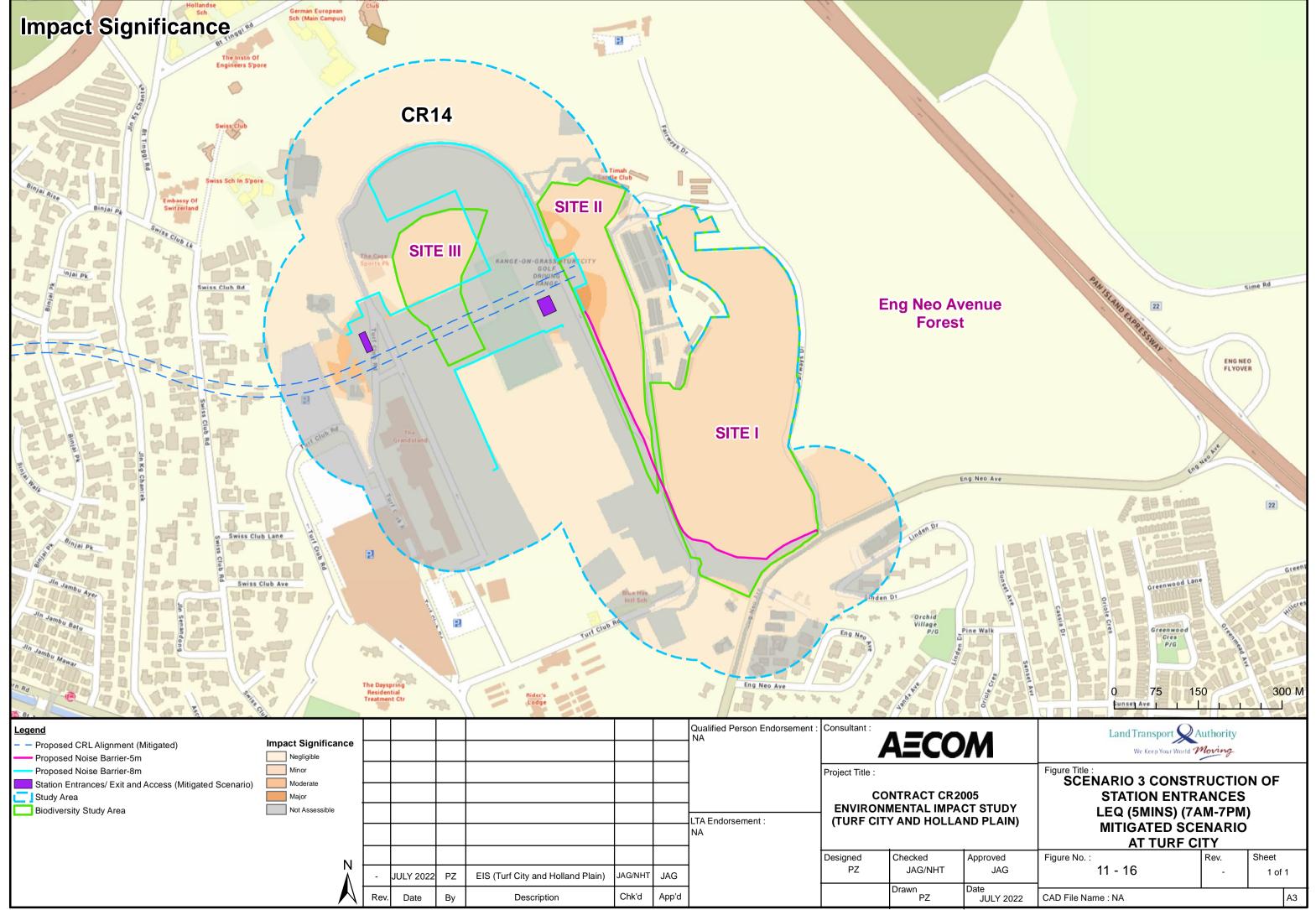
Comparison of Base and Post Mitigated Scenarios of CR14 worksite are presented in Figure 11-24 to Figure 11-26. The area of "Major" impact significance is expected to be reduced significantly and can be seen obviously in the figures.

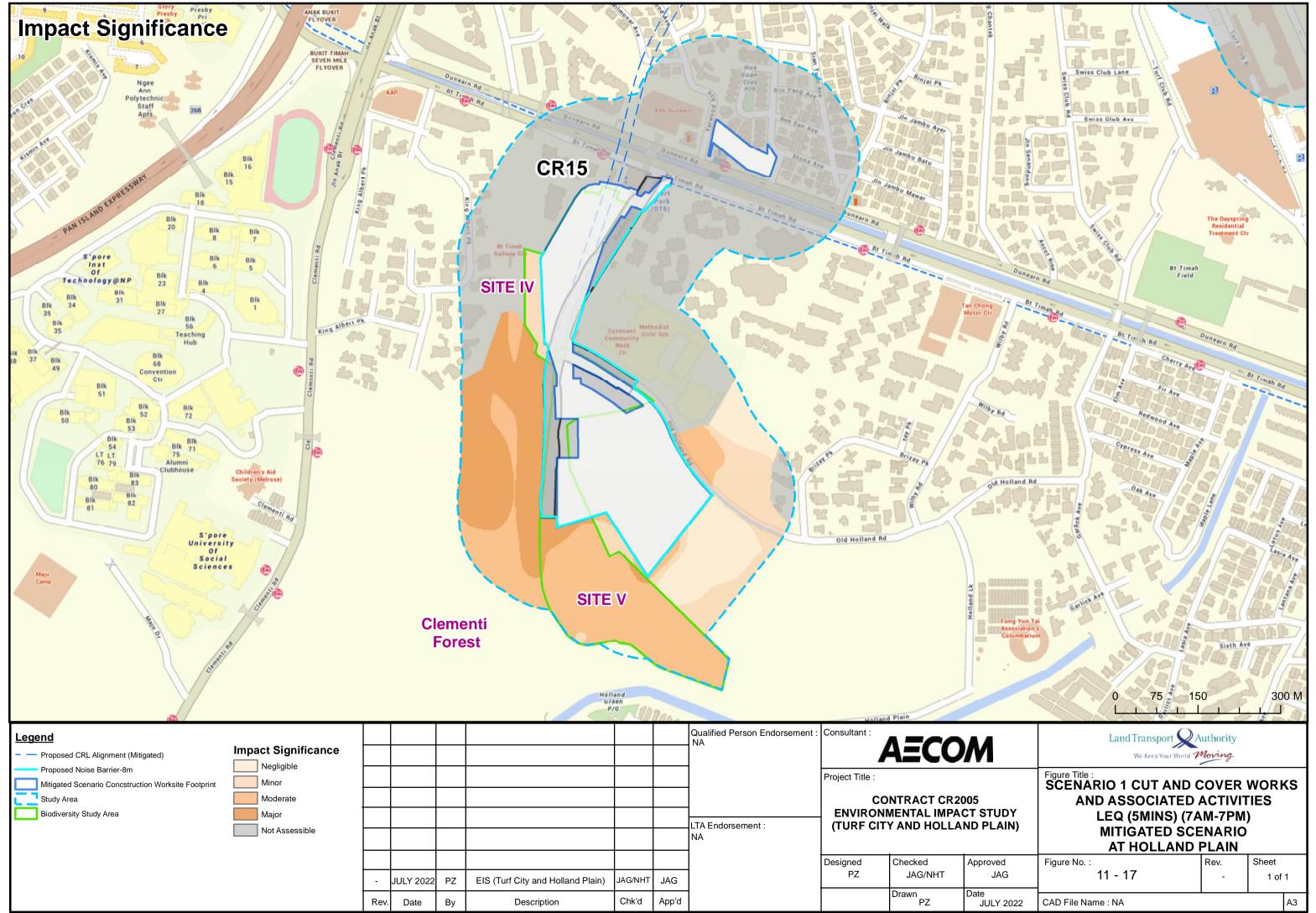
Since the expected noise impact during the operational phase will be negligible (refer to section 11.7.2.1), no residual impact was evaluated for operational phase.

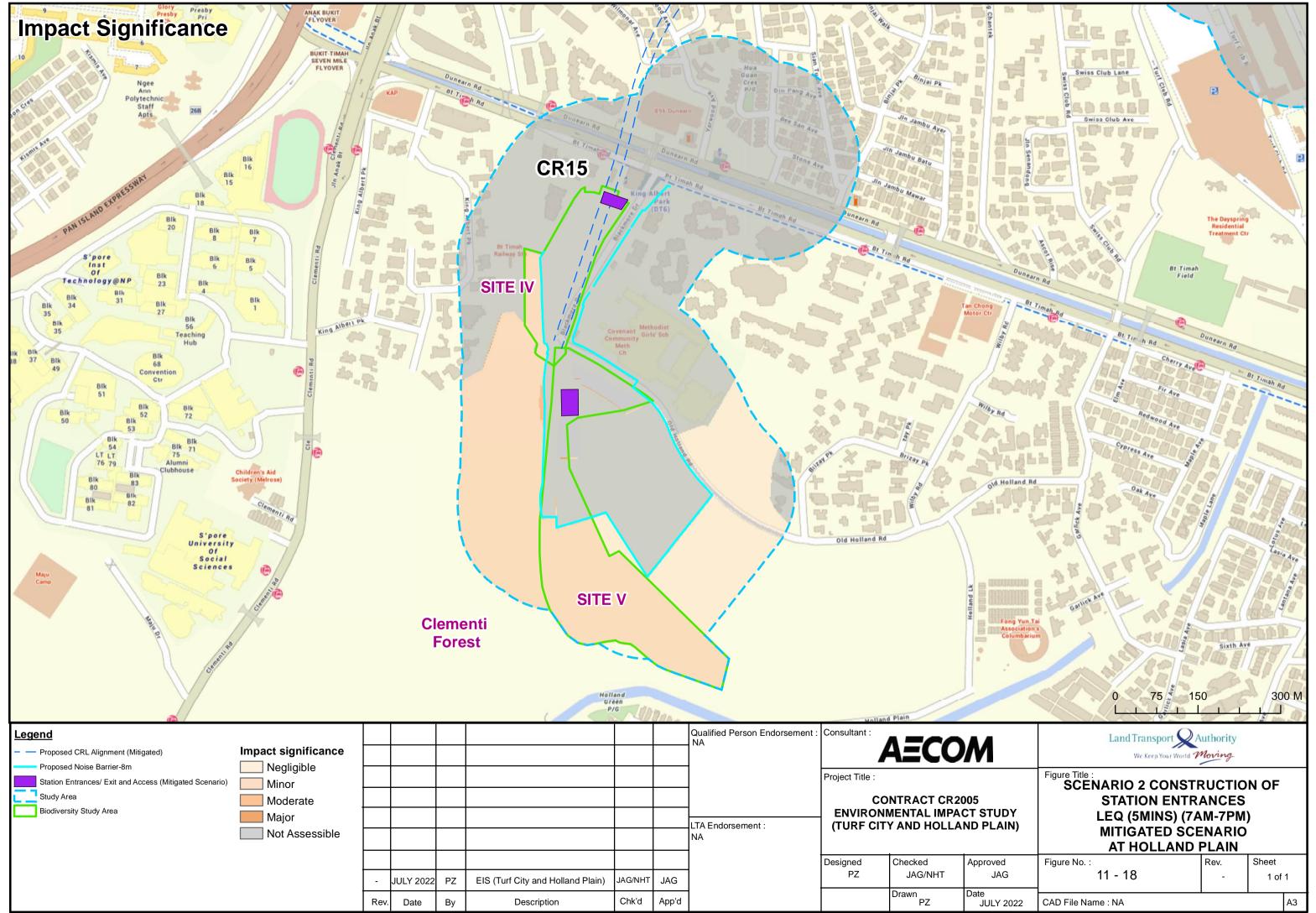


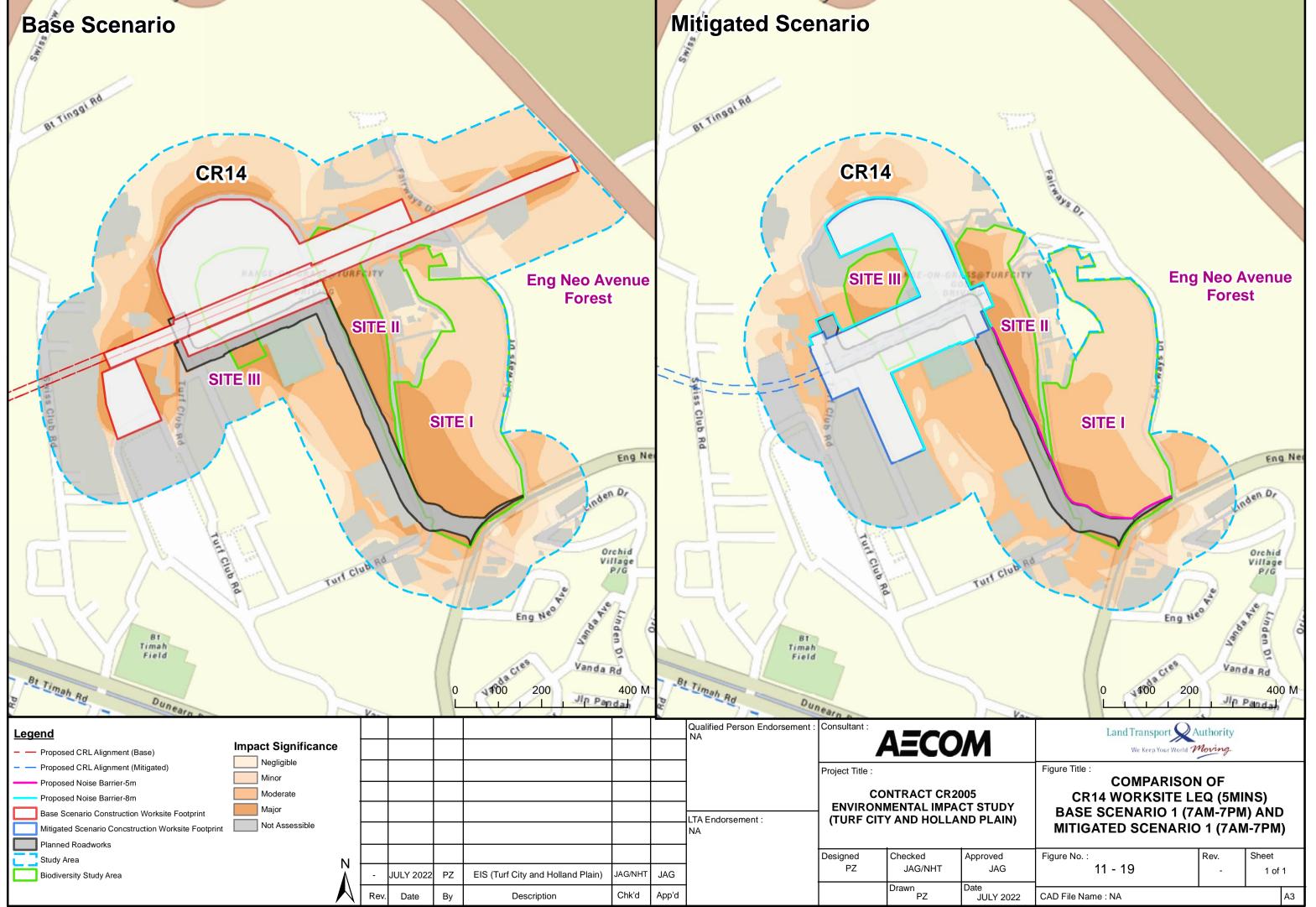


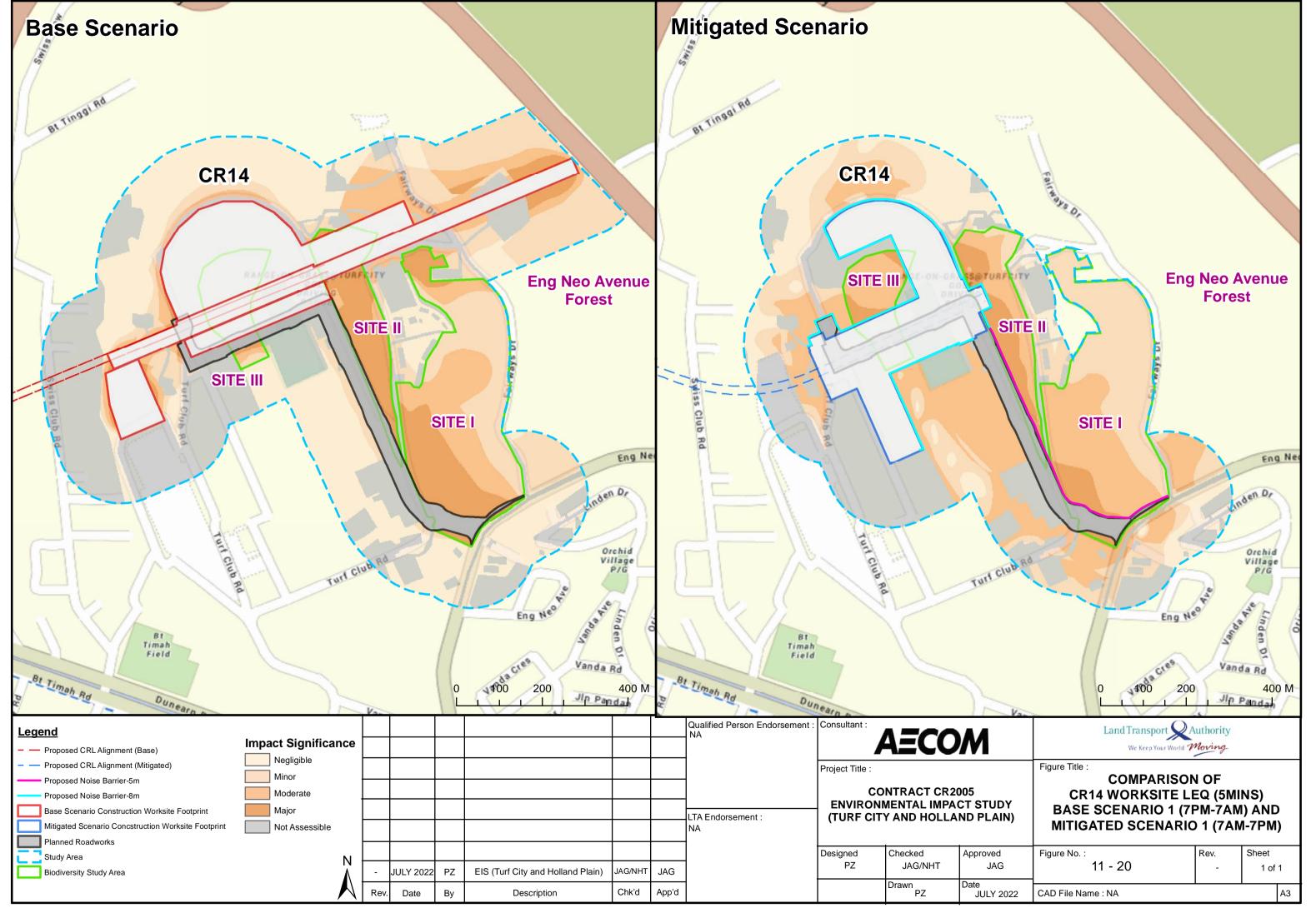


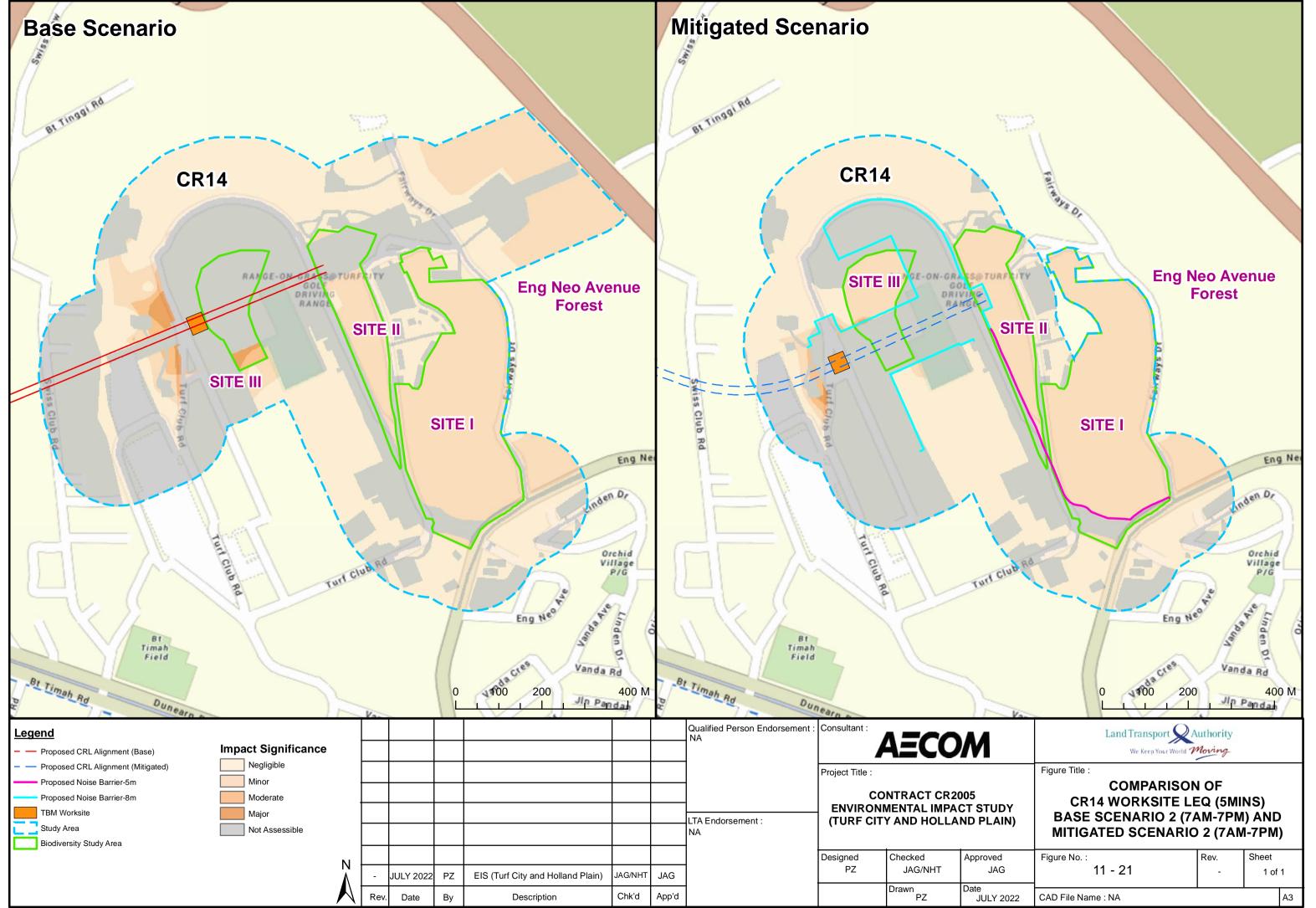


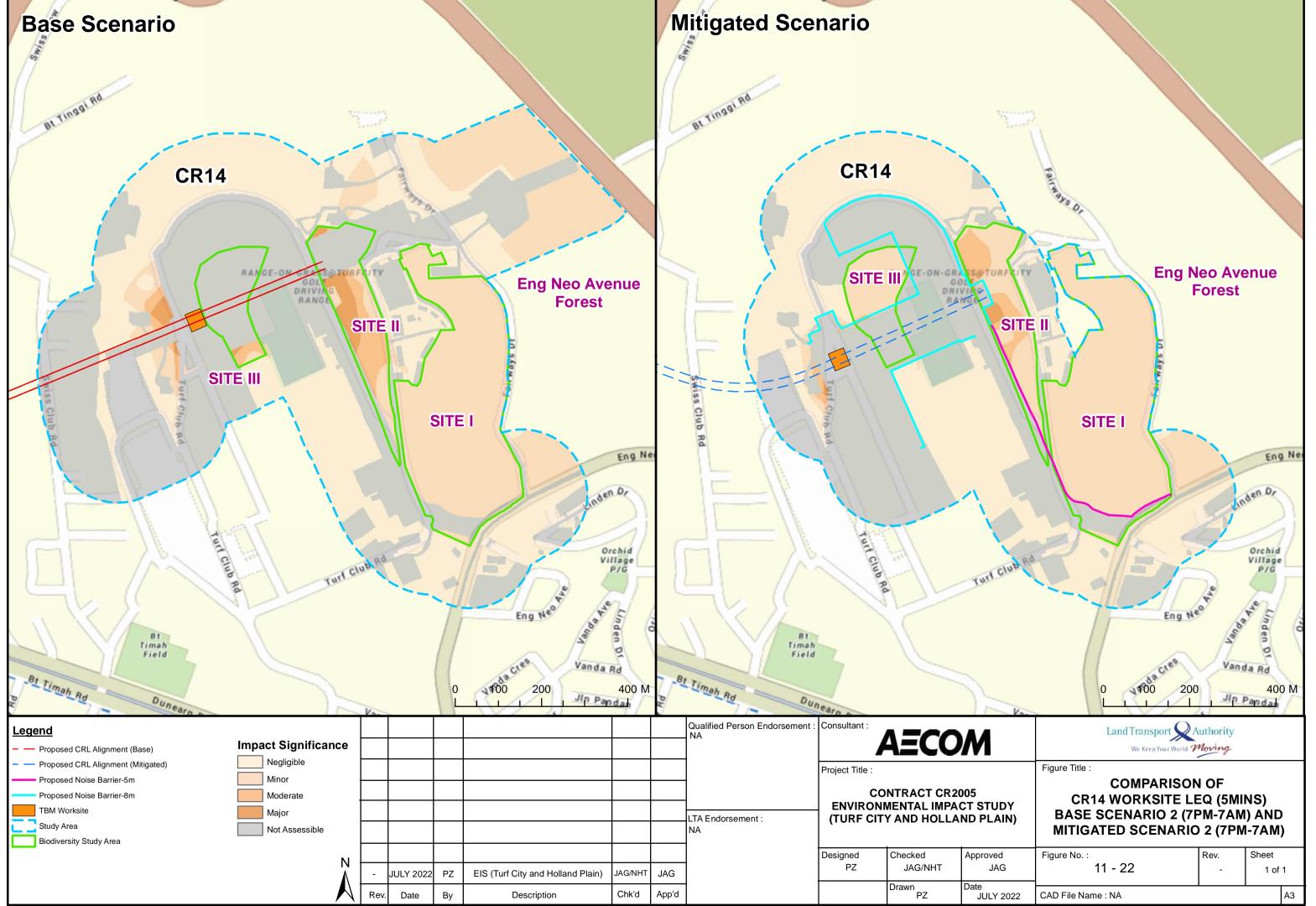


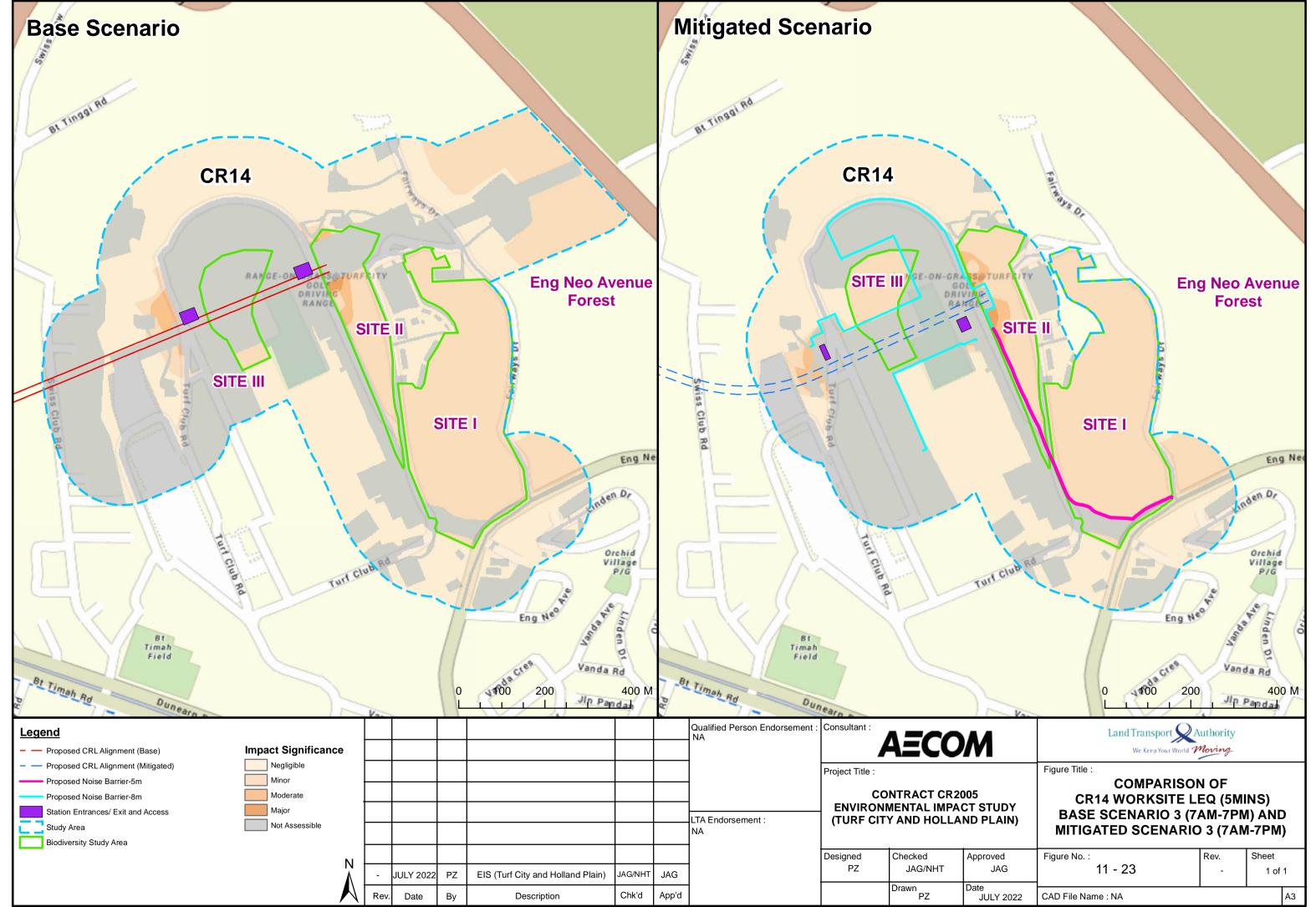


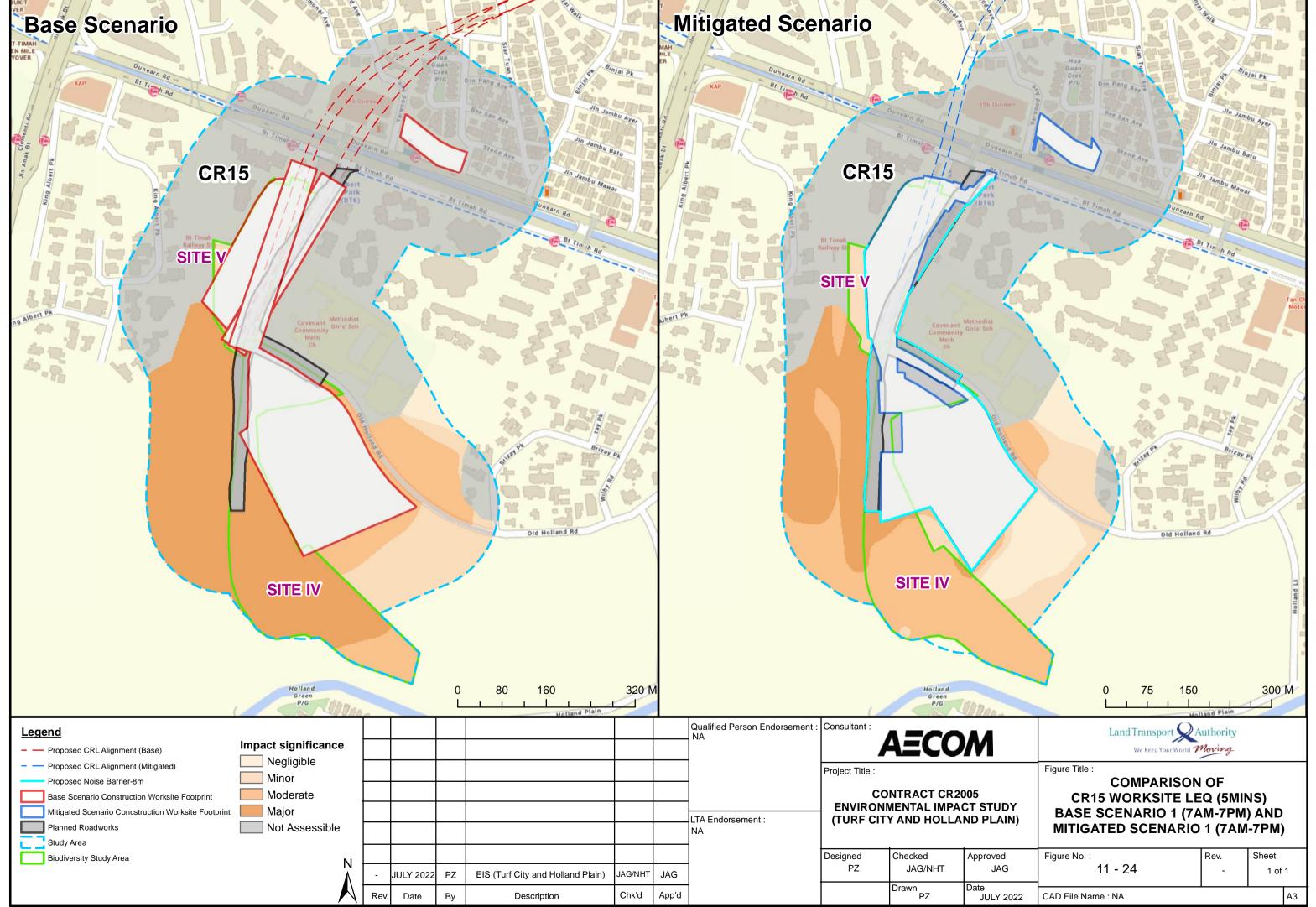


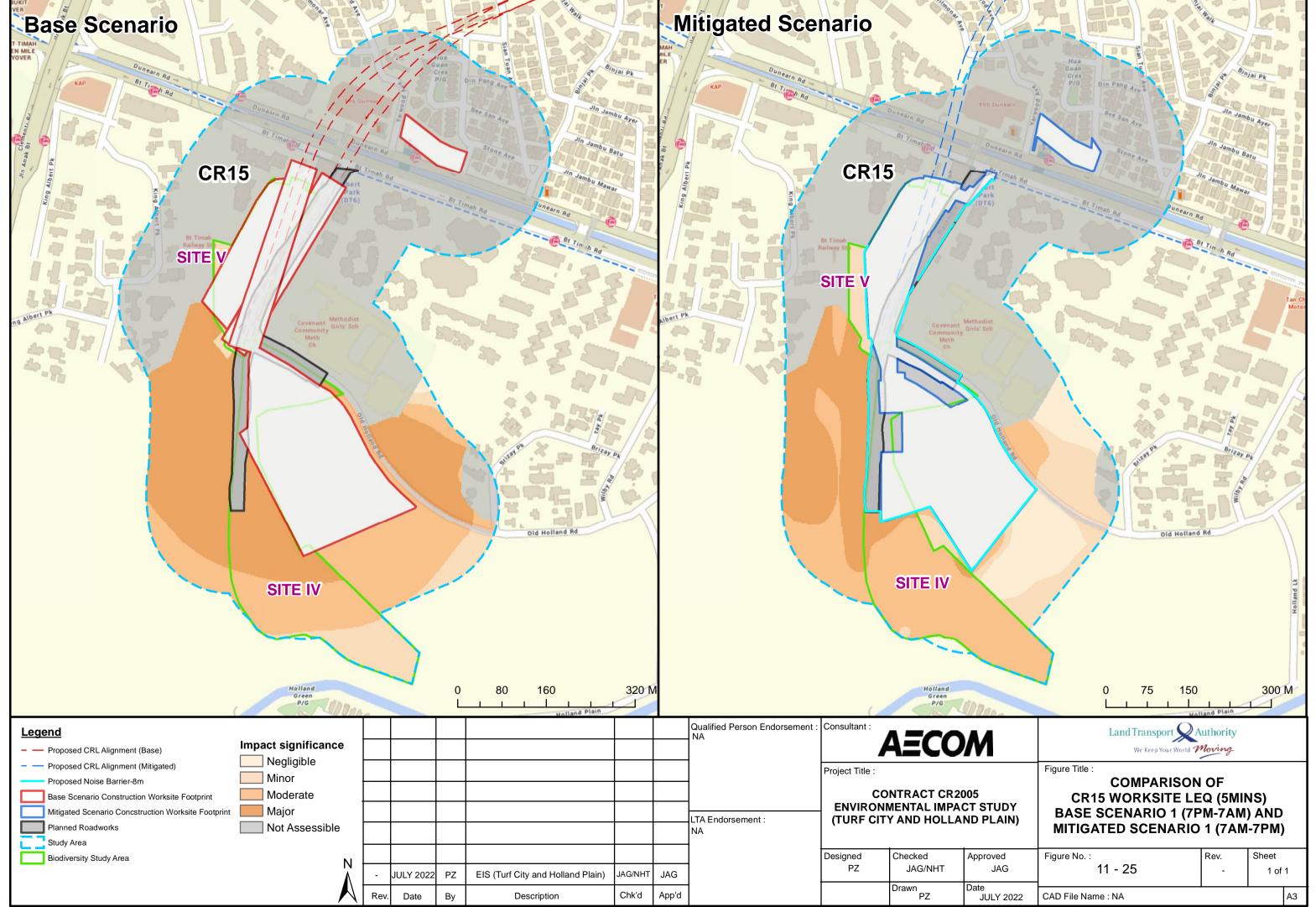


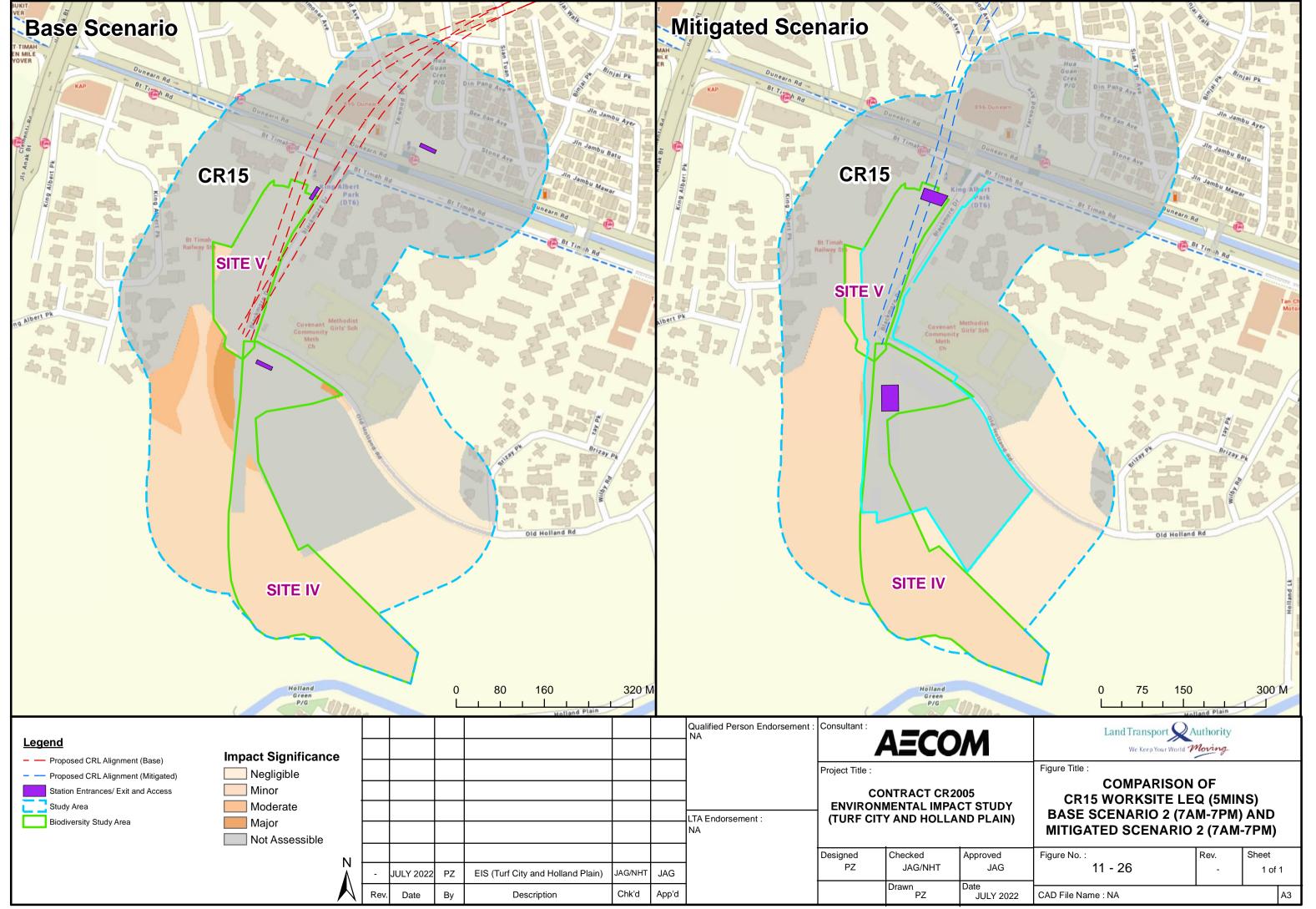












11.10 Cumulative Impacts from Other Major Concurrent Development

11.10.1 Construction Phase

It is known that construction activities are planned to occur in the vicinity of the Project as highlighted in Section 3.4.1. Therefore, cumulative impacts from other relevant major concurrent development in the vicinity of the Project shall be assessed qualitatively and discussed in this section. Concurrent developments include A1-W2, CR16, Old Jurong Line Nature Trail and Clementi Forest Stream Nature Trail. Typical construction works at the Old Jurong Line Nature Trail, and Clementi Forest Stream Nature Trail are unlikely to cause higher noise levels than this Project. Hence this Project's worksite activities, along with A1-W2 and CR16, are the primary source of noise impact within the Biodiversity Study Area.

11.10.1.1 CR14 Worksite

Cumulative impacts were assessed based on the worst-case construction activities where the timelines of CR14 worksite and A1-W2 worksite coincide. The A1-W2 worksite with mitigation measures was included as part of the noise model based on the modelled noise levels in Table 11-7 to assess the cumulative noise impact. Based on the residual airborne construction noise prediction, there is a potential for **Major** impact significance area will be increased significantly especially at Site I- from 1 hectare (CR14 alone) to 2.5 hectares (CR14 and A1-W2), and at Site II-from 1.8 hectares (CR14 alone) to 3.2 hectares (CR14 and A1-W2) on the impacted ecological sensitive receptors after implementing mitigation measures. Therefore, the noise contribution from this concurrent activity to CR14 of this project is considered major. The residual cumulative construction noise impact from A1-W2 worksite and CR14 worksite is shown in Table 11-24 and Figure 11-27.

Table 11-24 Summary of Residual Construction Noise Impact from CR14 Worksite and A1-W2 Worksite

Ecologica Ily sensitive Study Area	Recept or Priority	Maximu m Noise Level Observ ed, dB(A)	Maximum Exceedan ce Observed *, dB(A)	Impact Intensi ty	Impact Conseque nce	Likeliho od	Impact Significan ce	Major Impact Significan ce Area (Hectares
Site I	1	82	26	High	High	Certain	Major	1.2
Site II	1	79	27	High	High	Certain	Major	3.2
Site III	1	72	18	High	High	Certain	Major	0.5
Note * Ecological receptors noise impact to be assessed against the baseline noise level as the noise criterion.								

11.10.1.2 CR15 Worksite

Cumulative impacts were assessed based on the worst-case construction activities where the timelines of CR15 worksite and CR16 worksite coincide. The CR16 worksite with mitigation measures was included as part of the noise model based on the modelled noise levels in Table 11-7 to assess the cumulative noise impact. Based on the residual airborne construction noise prediction.

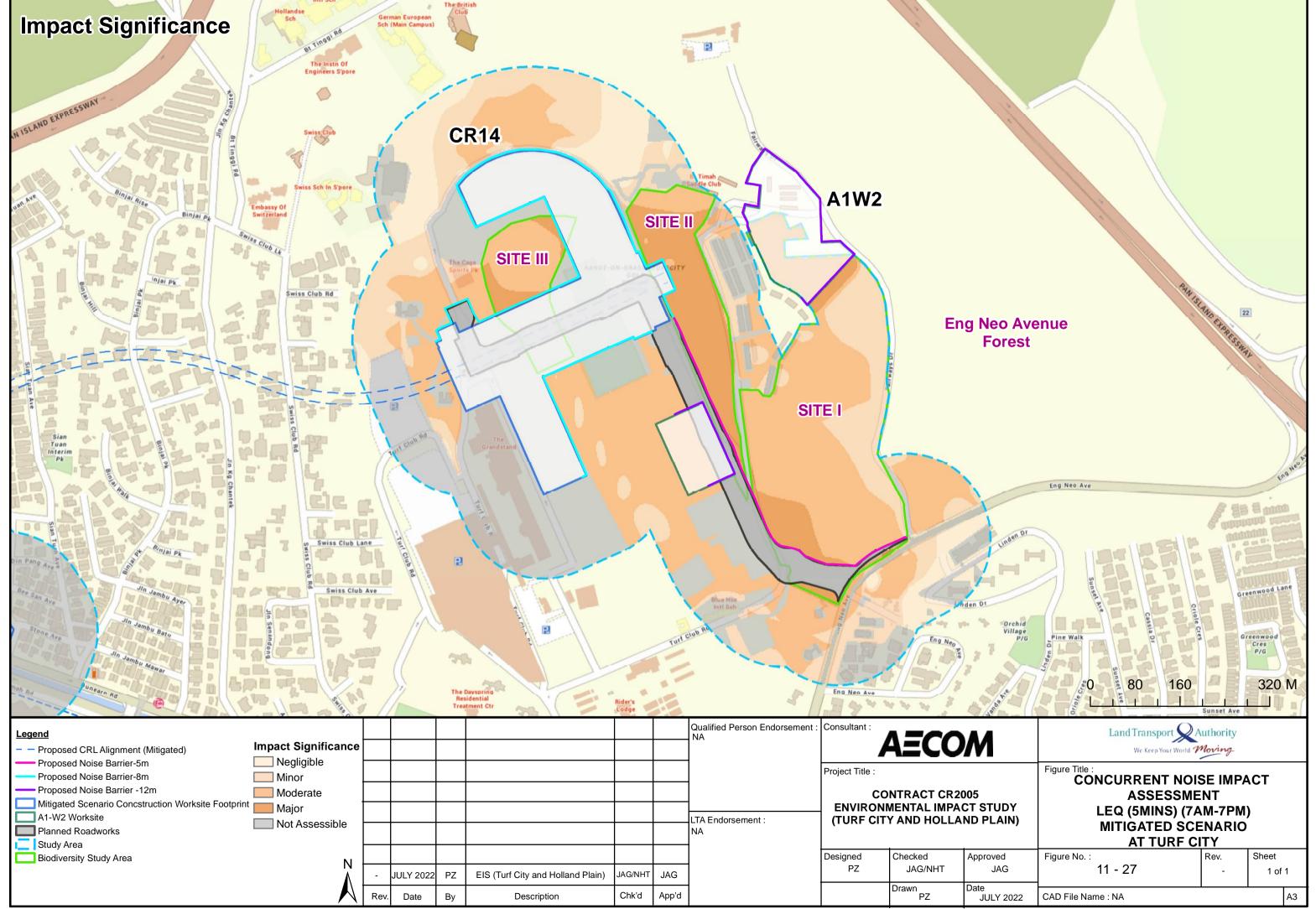
Table 11-25 Summary of Residual Construction Noise Impact from CR15 Worksite and CR16 Worksite

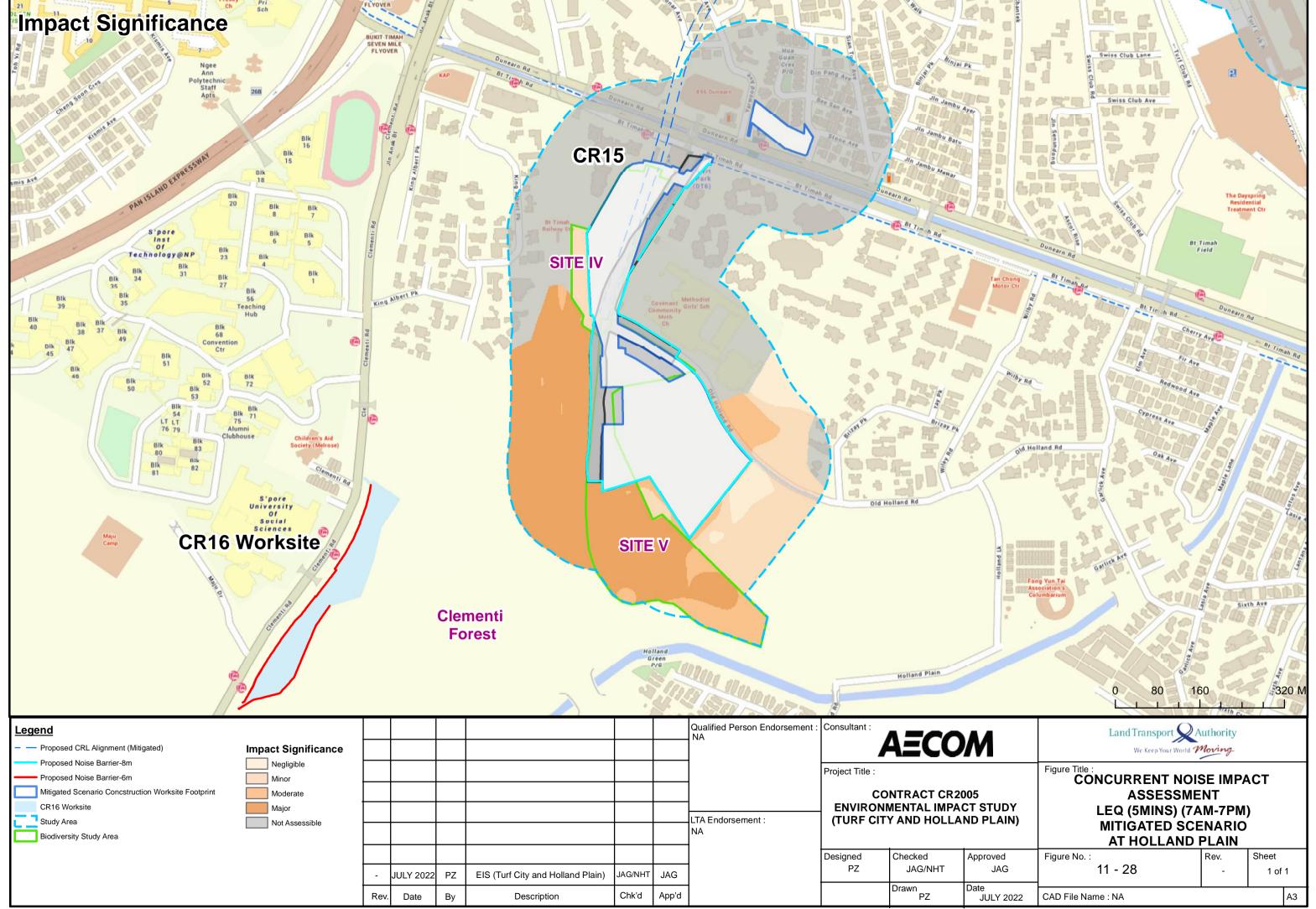
Ecologic ally sensitive Study Area	Recept or Priority	Maximu m Noise Level Observ ed, dB(A)	Maximum Exceedan ce Observed *, dB(A)	Impact Intensi ty	Impact Conseque nce	Likeliho od	Impact Significa nce	Major Impact Significa nce Area (Hectares
Site IV	1	73	-	Negligi ble	Very Low	Certain	Minor	
Site V	1	84	34	High	High	Certain	Major	4.2
Note * Ecological i	Note * Ecological receptors noise impact to be assessed against the baseline noise level as the noise criterion.							

•

11.10.2 Operational Phase

No cumulative impacts were considered significant during operational phase at A1-W2 site, CR14 worksite, CR15 worksite, CR16 worksite. Currently there are no other developments planned near CR14 worksite and CR15 worksite, however, if similar developments are planned around it in distant future, the cumulative impact may need to be assessed at that stage as well.





11.11 Summary of Key Findings

Noise impact assessment was carried for the construction phase of the proposed worksites for CR2005. The construction noise study area was defined as combination of Site I, Site II, Site III and 150 m from CR14 worksites, and combination of Site IV, Site V and 150m from CR15 construction worksite whichever is greater. The noise impact assessment for the operational phase of the proposed worksites for CR2005 included providing noise boundary criteria for ACMV noise at the facility buildings and qualitatively assessing traffic noise to the noise sensitive receptors. However, it is to be noted that the LTA may not be designing in detail for the compliance to noise criteria at this stage, in which case the imposed criteria at boundary shall form a mandatory requirement when the worksite is designed during detailed design stage. Baseline noise monitoring was carried out at nine (9) locations. Uncorrected baseline noise was used as a more stringent criteria for assessment of ecological receptors in this Study. Besides, the baseline airborne noise monitoring was supplemented with secondary baseline data obtained from the concurrent study carried out by AECOM in the vicinity, to obtain the baseline noise levels within the Study Area.

The baseline study recorded average $L_{Aeq(12 \text{ hour})}$, $L_{Aeq(1 \text{ hour})}$ and $L_{Aeq(5 \text{ min})}$ baseline noise levels and compared against the construction criteria provided by NEA guidelines. The baseline noise levels were used to develop project-specific criteria.

For the assessment on construction phase, the noise levels generated from the equipment used during construction detailed in Section 11.3.1 was predicted using SoundPLAN ver 8.2. Topography plays an important role in noise propagation and were included in this assessment. A quantitative assessment at the noise sensitive receptors (within the Study area) was carried out and compared with the stipulated *Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008.* Uncorrected baseline noise was used as a more stringent criteria for assessment of ecological receptors in this Study. The identified noise sensitive receptors were assessed in accordance with the impact evaluation matrix as shown in Section 6.4.2. Noise contours were provided to the extent that topography is available. Based on the impact evaluation, mitigation to reduce airborne noise impacts were recommended for the affected ecological noise sensitive receptors.

The study on construction noise impact to the noise sensitive receptors focused on three (3) different construction scenarios in CR14 worksite and two (2) different construction scenarios in CR15 worksite. The three (3) different construction scenarios in CR14 worksite are: Scenario 1: Cut and cover works and associated activities; Scenario 2: Tunnel Boring Machine (TBM) works; and Scenario 3: Construction of station entrances. The two (2) different construction scenarios in CR15 worksite are: Scenario 1: Cut and cover works and associated activities; and Scenario 2: Construction of station entrances. It must be noted at this stage that worst-case assumptions on equipment usage, period of usage, and more conservative approach for barrier heights were proposed to predict the worst impacts to these locations of highly sensitive nature. Noise sensitive receptors were determined based on the species and habitats identified during ecological surveys undertaken within the Biodiversity Study Area. Data collected outlined how species utilise habitats within the Study Area; a habitat sensitivity map was created to indicate the sensitivity of habitats and the species they support to airborne noise. Urban habitats and features, such as hardstanding areas, identified nearby the Biodiversity Study Area and Proposed Development, which are not considered suitable to support fauna, were assessed as 'Not Assessable'. As per NG Engagement held on 23rd March 2022, it was mutually agreed that habitat sensitivity map would be used for this Project to determine the probability of finding species within Study Area.

Site I, Site II and Site III

The modelling undertaken as part of the impact assessments for CR14 construction worksite base scenario 1 to base scenario 3, results indicated that an impact significance of **Major** is likely to occur, with a maximum exceedance of 20 dB(A) in Site I, 23 dB(A) in Site II and 18 dB(A) at Site III respectively. Note that since the intensity of impact is much higher than the criteria, mitigation measures are proposed in Section 11.8 with residual impacts shown in Section 11.9. Efforts were also made to optimise the size of CR14 worksite as much as possible. The revised design was re-evaluated in this Report as the mitigated scenario. Following the assessment of all design optimisation options it is recommended that noise barriers, with a height of 5m, 8m respectively, be installed as a mitigation measure at the CR14 worksite (as shown in Figure 11-12).

Based on the residual airborne noise impact assessment above, the proposed 5m and 8m noise barriers at the CR14 worksite will be beneficial by reducing the area of major impact significance significantly from 3.9 hectares (Base Scenario) to 1 hectare (Post Mitigated scenario) at Site I, from 2.6 hectares (Base Scenario) to 1.8 hectares (Post Mitigated scenario) at Site II and from 0.2 hectares (Base Scenario) to less than 0.1 hectares (Post Mitigated scenario) at Site III respectively.

Given that the residual impact significance is **Major**, it is recommended that portable noise barriers are installed near to noisy equipment and/or activities. Furthermore, it is essential that no night works are carried out beyond 7pm for all non-safety critical activities as the site is situated next to sensitive receptors.

For rock breaking and excavation works proposed at the CR14 worksite, the approach taken was to provide a guideline to the criteria as set out in BS5228-2:2009+A1:2014. Based on assumptions made (rock breaking and excavation location, depth, breaking method) and known information (distance to nearest receptors), this assessment provides an estimate on the maximum amount of MIC (explosive charge mass, kg) that should be permitted in order to keep air overpressure within the stated criteria. Predictive methods in AS 2187.2-2006 Explosive – Storage and Use Part 2 were used to predict air overpressure based on constants recommended within the guideline.

Based on the impact assessment, from CR14 worksite (Mitigated Scenario) rock breaking and excavation works, Priority 1 ecologically sensitive receptors from Site I and Site III will potentially experience low impact intensity with very low impact consequence. Since the likelihood of rock breaking and excavation works occurring during the entire construction is regarded as Certain and the resulting impact significance is **Minor**. The Priority 1 ecologically sensitive receptors at Site II will potentially experience medium impact intensity with medium impact consequence. Since the likelihood of rock breaking and excavation works occurring during the entire construction is regarded as Certain and the resulting impact significance is Major. Since the impact significance is Major in Site II, the further mitigation measures refer to Section 12.9.1.2 from vibration section and EMMP requirement from Section 13.11 need to apply to reduce the residual impact and the resulting impact significance is **Minor-Moderate** after applying the mitigation measure.

Site IV and Site V

The modelling undertaken as part of the impact assessments for CR15 construction worksite base scenario 1 to base scenario 2, results indicated that an impact significance of **Major** is likely to occur, with a maximum exceedance of 20 dB(A) in Site V and impact significance of **Minor** to **Major** with a maximum exceedance of 5 dB(A) in Site IV respectively. Note that since the intensity of impact is much higher than the criteria, mitigation measures are proposed in Section 11.8 with residual impacts shown in Section 11.9. Efforts were also made to optimise the size of CR15 worksite as much as possible. The revised design was re-evaluated in this Report as the mitigated scenario. Following the assessment of all design optimisation options, it is recommended that noise barriers, with a height of 8m, be installed as a mitigation measure at the CR15 worksite (as shown in Figure 11-12).

Based on the residual airborne noise impact assessment above, the proposed 8m noise barriers at the CR15 worksite will be beneficial by reducing the impact significance and area of major impact significance from Major (Base Scenario) to **Minor** (Post Mitigated scenario) at Site IV, and the area of major impact significance significantly from 4.6 hectares (Base Scenario) to 0.4 hectares (Post Mitigated scenario) at Site V.

Given that the residual impact significance is **Major**, it is recommended that portable noise barriers are installed near to noisy equipment and/or activities. Furthermore, it is essential that no night works are carried out beyond 7pm for all non-safety critical activities as the site is situated next to sensitive receptors.

Potential Source of Impact	Impact Significance with Minimum Control	Residual Impact Significance with Mitigation Measures (if required)
Construction Phase		
Site I	Minor- Major	Minor- Major ¹
Site II	Minor- Major	Minor- Major ¹
Site III	Minor- Major	Moderate- Major ¹
Site IV	Minor- Major	Minor
Site V	Major	Minor – Major ¹
Operational Phase		
Site I	Negligible	Negligible ²
Site II	Negligible	Negligible ²
Site III	Negligible	Negligible ²
Site IV	Negligible	Negligible ²
Site V	Negligible	Negligible ²
Note:		

Potential Source of Impact

Impact Significance with Minimum Control

Residual Impact Significance with Mitigation Measures (if required)

- 1. Due to surrounding extremely low ambient noise levels, sensitive receptor in the close proximity, and undulant terrain with high elevated area which cannot be blocked by the proposed noise barrier.
- 2. The initial impact assessment with minimum controls was considered insignificant (Negligible to Minor), no residual impact assessment was undertaken, hence the impact significance remained the same.

Cumulative impacts from other relevant major concurrent development in the vicinity of the Project were assessed quantitatively based on the worst-case construction activities where the timelines of CR14 worksite and CR15 worksite coincide with other major concurrent development such as the A1-W2 worksite and CR16 worksite. Based on the residual airborne construction noise prediction, there is a potential for Major impact significance area to be increased significantly especially at Site I from 1 hectare (CR14 alone) to 2.5 hectares (CR14 and A1-W2), and at Site II from 1.8 hectares (CR14 alone) to 3.2 hectares (CR14 and A1-W2) on the impacted ecological sensitive receptors after implementing mitigation measures. Therefore, the noise contribution from this concurrent activity to CR14 of this project is considered Major (refer to Table 11-24 and Figure 11-27). Based on the residual airborne construction noise prediction, there is a potential for Major impact significance area will be increased significantly especially at Site V from 0.4 hectares (CR15 alone) to 4.2 hectares (CR15 and CR16) on the impacted ecological sensitive receptors after implementing mitigation measures. Therefore, the noise contribution from this concurrent activity to CR15 of this project is considered major (refer to Table 11-25 and Figure 11-28).

No cumulative impacts were considered significant during operational phase at A1-W2 site, CR14 worksite, CR15 worksite, CR16 worksite. Currently there are no other developments planned near CR14 worksite and CR15 worksite, however, if similar developments are planned around it in distant future, the cumulative impact may need to be assessed at that stage as well.

12. Ground-borne Vibration

12.1 Introduction

This section presents the assessment of vibration impacts arising from the construction and operational phases of the project on ecologically sensitive receptors within vibration sensitive biological study areas. The sensitive ecological receptors may feel ground-borne vibration from CR14 and CR15 worksites during the construction phase. During the operational phase, underground train movements might be experienced by the sensitive ecological receptors which are at/near the tunnel.

Ground-borne noise impact assessment is excluded as ground-borne noise is generated by the vibration of walls, ceilings and floors inside buildings. Ground-borne noise impacts only occur to receptors inside buildings rather than outside in the open. Therefore ground-borne noise impacts are not assessed on biodiversity areas, including fauna. In this assessment, the flora is excluded from the study as it is less sensitive to vibration impacts than fauna.

The critical steps for conducting the ground-borne vibration impact assessment are as follows:

- Define the study area (Section 4.1).
- A baseline vibration study to determine the current vibration levels in the study area.
- · Review secondary baseline vibration monitoring data.
- Establish assessment criteria for the ground-borne vibration impact assessment.
- Identify activities in project construction and operational phases which may cause significant ground-borne vibration impact to the fauna in the study area.
- Identify and classify the sensitivity of the faunal receptors in the study area.
- Identify minimum controls to be implemented by the engineering team for managing or avoiding ground-borne vibration impacts in the construction and operational phases.
- Predict ground-borne vibration levels from significant activities on the faunal receptors assuming minimum controls are in place.
- Recommend additional mitigation measures to be implemented if required.
- Determine the overall significance of the residual ground-borne vibration impacts after commitment to and implementation of the mitigation measures; and
- Define an appropriate monitoring and management plan to be observed during construction and operational phases to maintain consistency with the findings of this study.

12.2 Methodology

The sections below outline the methodology used in the ground-borne vibration impact assessment for both construction and operational phases, including the determination of the study area and baseline vibration.

12.2.1 Baseline Vibration Study

The purpose of the baseline vibration study is to understand the existing vibration levels at the sensitive receptors. The baseline vibration data is used to develop the impact intensity criterion. The baseline data is recorded as Peak Particle Velocity, PPV, and mm/s vibration levels. The Primary baseline vibration data source is vibration monitoring data for this Project, and the secondary source is baseline vibration data from other projects.

12.2.1.1 Primary Data Collection (Baseline Monitoring)

AECOM conducted baseline ground-borne vibration monitoring at four (4) locations within the study area (Table 12-1 and Figure 12-1). These were considered representative of the baseline vibration levels of the faunal receptors. Monitoring location VM1 is located within Site I, VM2 is located within Site III, VM3 is located at the south of Site V and VM4 is located at the north of Site V (near Site 4). Table 12-1 and Figure 12-1 show the baseline vibration monitoring locations.

The baseline vibration monitoring locations were selected based on the following considerations:

Identification of the vibration sensitive receptors (VSR) nearest to the construction worksite/ Project footprint comprises the fauna of high conservation value.

- VSRs outside the study area (100 m from the construction worksite/ Project footprint areas) were not included in the initial assessment.
- VSRs were not used within areas of ongoing construction works for other projects.
- The closest VSR to the construction worksite areas were selected; and
- Monitoring was conducted at the ground level to capture the baseline vibration based on the existing geological profile experienced by the VSRs.

The Svantek 958A and SV85 tri-axis transducers monitored x, y and z-axis baseline vibration levels over 1 week at 1-minute intervals. The baseline vibration monitoring levels are reported in Section 12.5.

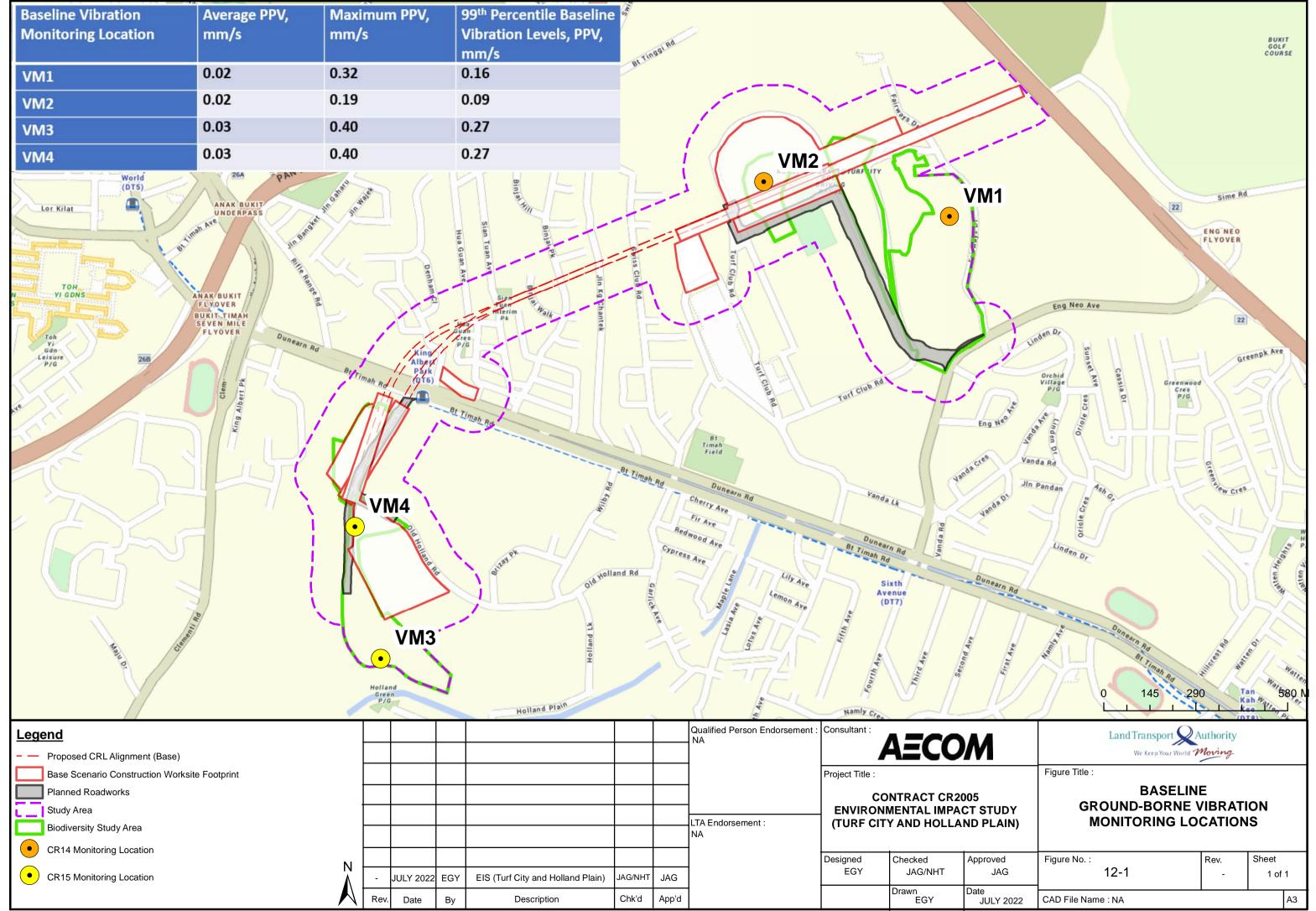
CR2005
AECOM

Table 12-1 Primary Baseline Ground-borne Vibration Monitoring Locations

Monitoring Location	Nearest Construction Worksite Area / Project Footprint	Sensitivity of Receptor	Justification	Photo of Monitoring Location
Within Site I – VM1	Turf City Worksite	Priority 1	Representative baseline vibration monitoring location of Site I and Site II.	
Within Site III – VM2	Turf City Worksite	Priority 1	Representative baseline vibration monitoring location of Site III.	

CR2005

Monitoring Location	Nearest Construction Worksite Area / Project Footprint	Sensitivity of Receptor	Justification	Photo of Monitoring Location
South of Site V – VM3	Holland Plain Worksite	Priority 1	Representative baseline vibration monitoring location of Site V.	
North of Site V – VM4	Holland Plain Worksite	Priority 1	Representative baseline vibration monitoring location of Site IV.	



12.2.2 Assessment Criteria

The study assesses the vibration impacts on the structural integrity of the burrows belonging to the fossorial species and the behaviour of the ecologically sensitive receptors in the biodiversity area.

Currently, there are no applicable Singapore or international standards or guidelines that assess the impacts of ground-borne vibration from the construction and operation of the railway on faunal/ ecological receptors. Based on the literature review, the impacts on the behaviour of ecological species and burrow collapse depend on the vibration level and frequency.

Some species (burrowing rodents, ground spiders and termites.) use low amplitude and low-frequency vibration as a communication mechanism for fossorial fauna (animals adapted to living underground, often by digging burrows and tunnels). It is assumed that while their typical sensitive frequencies are within the range of frequencies anticipated to be produced by construction activities, the amplitudes of their vibration communications are typically below the baseline vibrations determined during the study. Therefore, fossorial fauna occupying the site can potentially accommodate construction induced vibration through frequency discrimination or otherwise due to the transient nature of construction vibration. This field of study is data deficient in the international arena and, in particular, the local context of Singapore to explore any deducible impact analysis. Therefore, this assessment has not considered the frequency range of construction vibration.

Vibration magnitude can impact a living being in two ways: 1) structural damage to its home/ abode (in the context of fauna, burrows for fossorial mammals), and/or 2) behavioural impact, which includes but is not limited to feeding and mating. While some information on the impact on fauna from vibration levels in other contexts is available, there is limited or no data available to correlate vibration levels to behavioural impact on fauna. Therefore, a criterion has been developed based on the step change of the Human Comfort Criteria

Once structural damage occurs, it can potentially lead to fauna mortality. Hence the likelihood aspect of the assessment was removed, and the impact was assessed using intensity. However, behavioural impacts may be temporary or permanent; therefore, the likelihood/duration of impact was important in this case.

Note that there is minimal literature on how vibration may impact fauna. Therefore, this area requires several studies before reliable criteria can be established. A criterion has been developed based on the Human Comfort Criteria step change without reliable criteria.

12.2.2.1 Structural Integrity Criteria for Burrows

The literature review on the impact of vibration on fauna found insufficient data to provide reliable criteria. The available data are presented in Table 12-2 and include well-established criteria for buildings from the FTA [R-56] and information on the collapse of rat burrows [W-85].

Based on these data, it was determined that a PPV of 10 mm/s causes partial burrow collapse. Thus, a threshold of 5 mm/s was used to screen out activities (i.e., 50% of the threshold identified in the study, activities such as rock breaking and excavation) assessed for structural impact in this study as nature's ecological structures (such as burrows for fossorial species) may be susceptible to vibration damage and collapse, thus entombing the fossorial species. Since the impacts could impact mortality rates of the fossorial species, an assessment using a vibration threshold is most conservative for this Project. The vibration threshold for partial burrow collapse in a desert environment is 10 mm/s PPV [W-85]. Hence, it should be noted that the vibration threshold causes site-specific burrow collapses. To avoid an overly onerous assessment that may be impractical for the Singapore context, This Study suggests taking the 80% value of the upper vibration threshold as the assessment criteria. Thus, a vibration threshold of PPV 8 mm/s is recommended for the assessment.

Table 12-2 discusses the vibration thresholds for structural damage.

Table 12-2 Vibration Thresholds for Structural Damage

Structure of Concern	PPV (mm/s)
Reinforced-concrete, steel or timber (no plaster) [R-56]	13
Engineered concrete and masonry (no plaster) [R-56]	8

Structure of Concern	PPV (mm/s)
Non-engineered timber and masonry buildings [R-56]	5
Buildings are extremely susceptible to vibration damage [R-56]	3
Partial Burrow collapse for Kangaroo Rat in Desert conditions [W-85].	10

12.2.2.2 Behavioural Criteria for Fauna

Vibration affects fauna in several ways (refer to Section 12.4.2). For a detailed assessment, vibration frequency and amplitude must be studied extensively before reliable impact criteria can be adopted across various Projects.

Fauna of conservation species such as straw-headed bulbul (*Pycnonotus zeylanicus*) and Sunda pangolin (*Manis javanica*) have been observed to inhabit both Turf City and Holland Plain (Section 7.2.5), with a baseline vibration level of PPV 0.09 mm/s to 0.16 mm/s and 0.27 mm/s at Turf City and Holland Plain respectively (Section 12.4.2). However, further vibration monitoring and ecological surveys would be required to determine the extent of habitation and the corresponding vibration levels across both areas.



Straw-headed Bulbul
(Source:https://ebird.org/species/sthbul1)

Sunda pangolin (Manis javanica) (Source:https://www.pangolinsg.org/pangolins/sunda-pangolin/)

Researchers studying the behaviour of laboratory mouse rats (a highly adaptable species) found transient responses in their creatures, including abrupt freezing of motion, contorted postures, and a wide range of responses [W-91]. The vibrations that cause these responses are from 70 to 100 Hz at PPV 1–1 - 2.0 mm/s, lasting between 2 and 10 seconds. Animals did not exhibit any behavioural response or impact when exposed to PPV 0.1 mm/s at 70 to 100 Hz.

Whilst the mouse rats used in this study seem to adapt to human movements and presence, the fauna in the wild are considered to be shyer and may not be used to fluctuations in vibration caused by human intervention such as sudden vibration from piling, rock breaking and excavation as well as bulldozer movements in the vicinity of their home range.

Guidance on human response to vibration in buildings is available from BS 5228-2:2009+A1:2014, BS 6472-1:2008 and BS 6472-2:2008. This guidance advises that humans respond differently according to individual sensitivities and the vibration time (day or night).

Whilst human response and faunal behaviour are not directly comparable, a grading of impact intensity (negligible, low, medium and high) for fauna has been derived based on the step change of human response from BS 5228-2_2009+A1_2014 (human comfort criteria) and the ⁹9th percentile of baseline vibration for the Study Area (Table 12-3). The difference between impact intensity values was also used to derive each vibration threshold curve for the assessment. The following explains how the impact intensity criteria are developed:

• Step 1: Calculate step increment between each threshold of the Human Comfort Criteria (see column 3 of Table 12-3).

- Step 2: Apply the calculated step increment to the baseline of 0.27 mm/s to obtain the absolute values for impact intensity (see column 4 of Table 12-3).
- Step 3: Calculate the difference (delta) between absolute values (see column 5 of Table 12-3).
- Step 4: PPV values below baseline are not assessed. Hence, the first threshold (T1) would start from ambient (see row 2 of Table 12-7).
- Step 5: Add the first delta value to the baseline to obtain T1 (see row 3 of Table 12-7).
- Step 6: Add the second delta value to T1 to obtain T2 (see row 4 of Table 12-7).
- Step 7: For Turf City and Holland Plain, T3 ranges from T2 to Windsor's fourth absolute value (2.49) (see row 5 of Table 12-7).
- Step 8: For Turf City and Holland Plain, T4 ranges from T3 to Windsor's fifth absolute value (4.99) (see row 6 of Table 12-7).

The step-change in vibration intensity thresholds for Turf City is presented in Table 12-3.

In addition to using these derived criteria to complete the evaluation, the Study considers the known behaviour of the animals, the intensity of behavioural changes, and the extent of impacts on the home range.

Table 12-3 Step Change in Vibration Intensity Thresholds for Turf City

Based on Hur BS5228-2: 200	man Comfort C 09+A1:2014	riteria		Criteria for F	auna	
Impact Intensity (Human Comfort Criteria)	Human Response Absolute Level PPV (mm/s)	Relative Change from Previous Intensity Level	Absolute Values Impact Intensity for Site I and II	Difference between Impact Intensity Values for Site I and II	Absolute Values Impact Intensity for Site III	Difference between Impact Intensity Values for Site III
Just perceptible in most sensitive situations	0.14	-	0.16	-	0.09	-
Just perceptible in residential	0.3	0.3 / 0.14 = 2.14	0.34	0.18	0.19	0.10
Complaints in residential	1.0	1.0 / 0.3 = 3.33	1.14	0.80	0.64	0.45
Intolerable	10	10.0 / 1.0 = 10	2.49 4.99 (Does not use Relative Change from Column 3, values from Windsor)	No difference required, use the same Absolute Values from Windsor	2.49 4.99 (Does not use Relative Change from Column 3, values from Windsor)	No difference required, use the same Absolute Values from Windsor

The step-change in vibration intensity thresholds for Holland Plain is presented in Table 12-4.

Table 12-4 Step Change in Vibration Intensity Thresholds for Holland Plain

Based on Human Comfort Criteria BS5228-2: 2009+A1:2014			Criteria for Fauna		
Impact Intensity (Human Comfort Criteria)	Human Response Absolute Level PPV (mm/s)	Relative Change from Previous Intensity Level	Absolute Values Impact Intensity for Sites IV and V	Difference between Impact Intensity Values for Sites IV and V	
Just perceptible in most sensitive situations	0.14	-	0.27	-	
Just perceptible in residential	0.3	0.3 / 0.14 = 2.14	0.58	0.31	
Complaints in residential	1.0	1.0 / 0.3 = 3.33	1.92	1.34	
Intolerable	10	10.0 / 1.0 = 10	2.49 4.99 (Does not use Relative Change from Column 3, values from Windsor)	No difference required, use the same Absolute Values from Windsor	

Table 12-5 discusses the difference between intensity values to generate the thresholds and their ranges for Sites I and II at Turf City.

Table 12-5 Thresholds for Vibration Impact Assessment for Sites I and II at Turf City

Threshold	Range for Sites I and II, mm/s
-	< Ambient (0.16)
T1	Ambient (0.16) + 0.18 = 0.34
T2	T1 + 0.79 = 1.13
Т3	T2 (1.13) to 2.49
T4	T3 (2.49) to 4.99
> T4	> T3 (2.49) to 4.99

Table 12-6 discusses the difference between intensity values to generate the thresholds and their ranges for Site III at Turf City.

Table 12-6 Thresholds for Vibration Impact Assessment for Site III at Turf City

Threshold	Range for Site III, PPV, mm/s
-	< Ambient (0.09)
T1	Ambient (0.09) + 0.10 = 0.19

Threshold	Range for Site III, PPV, mm/s
T2	T1 + 0.45 = 0.64
Т3	T2 (0.64) to 2.49
T4	T3 (2.49) to 4.99
> T4	> T3 (2.49) to 4.99

Table 12-7 discusses the difference between intensity values to generate the thresholds and their ranges for Holland Plain

Table 12-7 Thresholds for Vibration Impact Assessment Holland Plain

Threshold	Range for Holland Plain, PPV, mm/s
-	< Ambient (0.27)
T1	Ambient (0.27) + 0.31 = 0.58
T2	T1 + 1.34 = 1.92
Т3	T2 (1.92) to 2.49
T4	T3 (2.49) to 4.99
> T4	> T3 (2.49) to 4.99

Birds tend to move away more easily and find other sources of habitation. Fossorial animals may find it harder to do so and may/ may not adapt to the conditions. With the paucity of information coupled with the myriad behaviours of fauna, vibration impacts are hard to predict. Therefore, as a conservative approach, species deep in the forest behave differently than those living near the road. Species may habituate to the road vibration levels for their activities.

In contrast, species living deep in the forest are more sensitive to vibration levels. This is a conservative approach that may not represent fauna adaptation capability. However, this study erred on caution due to the paucity of information on vibration impacts on fauna.

The sections below detail how this approach was materialised into intensity criteria and likelihood for predicting and evaluating impacts.

12.2.2.3 Determining Impact Intensity

For the construction phase, the assessment in this Report predicts the ground-borne vibration impacts during identified stages of the construction phase. AECOM referred to BS 5228-2:2009+A1:2014, BS 6472-1:2008, BS 6472-2:2008 and the FTA Transit Noise and Vibration Impact Assessment Manual (2018) for guidance in predicting vibration levels of the construction activities for this EIS.

Suppose the predicted vibration level is greater than PPV, 5.00 mm/s. In that case, it may result in severe impacts such as fauna mortality in some cases. Impacts from these construction activities are assessed in this Study. Emphasising the impact intensity with an objective for it to be kept as low as reasonably practicable below a threshold value of PPV, 8.00 mm/s (see Section 12.4.2).

For behavioural impact assessment, the fauna is mobile within the Biodiversity Study Area and neighbouring areas, which are wooded and provide appropriate habitat. The Biodiversity Study Area that faunal species use for feeding, resting and breeding is their home range. It is anticipated that a high impact intensity over a small fraction of the home range could be considered low as the fauna are mobile. Also, a low impact intensity over a huge fraction of

the home range could be considered low. Hence these two parameters are not independent, and an impact intensity matrix has been derived for this Study.

Table 12-8 Impact Intensity Assessment for Construction and Operational Vibration

Area Affected (ha)	Impact Intensity				
6 < area	Negligible	Low	Medium	High	High
4.8 < area ≤ 6	Negligible	Low	Medium	Medium	High
2.4 < area ≤ 4.8	Negligible	Low	Low	Medium	High
1.2 < area ≤ 2.4	Negligible	Negligible	Low	Medium	Medium
0 < area ≤ 1.2	Negligible	Negligible	Low	Medium	Medium
Ambient Level	Ambient to T1	T1 to T2	T2 to T3	T3 to T4	> T4

12.2.3 Prediction and Evaluation of Impact Assessment

The assumptions, predictions and evaluation of impact assessment methodology for the construction and operational phases are presented in this section. Based on the geographical profile study (refer to Section 4.7), the local geological profile along the Project alignment is mainly dominated by Bukit Timah Granite (Rengam Facies).

12.2.3.1 Construction Phase

12.2.3.1.1 Identification of Potential Sources of Impacts

In a typical underground railway construction phase described in Section 3.2, there are several potential sources of ground-borne vibration impacts such as rock breaking and excavation, vibratory compactors, tunnel boring and bulldozers. Equipment operating simultaneously could increase vibration levels substantially, but predicting any cumulative increase is impossible without a detailed construction programme. FTA Transit Noise and Vibration Impact Assessment Manual (2018) [R-56] states that each piece of equipment's potential effects from construction vibration shall be assessed individually. Both underground and above-ground construction works are expected at Turf City and Holland Plain worksites.

12.2.3.1.2 Identification of Sensitive Receptors

Ecologically sensitive receptors at Turf City and Holland Plain may be impacted by the construction and operation of the project. Sensitive receptors are identified based on the study area (i.e. Biodiversity Study Area around the construction worksites during the construction phase; Biodiversity Study Area around the rail alignment during the operational phase). Based on the studies on the vibration impact on humans, construction and operation-generated vibration effects generally do not occur outside the vibration study area as the vibration levels by this distance typically tend to dissipate to insignificant levels. Suppose the vibration impacts from rock breaking and excavation are significant within the Vibration Study Area. In that case, the Biodiversity Study Area is assessed until the impact dissipates to near ambient conditions. Vibration sensitive receptors are sub-categorised into three categories: Priority 1, Priority 2 and Priority 3 (from the most sensitive to the least) based on the known impact of vibration and species sensitivity in the available literature.

12.2.3.1.3 Understanding of Baseline Conditions

Primary data was used to establish the baseline conditions of vibration levels from existing natural and anthropogenic (human) sources.

12.2.3.1.4 Minimum controls

During this report's development, meetings with LTA and 'TA's appointed technical advisor were held to provide inputs into the design and therefore try to optimise the design with the least environmental impact. Therefore, these recommendations have been incorporated into the design and considered essential minimum control.

12.2.3.1.4.1 Rock Breaking and Excavation at CR14

The prediction in the EIS is highly conservative. It provides a high-level assessment of the vibration impacts on ecologically sensitive receptors. A study [W-87] states that variations in geological profile (excavation is sequentially carried out) can change the vibration attenuation significantly. The vibration on the ground surface is much smaller than below the ground surface; the vibration wave attenuation of rock is much lower than in soil.

As mentioned in Section12.2.2, the vibration threshold for assessing structural integrity is PPV, 8.00 mm/s.

Several researchers have investigated how ground vibration can be predicted and have proposed various formulae based on field observations from several sites. CR2005 has predicted vibration levels for rock breaking and excavation following the guidance of BS 647-2-2008 and, secondly, with an empirical equation (from LTA Contract T207).

Using the guidance of BS 6472-2-2008, the Project predicts the vibration levels emitted for the various MIC and slant distance combinations for the construction vibration impact assessment. The empirical relationship between predicted vibration level, PPV (mm/s), MIC (kg) and distance, x (m), is expressed in the equation below:

Equation 1
$$PPV = 1291 \left(\frac{x}{\sqrt{MIC}}\right)^{-1.5}$$

Based on The prediction in the EIS is highly conservative. It provides a high-level assessment of the vibration impacts on ecologically sensitive receptors. A study [W-87] states that variations in geological profile (excavation is sequentially carried out) can change the vibration attenuation significantly. The vibration on the ground surface is much smaller than below the ground surface; the vibration wave attenuation of rock is much lower than in soil.

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Using the guidance of BS 6472-2-2008, the Project predicts the vibration levels emitted for the various MIC and slant distance combinations for the construction vibration impact assessment. The empirical relationship between predicted vibration level, PPV (mm/s), MIC (kg) and distance, x (m), is expressed in the equation below:

Equation 1 above, the PPV, 8.00 mm/s, occurs at 8 m (horizontal distance) from the source at a MIC of 0.7 kg, as seen in Table 12-9.

Table 12-9 Predicted Values Using BS 6472-2-2008 Equation

Depth / m	Horizontal Distance /						
	m	/ m	0.6	0.7	0.8	1.5	1.6
			Peak Particle Velocity, mm/s				
25	8	26	6.5	7.3	8.1	13.0	13.7

The predicted vibration levels of rock breaking and excavation are presented in Section 12.2.3.1.4.1 for the CR14 and CR15 worksites. Appendix T presents the detailed heatmaps.

An equation from T207 has been used for added comparison to predict vibration levels for the same activities. The formula is:

Equation 2
$$PPV = K(D/\sqrt{MIC})^{-n}$$

D is the distance (m), MIC is the charge (kg), K is the site-specific constant (1200), and n is the site-specific constant (1.6). The prediction assumes that the site constants apply to the CR14 and CR15 worksites.

The predicted vibration levels of rock breaking and excavation are presented in Section 12.2.3.1.4.1 for the CR14 and CR15 worksites. Appendix T presents the detailed heatmaps. The predicted vibration levels of rock breaking and excavation are presented in Section 12.2.3.1.4.1 for the CR14 and CR15 worksites. Appendix T presents the detailed heatmaps.

An equation from T207 has been used for added comparison to predict vibration levels for the same activities. The formula is:

Equation 2 above, the PPV, 8.00 mm/s, occurs at 8 m (horizontal distance) from the source at a MIC of 1.3 kg, as seen in Table 12-10.

Table 12-10 Predicted Values Using T207 Equation

Depth / m	Horizontal Distance /						
	m	/ m	1.2	1.3	1.4	2.3	2.4
				Peak Part	ticle V	elocity,	mm/s
25	8	26	7.4	7.9	8.4	12.5	13.0

The equation from T207 gives higher estimates for the same MIC and distance combinations between the two prediction methods. The vibration level calculated at $MIC = 1.3 \, kg$ was PPV, 8.00 mm/s at 8 m which coincides with the boundary of the Turf City worksite. Thus, the $MIC = 1.3 \, kg$ was used for further assessments. Given the potential for fauna mortality at its first instance of likelihood, the assessment for this activity was delinked from likelihood or duration (considering it definitive as a worst-case) and focused on the impact intensity.

The activities for bulldozing were predicted to be much lower than PPV, 8.00 mm/s; therefore, it was only assessed for behavioural impacts on the fauna. Activities such as tunnel boring, vibratory compactor, rock breaking, and excavation with predicted vibration levels of more than PPV, 5.00 mm/s were assessed for structural collapse and behavioural impacts.

12.2.3.1.4.2 Tunnel Boring

This study assessed the vibration impacts of tunnel boring in Turf City and Holland Plain (base and mitigated scenarios). The vertical alignment in the vibration Study Area remains the same for the base, and mitigated scenarios are controlled by the level below the rock head [O-11]. The ground-borne vibration levels caused by tunnel boring were predicted using the method stated in BS5228-2:2009+A1:2004. The geological profile is typically not homogamous; however, to simplify the process for the assessment, it is assumed to be. The predicted results are potentially conservative since the formula applies to soil types.

$$v_res \leq \frac{180}{r^{1.3}}$$

Where:

 v_res is the resultant ppv, in millimetres per second (mm/s)

 $10 \le r \le 100 \text{ m}$

r is the slope distance from the tunnel crown, in metres (m)

This study also predicts the vibration level from tunnel boring using the Esvelt equation used in the CRL1 EIS Report [R-1]. Esvelt formula assumes Bukit Timah Granite (G2 – G3 rock type) to have a substrate hardness factor, *B* of 0.95 . It is estimated that these rock types are primarily encountered at the tunnel boring level under Turf City and Holland Plain. Based on CRL 1 EIS Report [R-1] Esvelt equation with parameters was calibrated to empirical data based on granodiorite substrate (UK). The resulting prediction curve was independently verified using datasets from two other tunnelling sites (Sydney and Hong Kong). The Esvelt equation is a particular class of WISS equation used in the British Standard. The scalar parameter is determined as a TBM Diameter function, Material Density, and 3D Distance from TBM. It is the only available equation that parameterises the TBM cutter head diameter.

The BS5228-2:2009+A1:2004 and Esvelt equation is also used in the assessment for the transition tunnel, which comprises Bukit Timah Granite (G2 and G3 rock type).

The equation used is:

$$PPV = \frac{10BDia}{r^n}$$

Where:

Dia is the TBM cutting wheel diameter (Twin bored tunnel: 6.6m)

r is the slope distance from track level to receptor (m)

n is a site-specific constant (1.35) determined by calibration*

The prediction assumes that n = 1.35 applies to CR2005.

*In CRL1 EIS Report [R-1], it is reported that the Esvelt prediction model is based on measurements taken during the construction of the Epping to Chatswood Rail Line in Sydney, Australia and validated on the Kowloon, Southern Link construction in Hong Kong.

12.2.3.1.4.3 Bulldozing

The activities detailed in this section were predicted to be much lower than PPV, 3.00 mm/s; therefore, they only assessed for behavioural impacts on the fauna.

Bulldozing was also assessed for the base and mitigated scenarios at Turfy City and Holland Plain for entrances and worksites.

The vibration level from the bulldozer is predicted using the formula from the FTA [R-56]. The bulldozer is generally mobile as it tends to move around the worksite. However, the bulldozer is assumed stationary for the construction vibration impact assessment. The equation is used to predict the vibration attenuation over distance.

$$PPV_{equip} = PPV_{ref} \times (\frac{7.62}{D})^{1.5}$$

Where:

 PPV_{equip} is the peak particle velocity of the equipment adjusted for distance, mm/s

 $\textit{PPV}_{\textit{ref}}$ is the source reference vibration level at 7.62 m, mm/s

D is the distance from the equipment to the receiver, m

Note that the equation is based on point sources with normal propagation conditions.

The vibration source levels from typical large and small bulldozers are provided in Table 12-11. It presents the average source level in terms of velocity. The approximate rms vibration velocity level was calculated from the PPV limits using a crest factor of 4, representing a PPV-rms difference of 12 dB. Note that although the table gives one level for each piece of equipment, there is considerable variation in reported ground vibration levels from construction activities. The EIS assessed the vibration impacts from a typical large bulldozer in Section 12.7.

Table 12-11 Vibration Source Level for Construction Equipment from FTA [R-56]

Equipment	PPV at 25 ft (7.62 m), mm/s
Large Bulldozer	2.26
Small Bulldozer	0.08

12.2.3.1.4.4 Vibratory Compactor

The vibration level from the vibratory compactor is predicted using the formula from BS5228-2:2009+A1:2004. The vibratory compactor is used to construct planned road works near the Turf City and Holland Plain worksites and is assumed to be stationary. The equation is used to predict the vibration attenuation over distance.

$$PPV_{equip} = K\sqrt{n} \left(\frac{A}{x+L}\right)^{1.5}$$

Where:

 $\emph{PPV}_{\emph{equip}}$ is the peak particle velocity of the equipment, mm/s

K is the scale factor, where 75.0 is used

 \emph{n} is the number of vibrating drums (assuming 1 for this assessment)

A is the amplitude of the vibrating drum, mm, where 2.05 mm is used for High vibration and 0.87 mm is used for Low vibration based on the Sakai 10 tonne compactor

x is the distance from the vibrating drum

L is the width of the vibrating drum

12.2.3.1.5 Classification of Overall Consequence

A consequence category is derived based on receptor sensitivity and impact intensity, as shown in Section 6.4.2.1. The ground-borne vibration impact assessment uses a matrix method to determine the overall consequence in Table 6-6.

12.2.3.1.6 Establishing Impact Significance

Refer Table 12-12, for the likelihood evaluation for construction activities for the construction vibration impact assessment.

Generally, ground-borne vibration impacts due to vibratory compactors, rock breaking, excavation, and tunnel boring occur during the construction phase.

In the operational vibrational impact assessment, the trains operate daily between 5.30 am and midnight. Train-induced vibration occurs during the operation unless an unplanned or catastrophic event results in the service's cessation. The duration of the ground-borne vibration impacts experienced by the receptor is only whilst the train is passing. Hence it is overly onerous to assume that the impact is continuous. According to LTA [O-16], the likelihood of occurrence for a single passage passing by a receptor is **Possible** since the operational vibration is present 23% of the time within 24 hours.

LTA [O-18] also studied the combined vibration results of simultaneous trains passing in both directions as an upper limit. It assumed that simultaneously passing trains occurred at all points along the alignment but only in specific locations. Therefore, the combined vibration levels give an overestimate of impact. A recent study by LTA showed that the maximum levels were similar between one single pass-by and a simultaneous pass-by. Therefore, the report scoped out the vibration impact of two simultaneous trains passing each other.

In this work, the predicted vibration from the train on the nearest track is taken as a representative vibration level for the operational impact assessment.

Table 12-12 Likelihood Evaluation for Construction Activities for Ground-borne Vibration Impact Assessment

Activity	Frequency of Exposure	Likelihood of Occurrence
Rock Breaking and Excavation	Work period = 1 Active vibration period for Machinery = 1 1 x 1 = 1	Certain
Bulldozer	Work period = 0.5 Active vibration period for Machinery = 0.5 0.5 x 0.5 = 0.25	Possible
Vibratory compactor	Work period = 0.5 Active vibration period for Machinery = 0.14 0.5 x 0.14 = 0.07	Less Likely
Tunnel Boring Machine (TBM)	Work period = 1 Active vibration period for Machinery = 0.72 0.72 x 1 = 0.72	Certain
Operational	MRT operational period per 24 h = 0.8 Bidirectional passing within 24 h = 0.23 0.8 x 0.23 = 0.20	Possible

^{*}Bulldozers may be used during groundworks; the actual duration is challenging to predict; this conservative assumption is for the operation to be not higher than 15% of the construction period.

12.2.3.1.7 Mitigation Measures and Monitoring Programme Recommendation

Based on the impact evaluation outcome, vibration mitigation measures are recommended for the affected ecologically sensitive receptors. The vibration mitigation measures are based on the principles:

- Elimination/avoidance;
- Minimisation (substitution);
- Minimisation (engineering controls); minimisation (administrative controls);
- · Remedy/repair/restore; and
- Compensation/offset.

In addition, an environmental monitoring program is proposed to validate the findings of the EIS report. Works shall be controlled or re-evaluated if the monitored levels differ significantly from the predicted ones.

12.2.3.1.8 Establishing Residual Impact Significance

With the mitigation measures included in the assessment, a residual impact significance using the same significance matrix was re-evaluated. The residual impact is reduced to insignificant levels or as reasonably practicable. An iterative process of suggesting mitigating measures and re-assessing was used where required.

12.2.3.2 Operational Phase

Independent noise and vibration consultants have carried out operational phase impact predictions under a separate study by LTA [O-13]. The findings available at the time of writing this report are summarised here.

Based on the information from LTA, the general prediction model is described below:

- Source of vibration.
- Propagation path of vibration; and
- Receptor response.

The vibration source was determined from vibration measured on the track slab of an existing operational underground railway alignment. A tunnel on the MRT Circle Line was used.

A two-dimensional (plane strain) finite element model (FEM) was used to estimate the change in the vibration transfer functions from source to receptor due to the different soil characteristics between the measured site and the CR2005 alignment, plus changes in tunnel depth and receptor distance.

In the separate study, LTA used GIS to calculate the expected vibration levels (in decibels, VdB) at the surface level for different tunnel depths along the alignment, based on:

- The horizontal and vertical alignment details from drawings reference PCRLSWD-PP9400, dated 29 January 2021, provided by LTA from a separate study. It should be noted that LTA has calculated vibration levels based on a maximum tunnel depth of 50 m in another separate study for this report.
- Referring to Section 4.7, the geological information for the Project describes the two main formations along the alignment:
 - Bukit Timah Granite Formation, partly with Kallang Formation on the top layer; and
 - o Jurong Formation, partly with Kallang Formation on the top layer.
- Single bore tunnels.
- Non-ballasted track.
- Standard baseplates pads¹⁰.
- Other train characteristics include:
 - o Number of cars: 8
 - Total train mass (tare condition): 40 ton

¹⁰ Baseplate pads are installed under the baseplate to reduce vibrations caused by wheel and track irregularities.

o Unsprung mass: 4.4 ton

As part of the LTA's separate study, prediction model validation measurements were conducted to compare the results of the modelling with the measured data:

- Trackside and surface measurements for two locations and the Circle Li

 –e PSA Club (Telok Blangah) on
 Jurong Formation and Singapore Polo Club (Caldecott) on Bukit Timah Granite Formation.
- Surface measurement at one location along Circle Li–e University Road Park.

Based on the predicted vibration levels from LTA, AECOM conducted an environmental impact assessment on the ecological receptors identified at Turf City and Holland Plain (i.e. Biodiversity Study Areas) according to the impact evaluation matrix stated in Section 6.4.2. The assessment results are presented and discussed in Section 12.7.2.

12.3 Potential Sources of Ground-borne Vibration Impacts

12.3.1 Construction Phase

Table 12-13 lists the potential sources of ground-borne vibration impacts during the construction phase.

Table 12-13 Potential Sources of Ground-borne Vibration Impacts during Construction Phase

Construction Activity	Associated Impacts
Compacting concrete using the vibrator equipment	Structural Damage
Piling works for the foundations of the facility building	Ecological Foraging Behaviour
Rotary piling works for ground improvements and underpinning works.	
Tunnel boring using the TBM	
Rock breaking and excavation	
Vibratory sheet piling for temporary works	
Heavy construction vehicles such as bulldozers and vibratory compactor	'S
Other Construction Equipment	
Stationary equipment with diesel engines	

Based on the review and the evaluation of the proposed construction methods for CRL2, the critical sources of construction-induced vibration are rock breaking and excavation, piling and tunnel boring works. The associated ground-borne vibration impacts from these activities works may cause disturbance to the ecological foraging behaviour to the receptors near the construction area.

12.3.1.1 Rock Breaking and Excavation

Rock breaking and excavation are potentially carried out at the Turf City worksite. When using combustible means to break up rocks, much energy is used to break up the rock and displace it from its original position. However, some excess energy is always converted into vibration that travels away from the combustion through the ground. The vibration attenuates with increasing distance away from the combustion. The rock breaking design controls the ground-borne vibration level, the distance to the combustion, rock breaking weight, and the intervening geology.

Rock breaking and excavation-induced vibration are impulsive, and each event's duration depends on the magnitude of the combustion. The variables of this activity include the number of delay intervals and rock breaking quantities, the method of rock breaking, the separation distance between the rock breaking and the receptor site, and the geological profile between the rock breaking and the combustion site. It is typically measured in terms of unfiltered time histories of three-component particle velocities from which the peak values can be identified. Typically soft ground conditions (clay, sand, alluvial) transmit less ground-borne vibration than hard ground (granite, rocks). Building damage associated with rock breaking and excavation is predominantly due to the air overpressure exciting the building elements of receptor buildings rather than ground-borne vibration.

12.3.1.2 Tunnel Boring

Tunnel boring occurs along the entire alignment of CRL2. Both ground-borne noise (or structure radiated noise) and ground-borne vibration potentially occur on the ground surface and in buildings above the tunnel. The typical activities during the tunnelling process that generates vibration include tunnel boring machines, excavators, tunnel segmental lining placement and hydraulic drilling.

12.3.1.3 Other Construction Equipment

Typical construction equipment that emits vibration is vibratory compactors and bulldozers for this Project.

A vibratory compactor is used to densify soil, asphalt or other materials by applying combined static and dynamic forces via a drum to increase the load-bearing capacity of the surface. Vibrations are generated by one or more eccentric weights rotating on a shaft centred at the drum.

A bulldozer consists of a heavy, broad steel blade mounted on the front of a tractor. The bulldozer is used for:

- · shallow digging and ditching;
- short-range transportation of material;
- spreading soil dumped from trucks; final trim grading;
- · removing trees, stumps, and boulders; and
- · cleaning and levelling around loading equipment.

12.3.1.4 Heavy Construction Vehicles

Vibration can be generated from heavy construction vehicles travelling on the road with an uneven surface profile. The interaction between the wheels and the road surface causes waves to propagate in the soil and nearby sensitive receptors. Road-induced vibration impacts are usually minimal unless there are frequent potholes in the road and the vehicles are heavy/ fast. Generally, the vibration from construction vehicles is less than from activities such as piling works.

12.3.1.5 Diesel Engines

Continuous vibration at low intensities can be emitted from diesel engines, e.g. from impact bored piling winches mounted on the skids, crawler-mounted base machines and attendant plants. Diesel engines produce vibration at frequencies about 50 Hz, and those vibrations about this frequency (and higher) will be attenuated more aggressively by material absorption. Such vibrations are unlikely to remain significant outside the worksite boundary.

12.3.2 Operational Phase

During the operational phase, the vibration sources are potentially the trains travelling on the CRL2 alignment and road traffic on roads within the Study Area (Table 12-14).

Table 12-14 Potential Sources of Ground-borne Vibration Impacts during Operational Phase

Operation Activity	Potential Impacted Parameter	Associated Impacts
CRL2 Alignment	Ground-borne vibration	Annoyance
Road Traffic	Structure-borne vibration	Ecological Foraging Behaviour

Train-induced vibration is caused by the roughness of the wheels and rails. The vibration also depends on the train suspension and tracks supporting system, as these may have resonances that result in increased vibration.

Road traffic vibration is mainly due to heavy vehicles passing at speed with an uneven surface profile. Interaction between wheels and road surface causes a dynamic excitation that propagates waves in the soil and nearby sensitive receptors. Based on the land use of the Project site, the presence of heavy vehicles at speed is rare. The construction of roads in Singapore usually has an even surface profile. It is unlikely that the road traffic causes high ground-borne vibration levels in the Study Area. Thus, it does not significantly impact nearby sensitive receptor buildings and ecological receptors nearby. In addition, the existing road is unlikely to have an increase in traffic during the operation. Thus, it is also unlikely to cause high ground-borne vibration levels in the Study Area. Hence, it will not significantly impact nearby sensitive receptor buildings and ecological receptors.

12.4 Identification of Ground-borne Vibration Sensitive Receptors

Ecologically sensitive/ faunal receptors within the Study Area may be impacted by the construction and operation of the Project. It is anticipated that effects from construction and operation-generated vibration will not occur outside the vibration Study Area based on the experience of similar projects on the impact on humans. Suppose an impact

is significant within the whole Study Area. In that case, this area is typically increased to assess and envelope a wider area

In addition, since there are urban patches of land nearby which may not be suitable to support the presence of fauna, this Study will assess these regions as "Not Assessable".

12.4.1 Habitat Receptor Sensitivity to Ground-borne Vibration

A desktop review of available studies was conducted to categorise the various ecological receptors in the Study Area. The species are first evaluated for their sensitivity towards ground-borne vibration and further classified into Priority 1, Priority 2 and Priority 3 based on their Conservation Significance.

The habitats are classified into Priority 1 (secondary forests), Priority 2 (forest fragments) and Priority 3 (managed vegetation), with Priority 1 being the most sensitive. All urban areas such as houses and existing roads are not assessed as they are not a natural stronghold for fauna.

12.4.2 Fauna Receptor – Species Sensitivity to Ground-borne Vibration

The prioritisation of the sensitive ecological receptors within the sensitive ecological sites follows the approach listed in order below:

- 1. The actual presence or likely presence (from records) from the faunistic field assessment conducted
- 2. The conservation significance or importance of the identified ecological receptors
- 3. The ecological receptor's likely sensitivity to vibration impacts

Based on faunistic field assessment within the sensitive ecological sites, the receptors of concern in line with the biodiversity section are discussed below.

The complete list of sensitive ecological receptors is shown in Appendix O.

12.4.2.1 Turf City

The faunistic survey identified 589 species of probable occurrence at Sites I to III. The field assessment documented 197 species, dominated by birds (71 species) and butterflies (38 species), see Section 7.3.1.3.

From these, 16 species of conservation significance were also recorded. Two of the recorded species (one bird and one bat) were not listed as probable species, see Table 12-15. Species of conservation significance that were found only in Sites I and II but not in Site III include the Sunda pangolin (*Manis javanica*), the red-legged crake (*Rallina fasciata*) and the Formosan swift (*Borbo cinnara*). In particular, the pangolin was detected utilising the entire area of Sites I and II. Forest dependent species like the Sunda colugo (*Galeopterus variegatus*) were also found in Sites I and II. One of the exclusive findings at Site III was the oriental pied hornbill (*Anthracoceros albirostris*), on top of high butterfly species richness, including an abundant common birdwing (*Troides helena cerberus*) population.

Table 12-15 List of Faunal Species of Conservation Significance Recorded in Sites I to III

Taxon	Species	Common Name	Local Status	Global Status	Locations of Records
Butterfly	Borbo cinnara	Formosan swift	Endangered	Not Assessed	Sites I and II
Butterfly	Arhopala amphimuta amphimuta	NA	Nationally Extinct (Rediscovered)	Not Assessed	Site I and II
Butterfly	Troides helena cerberus	Common birdwing	Vulnerable	Not Assessed; CITES protected (Appendix II)	Sites I and II; Site III

Taxon	Species	Common Name	Local Status	Global Status	Locations of Records
Bird	Accipiter trivirgatus	Crested goshawk	Critically Endangered	Least Concern; CITES protected (Appendix II)	Sites I and II
Bird	Anthracoceros albirostris	Oriental pied hornbill	Critically Endangered	Least Concern; CITES protected (Appendix II)	Site III
Bird	Copsychus saularis	Oriental magpie-robin	Endangered	Least Concern	Site III
Bird	Gallus gallus	Red junglefowl	Endangered	Least Concern	Sites I and II; Site III
Bird	Loriculus galgulus	Blue-crowned hanging-parrot	Endangered	Least Concern; CITES protected (Appendix II)	Sites I and II; Site III
Bird	Psittacula longicauda	Long-tailed parakeet	Not Assessed	Vulnerable; CITES protected (Appendix II)	Sites I and II
Bird	Pycnonotus zeylanicus	Straw-headed bulbul	Endangered	Critically Endangered; CITES protected (Appendix II)	Sites I and II; Site III
Bird	Rallina fasciata	Red-legged crake	Vulnerable	Least Concern	Sites I and II
Bird	Strix seloputo	Spotted wood owl	Critically Endangered	Least Concern; CITES protected (Appendix II)	Sites I and II
Mammal	Macaca fascicularis	Long-tailed macaque	Least Concern	Vulnerable; CITES protected (Appendix II)	Sites I and II; Site III
Mammal	Manis javanica	Sunda pangolin	Critically Endangered	Critically Endangered; CITES protected (Appendix I)	Sites I and II
Bat	<i>Tylonycteri</i> s sp.	Bamboo bat	Vulnerable	Least Concern	Sites I and II

12.4.2.2 Holland Plain

The faunistic survey identified 558 species of probable occurrence at Sites IV and V, including 49 species of conservation significance, see Section 7.3.2.3.

The field assessment documented 160 species, dominated by birds (71 species) and odonates (29 species). From these, 11 species of conservation significance were recorded, all of which were listed as probable. The list of probable and recorded species is available in Table 7-25.

Table 12-16 List of Faunal Species of Conservation Significance Recorded in Sites IV and V

Taxon	Species	Common Name	Local Status	Global Status	Location Of Records
Butterfly	Troides helena cerberus	Common birdwing	Vulnerable	Not Assessed; CITES protected (Appendix II)	Site V
Odonate	Indothemis limbata	Restless demon	Endangered	Least Concern	Site V

Taxon	Species	Common Name	Local Status	Global Status	Location Of Records
Bird	Nisaetus cirrhatus	Changeable hawk- eagle	Endangered	Least Concern; CITES protected (Appendix II)	Site V
Bird	Vanellus indicus	Red-wattled lapwing	Endangered	Least Concern	Site V
Bird	Gallus gallus	Red junglefowl	Endangered	Least Concern	Sites IV and V
Bird	Halcyon coromanda	Ruddy kingfisher	Critically Endangered	Least Concern	Site IV
Bird	Loriculus galgulus	Blue-crowned hanging-parrot	Endangered	Least Concern; CITES protected (Appendix II)	Sites IV and V
Bird	Psittacula longicauda	Long-tailed parakeet	Not Assessed	Vulnerable; CITES protected (Appendix II)	Sites IV and V
Bird	Pycnonotus zeylanicus	Straw-headed bulbul	Endangered	Critically Endangered; CITES protected (Appendix II)	Site V
Bird	Rallina fasciata	Red-legged crake	Vulnerable	Least Concern	Sites IV and V
Mammal	Manis javanica	Sunda pangolin	Critically Endangered	Critically Endangered	Site V

Due to the connectivity of Sites IV and V to CCNR and proximity to the adjacent Clementi Forest, it might serve as an additional refugia for rare or forest-dependent species. The Study Area provides habitats for several species of conservation significance, including the globally Critically Endangered straw-headed bulbul (*Pycnonotus zeylanicus*), nationally Critically Endangered ruddy kingfisher (*Halcyon coromanda*), and nationally Endangered red-wattled lapwing (*Vanellus indicus*). Other noteworthy findings include the Sunda pangolin (*Manis javanica*), which was caught on camera trap within the scrubland and herbaceous vegetation at Site V. Pangolins were also sighted previously by Ho et al. (2019) in Clementi Forest, which could indicate that the pangolin population is utilising the entire forested area, making Sites IV and V another important patch for this globally and nationally Critically Endangered species.

In addition, the freshwater marshland in Site V also serves as an important habitat for odonates, amphibians and foraging grounds for migratory bee-eaters and kingfishers. The mere 0.3 ha marsh currently supports a diverse community of odonates (21 species), including certain marsh-specific species which thrives in such habitats like the crenulated spreadwing (*Lestes praemorsus*) and the nationally Endangered restless demon (*Indothemis limbata*). On the other hand, the waterbody in Site IV does not support as many species like the freshwater marsh, albeit it remains a hotspot for some odonates like the uncommon sultan (*Camacinia gigant*).

For this report writing, pangolins and mousedeers are also considered indicator species for both Turf City and Holland Plain.

This section presents the literature review of the sensitivity of fauna to ground-borne vibration. In the study of anthropomorphism of fauna species, existing research does not provide sufficient documentation for treating fauna as human behaviours and responses [W-84].

In an ecological context, vibrational signalling, vibration reception and behaviour (prey catching, courtship, territorial behaviour) are guided by substrate vibrations. These have been best studied in vertebrates and arthropods.



Figure 12-2 Examples of Fauna (Toads, Rats) That Utilise Vibration for Signalling And Behaviour [W-38]

This section presents the literature review of the sensitivity of fauna to ground-borne vibration. In the study of anthropomorphism of fauna species, existing research does not provide sufficient documentation for treating fauna as human behaviours and responses [W-84].

In an ecological context, vibrational signalling, vibration reception and behaviour (prey catching, courtship, territorial behaviour) are guided by substrate vibrations. These have been best studied in vertebrates and arthropods.

When studying the effects of vibration on ecology, it can be challenging to separate vibration effects from other sensory disturbing effects (for example, noise, visual and olfactory cues).

The vibration sources and character from the works are as follows:

- Rock breaking and excavation work are aimed to reduce the size of rocks for tunnel boring and excavation. The vibration produced is instantaneous.
- Rotary bored piling is used in the construction, and the vibration caused by rotary bore piling is episodic¹¹ at the start and completion of a piling process. When the pile is driven into the ground, the vibration is continuous.
- A bulldozer is used for groundwork. Typically, the vibration produced is transitory as it moves over rough terrain.
- A tunnel boring machine is used to construct the underground railway tunnel. For tunnel boring, the critical
 frequency of the activity is generally below 100 Hz. The vibration caused by tunnel boring is predominantly
 subsurface except during the launch and retrieval of the tunnel boring machine. Hence, when the tunnel boring
 is either launched or retrieved, the initial effect will likely cause some species in nearby proximity to be alarmed
 and move away briefly.

Based on observations from other site surveys at Mandai and literature on the species' behaviour, instantaneous vibration is more likely to cause the Sunda pangolin to curl into a ball and remain stationary. The Lesser mousedeer is likely to dash from cover to cover. However, it is unlikely to dash across the road due to the mousedeer's timid nature. Fossorial snakes and reptiles are also unlikely to dash across the road. The wild boar, a highly adaptable urban species, is potentially the only species that might exhibit flee response and end up on the road.

Continuous vibration tends to be more tolerable for terrestrial animals, including bats, snakes and migratory bird species. It can be reasonably assumed that the low ground-borne vibration levels are potentially more tolerable by terrestrial fauna. It is anticipated that several species (e.g. Sunda pangolin and Lesser mousedeer) would move further away during the rotary bore piling period. They will return to the vicinity of the worksite once habituated to the vibration.

¹¹ Rotary bore piling will be conducted for one pile (an episode) with no breaks/stops in between until the next pile (another episode) begins.



Sunda pangolin (Source:https://www.wrs.com.sg/en/protectingwildlife/conservation/our-work/understanding-local-sundapangolins.html)



Lesser mousedeer (Source:https://www.nparks.gov.sg/florafaunaweb/fauna/2/1/21#gallery-1)

Figure 12-3 Examples of Vibration Sensitive Species

The vibratory sensors of ecological receptors are highly complex in nature and frequency-dependent. Some fossorial species (e.g. snakes, rats, spiders and shrews) use low amplitude/ low-frequency vibration as a communication mechanism. Vibration detection by fossorial snakes was explored in Cerastes, which showed the species responded to natural and artificial ground-borne vibration stimuli. These snakes were hunting using vibration detection [W-84].

Studies have shown that fossorial species such as talas tuco-tuco (*Ctenomys talarum*) [P-122], spadefoot (*Spea hammondii*) [P-121] have a home range more minor than that of the Lesser Mouse-deer [P-112, P-120 and P-114]. It is also mentioned that fossorial species are predicted to have smaller home ranges than their nonfossorial relatives [P-115]. While their typical sensitive frequencies are within the range of frequencies anticipated to be produced by construction activities, the amplitudes of their vibration communications are typically below the ambient transient vibrations determined during the Study (refer to Section 7.4). Therefore, the site's fossorial fauna shall be required to accommodate construction-induced vibration through frequency discrimination or communicate otherwise due to the transient nature of construction vibration.

The Singapore Blue Tarantula, *Omothymus violaceopes*, typically stay hidden in their burrows as spiderlings but come out late at night to hunt if their prey doesn't walk right in front of their burrow [W-86]. The Singapore Blue Tarantula species act much more like a fossorial tarantula at this size than an arboreal tarantula.

The most considerable vibration impact on fossorial fauna is assumed to be burrow collapse, the levels for which may occur from rock breaking and excavation (refer to Section 12.7). The outcome of the impact significance provides a conservative impact assessment result for all the ecologically sensitive receptors.

The scientific literature on ground-borne vibration impacts on ecology is inconclusive concerning their perceptibility of vibration from a subsurface source. Since most affected terrestrial species (e.g., Red-legged crake, Red junglefowl and Sunda pangolin) live on the ground surface, the effects on home range and activities are negligible. Some affected species in the vicinity could partially be habituated to the vibration levels over time, provided that the vibration levels remain relatively consistent during the tunnel boring duration.

Species that prefer burrow habitats include the golden mouse, dusky-footed wood rat, brush mouse and pinion mouse. This preference could be due to predators such as foxes, racoons, skunks, and coyotes leaving their habitats as they experience ground-borne vibration from the road surface [W-38; W-41]. Burrowing and ground-dwelling mammals are susceptible to vibration [P-94]. Therefore, this study considers this behaviour to represent small mammals that move on land, which are assumed to experience high sensitivity to ground-borne vibration for this assessment.

Invertebrates such as bees often build hives on the trunks of trees and, in hollows, may be sensitive to vibrations. Bees can hear airborne sounds (Krichner et al., 1991) and are auditory sensitive. They also use vibration to communicate within the hive.

Adult odonates¹² are not ground-dwelling and, therefore, not vibration sensitive. Most aquatic invertebrates are less impacted by low-frequency noises, characteristic of anthropogenic sources. Odonate nymphs (macropredators) have prey (e.g. tadpoles and fishes) that are sensitive to low-vibration sounds (Nedwell et al., 2003; Castaneda et al., 2020). Thus, they have been treated as vibration sensitive receptors.

Lepidopteran larvae (caterpillars) respond to low-frequency vibrations to avoid insect predators and parasites (Taylor, 2009). Some adult butterflies are known to use airborne sounds to avoid predators (Fournier, 2011). Night-flying butterflies and moths are also highly dependent on hearing to avoid bat predation (Yack & Fullard, 2000). As such, lepidopterans are highly vibration sensitive species

All fully aquatic species are negatively impacted by low-frequency vibrations (Nedwell et al., 2003; Castaneda et al., 2020). As such, all aquatic species are considered high vibration sensitive species.

Tadpoles are treated with other aquatic species and are regarded as vibration sensitive. Ground-dwelling frog species are vibration sensitive.

Snakes, in general, are deaf as they do not have an ear [P-85]. Therefore, vibration energy usually impacts the behaviour of these creatures, and they are startled by vibration.

Sunda colugo (*Galeopterus variegatus*) is a nocturnal mammal. It spends most of its life in trees and moves by gliding from tree to tree. There is insufficient research or literature on the impacts of vibration on these animals. A study was conducted by radio-tracking 32 lemuroid ringtail possum (*Hemibelideus lemuroides*). Their movements were monitored by a 7 m wide road and an 80 m wide powerline corridor [P-66]. No possums were observed crossing the road or powerline corridor at ground level or residing in the intervening matrix due to the loss of canopy connectivity. (The loss of canopy connectivity negatively impacts their movements.) Considering that they spend most of their time above ground on trees, these creatures potentially experience low sensitivity to ground-borne vibration.

The research or literature on vibration impacts on the Greater Mouse-eared Bats is insufficient. However, a study conducted on piling-induced vibration impacts on Pilbara Leaf-Nosed and Ghost Bat [P-67, P-68]. This Study used a drill to penetrate a cavity at the rear of an unoccupied cave in the Pilbara region of Western Australia. Vibration levels PPV, 0.4 - 0.6 mm/s and a noise level of 60 dB(A) were measured at 50 m from the drill. The Study concluded that these impacts were unlikely to cause the bats to abandon the cave.

Roosting bats are negatively impacted by vibrations and are considered vibration sensitive (Voigt & Kingston, 2016). Considering the above, this Project assumes that the bats with the CR2005 Study Area behave similarly to roosting bats and hence have high sensitivity to ground-borne vibration.

Ground-dwelling species of birds are considered highly sensitive to vibration. Resident swiftlets breed and roost in caves and culverts and are also considered sensitive to vibrations (Chia et al., 2019).

Terrestrial bird species like the Red Junglefowl (*Gallus gallus*) are usually found in open ground and dense vegetation. Such places may be around human activities or living areas and travel through forests to other clearings or food sources. Assuming that these species are accustomed to vibration on the ground, they are less likely to be impacted unless the vibration levels become significantly higher than they are familiar with.

Aerial birds live most of their lives in flight; thus, they are less impacted by construction-induced vibration. Therefore, these birds are assumed to have a low sensitivity to ground-borne vibration.

Arboreal birds spend most of their time in trees and dense foliage. They perch and roost in trees and forage in holes and tree cavities, looking for insects and seeds. Little research or studies have shown the impacts of ground-borne vibration on them. Considering their behaviour, these birds are assumed to have a low sensitivity to ground-borne vibration.

There have been studies on vibration impacts on benthic invertebrates due to sediment vibration and; on invertebrates due to substrate-borne vibrations.

Concerning non-benthic invertebrates, there is insufficient evidence on the effects of vibration on behaviour. Hence, it is assumed that the species have low sensitivity.

¹² Odonates are predaceous insects comprising the dragonflies and damselflies.

Spiders of all kinds are sensitive to vibratory stimulation as this is the method used to alert them to the presence of prey on their webs or foliage [W-42]. Spiders attack the vibration source if the vibrations are within a defined frequency and amplitude range. Vibrations with characteristics outside these biologically meaningful ranges do not induce an attack response. There is insufficient evidence to suggest that the ground-borne vibration is within these ranges. Hence this assessment assumes that spider species have moderate sensitivity to ground-borne vibration.

Studies have been conducted on vibration in water bodies caused by underwater drilling, rock breaking and excavation. Based on the research, vibration propagation is frequency-dependent as the medium profile of land and water is not the same. Research shows that aquatic vertebrates have a lateral line to sense vibrations in the water and perceive their surroundings. Hence, this assessment assumes that the fishes are susceptible to ground-borne vibration.

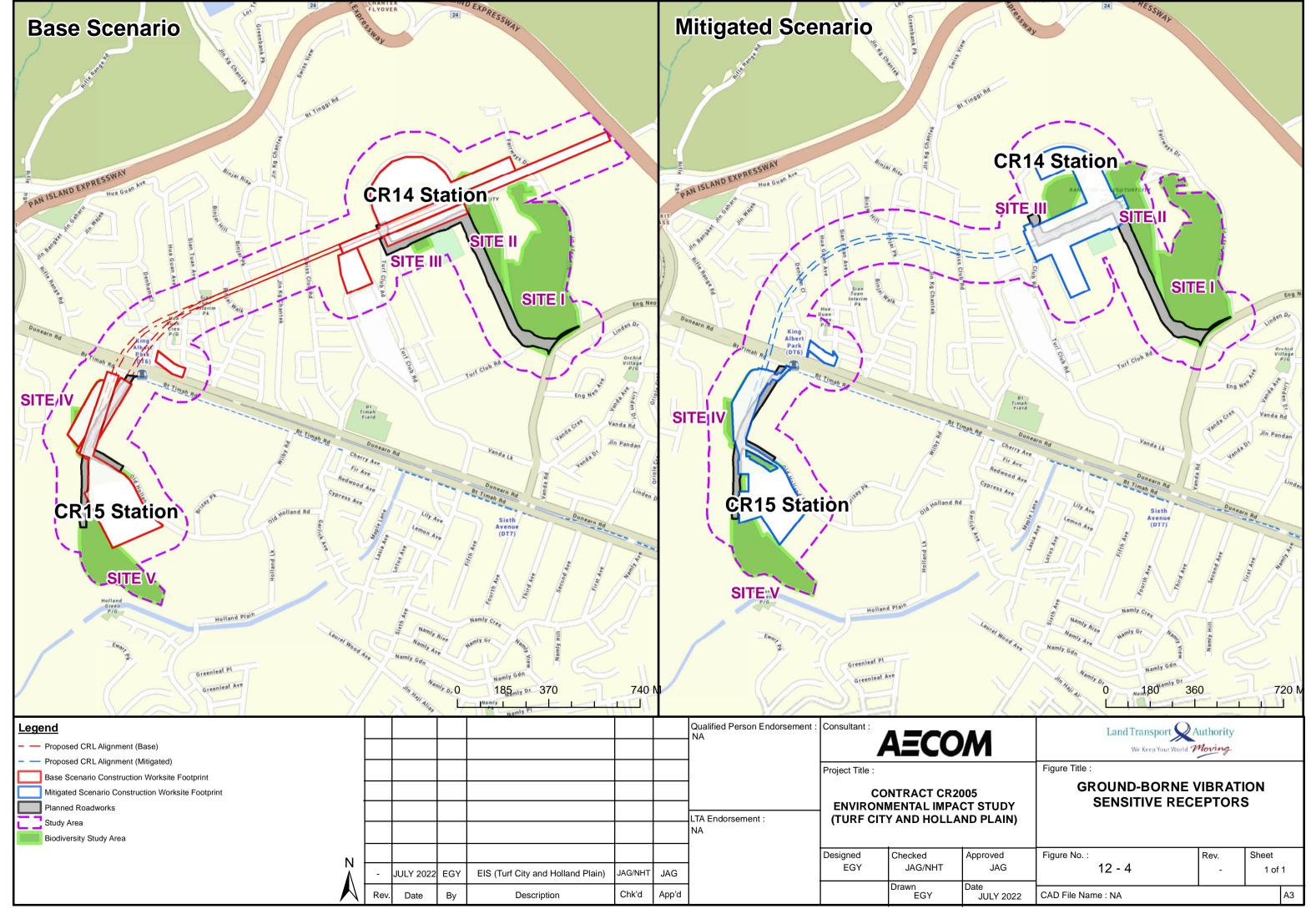
Airbreathing walking catfish like the *Clarias cf. batrachus* and swamp eels (*Monopterus iavanensis*) can move overland for short distances. There is insufficient evidence to suggest their sensitivity to vibration. However, considering their behaviour on land, the assessment assumes that they have a high sensitivity to ground-borne vibration.

Snakeheads like the Channa striata can burrow in the mud during the dry season for survival. There is insufficient evidence to suggest their sensitivity to vibration. However, considering their behaviour in wetlands, the assessment assumes they have a high sensitivity to ground-borne vibration.

Table 12-17 presents a summary of vibration thresholds for different species from the literature review.

Table 12-17 Summary of Vibration Thresholds (PPV, mm/s) from Literature Review

Receptors	Vibration Thresholds, PPV, mm/s
Bees	0.02
Caterpillars (Lipidopteran larvae)	0.61
Fish	0.531 - 1.11
Frogs	0.00159
Pilbara Leaf-Nosed and Ghost Bat	0.40 - 0.60
Snakes	0.0016
Rats	0.30 – 9.70
Mice	0.40 – 1.80
Pigs	8.80
Tortoise	10.00 – 25.40
Rhesus monkeys	52.00



12.5 Baseline Ground-borne Vibration Levels

12.5.1 Primary Data Collection (CR2005 Baseline Monitoring)

CR2005 conducted baseline ground-borne vibration monitoring at four (4) locations within the study area in proximity to the sensitive receptors. It represented the baseline vibration levels of the sensitive receptors. Tri-axis transducers were used, orientated in the vertical direction. At the beginning and end of the monitoring period, the vibration data has been omitted to exclude the vibration caused while setting up and removing the equipment. The baseline vibration monitoring report prepared by CR2005 is presented in Appendix P.

Baseline vibration monitoring locations VM1 to VM4 are in a forested area within Turf City and Holland Plain, respectively. Transient passers-by were the sources of vibration within the vicinity. The average, maximum and 99th percentile baseline ground-borne vibration levels are summarised in Table 12-18.

Table 12-18 Summary of Baseline Ground-borne Vibration Levels

Baseline Vibration Monitoring Location	Date	99 th Percentile Baseline Vibration Levels, PPV, mm/s
VM1: Turf City Site I	1st July 2022 – 8th July 2022	0.16
VM2: Turf City Site III	1st July 2022 – 8th July 2022	0.09
VM3: Holland Plain South of Site V	23 rd June 2022 – 30 th June 2022	0.27
VM4: Holland Plain North of Site V	23 rd June 2022 – 30 th June 2022	0.27

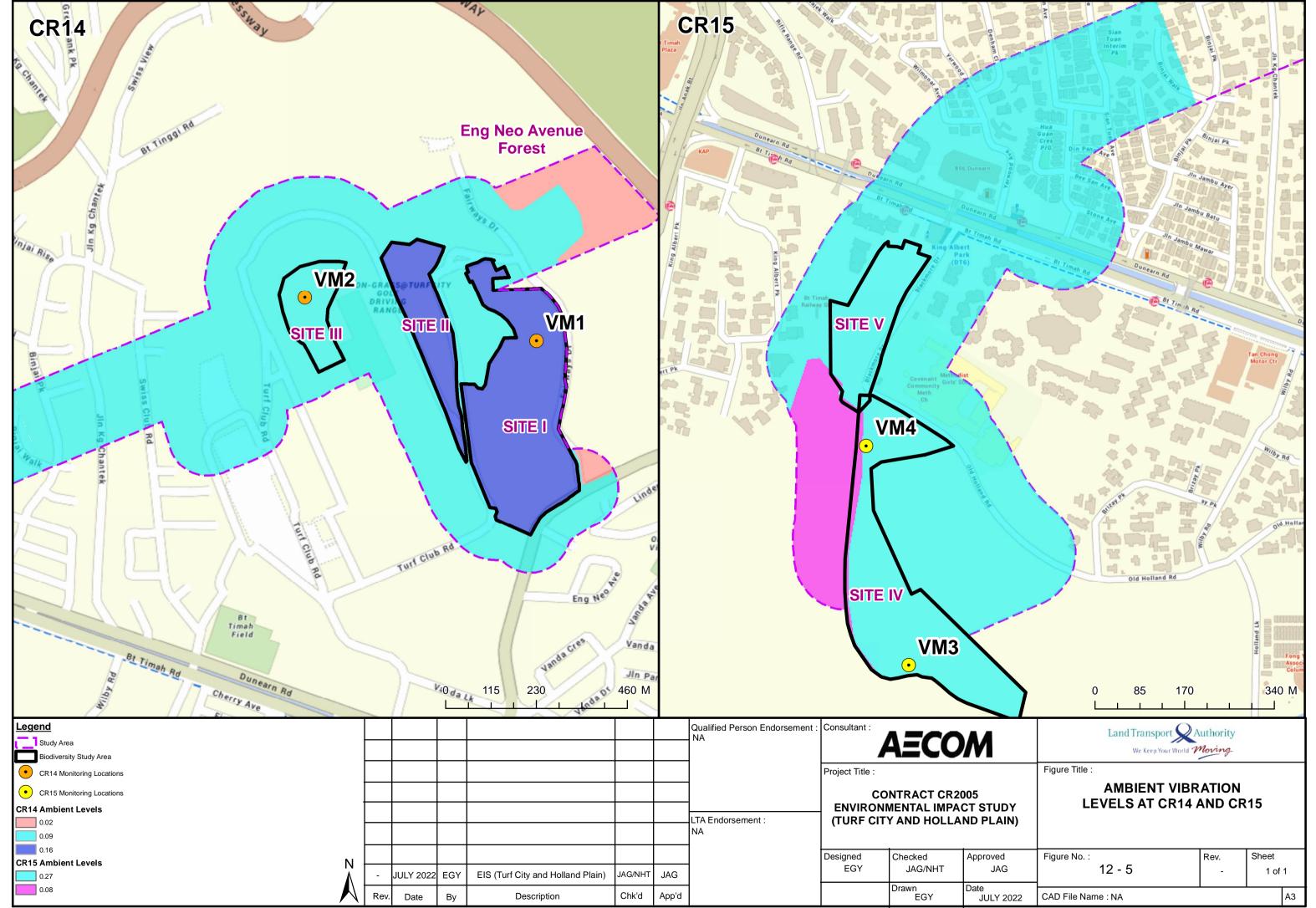
12.5.2 Baseline Analysis at Turf City

There are two baseline monitoring data at Turf City for this project. Site I is a forested area, approximately 30 m away from a road and trail for the horses, which seems to be the source of vibration. Site III was a forested area with a trail for bikers and runners, which seemed to be the source of vibration. For consistency, for these locations, the ⁹9th percentile data were used to represent the baseline vibration level of the biodiversity study areas in Sites I and III. Due to the proximity of VM1 to Site II, the results of VM1 were used to represent Site II's baseline conditions. The baseline vibration level for construction and operational vibration impact assessment in Sites I to III are shown in Figure 12-5.

12.5.3 Baseline Analysis at Holland Plain

There are two baseline monitoring data at Holland Plain for this project. These areas were forested, with a walking trail for the public, which seems to be the source of vibration. The 99th percentile data were used to represent the baseline vibration level of the biodiversity study areas in Sites IV and V. There are two Biodiversity Study Areas – Sites IV and V. Site IV was not accessible; hence baseline vibration monitoring location VM3 was set at the North of Site V, which was the closest point to Site IV to present the baseline condition for Site IV. Vibration monitoring location VM4 was at Site V.

Figure 12-5 shows the ⁹9th percentile baseline vibration data measured at both points.



12.6 Minimum Control for Potential Impacts

12.6.1 Construction Phase

This section proposes minimum controls, or standard practices commonly implemented in Singapore for similar construction activities, that are assumed to be implemented for impact assessment. The minimum control measures are summarised in Table 12-19.

Table 12-19 Minimum Controls (Ground-borne Vibration)

Potential Source of Impacts	Minimum Controls
Compacting concrete using the vibrator equipment Tunnel boring using the TBM Rock breaking and excavation Vibratory compactors for planned road works Heavy construction vehicles such as bulldozers Other construction equipment Stationary equipment with diesel engines	Conduct dilapidation surveys of burrows when the predicted vibration levels approach or exceed a level of 80 % of the lowest criteria, in this case, ecological criteria. Use low vibration equipment and construction techniques. Limit the rotational speed of the cutting surface of the TBM or the thrust force and the progress rate of the tunnel boring. See minimum controls in rock breaking and excavation in Section 12.6.1.1. Impose and signpost a maximum speed limit of 25 km/hr on paved or surfaced haul roads and 15 km/hr on unpaved haul roads and work areas within the worksite, as well as local access roads leading to the site.

12.6.1.1 Rock Breaking and Excavation

Rock breaking and excavation are proposed for the station at Turf City. Typically, an assessment report and the method statement will be produced before conducting such works. It should be noted that vibration estimates are difficult to be precise due to the local geological profile and site conditions at the worksite. There are no planned events at Holland Plain for this activity.

Before the actual works, a trial of a rock breaking and excavation activity will provide critical data on the vibration transmitted through the ground on the structures. These data can refine the vibration predictions and re-assess the impact.

The vibration shall be monitored during the work to provide a real-time reading. It should be noted that these serve as knowledge purposes only, and a rock breaking and excavation engineer shall be responsible for designing this activity that meets the project requirements.

It should be noted that ground-borne vibration from the rock breaking and excavation cannot be eliminated. It can be managed to the criteria set by adopting a proper dose for combustion at various depths and frequency/ timing of conduct. Parameters that affect rock breaking, excavation-induced ground-borne vibration, and air overpressure impacts are detailed in Table 12-20.

Table 12-20 Parameters Affecting Rock Breaking and Excavation induced Ground-borne Vibration (and Air Overpressure)

Uncontrollable Parameters	Controllable Parameters MIC Dependant	Design Dependant
Geological characteristics and properties Distance from the source of combustion	MIC type Amount of MIC per delay Number of explosion holes per delay Delay times Decoupling charge	Explosion hole diameter and depth Burden and spacing Charge length and stemming Sub-drilling

The minimum controls expected for ground-borne vibration estimation for the Biodiversity Study Area are as below:

i. The maximum instantaneous charge per delay must be calculated, planned, and controlled using delay detonators. These provide an effective initiation sequence that delays the rock breaking of each charge.

Hence, the charges detonate in a controlled sequence, each separated by a few thousandths of a second. Therefore, to control ground-borne vibration generated, charge weight was minimised at any instant area of impact, timing, duration, and frequency.

ii. Promoting forward movement of the rock ensures that the charge energy is directed to break towards an open face. Multi-row rock breakings are fired using a time delay between successive rows of rock breaking. The burden on each rock breaking hole needs time to move after the commencement of rock breaking to create a practical free face. The fire towards this new free face developed during the rock breaking and excavation in the subsequent rows. Promoting the rock break and excavation activity in this sequence and directing it away from critical receptors reduces the vibration generated. Therefore, to control ground-borne vibration, it is necessary to ensure that the design of the activities promotes forward movement of the rock mass and allocate proper delay timings between rock breaking holes.

Implementing minimum controls is sufficient to alleviate any significant environmental construction impacts; contract-specific final mitigation measures are proposed in this section.

12.6.1.2 Loaded Trucks

As per the discussion with LTA, there is also a need for the traffic controller to release 3 trucks at a time.

12.6.1.3 Tri-axle Trucks

In general, tri-axle trucks, compared to tandem trucks, have an extra axle and suspension, allowing better loading on the frame and giving additional stability. Therefore, the load they carry on each trip is higher than the standard truck and can significantly minimise the number of truckloads required along this road during the construction phase. Thus, as the tri-axle truck travels along the access roads, the vibration caused by the wheels and road surfaces can be minimised more due to the reduction in the number of trips. As discussed with LTA, there is also a need for the traffic controller to release three trucks at a time.

12.6.1.4 Tunnel Boring

Mitigation measures for tunnel boring are limited. If the project requirements permit, it might be possible to control the vibration levels at the source by limiting the rotational speed of the cutting surface of the TBM or the thrust force and the progress rate of the tunnel boring. If circumstances do not permit the above, other mitigation measures include limiting the working hours for tunnel boring and pipe jacking and developing an engagement community programme shall be considered. Lubricant injection can also help to mitigate vibration by reducing frictional resistance and jacking force.

12.6.2 Operational Phase

This section proposes minimum controls or standard practices commonly implemented as ground-borne vibration control measures. A summary of minimum control measures is presented in Table 12-21. The Contractor shall determine concrete material/density at a later stage.

Table 12-21 Minimum Control Measures

Minimum Controls

Train, track, and tunnel design

Maintenance of vertical track alignment at the relevant longitudinal wavelengths

Maintenance of roughness of the railhead and wheel tread at the relevant longitudinal and circumferential wavelengths, respectively.

Maintenance of resilient elements in track construction, e.g. rail pads.

Maintenance of rail joints, switches, and crossings.

12.7 Prediction and Evaluation of Ground-borne Vibration Impacts

This section details the vibration impact assessment for construction and operational activities in the biodiversity areas Sites I to V. The predicted vibration levels from the activities are assessed for the following:

- 1. Impacts on the structural integrity of fossorial species' burrows.
- 2. Behavioural impacts on the ecologically sensitive receptors.

12.7.1 Construction Phase (Base Scenario)

The base case here is the worksites proposed at the onset of the construction of the alignment and station.

12.7.1.1 Structural Integrity of Burrows

The baseline fauna survey and burrows of fossorial species have been sighted and recorded at the Biodiversity Areas – Site I to Site V. Construction vibration levels are predicted, and the maximum levels for each activity are listed.

In the screening process, as the predicted vibration levels are higher than PPV, 5.00 mm/s, vibration caused by high amplitude vibratory compactors for Planned Road Works is likely to impact the burrows at Site I to Site V

As the depth increases along the alignment, the predicted vibration levels decrease. Eventually, fewer exceedances occur against the vibration threshold level for partial burrow collapse. For precautionary purposes and avoid damage/collapse of burrows, the appointed Contractor should hold conversations with a wildlife expert to ensure that the impact's magnitude and duration are appropriate. This type of communication can prove beneficial for controlling the impact and learning about the local fauna and their behaviour from this activity. The study recommends controlling the threshold value in the Biodiversity Study Areas accompanied by constant trigger monitoring.

Table 12-22 Predicted Vibration Levels of Construction Activities for Base Scenario

Construction	Construction	Max Predicted PPV, r	mm/s	
Worksite	Activities	Biodiversity Area – Site I	Biodiversity Area – Site II	Biodiversity Area – Site III
Turf City	Bulldozing (Entrances & Worksites)	1.5	1.5	1.5
	TBM Hypothetical Overall ¹³ ,, Esvelt	0.01	0.01	0.03
	TBM Spot, Esvelt	0.01	0.01	0.01
	Low Vibratory Compactor for Planned Road Works	1.4	1.4	1.4
	High Vibratory Compactor for Planned Road Works	5.2	5.2	5.2
Construction	Construction	Max Predicted PPV, r		
Worksite	Activities	Biodiversity Study A	rea – Site IV	Biodiversity Study Area – Site V
Holland Plain	Bulldozing (Entrances & Worksites)	1.5		1.5
	TBM Hypothetical Overall ¹² , Esvelt	0.4		0.1
	TBM Spot, Esvelt	0.3		0.1
	Low Vibratory Compactor for Planned Road Works	1.4	1.4	
	High Vibratory Compactor for Planned Road Works	5.2	5.2	

12.7.1.2 Behavioural Impacts on Fauna (Base Scenario)

The assessments in this section focus on the behavioural impacts on Priority 1 fauna receptors within Sites I to V. A summary of the impact significances and behavioural impacts can be seen in

Table 12-23 and from Figure 12-6 to Figure 12-15.

¹³ The hypothetical overall of TBM was assessed as full affected alignment. It should be noted that, the tunnel boring machine will only bore section by section along the alignment at a rate of 7 m/ day. Thus, this assessment also identified the key spots for detailed hotspot analysis of TBM passage impact on fauna at any time.

Table 12-23 Predicted Impact Significances and Behavioural Impacts of Construction Activities for Base Scenario

Scenario			
Construction Worksite and Activities	Base Scenario Impact Signif	icance	
Turf City	Site I	Site II	Site III
Bulldozing	Minor – Moderate	Minor - Moderate	Minor - Moderate
(Entrances & worksites)		Impacted Area (ha)	
	Moderate, 1	Moderate, 0.9	Moderate, 0.2
TBM Hypothetical Overall ¹⁴ , Esvelt	Not affected	Not affected	Minor
TBM Spot, Esvelt	Not affected	Not affected	Not affected
Low Vibratory Compactor for Planned Road Works	Negligible – Minor	Negligible – Minor	Negligible – Minor
High Vibratory Compactor for Planned Road Works	Negligible – Minor	Negligible – Minor	Negligible – Minor
Holland Plains	Site IV	Site V	
Bulldozing (Entrances & worksites)	Minor	Minor	
TBM Hypothetical Overall ¹² , Esvelt	Minor	Not affected by CR15 alignment. Fassessed with CR16 concurrent ac	
TBM Spot, Esvelt	Minor	Minor	
Low Vibratory Compactor for Planned Road Works	Negligible - Minor	Negligible - Minor	
High Vibratory Compactor for Planned Road Works	Negligible - Minor	Negligible - Minor	

Summary:

- Overall, the construction activities produce impact significances of Minor and Moderate.
- Minor impact significances may cause some sensitive fauna to be impacted. At the same time, other
 species may avoid the area because of the increased levels of activity in the area. Many species
 would become habituated to the bulldozer. They would return to normal activity in a few days when
 the machine passed.

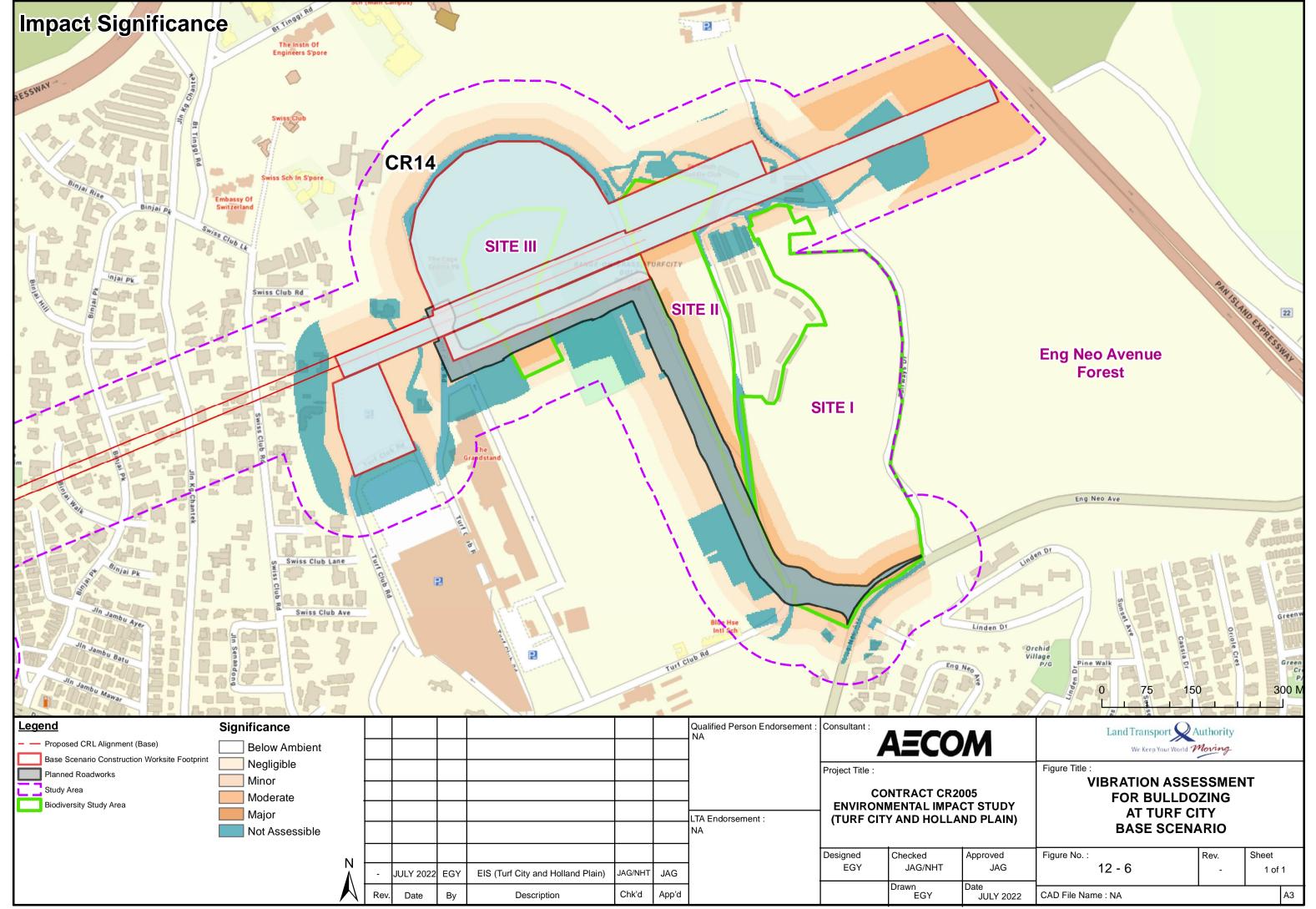
¹⁴ The hypothetical overall of TBM was assessed as full affected alignment. It should be noted that, the tunnel boring machine will only bore section by section along the alignment at a rate of 7 m/ day. Thus, this assessment also identified the key spots for detailed hotspot analysis of TBM passage impact on fauna at any time.

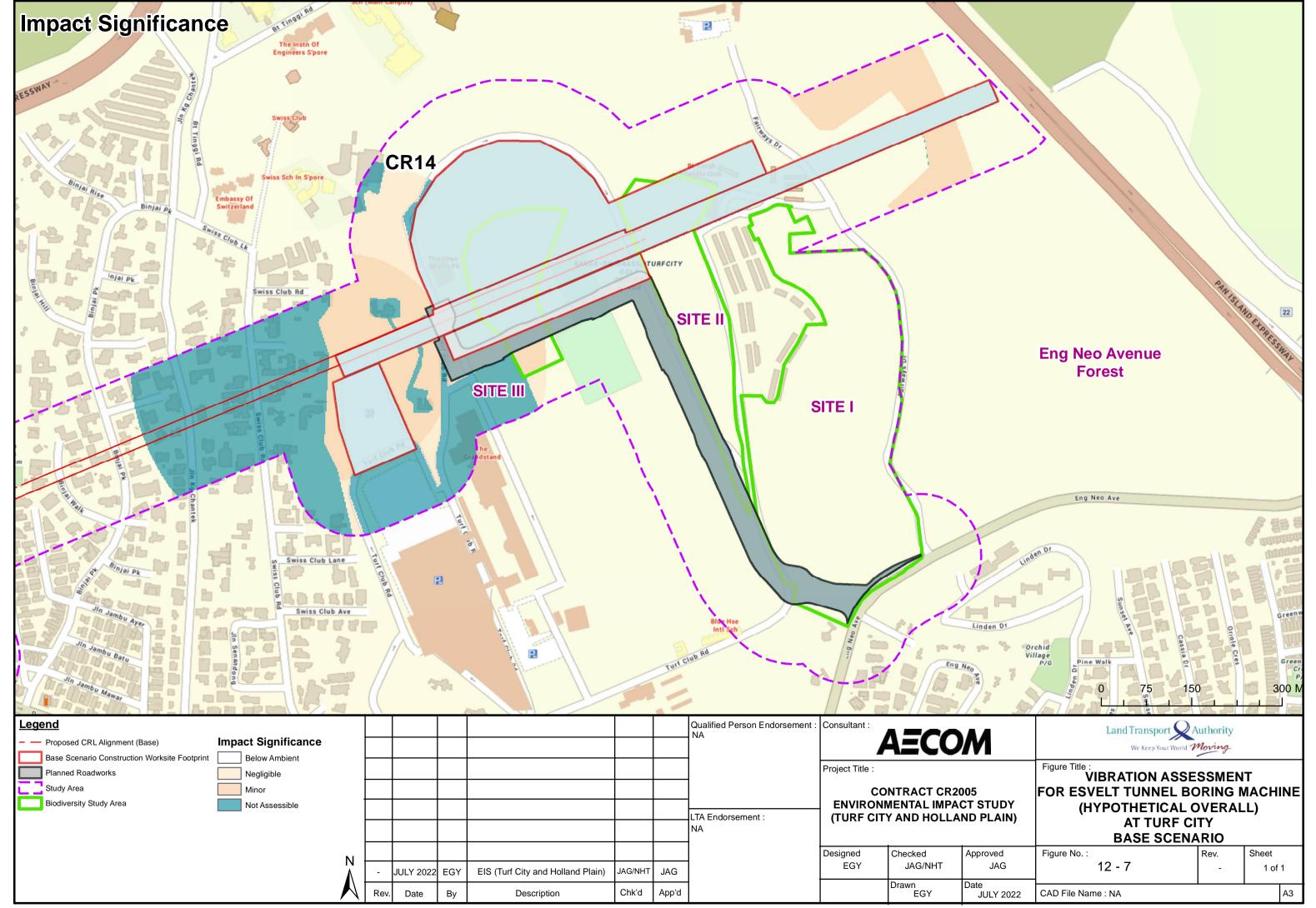
Construction Worksite and Activities

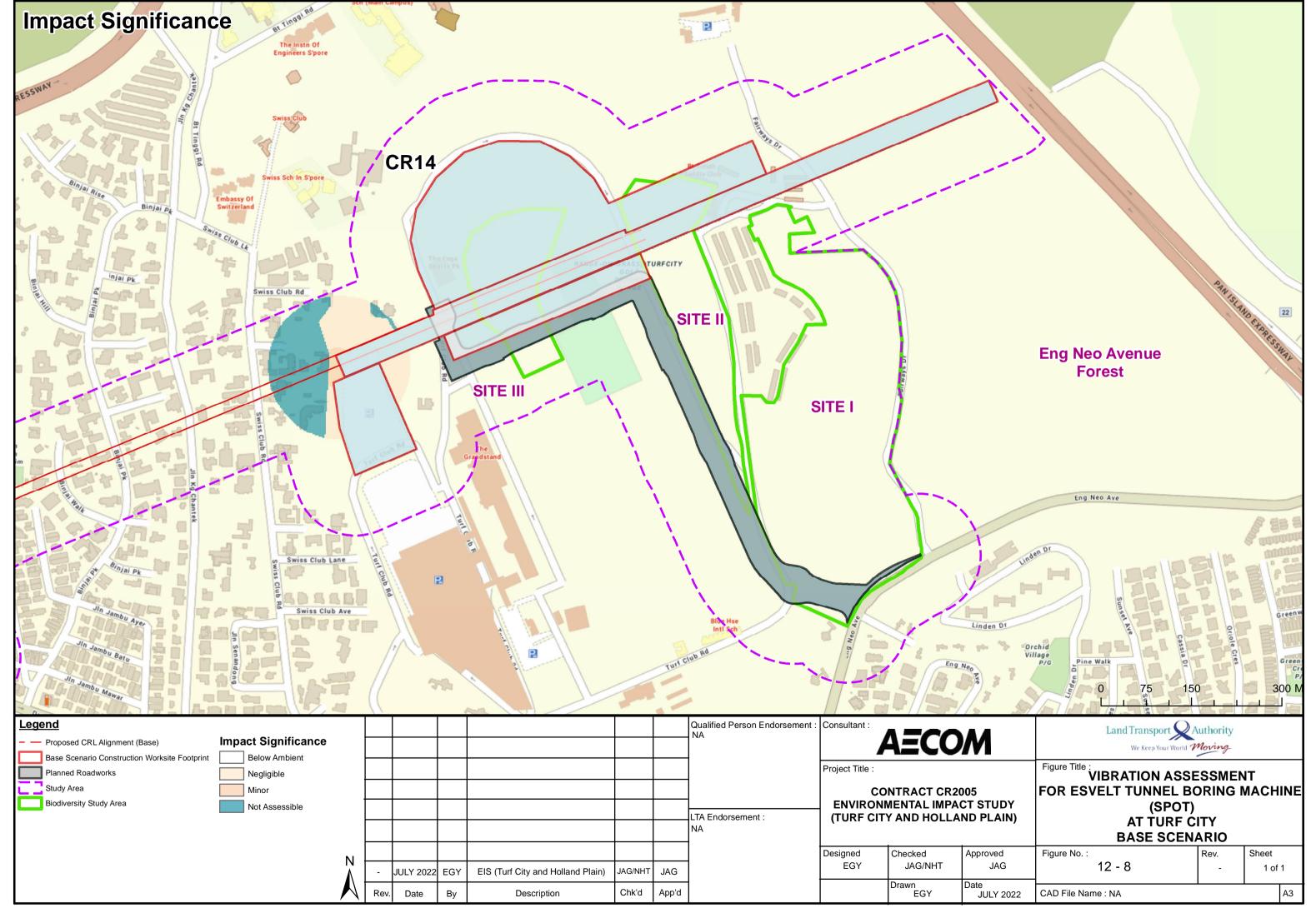
Base Scenario Impact Significance

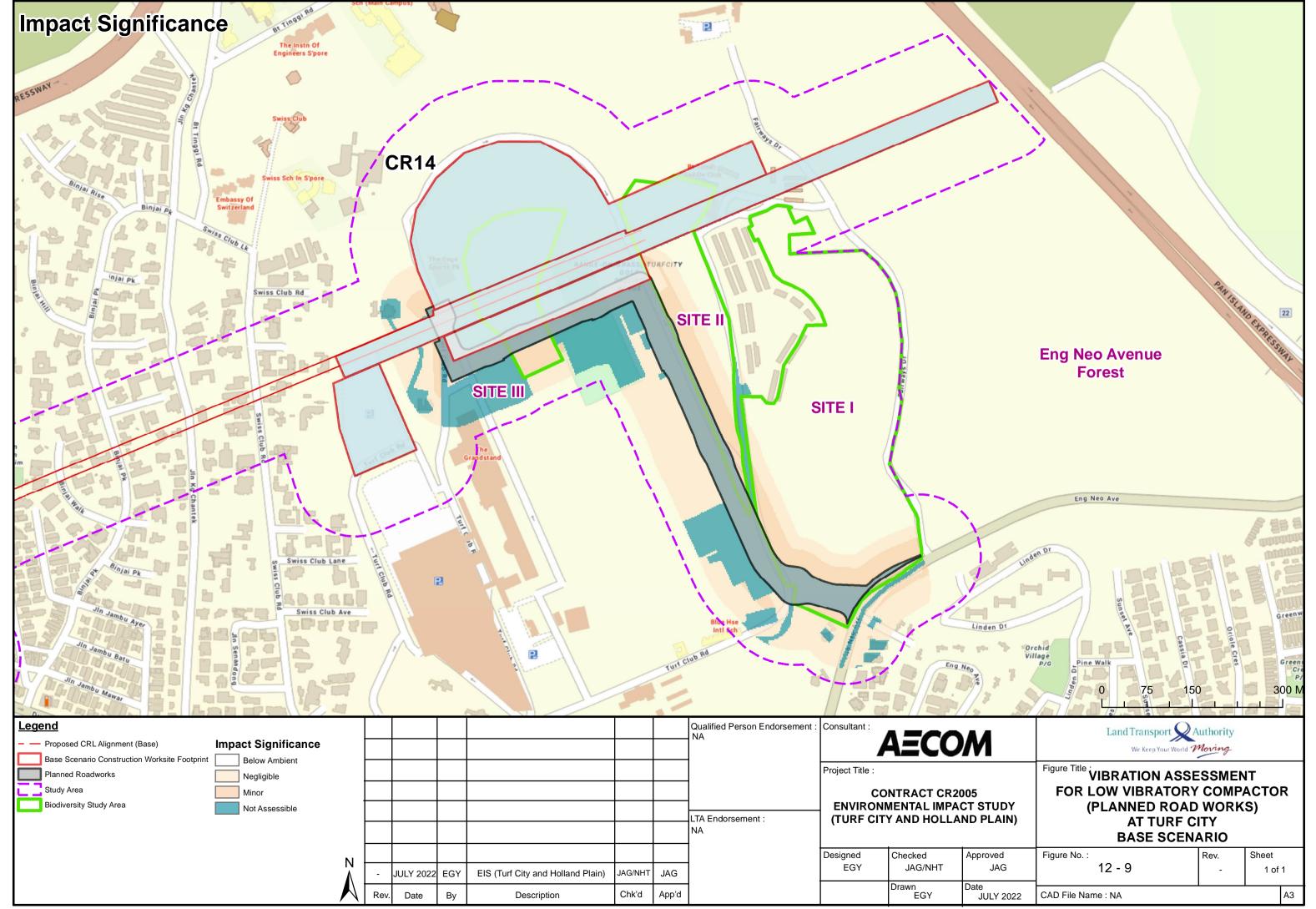
 Moderate impact significances may impact sensitive fauna on their daily activities (communication/ foraging) for a short period in the zone of impact and may leave the area. Displacement is expected to be temporary, and they are expected to return after a while.

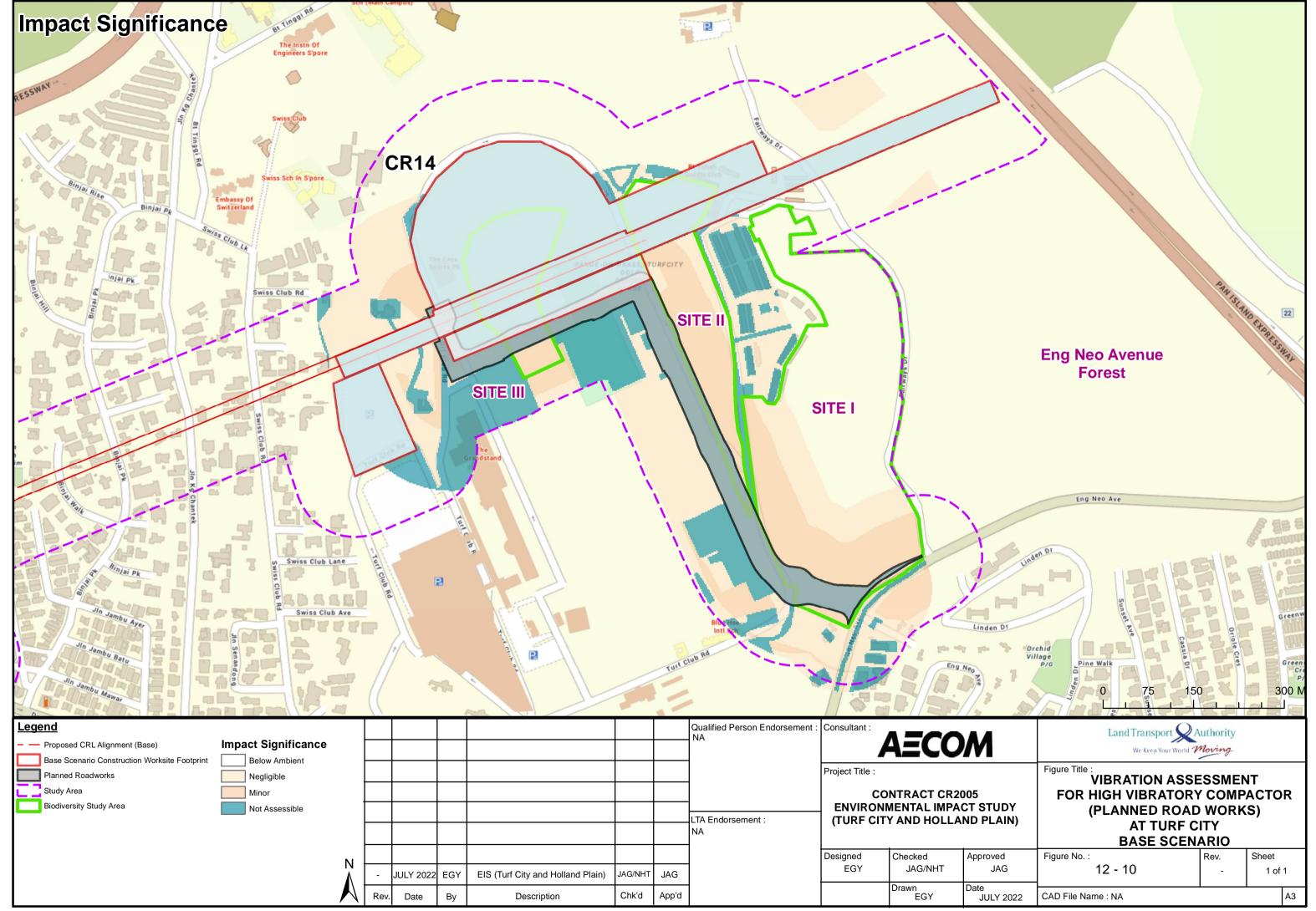
Thus, mitigation measures are recommended as discussed in Section 12.8.

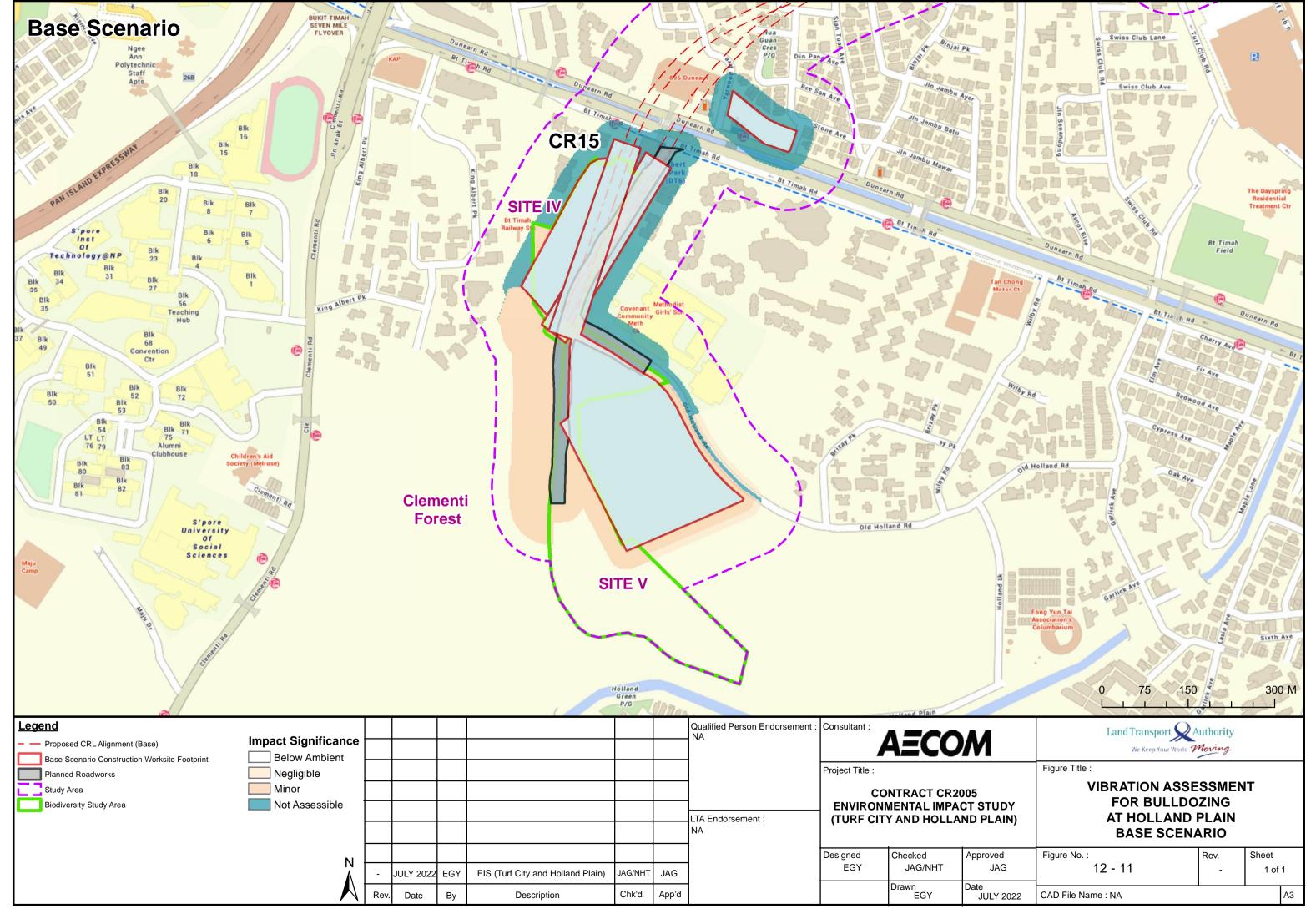


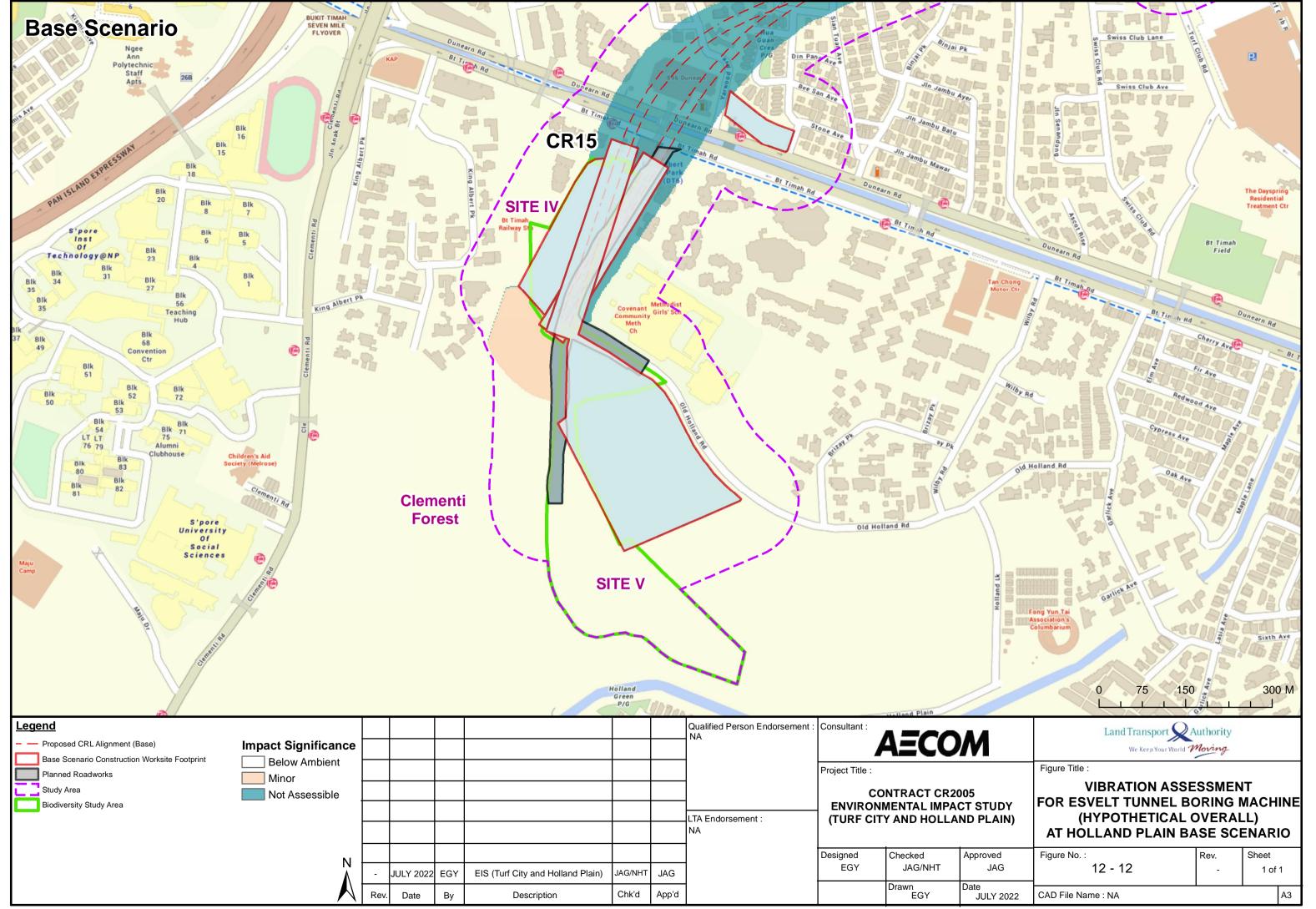


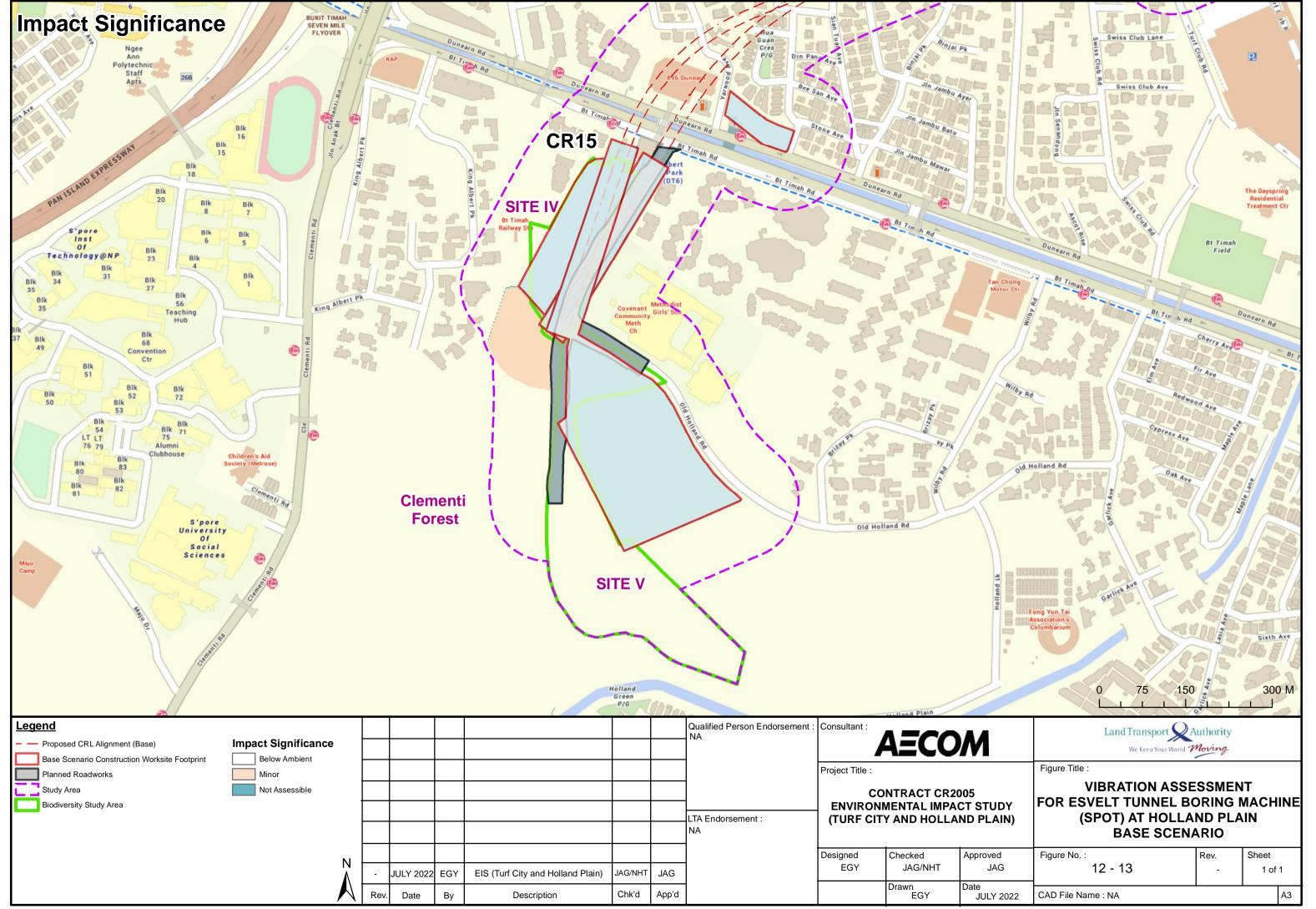


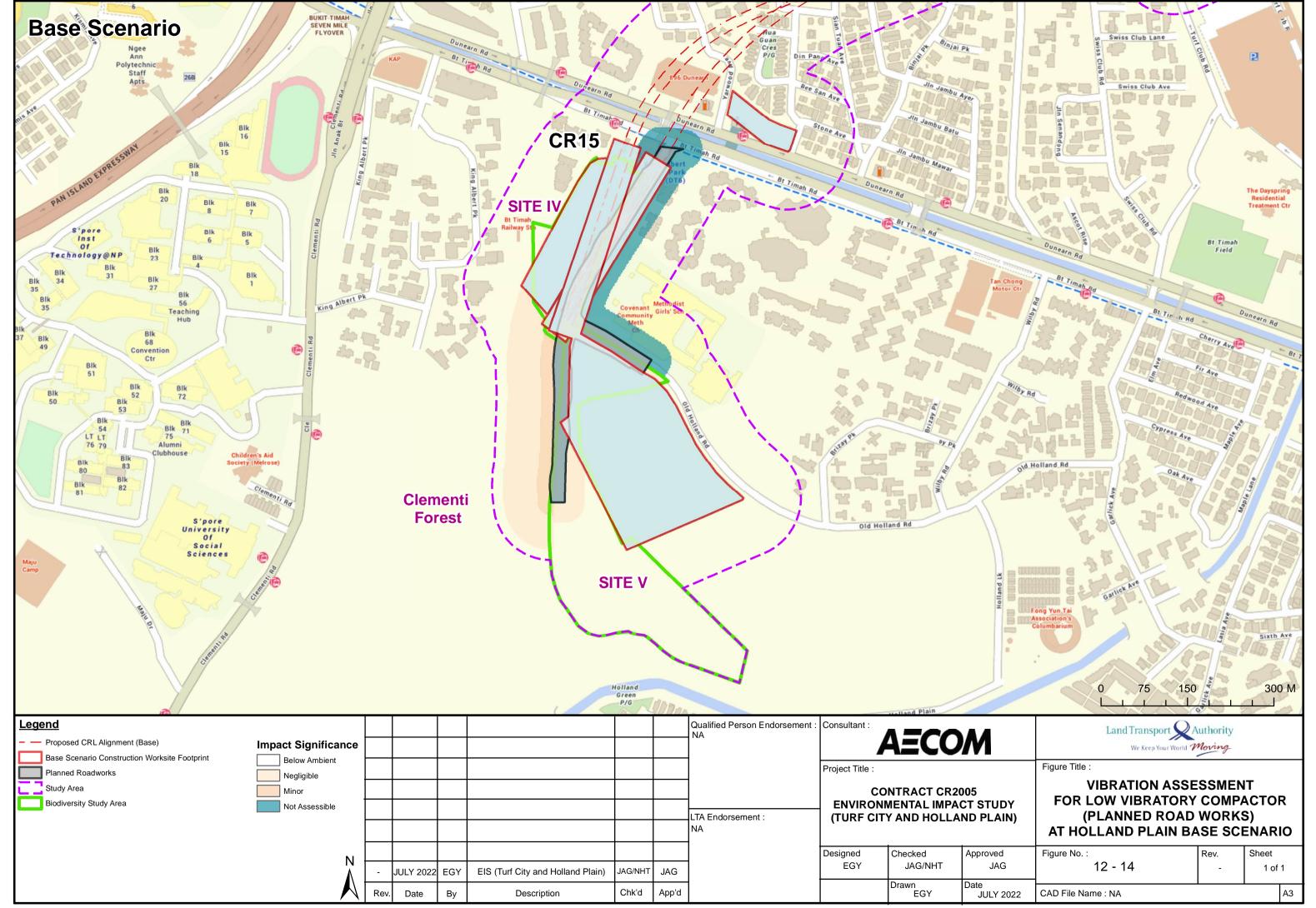


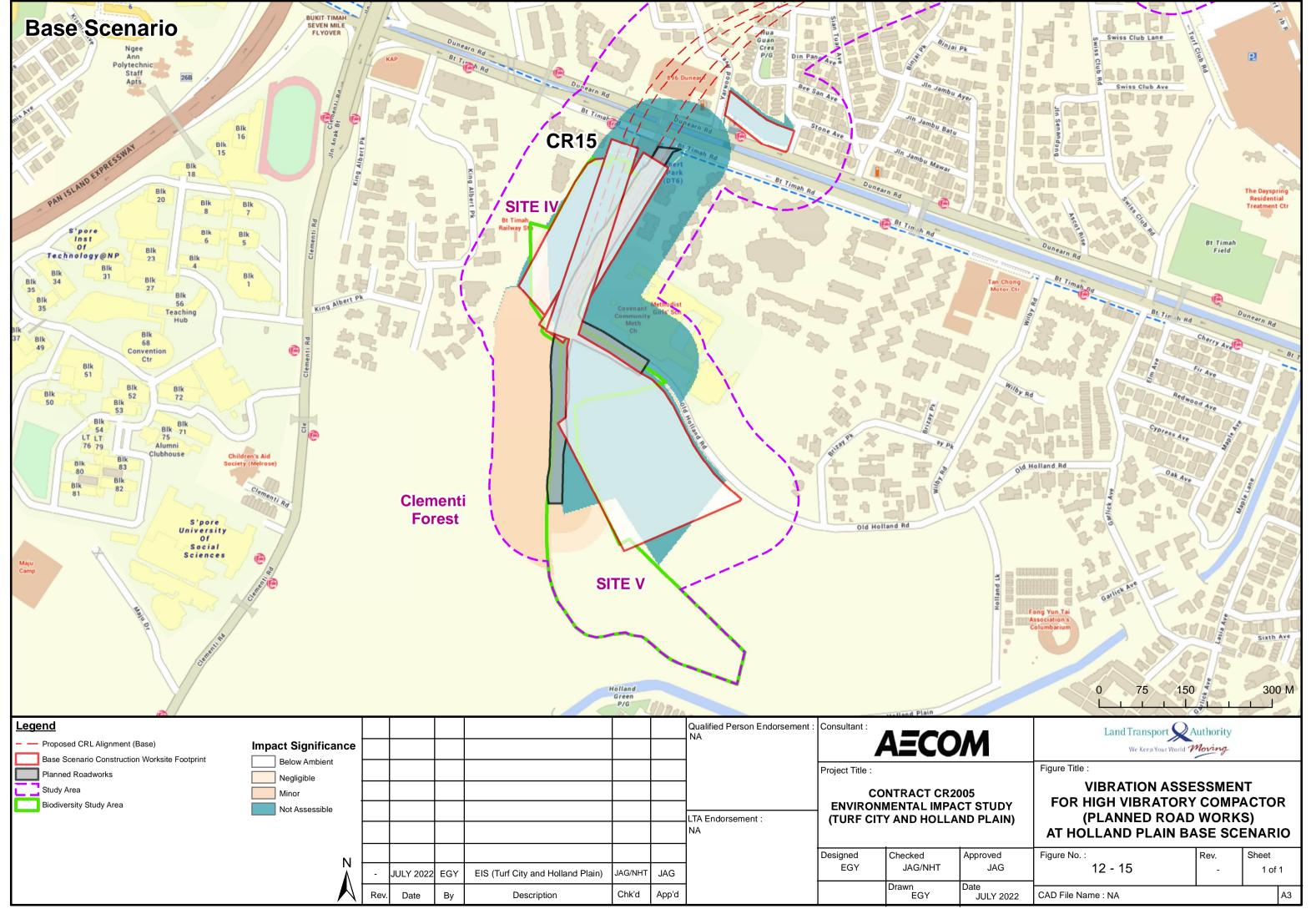












12.7.2 Operational Phase (Base Scenario)

There are no predicted vibration levels due to train operations for the base scenario for both Turf City and Holland Plain.

12.8 Recommended Mitigation Measures for Construction Phase

Based on best practices for building near a nature reserve or an area of high biodiversity value, mitigation measures for construction vibration impacts on sensitive fauna species are recommended.

The Contractor shall control construction vibration levels using best available techniques (BAT) for high vibratory compactors. The Contractor shall also ensure that the vibration levels at Turf City and Holland Plain (excluding the worksite area) do not exceed PPV, 8.0 mm/s. The full mitigation measures can be seen in Section 13.11.

A summary of mitigation measures is provided below:

- Schedule high vibration activities during the daytime.
- Restrict high vibration activities to below vibration threshold of PPV, 8.0 mm/s in biodiversity sensitive
 areas/ forested areas.
- Use of tri-axle trucks to reduce truck trips on the road.
- No night works should be conducted after 7 pm for all non-safety critical activities since the site is next to the human and fauna sensitive receptors.

Suppose there are justified complaints from the construction works, particularly vibratory compactors. In that case, the operation may need to mitigate vibration levels to the most practical levels.

12.9 Residual Impacts

12.9.1 Construction Phase

The mitigated case here refers to the worksites proposed at the onset of the construction of the alignment and station.

Based on the assessment results in Section 12.7, the potential impact significances for base scenario during the construction phase is expected to be **negligible – major**. With the optimised worksites and construction activities, the mitigated scenario is still expected to have an impact significance of **negligible – major**. Thus, further mitigation measures and implementation of effective management strategies during construction phase are required to potentially reduce the impact significance to **moderate**.

12.9.1.1 Structural Impacts of Fauna (Mitigated Scenario)

The construction activities were assessed for the mitigated scenario which are summarised in Table 12-24. Out of all the assessments, high amplitude vibratory compactors generate vibration levels exceeding PPV, 5.0 mm/s. Thus, these activities were screened for partial burrow collapse. Hence, further mitigation measurements are required (see Section 13.11.) Results and heatmaps for rock breaking and excavation and tunnel boring using the British Standard guideline can be seen in Appendix T.

Table 12-24 Summary of Maximum Predicted PPV for Construction Activities (Mitigated Scenario)

Worksite	Activity	N	Max PPV (mm/s)			Exceedances of Vibration Threshold for Partial Burrow Collapse at PPV, 8.0 mm/s, mm/s			
		Site I	Site II	Site III	Site I	Site II	Site III		
Turf City	Rock Breaking and Excavation, T207	0.4	7.3*	0.3	-	-	-		
	Bulldozing (Entrances & worksites)	1.5	1.5	1.5	-	-	-		
	Tunnel Boring Machine (Hypothetical Overall), Esvelt	0	0	0.1					
	Tunnel Boring Machine (Spot), Esvelt	0	0	0.1	-				
	Low Vibratory Compactor	1.4	1.4	0.3	-	-	-		
	High Vibratory Compactor*	5.2*	5.2*	0.9	-	-	-		
Worksite	Activity	Max PPV (mm/s)			Exceedances of Vibration Threshold for Partial Burrow Collapse at PPV, 8.0 mm/s, mm/s				
		Site IV Site			Site IV	Site			
Holland Plain	Bulldozing (Entrances & worksites)	1.5	5	1.5	-	-			
	Tunnel Boring Machine (Hypothetical Overall), Esvelt	0.3	3	0.1	-	-			
	Tunnel Boring Machine (Spot), Esvelt	0.3		0.1	-	-			
	Low Vibratory Compactor		1	1.4	-	-			
	High Vibratory Compactor*	5.2	*	5.2*	-	-			

Notes:

^{*} Since the PPV has exceeded 5.0 mm/s (screening criteria), the construction activities were screened for this value.

[•] The Contractor shall control construction vibration levels for high vibratory compactors and rock breaking and excavation using best available techniques (BAT). The Contractor shall ensure that the vibration levels at Turf City and Holland Plain (excluding the worksite area) for any construction activities do not exceed PPV, 8.0 mm/s.

12.9.1.2 Behavioural Impacts on Fauna (Mitigated Scenario)

Comparisons were made between the base and mitigated impact significances as seen in Table 12-25 Since the impact significances for some of the construction activities in the mitigated scenarios were major, additional mitigation measures were introduced, and the resultant impact significance were determined. The heatmaps can also be seen in Figure 12-17 to Figure 12-26.

Table 12-25 Comparison between Base and Mitigated Impact Significances with Mitigation Measures for Mitigated Scenario

Base Scenario Ir	npact Significance		Mitigation Measures	Mitigated Scenario Impact Significance		Changes in Impact Significance (Increased/Decreased/No Change?)	Further Mitigation Measures	Resultant Impact Significance					
Site I	Site II	Site III		Site I	Site II	Site III							
			ı										
N/A	N/A	N/A	N/A	Negligible – Minor	Minor – Major	Minor – Major	Increased due to additional activity required in the mitigated separate	No night works after 7 pm should be conducted. Towns are the priors of 1.	Negligible - Moderate				
					Moderate, 1 ha	Moderate, 1 ha	in the magazed decidate.	m height) should be implemented as seen					
									Major, 2.2 na Major, 0.1 na	Major, 0.1 ha 3. Hoardings worksites. Troadkills duto dash ont		3. Hoardings must be ensured at the all worksites. These will potentially mitigate roadkills due to the impacted fauna trying to dash onto a road during the construction activity.	
								Noise barriers must also be present to double as barriers to prevent road kill.					
Minor – Moderate	Minor – Moderate	Minor – Moderate	Optimization of the worksite, reducing coverage within	Minor – Moderate	Minor – Moderate	Minor – Moderate	No Change	Since the impact significance still Moderate, EMMP measures should be applied.	Minor - Moderate				
Moderate, 1 ha	Moderate, 0.9 ha	Moderate, 0.2 ha	Biodiversity Study Areas.	Moderate, 0.9	Moderate, 1 ha	Moderate, 0.6 ha							
Not affected	Not affected	Minor	Mitigation measures are not required as it is reasonable to assess the duration	Not affected	Not affected	Minor	No Change	None required as the impact significance is Minor 1.	Minor				
Not affected	Not affected	Not affected	of impacts to be transient during the pass-by of a tunnel	Not affected	Not affected	Minor	No Change		Minor				
Negligible - Minor	Negligible - Minor	Negligible - Minor	_	Negligible – Minor	Negligible – Minor	Negligible	No Change		Negligible				
Negligible - Minor	Negligible - Minor	Negligible - Minor	NA	Negligible - Minor	Negligible - Minor	Negligible - Minor	Increased		Negligible - Minor				
	Site I N/A Minor – Moderate Moderate, 1 ha Not affected Not affected Negligible - Minor	N/A N/A N/A N/A N/A N/A Ninor – Moderate Moderate, 1 ha Moderate, 0.9 ha Not affected Negligible - Minor Negligible - Minor	Site I Site II Site III N/A N/A N/A N/A Minor – Moderate Minor – Moderate Moderate Moderate, 1 ha Moderate, 0.9 ha Not affected Not affected Minor Not affected Not affected Not affected Negligible – Megligible – Minor Negligible – Minor Negligible – Negligible – Minor Negligible – Minor	Site I Site II Site III N/A N/A N/A N/A N/A N/A Minor – Moderate Minor – Moderate worksite, reducing coverage within Biodiversity Study Areas. Not affected Not affected Minor Mitigation measures are not required as it is reasonable to assess the duration of impacts to be transient during the pass-by of a tunnel boring machine in a day. Negligible - Negligible - Minor Negligible - Minor Negligible - NA	Site I Site II Site III Site III Site III N/A N/A N/A N/A N/A N/A Negligible – Minor — Moderate Moderate Moderate Moderate, 1 ha Moderate, 0.9 ha Not affected N	Site I Site II Site III Site III Site II Site II Site II N/A N/A N/A N/A N/A N/A Negligible — Minor — Major Minor — Moderate, 1 ha Major, 2.2 ha Minor — Moderate Minor — Moderate, 1 ha Moderate, 1 ha Moderate, 1 ha Moderate, 1 ha Moderate, 0.2 ha Not affected Not affected Minor Minor Minor — Moderate ossess the duration of impacts to be transient during the pass-by of a tunnel boring machine in a day. Negligible — Negligible — Minor Negligible — Minor Megligible — Minor Negligible — Minor Negligible — Minor Negligible — Minor Negligible — Neg	Site I Site II Site II Site II Site II Site II Site II Site III N/A	Site I Site II	Site II Site III III No night works after 7 pm should be conducted. N/A				

Construction	<u></u>				io Impact Significance	Changes in Impact	Further Mitigation Measures	Resultant Impact	
Worksite and Activities	Site IV	Site V	Measures	Site IV	Site IV Site V			Significance	
Holland Plain									
Bulldozing	Minor	Minor	Optimization of the worksite, reducing coverage within Biodiversity Study Areas.	Minor	Minor	No change	None required as the impact significance is Minor	Minor	
Tunnel Boring Machine (Hypothetical Overall), Esvelt	Minor	Not affected by CR15 alignment. However, it will be assessed with CR16 concurrent activities in Section 12.10.	Mitigation measures are not required as it is reasonable to assess the duration	Minor	Not affected by CR15 alignment. However, it will be assessed with CR16 concurrent activities in Section 12.10.	No change		Minor	
Tunnel Boring Machine Spot, Esvelt	Minor		of impacts to be transient during the pass-by of a tunnel	transient during the	Minor		No change		Minor
Low Vibratory Compactor for Planned Road Works	Negligible - Minor	Negligible - Minor	day.	Negligible - Minor	Negligible - Minor	No change		Minor	
High Vibratory Compactor for Planned Road Works	Negligible - Minor	Negligible - Minor	Optimization of the worksite, reducing coverage within Biodiversity Study Areas.	Negligible - Minor	Negligible - Minor	No change		Minor	

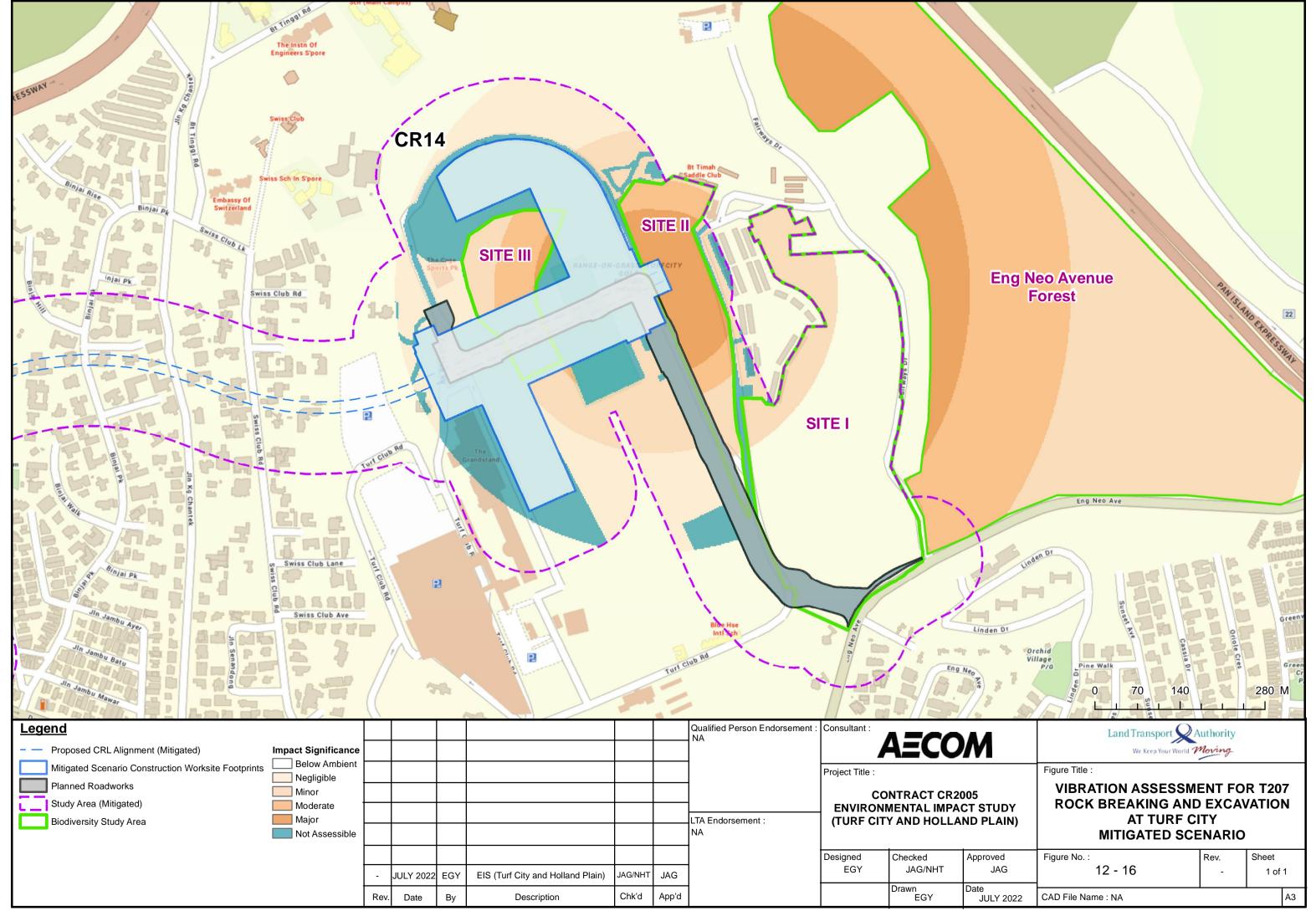
Summary:

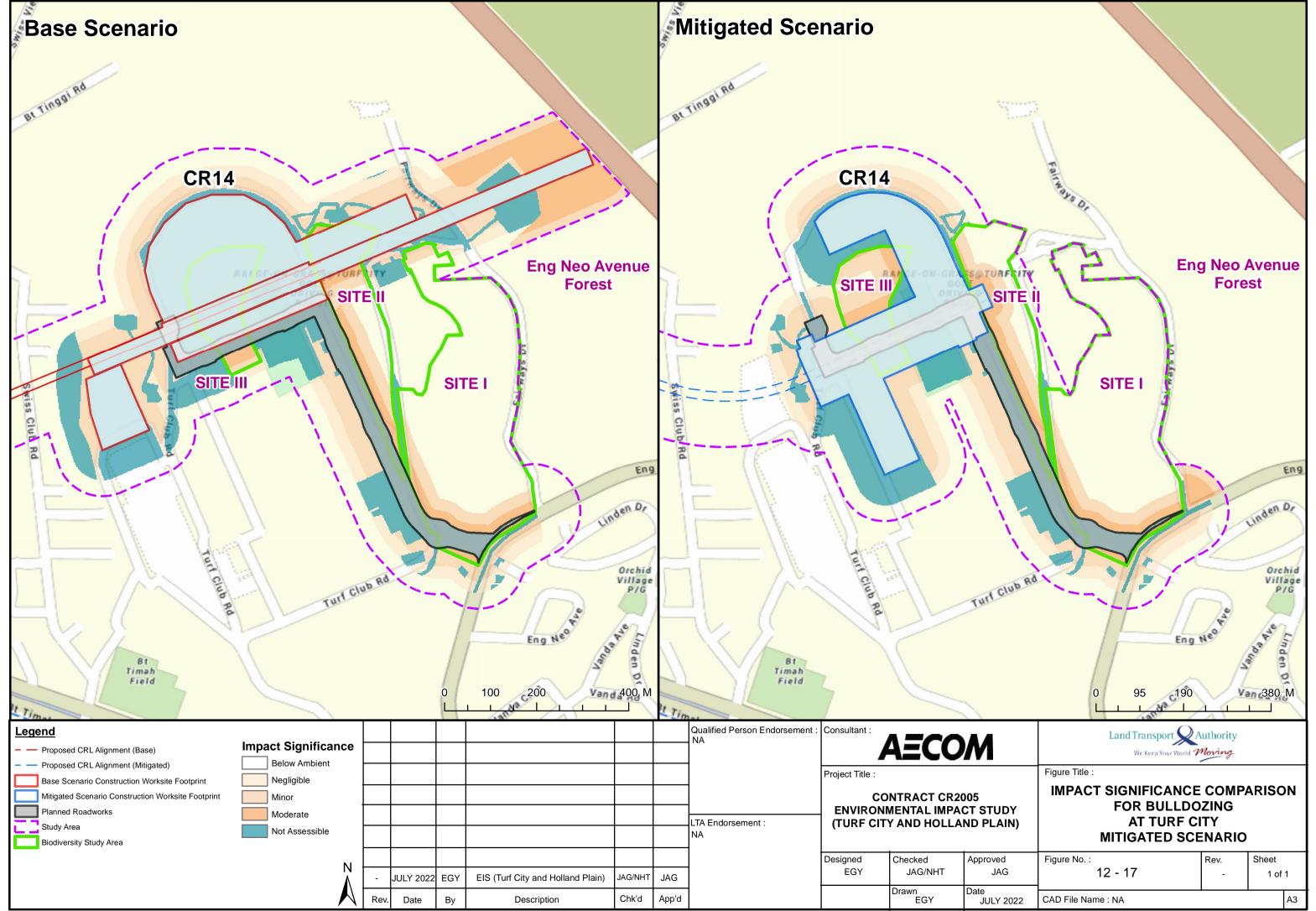
Overall, the construction activities produce impact significances of **Negligible, Minor, Moderate** and **Major**.

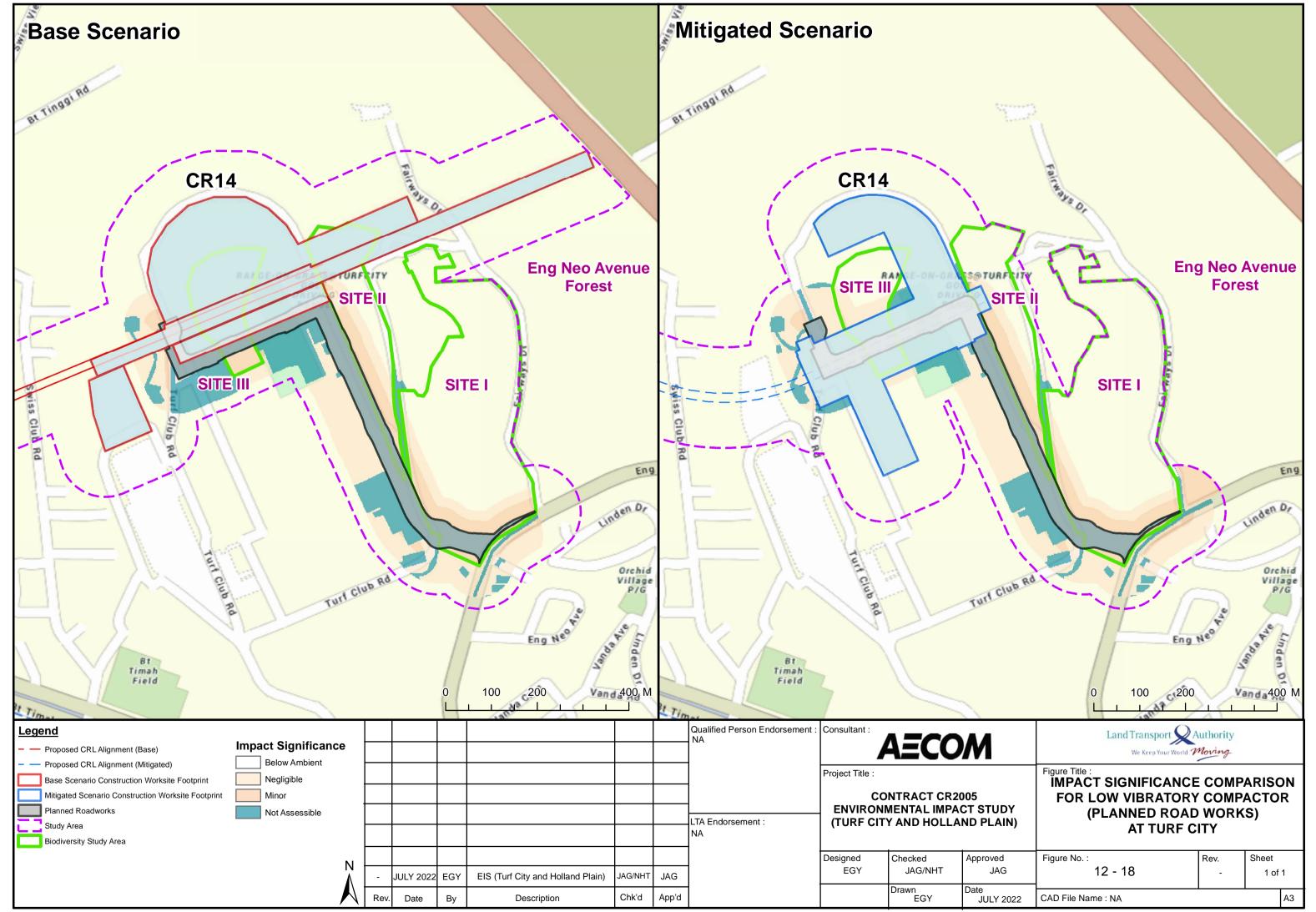
- For **Negligible** impact significances, there should be no detectable behavioural change to indicator species;
- For **Minor** impact significances, some sensitive fauna may be impacted. At the same time, other species may avoid the area because of the increased levels of activity in the area. Many species would become habituated to the tunnel boring machine and would return to normal activity in a few days when the machine has passed by;
- For **Moderate** impact significances, it may impact sensitive fauna on their daily activities (communication/ foraging) for a short period in the zone of impact and may leave the area. Displacement is expected to be temporary, and they are expected to return after a while: and
- **Major** impact significances may cause permanent effects, and affected indicator species are not expected to adapt to using this area. Thus, it is reasonable to assume that vibration from tunnel boring may impact part of their habitat (pangolins' burrows), and foraging opportunities. The mousedeer (*Tragulus kanchil*) and Sunda pangolin (*Manis javanica*) may move out of affected areas during the day and return at night to forage in these areas where food sources are available nearby.

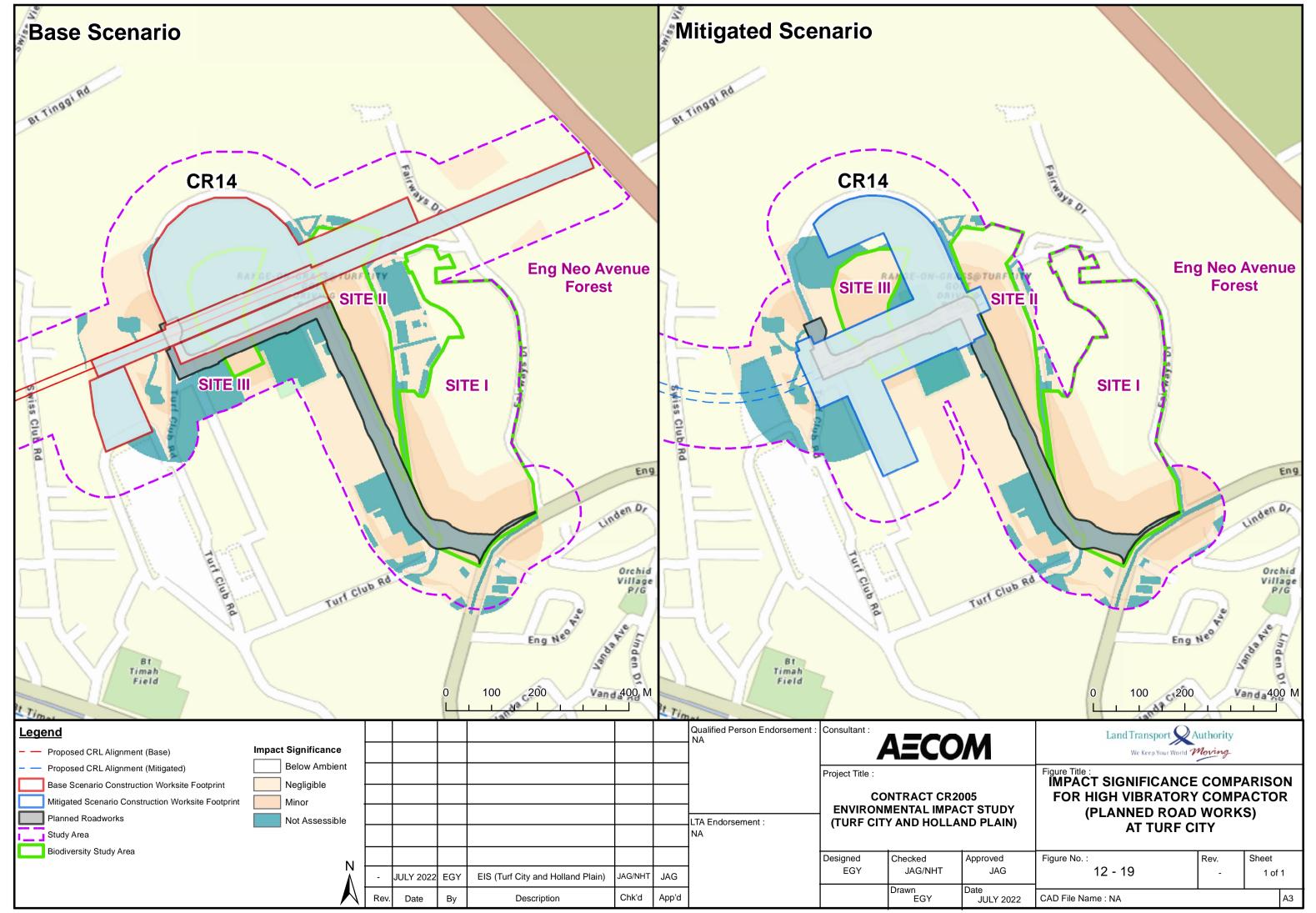
During rock breaking and excavation, sensitive fauna may also flee, freeze or be frightened by the instantaneous vibration.

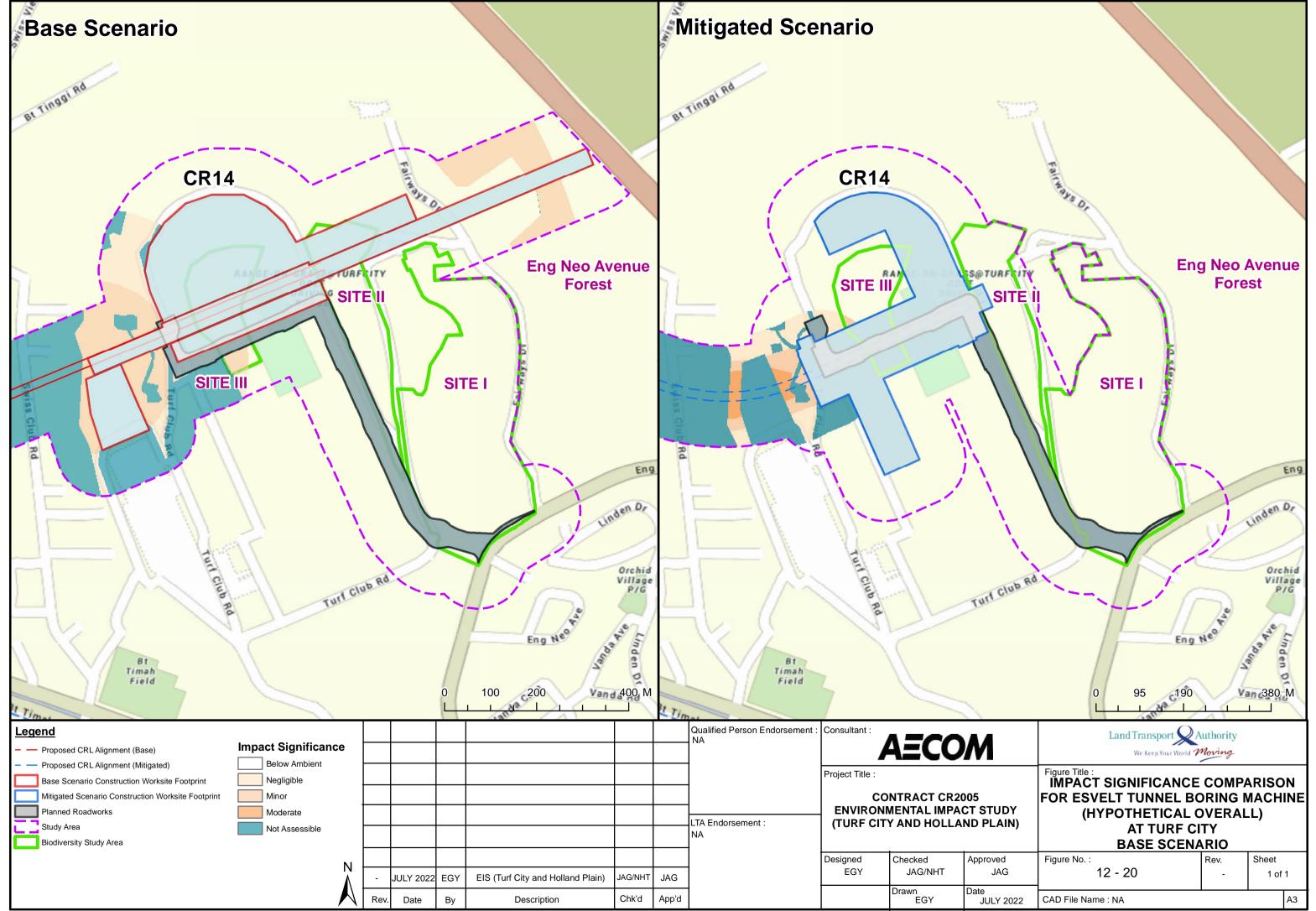
Thus, future mitigation measures and EMMP are recommended as discussed in Section 13.11.

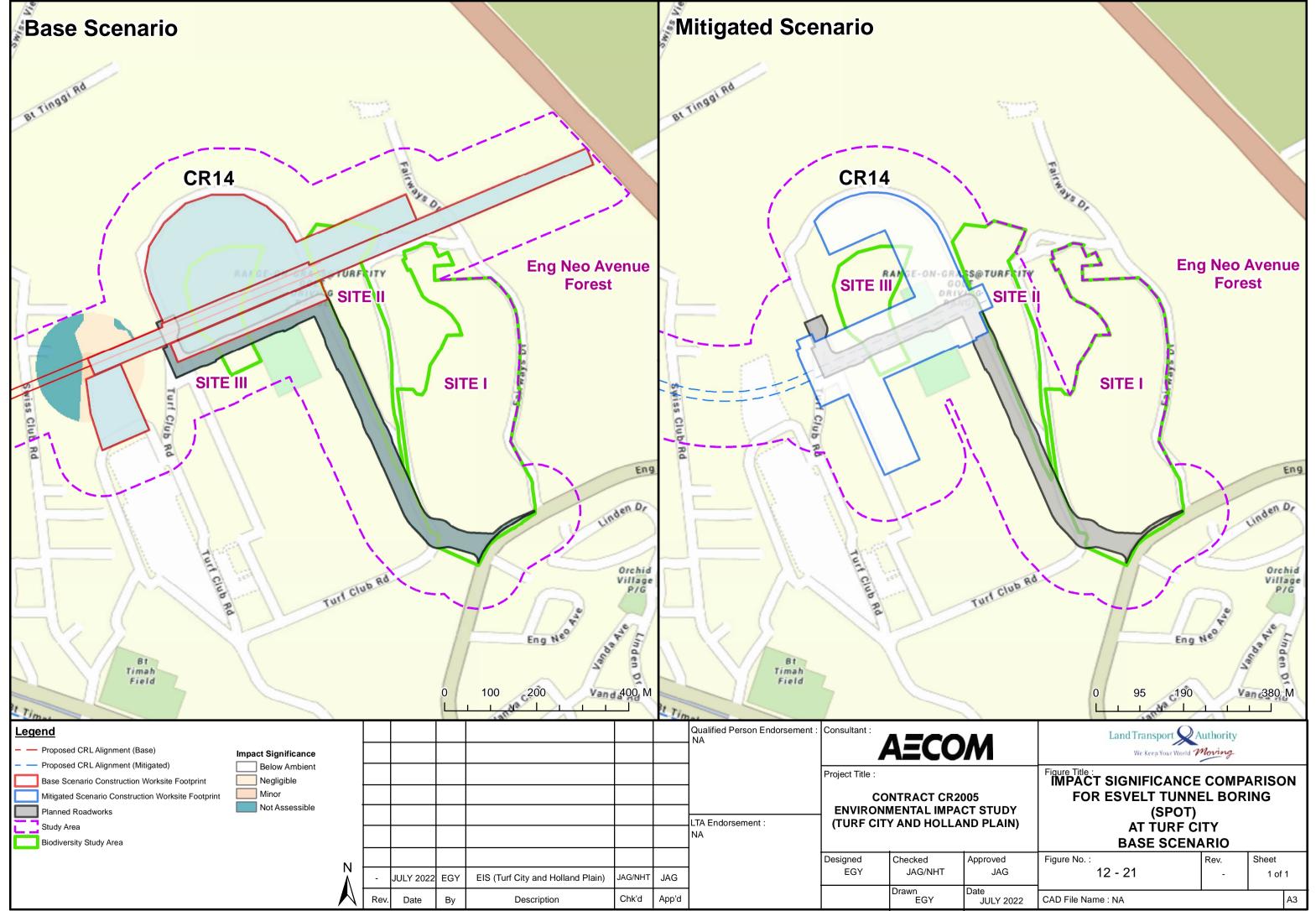


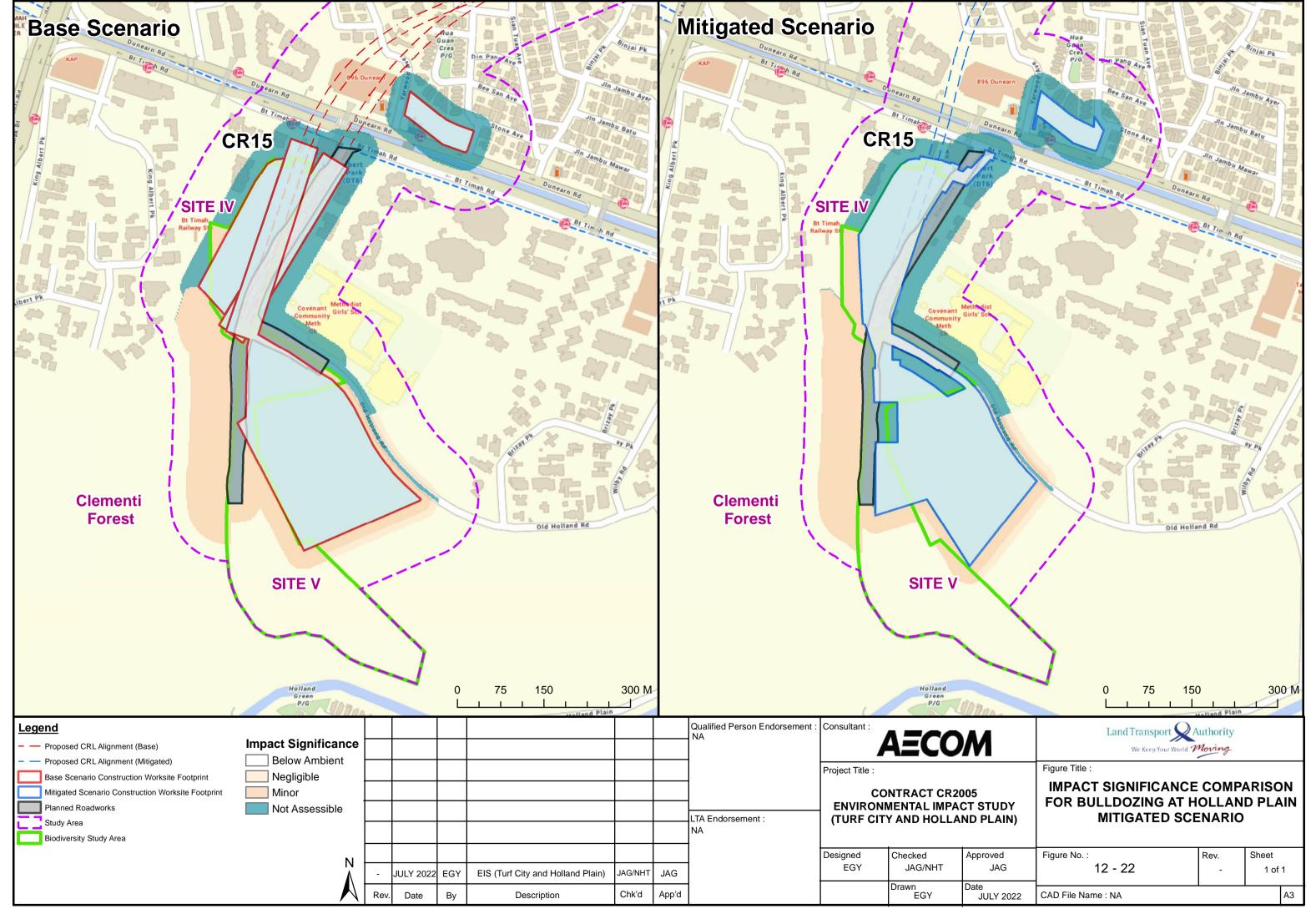


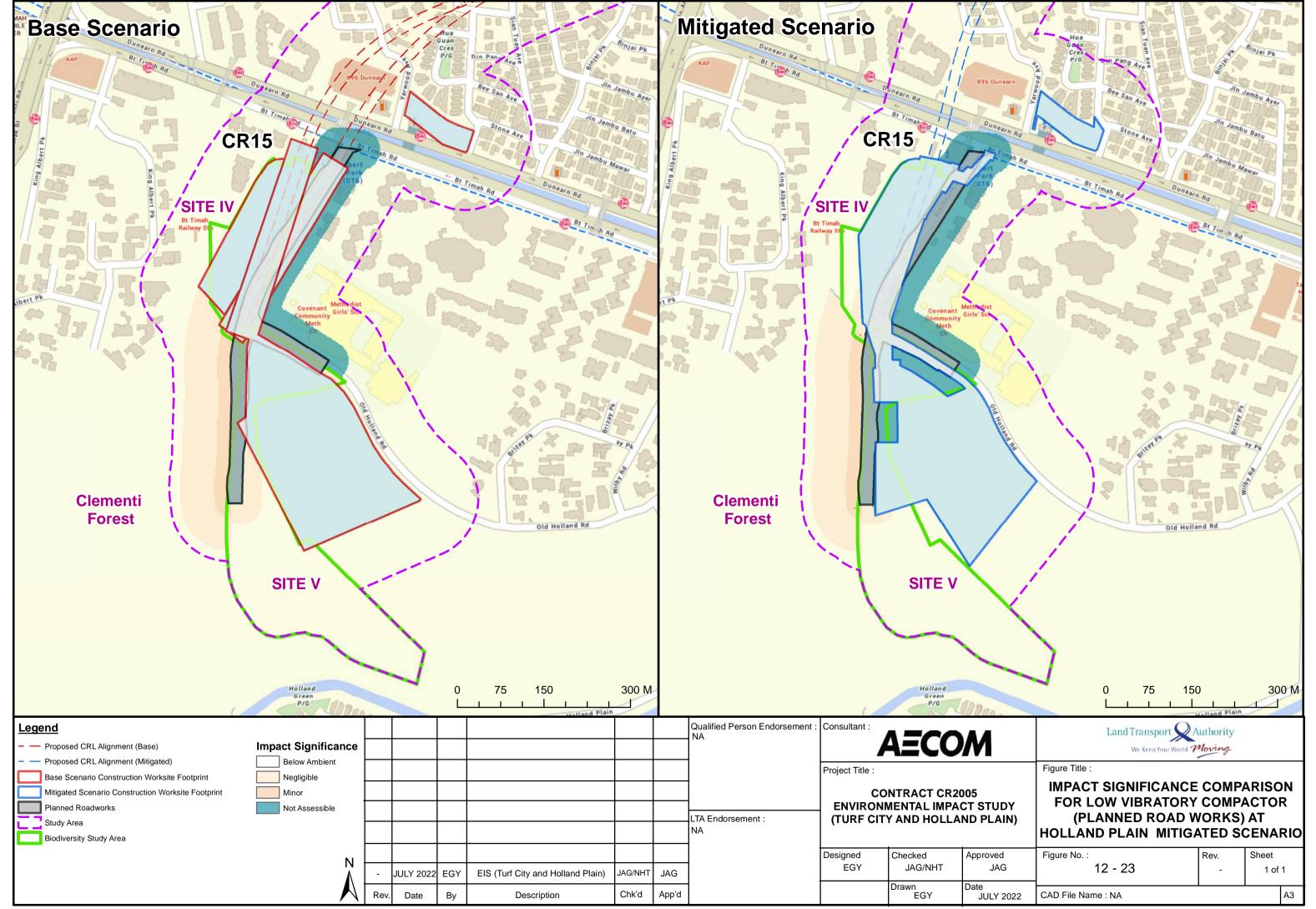


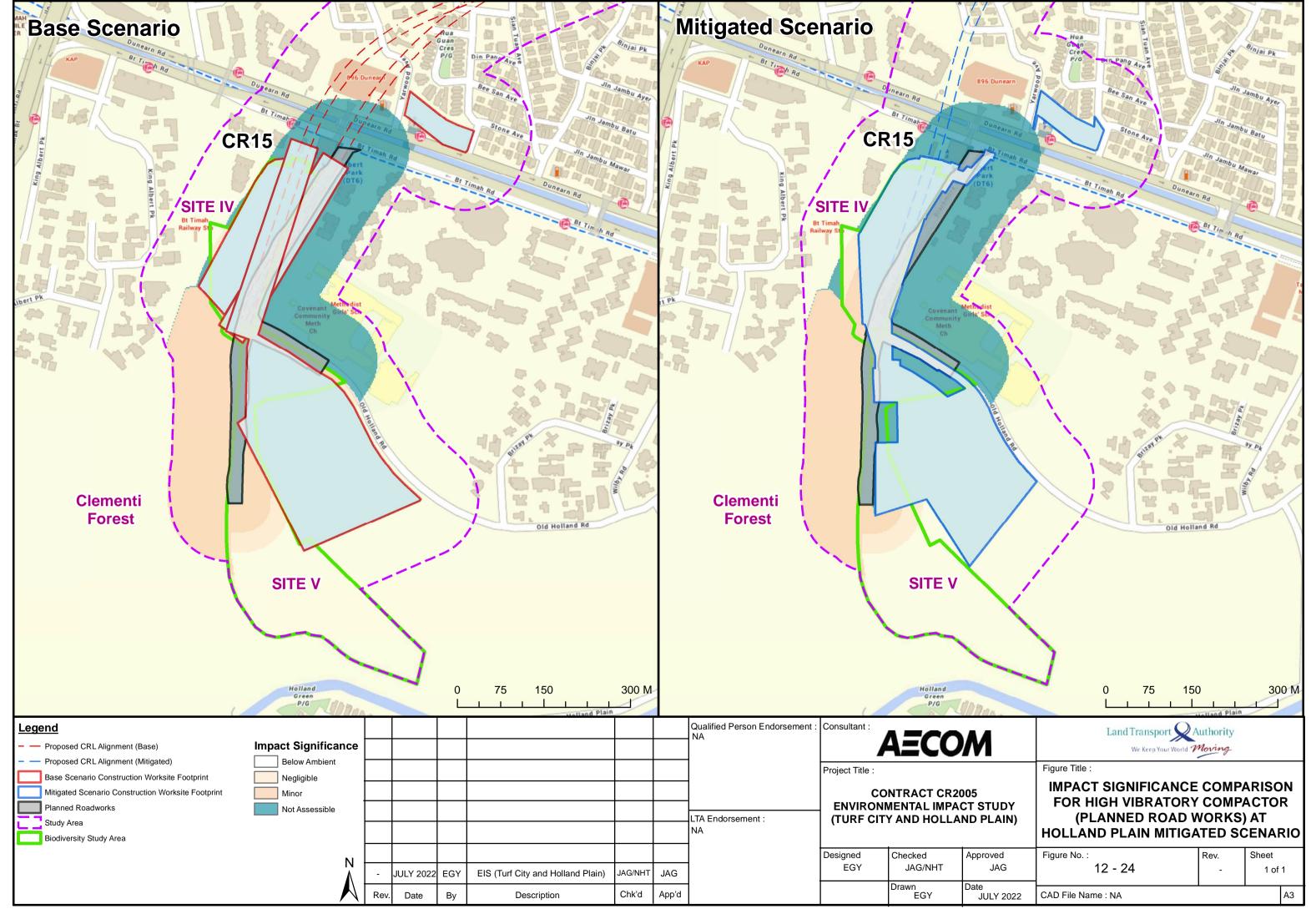


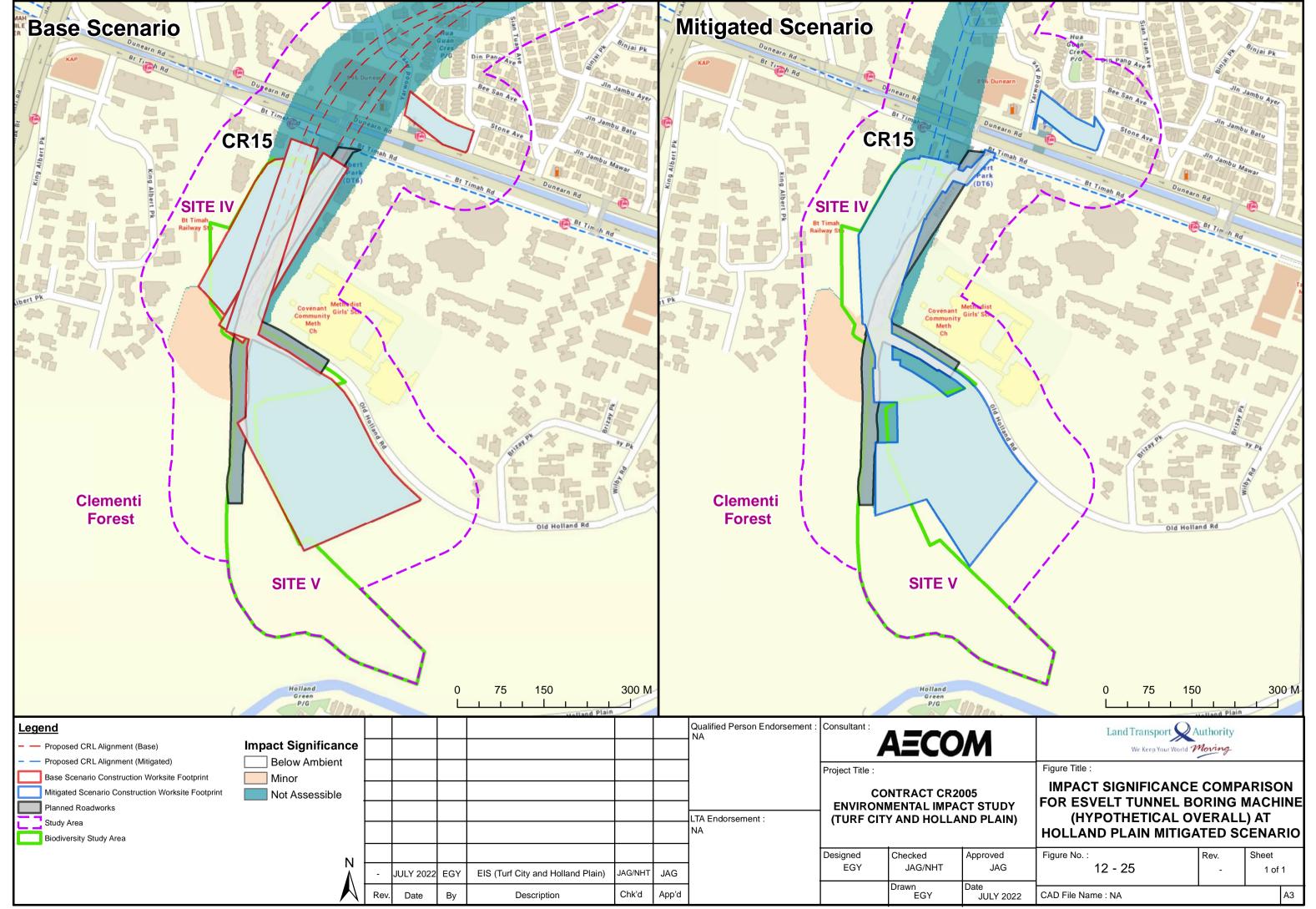


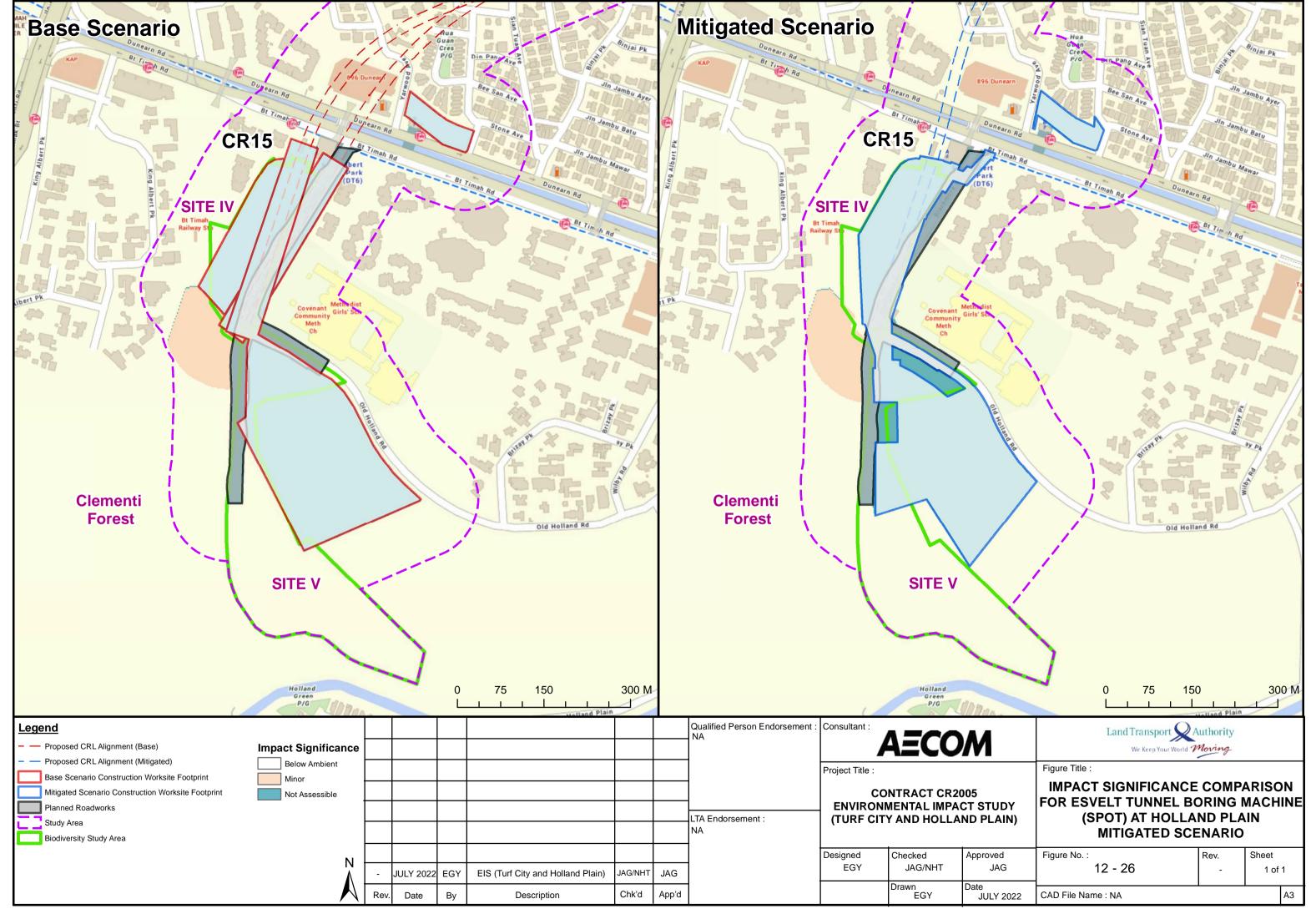












12.9.2 Operational Phase

Based on the assessment results in Section 12.7.2, the potential impact significance for the base scenario during the operational phase is expected to be **minor**. Nevertheless, for precautionary purposes, monitoring the behaviour of fauna by an ecologist is recommended during the Testing and Commissioning Phase. Regular track maintenance is also encouraged to ensure that the operational trains do not generate excessive vibration.

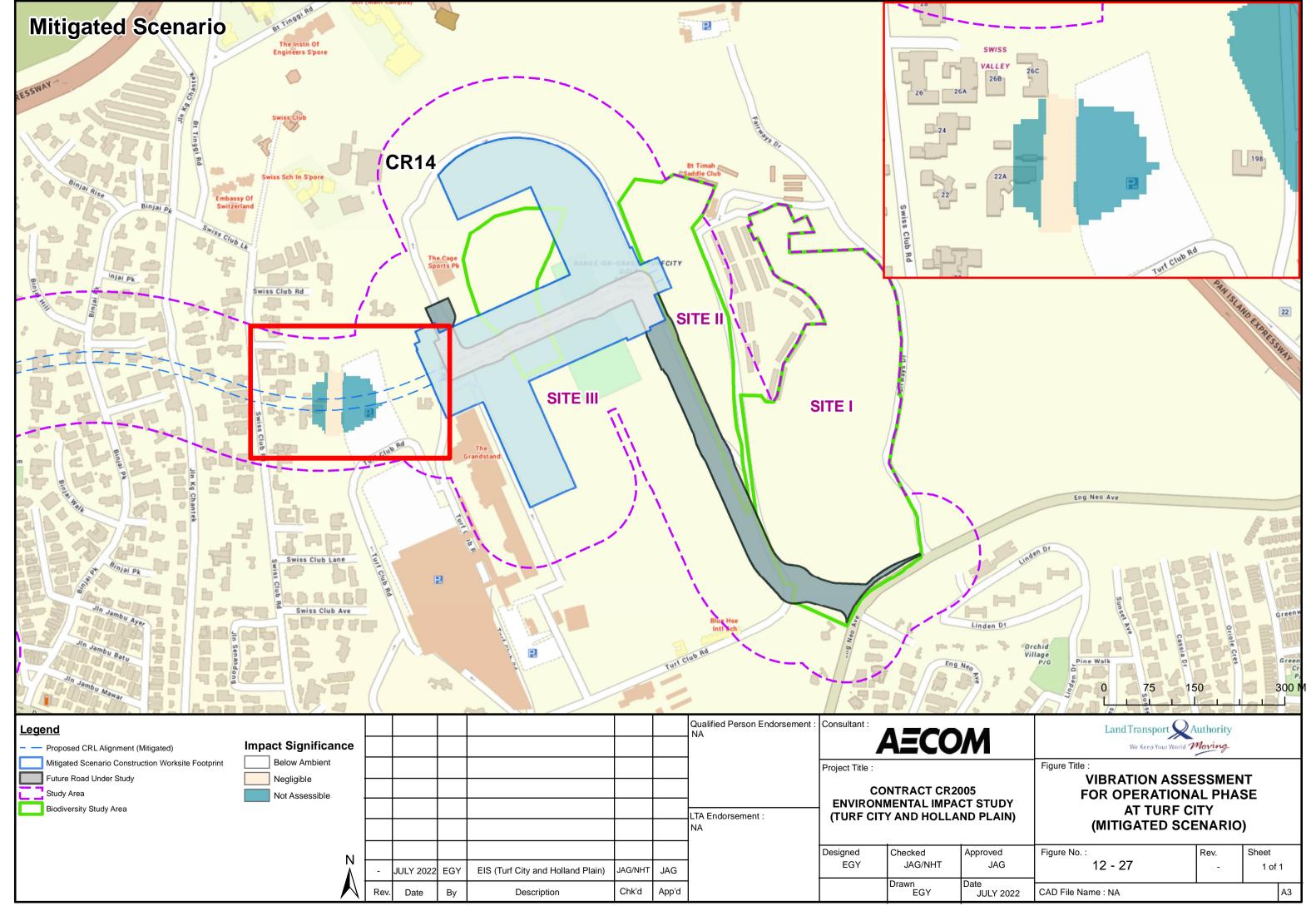
The maximum vibration levels for Sites I to V are summarised in Table 12-26. The respective figures can be seen in Figure 12-27 and Figure 12-28. The detailed impact assessment results of these vibration sources are in Appendix T.

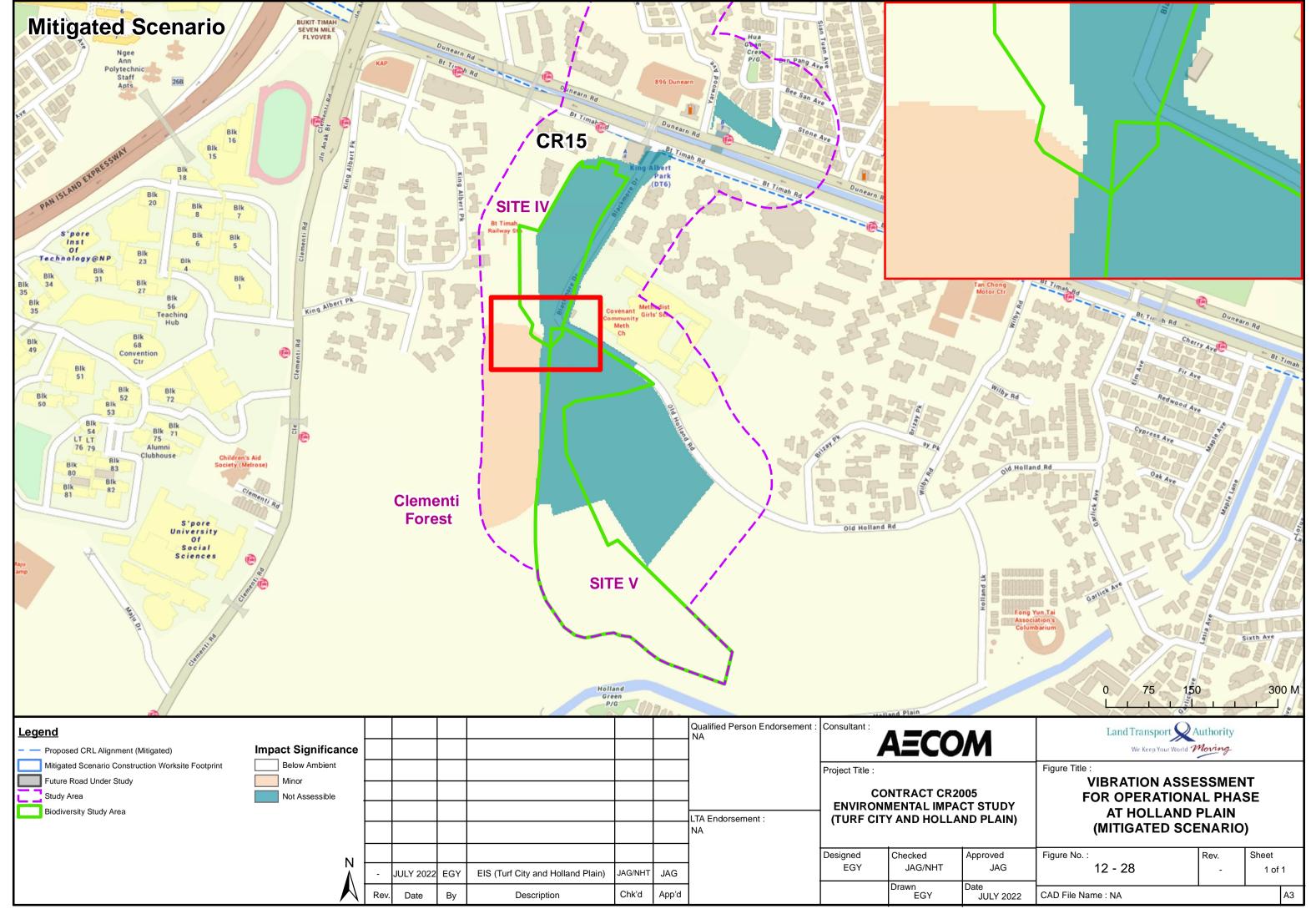
Table 12-26 Results of Operational Impact Assessment at Turf City and Holland Plain for Train operation

Operational Vibration Impact Assessment	Max PPV, mm/s Outside Worksite and Within Biodiversity Study	Evaluation Outcome
Turf City	-	
Train Mitigated Scenario Cumulative Biodiversity Study Area (Site I)	Not affected	Unlikely to cause damage/collapse to the burrow
Train Mitigated Scenario Cumulative Biodiversity Study Area (Site II)	Not affected	
Train Mitigated Scenario Cumulative Biodiversity Study Area (Site III)	Not affected	
Operational Vibration Impact Assessment	Max PPV, mm/s Outside Worksite and Within Biodiversity Study	Evaluation Outcome
Holland Plain		
Train Mitigated Scenario Cumulative Biodiversity Study Area (Site IV)	0.1	Unlikely to cause damage/collapse to the burrow
Train Mitigated Scenario Cumulative	0.1	
Biodiversity Study Area (Site V)		
Note The vibration threshold for damage/colla	apse of the burrow is PPV, 8.0 mm/s.	

Table 12-27 Mitigated Scenario Impact Significances for Operational Activities at Biodiversity Study Areas

Operational Vibration	Mitigated Scenario Impac	ct Significance	Behavioural Impacts
Impact Assessment	Biodiversity Study Area - Sites I to III	Biodiversity Study Area - Sites IV & V	on Ecological Receptors at Vibration Biodiversity Study Areas
Full Alignment	Not affected	Minor	For all mitigated construction activities that have an impact significance of minor, despite the increase in vibration levels, fauna species are likely to adapt to the construction activities and would potentially return to their normal activity and habitat.





12.10 Cumulative Impacts from Other Major Concurrent Development

Concerning Section 3.4.1, there is other concurrent development during the construction and operational phase of CR2005. The cumulative ground-borne vibration impacts from these developments will be qualitatively discussed in this section.

12.10.1 Construction Phase

Other worksites include A1-W2, CR16, Old Jurong Line Nature Trail and Clementi Forest Stream Nature Trail. Typical construction works at the Old Jurong Line Nature Trail, and Clementi Forest Stream Nature Trail are unlikely to cause higher vibration levels than this Project. Hence this Project's worksite activities, along with A1-W2 and CR16, are the primary source of impact within the vibration Biodiversity Study Area.

Cumulative impacts were assessed based on the worst-case construction activities where the timelines of A1-W2 and Turf City, CR16 and Holland Plain coincide. In addition, the assessments were based on the mitigated scenarios for all worksites. A temporary access road will be constructed to connect the A1-W2 temporary worksite to Eng Neo Avenue via Fairways Drive and Turf Club Road.

A1-W2 worksite is likely to have underground, and above-ground construction works. There could be overlapping construction works for tunnel boring, rock breaking and excavation with CR14 and A1-W2 worksites. There is a potential for **Moderate** impact significance on the impacted ecological sensitive receptors after implementing mitigation measures.

CR16 worksite is likely to have similar works, and there could be overlapping construction work schedules with CR15 worksites. The potential impact significance on the sensitive ecological receptors is **Moderate** after implementing mitigation measures.

A summary of the predicted PPV and impact significance assessments can be seen in Table 12-29 and Figure 12-29 to Figure 12-33.

Table 12-28 Summary of Maximum Predicted PPV for Concurrent Construction Activities (Mitigated Scenario)

Activity from Turf City	Activity from A1-W2		Max	PPV (mm/s)#		Exceedances of	Burrow Collapse at		
		Site I	Site II	Site III	Eng Neo Avenue Forest	Site I	Site II	Site III	Eng Neo Avenue Forest
High Vibratory Compactor	Rock Breaking and Excavation	5.2*	5.2*	0.9	3.4	-	-	-	-
Bulldozer	Rock Breaking and Excavation	1.5	1.5	1.5	0.9	-	-	-	-
Rock Breaking and Excavation	Rock Breaking and Excavation	0.4	7.3*	0.3	0.17	-	-	-	-
Activity from Holland Plain	Activity from CR16		Max F	PPV (mm/s) #	Exceedances of		reshold for Partial 3.0 mm/s, mm/s	Burrow Collapse at	
		Site IV	1	Site V	CR16	Site IV		Site V	CR16
Bulldozing (Entrances & worksites)	Pipe Jacking	1.5		1.5	9**	-		-	1.0**
Tunnel Boring Machine, Esvelt	Rock Breaking and Excavation	0.3		0.1	7.1*	-		-	-
High Vibratory Compactor	High Vibratory Compactor	5.2*		5.2*	5.2*	-		-	-

Notes:

The Contractor must control construction vibration levels for high vibratory compactors and pipe jacking using best available techniques (BAT). The Contractor must ensure that the vibration levels at all Sites 1 to 5, Eng Neo Avenue Forest and Clementi Forest (excluding the worksite area) for any construction activities do not exceed PPV, 8 mm/s.

[#]The PPV generated by both activities were compared, and the maximum values within the Biodiversity Study Areas were obtained.

^{*} Since the PPV has exceeded 5 mm/s (screening criteria), the construction activities were screened for this value.

^{**} Since the PPV has exceeded the threshold of 8 mm/s, the construction activities may potentially cause partial burrow collapse. Thus, additional mitigation measures are required, as seen in Section 13.11.

^{1.} Ecologists should be present to survey for burrows. If burrows are detected within the Biodiversity Study Areas, camera traps should be deployed to assess fauna activity, if any. If there are no burrows or fauna activity detected, construction works are allowed to be continued.

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12.10.1.1 Behavioural Impacts on Fauna (Mitigated Scenario)

Comparisons were made between the base and mitigated impact significances for all three stages as seen in Table 12-29. Since the impact significances for some of the construction activities in the mitigated scenarios were major, additional mitigation measures were introduced, and the resultant impact significance were determined. The heatmaps can also be seen in Figure 12-29 to Figure 12-34.

Table 12-29 Summary of Impact Significances for Concurrent Construction Activities (Mitigated Scenario)

Activity from Turf			nificance			Mitigation Measures	Resultant Impact Significance			
City		Site I	Site II	Site III	Eng Neo Avenue Forest		Site I	Site II	Site III	Eng Neo Avenue Forest
High Vibratory Compactor	Rock Breaking and Excavation	Minor – Moderate Moderate, 2.4 ha	Minor – Moderate Moderate, 3.2 ha	Negligible - Minor	Minor – Moderate Moderate, 1.6 ha	Since the impact significance is Moderate, EMMP	Minor - Moderate	Minor - Moderate	Negligible - Minor	Minor - Moderate
Bulldozer	Rock Breaking and Excavation	Minor – Moderate	Minor – Moderate	Minor – Moderate	Minor – Moderate	measures should be applied.	Minor - Moderate	Minor - Moderate	Minor - Moderate	Minor - Moderate
Rock Breaking and Excavation	Rock Breaking and Excavation	Moderate, 3.3 Minor – Moderate Moderate, 2.4 ha	Moderate, 4.2 Minor – Major Moderate, 3.2 Major, 2.2 ha	Moderate, 0.6ha Minor – Major Moderate, 1 ha Major, 0.1 ha	Moderate, 1.9 Minor – Major Moderate, 17.5 ha Major, 5.4 ha	 No night works after 7 pm should be conducted. Temporary barriers (i.e. water barriers of 1 m height) should be implemented as seen in Figure 12-31. Hoardings must be ensured at the 	Minor - Moderate	Minor - Moderate	Minor - Moderate	Minor - Moderate
						all worksites. These will potentially mitigate roadkills due to the impacted fauna trying to dash onto a road during the construction activity.				
Activity from	Activity from CR16	Residual Impact Sign	nificance			Mitigation Measures	Resultant Impact S	gnificance		
Holland Plain		Site IV	Site V	Clementi Forest	Maju Forest		Site IV	Site V	Clementi Forest	Maju Forest
Bulldozing (Entrances & worksites)	Pipe Jacking	Minor	Minor	Minor – Major Moderate, 13.7 ha Major 5.4 ha	Negligible - Minor	No night works after 7 pm should be conducted.	Minor	Minor	Minor - Moderate	Negligible - Minor
Tunnel Boring Machine, Esvelt	Rock Breaking and Excavation	Minor	Minor	Minor – Major Moderate, 32.7 ha Major, 8.9 ha	Minor – Major Moderate, 10.4 ha Major 2.4 ha	2. Temporary barriers (i.e. water barriers of 1 m height) should be implemented along Brookvale Drive and Clementi Road. Canvas sheets should also be	Minor	Minor	Minor - Moderate	Minor - Moderate

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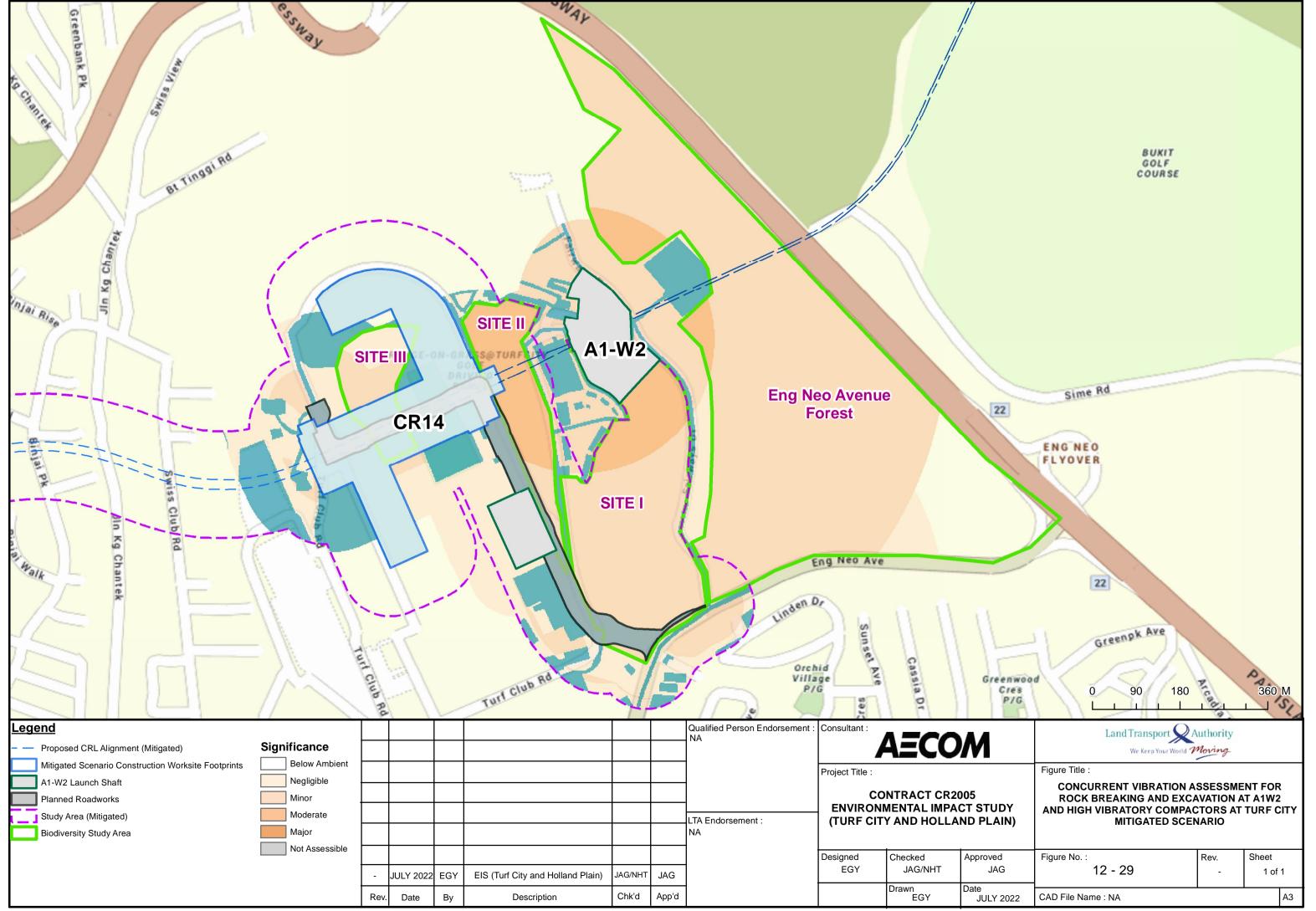
Activity from Turf	Activity from A1-W2	Residual Impact Significance				Mitigation Measures	Resultant Impact Signature	gnificance		
City		Site I	Site II	Site III	Eng Neo Avenue Forest		Site I	Site II	Site III	Eng Neo Avenue Forest
						used to cover the				
						holes on the				
						existing railings				
						along Brookvale				
						Drive and				
						Clementi Forest.				
						Hoardings must				
						be ensured at the				
						worksites and at				
						the existing				
						construction				
						beside Maju				
						Forest. These will				
						potentially				
						mitigate roadkills due to the				
						impacted fauna				
						trying to dash onto a road				
						during the				
						construction				
						activity.				
						activity.				
High Vibratory	High Vibratory	Minor	Minor	Negligible - Minor	Magligible Mine-	Nana required as the	Minor	Minor	Negligible - Minor	Negligible - Minor
Compactor	Compactor				Negligible - Minor	None required as the impact significance is				
						Minor				

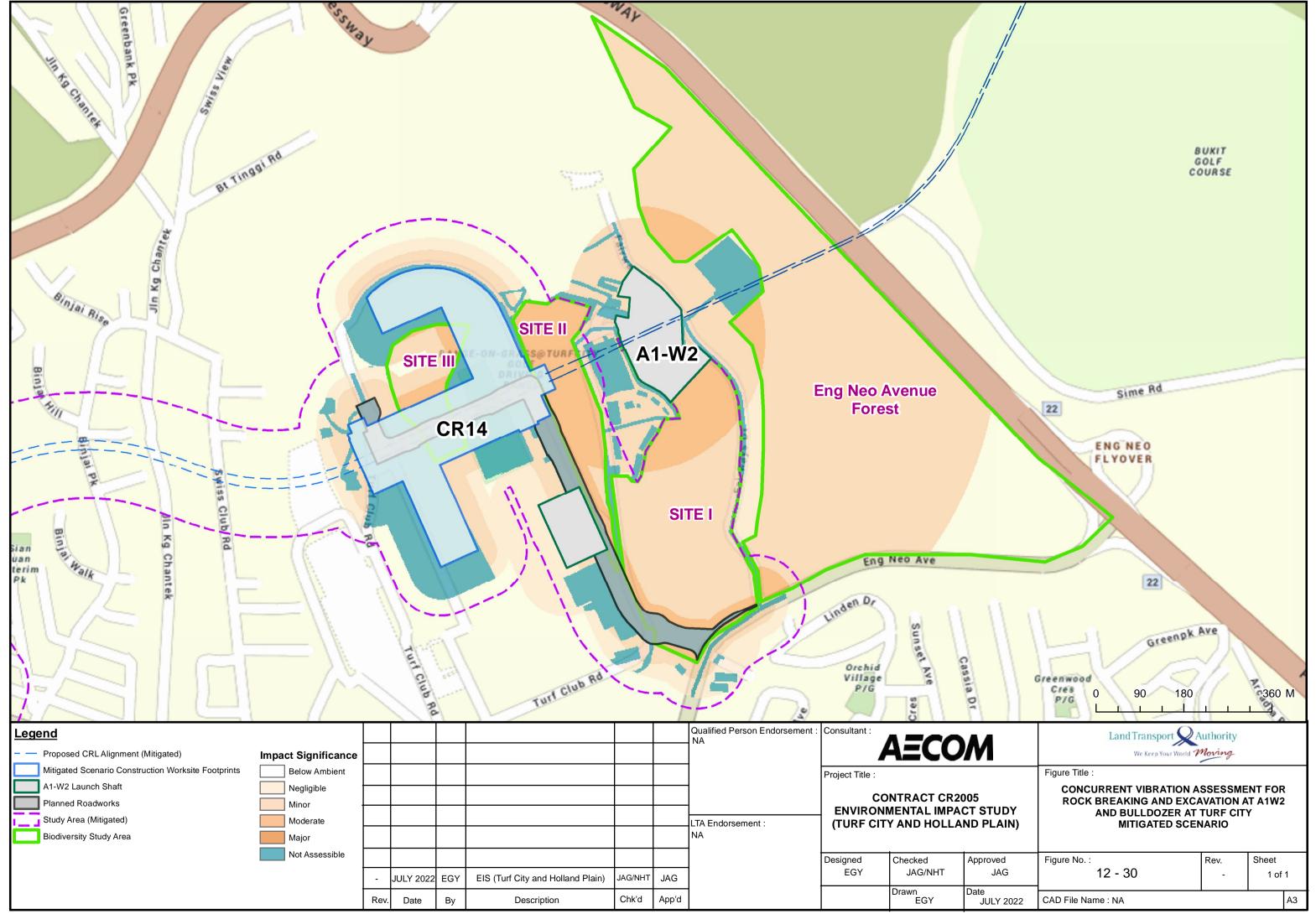
Summary:

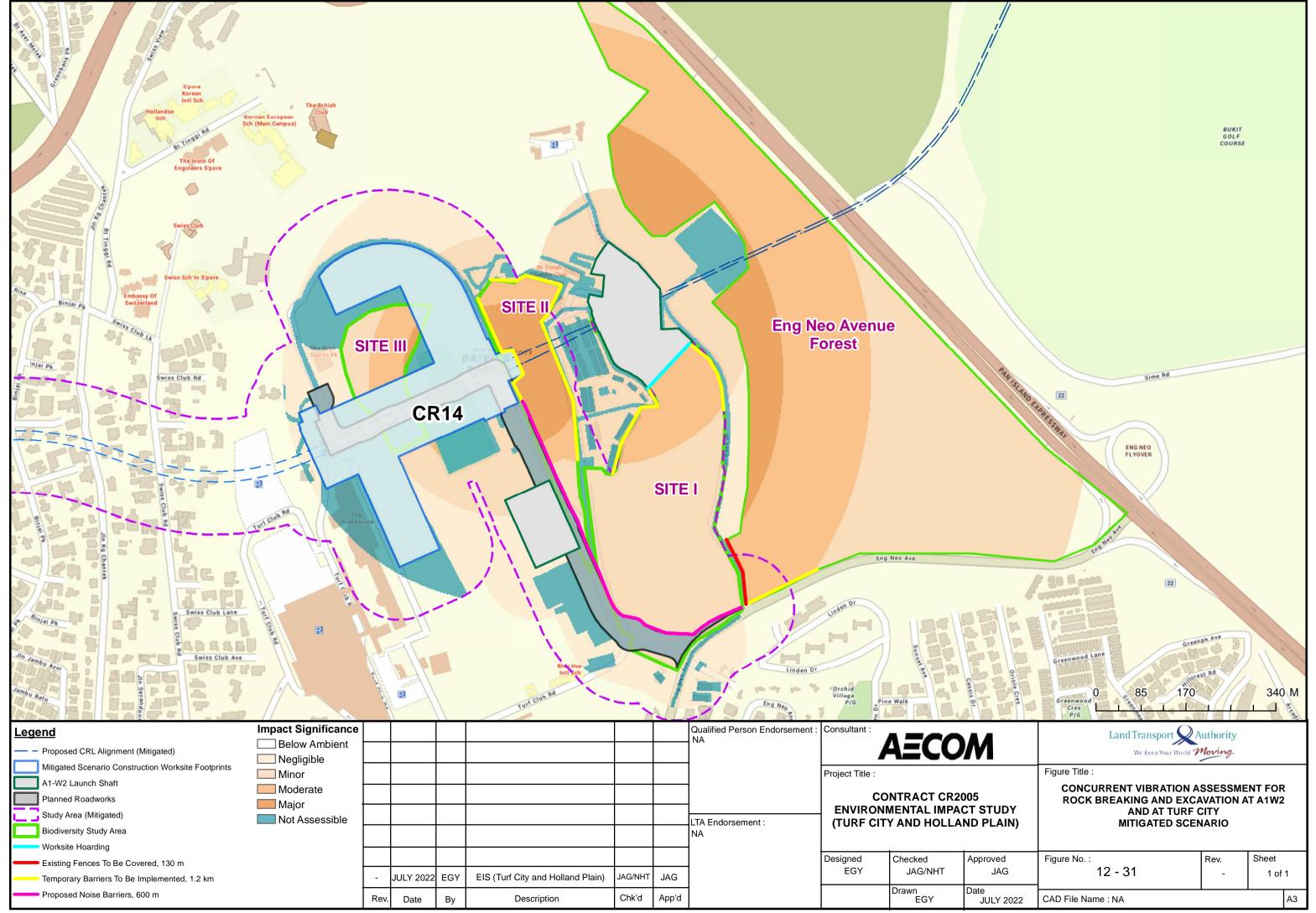
Overall, the construction activities produce impact significances of Negligible, Minor, Moderate and Major.

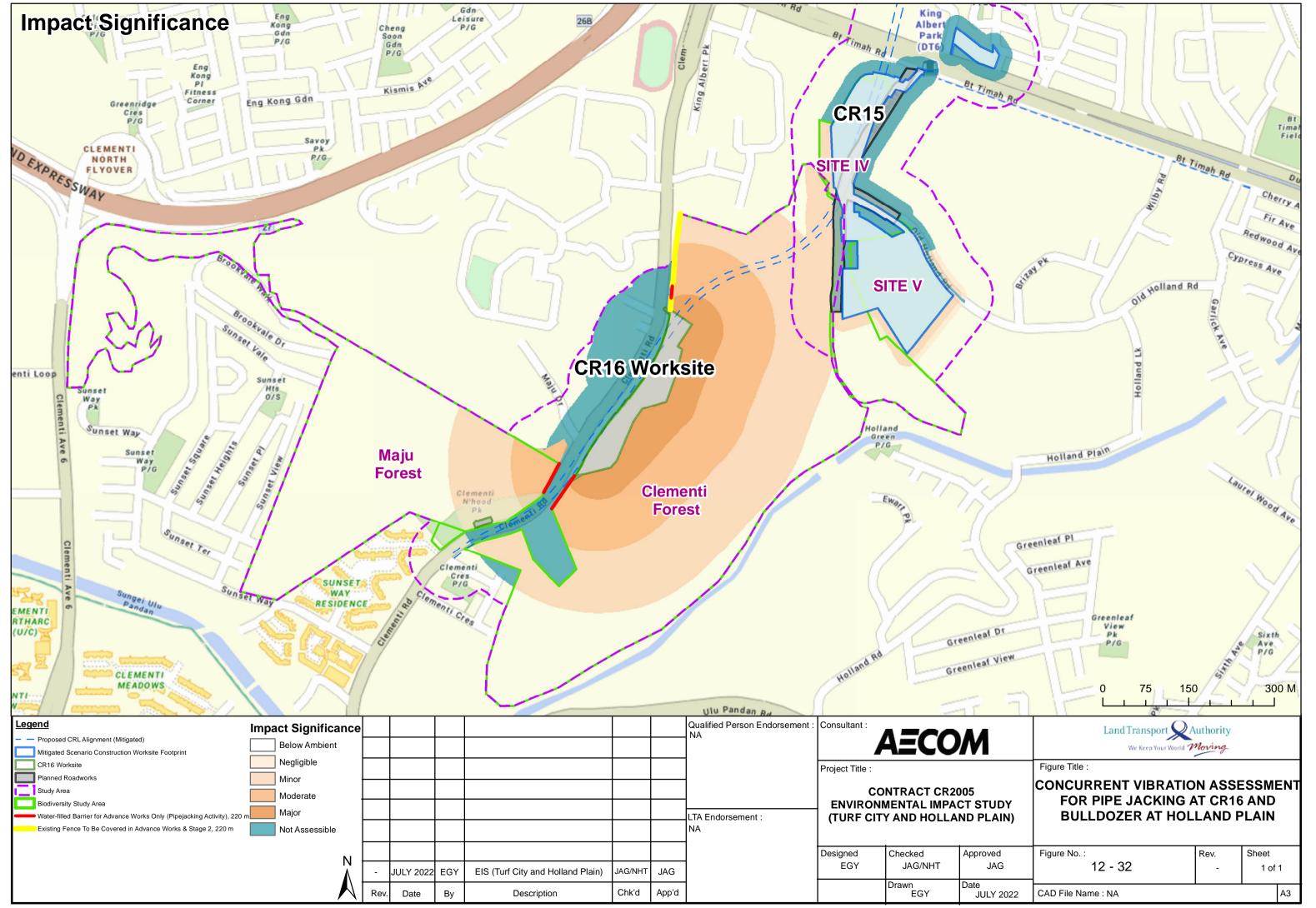
- For Negligible impact significances, there should be no detectable behavioural change to indicator species;
- For Minor impact significances, some sensitive fauna may be impacted, while other species may avoid the area because of the increased levels of activity in the area. Many species would become habituated to the tunnel boring machine and would return to normal activity in a few days when the machine has passed by;
- For Moderate impact significances, it may impact sensitive fauna on their day to day activities (communication/ foraging) for a short period in the zone of impact and may leave the area. Displacement is expected to be temporary, and they are expected to return after a while; and
- For Major impact significances, it may cause permanent effects and affected indicator species are not expected to adapt to using this area. Hence it is reasonable to assume that vibration from tunnel boring may impact part of their habitat (pangolins' burrows), and foraging opportunities. The mousedeer (*Tragulus kanchil*) and Sunda pangolin (*Manis javanica*) may move out of affected areas during the day and return at night to forage in these areas where food sources are available nearby.
- During rock breaking and excavation, sensitive fauna may also flee, freeze or be frightened by the instantaneous vibration.

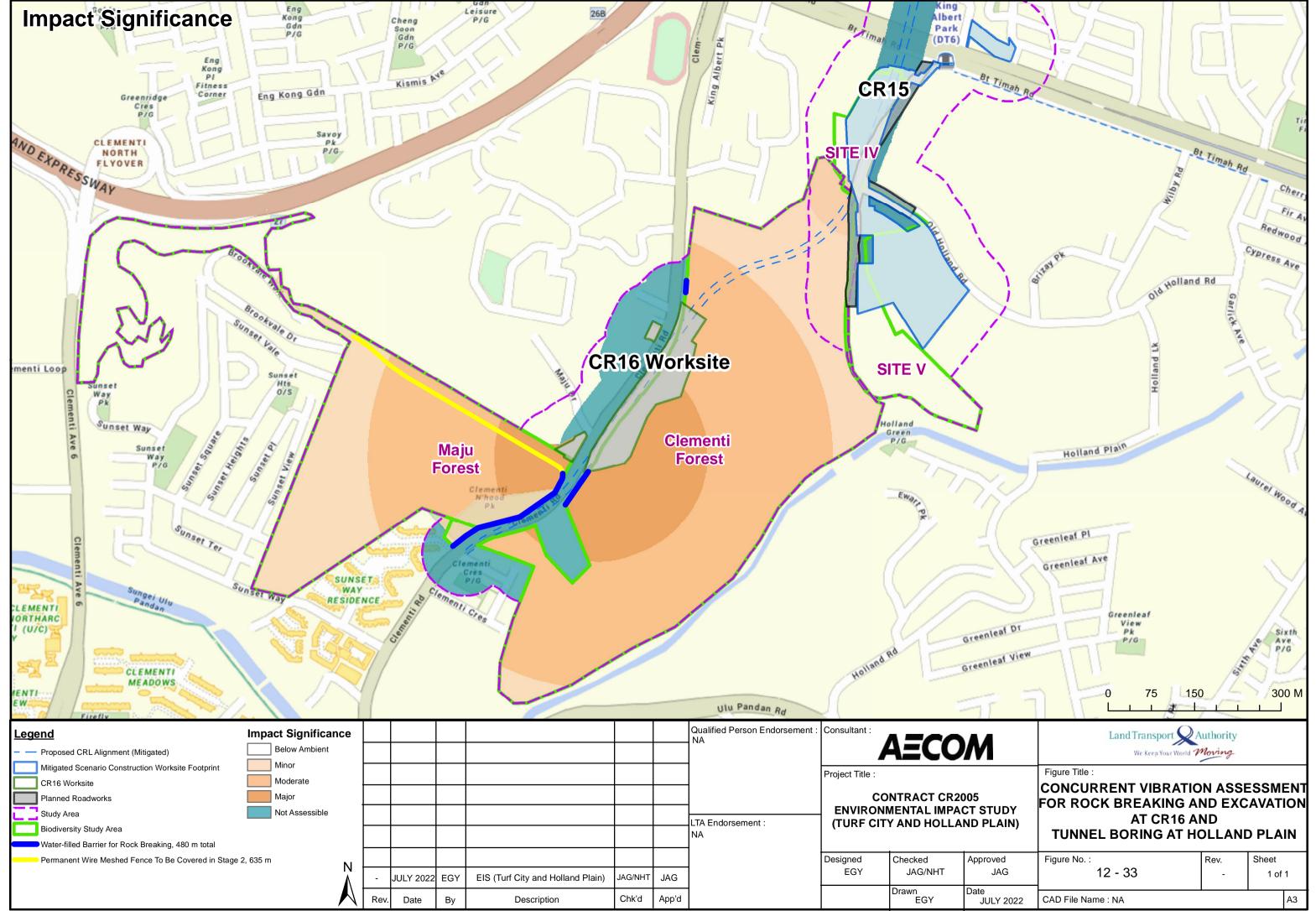
Thus, future mitigation measures and EMMP are recommended as discussed in Section 13.11.

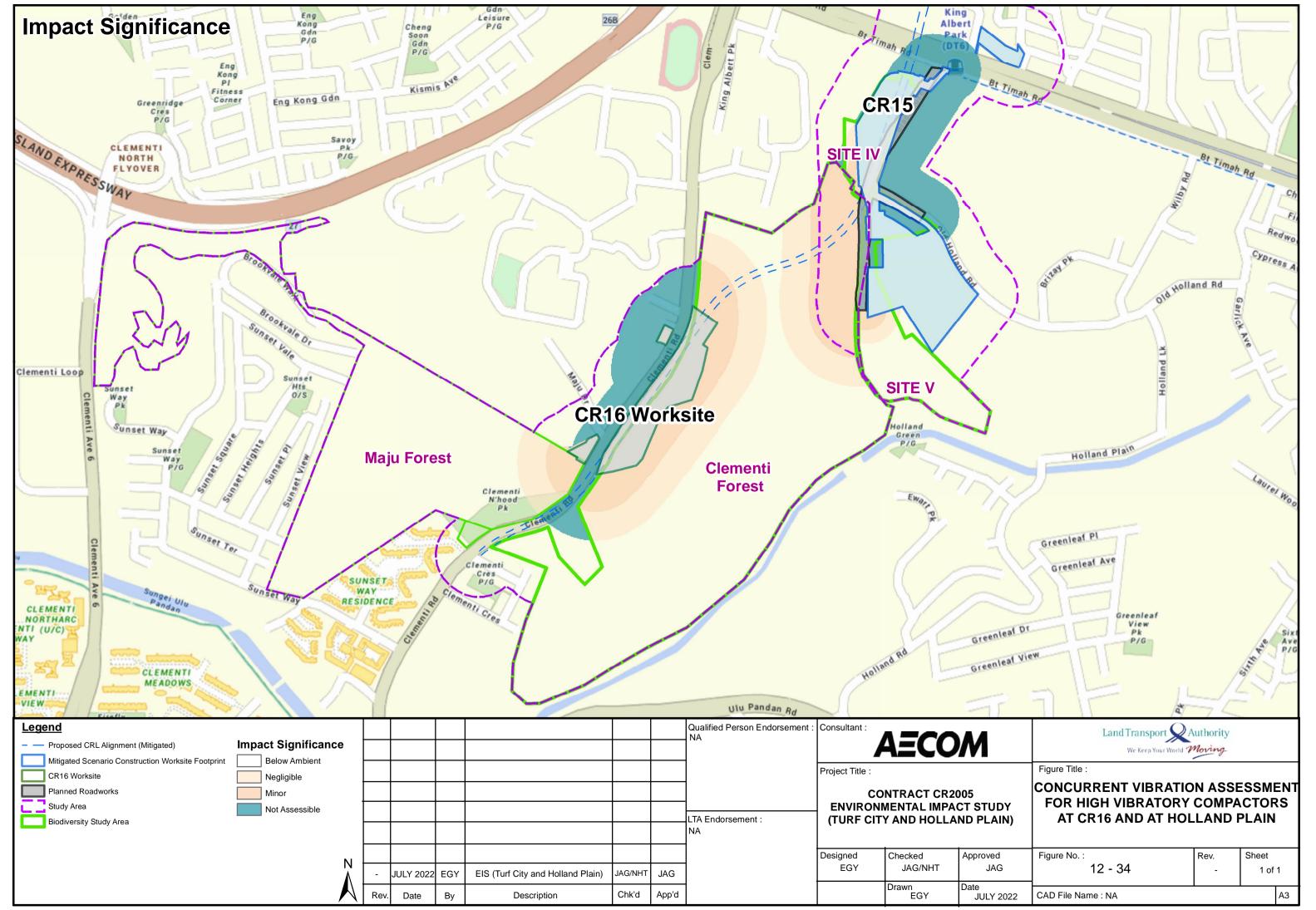












12.10.2 Operational Phase

During the operational phase of CR2005, the ground-borne vibration levels caused by the movement of the trains would have been mitigated by the track works. The levels will be insignificant in the cumulative impact of other concurrent developments.

12.11 Summary of Key Findings

The study assesses the impact of construction ground-borne vibration on the impacted areas within the biodiversity areas such as Sites I to V.

AECOM reviewed several works of literature to gather information on vibration thresholds of fauna. Research shows that vibration thresholds for fauna are species-specific. There is a limited amount of information in this area for the indicator species for the study. Therefore, the step threshold endured by humans was used to inform the study criterion used for this study.

The study assesses vibration impacts from construction and operational phases on the potential of burrow damage/collapse for fossorial species (i.e., structural impact assessment) and the ecological behaviour of the sensitive receptors. The biodiversity habitats/fauna species were classified into Priority 1, 2 and 3 ecologically sensitive receptors based on their ecological values and sensitivity towards vibration. The indicator species are mouse deer and pangolin. The predicted vibration levels from the construction and operational phases of the Project are then evaluated against the impact assessment matrix for impact intensity, impact consequence, likelihood and impact significance on the ecological behaviours of the ecologically sensitive receptors.

The construction works assessed for vibration impact were bulldozing, low and high amplitude vibratory compactors, rock breaking and excavation and tunnel boring for the CRL alignment. The worksites are CR14 for a station and CR15 for a station with a retrieval shaft. Based on the assessment results, mitigation measures were recommended and included major design modifications/ process modifications such as optimisation of CR14 and CR15 worksites.

12.11.1 Summary of Construction Activities

The Study predicted vibration levels for various construction equipment at the CR14 and CR15 worksites for base and mitigated scenarios. The vibration levels are assessed according to the impact assessment matrix.

Base Scenarios

For the base scenario, the bulldozer is predicted to cause minor – moderate vibration impact significance at Sites I to III and minor vibration impact significance at Sites IV to V. Low and high amplitude vibratory compactor causes negligible – minor impact significance in the base scenario for Sites I to V. Tunnel boring vibration levels in the base scenario predicted using the Esvelt method cause minor impact significance at Site III and IV, while Sites I, II and V were not affected by tunnel boring in the base scenario.

Based on the study outcome of the base scenario, the overall impact significance on ecological behaviour is **Minor** and **Moderate**. Thus, mitigation measures are recommended.

High vibratory compactors generate vibration levels exceeding PPV, 5.0 mm/s, the Contractor should use best available techniques (BAT) and control construction vibration levels to PPV, 8.0 mm/s at vibration sensitive biodiversity area/forested areas. Schedule high vibration activities during the daytime; no night works should be conducted after 7 pm for all non-safety critical activities since the site is next to the human and fauna sensitive receptors. Use tri-axle trucks to reduce truck trips on the road thus generating less vibration.

Mitigated Scenarios

For the mitigated scenario, the bulldozer causes minor – moderate vibration impact significance at Sites I to III and **minor** vibration impact significance at Sites IV to V. Avoiding construction work at night could reduce the vibration impacts impact significance from moderate to minor at Sites I to III. Low and high amplitude vibratory compactor for mitigated scenario is predicted to cause negligible – minor impact significance in the mitigated scenario for Sites I, II IV and V, and negligible impact significance at Site III. Tunnel boring vibration levels do not affect Site I, II and V in the mitigated scenario.

For the mitigated scenario, the rock breaking and excavation is predicted to cause **negligible – minor** at Site I. and **minor – major** vibration impact significance at Sites II and III. Hence, temporary barriers (i.e. water barriers of 1 m height) should be implemented. Hoardings must be ensured at all worksites to mitigate roadkills due to the

impacted fauna trying to dash onto the road during construction activity. No night works should be conducted after 7 pm. This could reduce vibration impact significance from **major** to **moderate**.

Based on the study outcome of the mitigated scenario, the residual impacts are predicted to be **negligible – moderate** for Site I and **negligible – major** for Sites II and III in Turf City, and **negligible – minor** for Sites IV and V in Holland Plain. Thus, future mitigation measures and EMMP are recommended.

12.11.2 Summary of Operational Activities

Operational vibration impact assessment results indicate that standard track form and deep tunnel depth are sufficient to mitigate vibration impacts on sensitive fauna species. The overall residual impact significance on ecological behaviour with mitigation measures is **minor** in Turf City and Holland Plain.

12.11.3 Summary of Concurrent Activities

Cumulative impacts were assessed based on the worst-case construction activities where the timelines of A1-W2, CR16, Turf City, and Holland Plain coincide. Typical construction works at Old Jurong Line Nature Trail and Clementi Forest Stream Nature Trail are unlikely to cause higher vibration levels than this Project.

Since there are overlaps in timelines, the concurrent activities were assessed for CR14 with A1-W2 and CR15 with CR16. For the former, three pairs of activities coincide. high vibratory compactors at CR14 coincide with rock breaking and excavation at A1-W2, causing minor – moderate impact significances at Sites I to III and Eng Neo Avenue Forest. Bulldozer at CR14 coincides with rock breaking and excavation at A1-W2, causing minor – moderate impact significances at Sites I to III and Eng Neo Avenue Forest. Lastly, rock breaking and excavation at CR14 and A1-W2 coincide, causing minor – major impact significances at Sites I, II and Eng Neo Avenue Forest, while Site III has a minor – moderate impact significance.

At CR15 and CR16, three pairs of activities coincide as well. Bulldozing at CR15 coincides with pipe jacking at CR16, causing **minor** impact significances at Sites IV and V, while Clementi Forest has a minor – major impact significance. Tunnel boring at CR15 coincides with rock breaking and excavation at CR16, causing minor impact significances at Sites IV and V, while Clementi Forest has a minor – major impact significance. Lastly, high amplitude vibratory compactors occur at the same time for both worksites, causing minor impact significances at Sites IV and V and negligible – minor impact significance at Clementi Forest.

During the operational phase of CR2005, the ground-borne vibration levels caused by the movement of the trains would have been mitigated by the track works. The levels will be insignificant in the cumulative impact of other concurrent developments.

This Project suggested implementing temporary barriers (i.e. water barriers of 1 m height) for activities that causes major impact significances such as rock breaking and excavation. In addition, the ecologist will monitor the environment for any faunal behaviours (e.g. charging) that could result in roadkill, burrow damage/collapse resulting in mortality and their presence and absence in and around the worksite. Suppose the mortality of fauna is under threat, the work is immediately halted, and mitigation measures are adapted to avoid such events in the future.

12.11.4 Conclusion

Overall, there are **negligible – major** residual impacts during the construction phase due to bulldozing, tunnel boring, vibratory compactors, rock breaking and excavation at Turf City, and **negligible – minor** residual impact significances at Holland Plain, excluding concurrent activities. The study recommends controlling vibration levels emitted to PPV, 8 mm/s where burrows of fossorial species are sighted to prevent damage/collapse of the burrows and entombing the species. Further mitigation measures include setting up (i.e. water barriers of 1 m height) along roads near the worksite and EMMP measures to reduce the impact significance to **negligible – moderate**. Concurrent construction activities at nearby works are unlikely to cause more impacts on the vibration Biodiversity Study Areas. Moving trains induce low ground-borne vibration levels and are insignificant to cause vibration impacts on the ecological receptors. Thus, there are no residual impacts for the operational phase.

Table 12-30 Summary of Impact Assessment for Ground Borne Vibration

Potential Source of Impact	Impact Significance with Minimum Control	Residual Impact Significance with Mitigation Measures (if required)			
Construction Phase					
Site I	Negligible – Moderate (see Note 2)	Negligible – Moderate (see Note 2)			
Site II	Negligible – Moderate (see Note 2)	Negligible – Major (see Note 3)			
Site III	Negligible – Moderate (see Note 2)	Negligible – Major (see Note 3)			
Site IV	Negligible – Minor (see Note 1)	Negligible – Minor (see Note 1)			
Site V	Negligible – Minor (see Note 1)	Negligible – Minor (see Note 1)			
Operational Phase					
Site I	Minor (see Note 1)	Minor (see Note 1)			
Site II	Minor (see Note 1)	Minor (see Note 1)			
Site III	Minor (see Note 1)	Minor (see Note 1)			
Site IV	Minor (see Note 1)	Minor (see Note 1)			
Site V	Minor (see Note 1)	Minor (see Note 1)			

Note:

- 1. The initial impact assessment with minimum controls was considered insignificant (Negligible to Minor), no residual impact assessment was undertaken, hence the impact significance remained the same. Note that this does not indicate that impacts are completely eliminated.
- 2. Construction activities such as bulldozing produce high vibration levels at the biodiversity sensitive receptors. It is essential to implement EMMP measures to reduce the impact significance to Moderate.
- 3. Construction activities such as rock breaking and excavation is only required in the mitigated scenario, which produces high vibration levels and impact significance at the biodiversity sensitive receptors. It is essential to implement EMMP measures to reduce the impact significance to Moderate.

13. Proposed Environmental Monitoring and Management Plan

The proposed EMMP is prepared for environmental impacts of the construction, commissioning and operational phases associated with the Project in overall for comprehensiveness of the study as well as to provide an overall picture of the potential roles and responsibilities required during each phase of the Project. The coverage of the proposed EMMP involves the environmental parameters that were assessed, namely air quality, airborne noise, ground-borne vibration, hydrology and surface water quality, soil and groundwater, and biodiversity. The EMMP details how the key mitigation measures recommended from the impact assessment/study are to be implemented and specifies environmental monitoring measures to assess the effectiveness of the proposed mitigation measures. These EMMP measures were also summarised and documented in the EIR (See Appendix A).

- During construction phase, this document is intended to provide a broad framework for various players in the construction phase to develop a more contract-specific EMMP, as per their responsibilities in Section 13.4 in order to comply with LTA's SHE specifications and any contract-specific requirements.
- During commissioning phase, this document is intended to provide a broad framework for various players
 with similar roles and responsibilities from construction phase (see Section 13.4) to further compliment
 their environmental protection effort by developing and implementing contract-specific EMMP after the
 completion of all the major construction activities. This is also to ensure smooth transition of the Project
 before handing over to the Rail Operator in operational phase.
- During the operational phase, this document is intended to provide a brief understanding of the
 responsibilities of Rail Operator (see Section 13.5) and other relevant personnel who perform or ensure
 the implementation of minimum control measures as per the relevant legislations and the proposed
 mitigation measures based on the impact assessment/study findings.

This section outlines the objectives of the EMMP, the Project organisation, describes the roles and responsibilities relevant to implementation of the EMMP, and summarises the EMMP requirements for each discipline. A summary of the proposed EMMP of different phases, incorporated with the relevant minimum controls and key mitigation measures, is provided in Section 13.13.

13.1 EMMP Objectives

The EMMP details the implementation and deliverables of the key mitigation measures recommended from the impact assessment for each technical discipline. The EMMP progressively scrutinises construction, commissioning and operational activities as they ensue and applies flexible monitoring and management procedures to protect the Project's environmental values throughout the Project period. The objective of the EMMP is twofold:

- Environmental monitoring focuses on overseeing those impacts to the Project's environmental values from construction and commissioning phases are within the anticipated level and tackle unforeseen impacts that may arise; and
- b) It also tracks the effectiveness of the recommended mitigation measures to allow amendment or review of the mitigation measures to better address any issues faced during construction, commissioning and operational phases of the Project.

Environmental management employs a more active approach to ensure those impacts on flora and fauna are directly avoided through documentation, auditing and enforcement.

13.2 Project Organisation during Construction and Commissioning Phases

The proposed Project organisation and lines of communication with respect to environmental protection works for construction and commissioning phases of this Project are presented in Figure 13-1. The roles and responsibilities of the various parties responsible for implementing the EMMP during the construction and commissioning phases are outlined in Section 13.4.

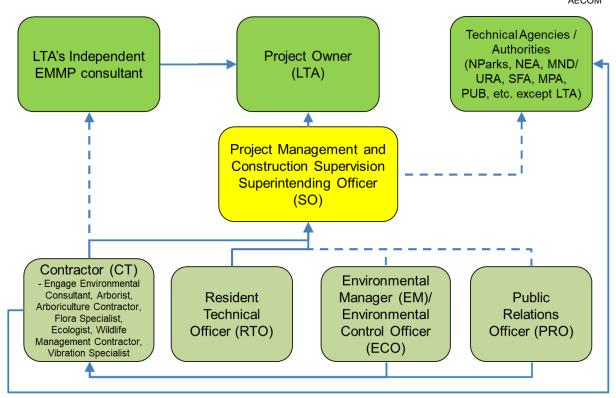


Figure 13-1 Project Organisation and Lines of Communication during the Projects' Construction and Commissioning Phases

13.3 Project Organisation during Operational Phase

The proposed Project organisation and lines of communication with respect to the general management and implementation of the recommended minimum control measures as well as key mitigation measures during operational phase of this Project are presented in Figure 13-2, forming a typical Environmental Management Committee or as part of the Environmental, Health and Safety (EHS) Committee for a particular organisation/operation. The roles and responsibilities of the various parties involved in the operational phase are outlined in Section 13.5.

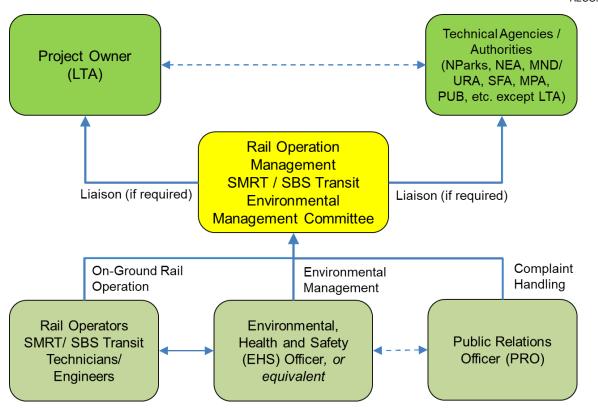


Figure 13-2 Project Organisation and Lines of Communication during the Projects' Operational Phase

13.4 Roles and Responsibilities during Construction and Commissioning Phases

This section describes the roles and responsibilities of the EMMP members presented on the organisational chart for construction and commissioning phases in Section 13.2.

13.4.1 Technical Agencies/ Authorities

Technical agencies/<u>authorities</u> constitute but are not limited to NParks, PUB, NEA, and URA. These agencies shall assess and approve the detailed EMMP for the construction and commissioning phases prior to commencement of works and where required during the course of the relevant Project phases.

13.4.2 Project Owner (LTA) and Resident Technical Officer (RTO)

LTA, being the Project owner, oversees the construction and commissioning phases of the Project in accordance with the design. LTA, in conjunction with the Resident Technical Officer (RTO) (Contractor), are required to:

- Ensure resources are available to achieve the requirements of the EMMP;
- Provide leadership in the development and implementation of the EMMP;
- Ensure all environmental incidents and near misses are promptly investigated and reported;
- Resolve any non-compliance issues;
- Record, respond to, and action on any complaints from members of the public, if any, with inputs from the Technical agencies, if required; and
- Reporting to the Technical Agencies regarding implementation of the EMMP.

13.4.3 Superintending Officer (SO)

The Superintending Officer is responsible for overseeing the construction works undertaken by various staffs, Contractors and sub-contractors. The SO should ensure that the construction works are performed by the Contractors and personnel in accordance with the specification, contractual requirements, and EMMP. The SO should also:

- Communicate the requirements of this plan to all staffs, Contractors and sub-contractors
- Monitor all staffs, Contractor's and sub-contractor's compliance with contract specifications and regulatory
 requirements, including the implementation of the environmental mitigation and monitoring measures and
 ensure their effectiveness, and other aspects of the environmental audit program;
- Coordinate with the Project's EM/ECO to monitor and participate in the implementation of the environmental audit program, and ensure that the requirements in the environmental audit program are correctly followed;
- Implement measures to reduce impacts where emission/discharge levels are exceeded;
- Coordinate with the Project Owner and RTO for submission of environmental audit reports;
- Carry out any complaint investigations with PRO (see Section 13.4.4.8);
- · Resolve any non-compliance issues; and
- Promote environmental awareness and responsibility and lead by example.

13.4.4 Contractor (CT)

The term "Contractor" refers to all construction Contractors and sub-contractors working onsite at any time, which also the "Occupier of Construction Site" as defined by NEA. In addition to reporting to the SO, the Contractor should:

- Work under the relevant contract scope, specifications, and other tender conditions;
- Ensure that the roles of Environmental Manager (EM), Environmental Control Officer (ECO), Certified Arborist, Arboriculture Contractor, Flora Specialist, Ecologist, Wildlife Management Contractor(s) are adequately resourced;
- Notify the Director-General of Public Health on the employment of ECO (also applicable for EM who shall
 also be an registered ECO in the context of this Project) by submitting the Notification on Employment of
 Environmental Control Officer (as per the format in the NEA's Code of Practice of Environmental Control
 Officers), as well as to notify in writing to the Director-General of Public Health and to employ another
 registered ECO/EM within 14 days of the termination of the employment of the originally appointed
 ECO/EM;
- Employ a temporary ECO or engage a registered Workplace Safety and Health Officer (WSHO) with valid ECO certificate obtained under NEA if both EM and ECO working on the construction site are on leave or absent for more than 5 days, and neither of them can take on the work responsibility of an ECO during the absence period;
- Endorse and submit the Site Environmental Control Programme prepared by the ECO/EM to the Director-General of Public Health at least two weeks before work commences on the construction site;
- Discuss about the Site Environmental Control Report with the EM/ECO within one week on receipt of the report, then countersign and stamp after finalization and implement the recommendations made by the ECO;
- Keep the Site Environmental Control Report available for inspection by the Director-General of Public Health or Public Health Officers when required, as well as to submit when required to so by the Director-General of Public Health;
- Participate in the required environmental site audits (via the SO) undertaken by a registered EM/ECO and undertake any corrective actions;
- Provide up-to-date information and advice to the RTO, SO, EM, ECO, Certified Arborist, Arboriculture Contractor, Flora Specialist, Ecologist, Wildlife Management Contractor(s) regarding any work activities which may contribute or continuously create adverse environmental conditions, or any changes to the work plan;
- Implement measures to reduce impacts where emission/discharge levels are exceeded;
- Prepare a detailed contract-specific EMMP, incorporating the relevant mitigation measures and monitoring
 works recommended in this study and seek technical agencies' approval prior to the commencement of
 any works for the construction and commissioning phases of the Project. This detailed EMMP shall
 include, as a minimum, a Standard Operating Procedure (SOP) detailing:

- Handling and storage of hazardous chemicals;
- Biodiversity management plan;
- Individual environmental management plans as detailed in the LTA's SHE Specifications (air, vector, waste, noise, water pollution management plans);
- Monitoring plans (including but not limited to noise, air, waste, ecology and water pollution);
- Environmental Impact Register;
- Existing legislation and environmental best practices to be implemented; and
- Contingency planning during emergency situations.

13.4.4.1 Environmental Personnel

According to LTA's SHE Specifications, the Contractor shall comply with all legislative safety, health and environmental (SHE) requirements as stipulated. SHE personnel refer to Workplace Safety and Health Officer (WSHO) registered with the Ministry of Manpower (MOM) and ECO registered with the NEA. After consultation with LTA, the Contractor shall engage the following environmental personnel during the construction and commissioning phases of this Project:

- Environmental Consultant, with strong and relevant experiences in developing and implementing EMMP for similar or larger construction Projects;
- Environmental Manager (EM), who is a NEA-registered ECO with strong and relevant experiences, to oversee/ lead/ guide environmental monitoring and auditing works on the construction site; and
- Environmental Control Officer (ECO), who shall assist the EM and is also registered with NEA, to perform and/or ensure implementation of EMMP, mitigation measures and minimum control measures on site.

13.4.4.1.1 Environmental Consultant

An environmental consultant shall be engaged by the Contractor to develop a contract-specific EMMP, air pollution control plan, water management plan, noise management plan, vector pollution control plan, etc. according to LTA's SHE specification [R-9] for implementation by all parties, including EM/ECO and relevant workers on site. The appointed environmental consultant may be required to re-establish baseline environmental conditions and perform the recommended environmental monitoring works throughout the construction and commissioning phases, as well as to provide environmental advisory services for the Contractor and to liaise with the authorities, stakeholders and/or LTA's independent EMMP Consultant from LTA during external audit (see Section 13.12.1.2), when necessary.

13.4.4.1.2 Environmental Manager (EM)/ Environmental Control Officer (ECO)

General Introduction

The Environmental Control Officer (ECO) Scheme was launched by NEA on 1 April 2000 to advocate good environmental practices within construction sites. Under the Environmental Public Health Act (EPHA), a part-time ECO working at least 15hr/week is required for construction sites with contract sum of between \$10 million and \$50 million, whereas a full-time ECO working at least 40hr/week must be engaged by construction sites with contract sum exceeding \$50 million.

The main role of a registered ECO is to advise the Occupier of the construction site on what needs to be done, which include advising construction site's Contractors on environmental remediation measures, facilitating compliance with the environmental laws, carrying out site inspections and engagement of stakeholders for environmental lapses, as well as educating workers on maintaining good environmental health standards. NEA has also specified that the role of ECO(s) in general would comprise the following aspects:

- · Disease-bearing insects and rodents;
- Proper disposal of construction waste/ marine clay;
- Noise, air and water pollution;
- Earth littering;
- Siltation of drains;
- Food hygiene in on-site canteens (if any);
- Proper maintenance of septic tank(s)/ holding tank(s), chemical/ portable toilet(s) and other sanitary facilities; and

Any other environmental health matters.

The registered ECO(s) shall be employed by the Occupier of the construction site (the Contractor) but may not be in any way as an associated body of the Contractor, the SO, or the Project's SHE team.

For this Project

As mentioned, both EM and ECO are environmental control officers registered under NEA. In view of the scale and nature of this Project, during construction and commissioning phases, EM shall be the leading role and is expected to have prior experience in EMMP for Projects with biodiversity sensitivity to manage and oversee the overall EMMP implementation and act as the key liaison with agencies and stakeholders on environmental-related matters when necessary; while the ECO can be the same person if possible, else a supporting role officer who is responsible for most of the implementation of EMMP and relevant environmental measures on ground.

Generally, a NEA-registered ECO (applicable for EM and/or ECO of this Project) shall comply with the latest NEA's *Code of Practice for Environmental Control Officers*, where the duties include but not limited to:

- Prepare and submit a Site Environmental Control Programme based on the latest required format in Appendix
 2 of the above-mentioned code of practice, within one month after the commencement of works on the construction site to NEA (after reviewed by the Project Owner LTA) via Form SG;
- Prepare and submit the Site Environmental Control Report(s) based on the latest required format in Appendix
 3 of the above-mentioned code of practice, after the commencement of construction works, and at least once
 a month or any other frequency required by NEA and/or LTA throughout the construction and commissioning
 phases;
- Identify and attend to all environmental issues, inform the Occupier of the construction site accordingly, and recommend measures to rectify the irregularities;
- Assist the authorities to investigate environmental issues and outbreaks of infectious, vector-borne or foodborne diseases on the construction site; and
- Organise campaigns, training, toolbox briefings and other relevant courses to develop the capability of all relevant workers in implementing EMMP, as well as to raise their environmental and biodiversity awareness in maintaining good environmental performance on site.
- Resources to implement the environmental monitoring program should be allocated in time to fulfil the
 environmental audit/ inspection requirements during construction works. The EM/ECO shall work closely with
 other EMMP members to ensure environmental compliance of the construction sites, as well as to ensure
 proper and safe working condition of relevant construction facilities and equipment:
- Oversee and manage the implementation of minimum control measures, mitigation measures and EMMP on site.
- Coordinate with various parties with respective to EMMP, which include:
- Liaise with the SO and/or WSHO regarding equipment, locations, and schedule of monitoring and auditing works; and
- Coordinate among the Client, Contractor, and other personnel within the Biodiversity Team for the implementation of the EMMP measures for biodiversity.
- Formulate and implement the environmental monitoring and audit program as required in this document;
- Monitor compliance with conditions in the EMMP, relevant environmental protection, pollution prevention and control regulations and contract specifications;
- Analyse environmental monitoring data and audit findings, review the adequacy of implementation of mitigation measures, identify adverse environmental impacts, and liaise with the SO;
- Carry out weekly site audits/ inspections against the Contractor's site practices, equipment and work
 methodologies with respect to pollution control and environmental mitigation, and effect proactive actions to
 pre-empt problems in coordination with the SO;
- Report the results of the environmental monitoring works and audit program, and any required changes to meet the requirements of the EMMP and legal obligations to the SO in a timely manner; and
- Coordinate the investigation of biodiversity-related incidents;

- Provide solutions and address complaints related to environmental incompliances or related incidents, with cooperation from SO and/or WSHO; and
- Compile and submit the updated findings, along with completed remedial actions supported by photographs to LTA fortnightly in the form of an Environmental Performance Report (also known as Environmental Inspection Report).

13.4.4.2 Arborist

An Arborist certified by the International Society of Arboriculture (ISA) plays an important role as part of the biodiversity monitoring programme during both construction and commissioning phases of this Project. He/She shall possess previous work experience in developments of similar size or complexity who is able to demonstrate capability in monitoring and managing all matters related to the adequate and successful conservation of trees and flora within and adjacent to the contract boundary. A detailed description of biodiversity monitoring programme is provided in Section 13.6, where the key responsibilities of the Arborist are listed as follows:

Construction Phase

The key responsibilities of an ISA-certified Arborist during construction phase include but not limited to:

- Carry out tree mapping and assessment;
- Implement tree protection plans;
- Provide advice on tree transplanting;
- Review Contractor's method statements for site clearance, tree felling and setting up of tree protection zones (TPZ);
- Assess forest edge effects and its associated changes;
- Implement tree maintenance and care; and
- Carry out monthly tree inspection and reporting.

Commissioning Phase

The key responsibilities of an ISA-certified Arborist during commissioning phase include but not limited to:

- Implement tree maintenance and care; and
- Carry out monthly tree inspection and reporting.

13.4.4.3 Arboriculture Contractor

The Arboriculture Contractor should meet NParks' safety requirements for work at height and LTA's requirements for temporary works along roadsides. All arboriculture workers engaged by the Arboriculture Contractor to perform tree climbing and chainsaw work shall possess a valid basic tree climbing certification based upon demonstrated competence in the Workforce Skills Qualifications (WSQ) module conducted by Centre for Urban Greenery and Ecology (CUGE) or an equivalent WSQ-approved training organisation; and

The arboriculture crew deployed by the Arboriculture Contractor for the Contract shall possess the following valid competences:

- Operation of chainsaw for ground work (LS-MT-103E-1);
- Chainsaw safety and maintenance (LS-MT-102E-1);
- Perform formative pruning of young trees (LS-MT-114E-1);
- Provide Arboriculture support on site (LS-MT-116E-1);
- Workplace safety and health operators (ES-WSH-101G-1);
- Respond to Emergency (LS-HM-208E-1);
- Perform advance rigging and climbing techniques (LS-HM-308S-1);
- Perform aerial tree access and aerial rescue skills (LS-HM-204S-1);
- Implement and apply appropriate risk and safety management to sector practices (LS- BP-301S-1);
- Prepare risk assessment report (LS-HM-406S-1); and

• Operate and work from an elevated work platform (CUGE-ARB-3501).

Construction Phase

The certified Arboriculture Contractor shall be responsible for pruning and maintenance of retained trees, as well as felling of trees during the construction phase of this Project.

Commissioning Phase

The certified Arboriculture Contractor shall be responsible for pruning and maintenance of retained and newly planted trees, as well as felling of trees (if required) during the commissioning phase of this Project.

13.4.4.4 Flora Specialist

For this Project, a Flora Specialist plays an important role in the implementation of flora-related EMMP measures (e.g. Flora Management Plans) as part of the biodiversity monitoring program during both construction and commissioning phases of this Project. He/She shall possess previous work experience in developments of similar size or complexity who is able to demonstrate capability in implementing flora management plans. A detailed description of biodiversity monitoring programme is provided in Section 13.6, where the key responsibilities of the Flora Specialist are listed as follows:

Construction Phase

The key responsibilities of a qualified Flora Specialist during construction phase include but not limited to:

- Review soil investigation locations and proposed site access to minimise excessive vegetation removal;
- Identify plant species (e.g., climbers, shrubs, epiphytes, ferns) of value that can be extracted for propagation and harvesting;
- · Recommend weed and invasive species management if necessary;
- Review planting palette of reforestation works and ensure that the specifications for planting are met; and
- · Carry out monthly flora inspection and reporting.

Commissioning Phase

The key responsibilities of a qualified Flora Specialist during commissioning phase include but not limited to:

- Recommend additional weed and invasive species management if necessary; and
- Carry out monthly flora inspection and reporting.

13.4.4.5 **Ecologist**

For this Project, an Ecologist plays an important role in the implementation of fauna-related EMMP measures as part of the biodiversity monitoring program during both construction and commissioning phases of this Project, who can also be known as a Fauna Specialist. He/She shall possess a degree (or equivalent) in ecology-related fields with experience in implementing fauna management plans. In addition, at least two (2) valid certifications of the following:

- Animal Management Professional Certification Programme (PCP) Basic Module (CUGE-PCP-7006A)
- Animal Management PCP Intermediate Elective Module Mammals (CUGE-PCTP-7006C)
- Animal Management PCP Intermediate Elective Module Reptiles (CUGE-PCP-7006B)

A detailed description of biodiversity monitoring programme is provided in Section 13.6, where the key responsibilities of the Ecologist are listed as follows:

Construction Phase

The key responsibilities of a qualified Ecologist during construction phase include but not limited to:

- Carry out fauna monitoring surveys including terrestrial transect surveys, aquatic sampling and camera trapping;
- Implement fauna management during site clearance;
- · Carry out pre-felling fauna inspections;

- · Carry out monthly fauna inspection and reporting; and
- Facilitate the implementation of the fauna response plan.

Commissioning Phase

The key responsibilities of a qualified Ecologist during commissioning phase include but not limited to:

- Carry out fauna monitoring surveys including terrestrial transect surveys, aquatic sampling and camera trapping; and
- Carry out monthly fauna inspection and reporting.

13.4.4.6 Wildlife Management Contractor

For this Project, the Wildlife Management Contractor (with at least one veterinary professional with experience within the team) would be responsible in carrying out animal rescue, trapping and transport of large fauna if any human-wildlife conflicts are encountered during construction and commissioning phases on site. The Wildlife Management Contractor shall be listed under NParks' public register of certified Wildlife Management Contractor and have experience carrying out animals rescue, trapping and transport of large fauna.

A detailed description of biodiversity monitoring programme is provided in Section 13.6, where the key responsibilities of the Wildlife Management Contractor are listed as follows:

Construction Phase

The key responsibilities of a qualified Wildlife Management Contractor during construction phase include but not limited to:

- Carry out fauna rescue and translocation in consultation with attending Ecologist and NParks; and
- Propose trapping of fauna in consultation with attending Ecologist and NParks to satisfy Section 10 of the Wildlife Act.

Commissioning Phase

The key responsibilities of a qualified Wildlife Management Contractor during commissioning phase include but not limited to:

• Carry out fauna rescue and translocation in consultation with NParks.

13.4.4.7 Vibration Specialist

- Vibration Specialist, with strong and relevant experiences, to oversee/ lead/ guide vibration monitoring on the construction site, and to ensure it is carried out according to guidelines and standards;
- Vibration Specialist, who shall assist the ECO, to perform and/or ensure implementation of EMMP, mitigation
 measures and minimum control measures on site.

13.4.4.8 Public Relation Officer (PRO) for Complaint Handling

The Public Relation Officer (PRO) is responsible for handling complaints and managing feedback and investigative work. The PRO shall be supported by the Project Owner, RTO, SO, EM/ECO, Contractor representatives, and any other relevant parties.

During the construction and commissioning phases, upon receipt of complaints, the PRO should undertake the following procedures:

- Log the complaint and record the date when the complaint is received onto the complaint database and inform the Project Owner, SO, EM/ECO immediately;
- Investigate the complaint with the EM/ECO to determine its validity and assess whether the source of the problem is due to construction works;
- If a complaint is valid and due to construction works, liaise with the EM/ECO on the mitigation measures and seek agreement from SO;
- Review the current situation and the EM/ECO's and SO's implementation of the mitigation measures;

- Engage the EM/ECO to undertake additional monitoring and auditing to verify the complaint if necessary.
 Ensure that any valid reasons for complaints do not re-occur by revising the work methods, procedures, machines and/or equipment, etc.;
- Submit a complaint report (as well as the implementation of mitigation measures and the effectiveness of the mitigation measures as advised by the EM/ECO) to the Project Owner, RTO and the SO; and
- Log a record of the complaint, investigation, follow-up actions and the results in the environmental audit reports.

The EM/ECO and SO should provide all the necessary information and assistance to the PRO in order to complete the complaint investigation. Following the investigation, the Contractor should promptly undertake the mitigation measures. The PRO and SO should ensure that the measures have been appropriately implemented. The Contractor, RTO, and SO should also be responsible for the reporting of complaint investigation results and followed up actions to the Project Owner. The complaint investigation report and corrective action plan should be prepared and approved by LTA and/or other relevant Authorities within 24 hr upon receipt of complaints.

13.5 Roles and Responsibilities during Operational Phase

This section describes the roles and responsibilities of the EMMP members presented on the organisational chart for operational phase in Section 13.3.

13.5.1 Technical Agencies/Authorities

Consultation and engagement with the technical agencies/authorities (e.g. NParks, PUB, NEA, etc) may be required if there are any major environmental concerns affecting their property, land boundary and/or related to the respective scope of responsibilities, or when inputs from technical agencies are necessary in addressing any major public complaints due to environmental incidents arising from the rail operation (if any) of this Project.

13.5.2 Project Owner (LTA)

The Land Transport Authority (LTA) is a statutory board in Singapore under the Ministry of Transport responsible for public transport in Singapore, which is also the Project owner for this Project.

During the operational phase, under LTA's New Rail Financing Framework (NRFF), LTA owns the rail operating assets (e.g., trains, signalling system) and other associated infrastructure (e.g. viaducts, tunnels, tracks). The role of LTA as the owner involves making decisions on building-up, replacement and upgrading of the rail operating assets and infrastructure, while the licensed rail operator (e.g., SMRT Trains, SBS Transit) is responsible for the operation and maintenance of those assets and infrastructure.

LTA oversees the rail operations and management of the rail operator during the operational phase. In terms of environmental management, the responsibility of LTA includes:

- Regulate the rail operation and maintenance through the stipulated Operating Performance Standard (OPS),
 Maintenance Performance Standards and ISO14001 Environmental Management System;
- Ensure resources and appropriate personnel are available to achieve the environmental requirements;
- Provide leadership in maintaining overall environmental performance;
- Ensure all environmental incidents and near misses are promptly investigated and reported by the rail operator;
- Resolve any environmental non-compliance issues with the assistance from the rail operator; and
- Record, respond to, and action any complaints from members of the public, if any, with inputs from the Technical agencies, if required, and
- Liaise with the Technical Agencies regarding any relevant issues arising from the environmental incidents, or environmental reporting and submission (if any) by the rail operator.

13.5.3 Rail Operator

As mentioned in Section 13.5.2, the role of rail operator (e.g. SMRT Trains, SBS Transit) is to operate and maintain the rail operating assets and infrastructure of the owner (LTA) which is governed under the NREF regulatory framework.

The responsibilities of rail operator shall include:

- Operate and conduct maintenance by complying with LTA's Operating Performance Standard (OPS),
 Maintenance Performance Standards and ISO14001 Environmental Management System;
- Allocate sufficient resources and appropriate personnel in maintaining environmental, health and safety
 of the rail operation;
- Appoint and work with EHS officer or equivalent to ensure environmental, health and safety of rail operations;
- Form an Environmental Management Committee who manage the overall environmental performance and for the decision-making in resolving any environmental-related issues reported by the on-ground rail operators and/or the EHS Officer, which include:
 - Investigate any environmental incidents or near misses identified by the EHS Officer and the onground rail operators, and report promptly to LTA;
 - Record, respond to, and take action on any complaints from members of the public, if any, with inputs from the Technical agencies, if required, and
 - Reporting to LTA and relevant Technical Agencies regarding environmental-related issues.

13.5.4 EHS Officer (or Equivalent)

In general, EHS Officer appointed by the rail operator is responsible for the overall environmental, health and safety during the operational phase of the Project. In terms of environmental management, the EHS Officer is required to:

- Conduct regular site inspections to ensure proper housekeeping as well as implementation of the minimum control measures and the proposed mitigation measures for operational phase in this document;
- Identify, record and report promptly any environmental non-compliance issues, incidents and near misses to the Environmental Management Committee; and
- Report the results of the environmental monitoring program, and any required changes, to meet the requirements of the EMMP to the rail operator and/or LTA in a timely manner.

13.5.5 Public Relation Officer (PRO) for Complaint Handling

The Public Relation Officer (PRO) is responsible for handling complaints and managing feedback and investigative work. The PRO shall be supported by the Project Owner, rail operator, EHS Officer and any other relevant parties.

- During the operational phase, upon receipt of complaints, the PRO should undertake the following procedures:
- Log the complaint and record the date when the complaint is received onto the complaint database and inform the rail operator and EHS Officer immediately;
- Investigate the complaint with the rail operator's Environmental Management Committee and EHS Officer to determine its validity and assess whether the source of the problem is due to operational works;
- If a complaint is valid and due to operational works, liaise with the EHS Officer on the mitigation measures and seek agreement from the rail operator's Environmental Management Committee;
 - Review the current situation and the EHS Officer's implementation of the mitigation measures;
 - Engage the EHS Officer to undertake monitoring works for inspection purpose as well as to verify the complaint if necessary. Ensure that any valid reasons for complaints do not re-occur by revising the work methods, procedures, machines and/or equipment, etc;
 - Submit a complaint report (as well as the implementation of mitigation measures and the effectiveness of the mitigation measures as advised by the EHS Officer) to the rail operator and/or LTA; and
 - Log a record of the complaint, investigation, follow-up actions and the results in the environmental inspection report.

The PRO should work with the rail operator's Environmental Management Committee and EHS Officer to gather all the necessary information and resources necessary to complete a complaint investigation. Following the

investigation, the Project/ Operation Manager (who leads the Environmental Management Committee) and EHS Officer shall undertake appropriate mitigation measures. Follow-up is required by the PRO to ensure that the mitigation measures have been appropriately implemented. The complaint investigation report and corrective action plan should be prepared and approved by LTA and/or other relevant Authorities within 24 hr upon receipt of complaints.

13.6 Biodiversity EMMP Requirements

13.6.1 Construction Phase

At the construction phase, EMMP for both flora and fauna are essential in minimising and managing construction impacts. It is important to note that EMMP for Interfacing Contracts at Site I is likely to run concurrently with this programme, and cooperation is expected to ensure cumulative impacts are effectively managed and kept to a minimum.

13.6.1.1 Flora and Arboriculture Monitoring Programme

The flora and arboriculture monitoring aims to assess the impacts of construction to vegetation and habitat, such as tree health, unauthorised and/or excessive vegetation removal, edge effects, habitat degradation from soil erosion, and rubbish dumping. The programme should include the following:

Arboriculture Monitoring Programme should include the following works:

- Monitoring of the condition of trees at the new forest edge to determine the physiological health and structural stability of trees as edge effects can lead to die back of canopies, and branch and structural failures.
- Review of method statements of construction works in proximity to retained trees, if any, to determine if additional tree removal is required post-site clearance.
- Recommendation of solutions such as design changes, reduction of working space, reduction of TPZ area and reassessment of trees in cases of conflict with proposed works.
- Assessment of physiological health, vigour and structural stability of retained trees. Recommend additional mitigating measures if necessary.
- Assessment of the condition of retained trees, if any, to ensure that there has been no deterioration or mechanical damage and to determine if additional tree removal is required.
- Assessment of the condition of the newly planted tree strip adjacent to the newly created freshwater marsh to determine effectiveness of reforestation.
- Where a tree exhibits signs of stress, the Arborist should inspect the tree and advise on strategies to
 reduce further impacts and rehabilitation measures. Where monitoring indicates that drying out or edge
 impacts are occurring, remediation measures shall be undertaken. These measures may be temporary
 (such as carrying out watering when there is seven continuous days without rainfall). Long-term solutions
 shall be investigated and implemented.
- Inspection of the integrity of TPZs.
- · Identification of excessive or unauthorised tree removal.

Flora Monitoring Programme should include the following works:

- Monthly flora inspections shall be conducted within the worksite boundary, in forested areas adjacent to the worksite up to 15 m from the hoarding and at the created freshwater marsh (at Sites IV and V only).
- Identification of any unauthorised removal of flora within areas of conservation or beyond the demarcated Project worksite.
- Identification of direct/indirect impacts to sensitive vegetation and habitats. Such impacts include soil
 erosion and degradation that has resulted from construction activities, and unauthorised dumping of waste
 material, construction debris or oil/chemical leakage.

- Identification of forest edge effects and recommendation of mitigation measures where necessary (Figure 13-3).
- Assessment of the status of invasive flora species and weeds and recommendation to remove them where necessary.
- Inspection of areas cleared of weeds to detect any seedlings of invasive species.
- Monitoring of the health of all retained and planted flora, including identification of diseases and recommendations for treatment.
- Monitoring of the establishment of aquatic and surrounding flora in the created freshwater marsh at Sites
 IV and V (i.e., species richness and vegetation percent cover) and recommendation of management
 where necessary.



Figure 13-3 Monitoring of Vegetation and Trees along the Hoarding Line for Unauthorised Vegetation Clearance and Forest Edge Effects.

13.6.1.2 Flora and Arboriculture Management Programme

The flora and arboriculture management programme aims to manage all matters related to the adequate and successful conservation of trees and vegetation within and adjacent to the contract boundary (up to 15-m from the contract boundary) and created freshwater marsh (Sites IV and V only). The programme should include the following works:

Arboriculture Management Programme should include the following works:

- Tree Mapping and Assessment
 - Trees within the worksite boundary, including any construction access roads, and newly planted tree strip adjacent to the newly created freshwater marsh shall be mapped and assessed by the Arborist before work commencement. These specimens shall be tagged with a unique serial number.
 - 2. The physiological health, presence of pests and diseases, and structural stability shall be assessed for all trees, single-stemmed palms and strangling Ficus species of ≥ 1.0 m girth or spread, respectively.
 - 3. Species of conservation significance—i.e., listed in Chong et al. (2009) as nationally Vulnerable, Endangered, Critically Endangered or Presumed Extinct (which indicates a rediscovery)—of ≥ 0.3 m girth or spread shall also be assessed. The locations, girth/spread, and height of these specimens shall also be recorded. These specimens shall be tagged with a unique serial number.

- 4. The trees to be felled or retained shall be determined by the Arborist.
- 5. A photographic report shall be provided for the trees affected by the proposed works.
- 6. No trees shall be felled without prior approval from NParks.

Tree Protection

1. Where there are trees to be retained within the worksite, specifications shall be formulated by the Arborist for the setting up of tree protection zones (TPZ) to meet NParks requirements (Appendix W).

Sapling Harvesting

- 1. Viable saplings and conservation significant trees that are suitable for harvesting shall be identified by the Arborist. Saplings or trees suitable for transplanting should:
 - Exhibit good physiological health and vigour
 - 2. Have no structural defects
 - Have good branch form
- 2. The root ball size to be extracted shall be based on the girth of the saplings or trees to be harvested as specified in Table 13-1.
- 3. Prior to transplanting, dead branches and climbers shall be cleared from the plant and canopy load and spread will be reduced where necessary, in consultation with the Arborist.
- 4. Manual trenching shall be carried out to determine the shape and size of root ball to be extracted. Where possible, feeder roots shall be retained without cutting.
- 5. The root ball shall be bur lapped with cellophane sheet to reduce desiccation effects. When directed by the Flora specialist or Arborist, leaves of the canopy may also need to be enclosed and covered by cellophane or clear plastic bags.
- The root ball shall be secured to the trunk to reduce risk of root ball disintegrating.
- 7. When handling/carrying the plant, care shall be taken not to damage any vegetative parts.

Tree Transplanting

1. Where trees and vegetation are moved or translocated within the Project area, the Arborist shall review the method statement proposed by the tree transplanting contractor and advise on additional recommendations necessary to ensure the tree's health during transplanting. The transplanting contract shall ensure in their best effort, intact and secured root balls at the point of extraction, during the lifting processes and during the installation at the receiving site. The transplant effort shall be documented for each individual tree to show intact root balls at all the stages mentioned. Transplanted trees shall be managed through adequate watering and monitoring of their health to ensure their long-term survival. Advice shall be sought from the Arborist if the tree exhibit signs of stress, e.g. peeling bark, withered leaves.

• Site Clearance and Tree Felling

- The Contractor's method statements for site clearance, tree felling and setting up of TPZ shall
 be reviewed by the Arborist to ensure compliance to the specifications. The site clearance and
 tree removal method statements shall consider directional felling methods with a hinge and back
 cut. Trees shall not be removed by pushing with an excavator or other heavy machinery. Cranes
 shall be deployed to offset the tension of trunks in the direction of the drop. Interlocking canopy
 branches shall be pruned prior to tree felling.
- 2. In cases where design changes may affect additional trees or the retained trees, the Arborist shall work with the structural engineers and recommend solutions that will meet NParks guidelines.
- 3. Whenever reasonable and practicable, cleared vegetation at sloped areas shall be covered with mulch or with 100% biodegradable fauna-friendly ECBs to control erosion of exposed soil. Exposed ground shall be revegetated as soon as possible to stabilise surfaces and minimise reentrainment of dust and potential for erosion of waste spoil to watercourses.
- 4. Clearance activities on-site shall not occur during rainfall or when storm events are forecast to occur within the vicinity to protect forest edge from wind throw. Where forest edges are exposed to wind, temporary measures (e.g., additional hoarding) shall be discussed with the Arborist, and put in place to protect the forest edge during storm events.
- 5. During site clearance, care will be taken when removing trees in riparian zones to reduce impacts to the bed and banks of waterways.
- 6. Where practicable, saplings, seeds and seed banks will be retained within the soil profiles for use in forest restoration.
- 7. Horticultural waste shall be removed on the same day. This is essential to reduce risk of fauna taking refuge within the cleared waste if left overnight

• Tree Maintenance and Care

- Where disease outbreaks are identified, the Arborist and/or Flora Specialist shall advise
 measures to manage them. Measures can include using selected insecticides/fungicides to
 control outbreaks; reduction of stressors (dust, water, etc.). The plant may be removed or
 quarantined if it poses a threat to surrounding individuals.
- Where forest edges are exposed following site clearance and where impacts to vegetation are
 evident (e.g., vegetation shows signs of drying out), additional watering shall be carried out to
 improve moisture differentials around forest edges.
- 3. The use of herbicides, pesticide shall be minimised. If herbicides or pesticides are used within the Project area, techniques that limit spray or non-target spray drift shall be used. These techniques include but are not limited to cut and paint techniques and drilling injection. All use of herbicides and pesticides shall be conducted in accordance with the relevant Material Safety Data Sheet (MSDS). Any incidents of off label use, spillage or damage to non-target species shall be reported and investigated.
- 4. When the site experiences seven continuous days without rainfall, the Contractor shall carry out additional watering of conserved trees within the TPZs and at the forest edge (up to 10 m) around the development boundary.
- 5. Post heavy rainfall, any snapped hanging branches that pose imminent hazards to workers within the site should be removed immediately

Girth (m)	Minimum root ball diameter to extract (m)
<0.1	0.4
0.1–0.2	0.6
0.2-0.3	0.8
0.3–0.4	1.2
0.4–0.5	1.5
>0.5	To be determined by Arborist

Flora Management Programme should include the following works:

- A. Verification and Review of Footprints for Hoarding, Access Roads and Soil Investigation Works
 - After the worksite's and planned road works' hoarding has been installed, the Flora Specialist shall conduct and inspection to verify that the footprint is as proposed, and that no excessive vegetation and tree removal has occurred because of deviations in the hoarding alignment.
 - The Flora Specialist shall review the proposed locations for the soil investigation works and the
 alignment of the construction access roads with the Client/Contractor. Feasible alternatives, if
 possible, shall be proposed to minimise vegetation and tree clearance.
- B. Weed and Invasive Species Management
 - Weeds and invasive species shall be cleared from the Project area progressively and shall be separated and transported to an appropriate disposal location. Transport shall occur within a covered vehicle to ensure seed/vegetative matter does not dislodge. All vegetative matter and seeds will be rendered inert at the disposal location through incineration at a licensed waste disposal facility. The Project area shall be carefully cleared of all remaining vegetative matter from the weeds/invasive species. Herbicides may be used to render any stumps/root systems inert. The cleared area shall be inspected monthly to detect any seedlings of invasive species. These seedlings shall be killed using approved herbicides or removed by hand weeding. Any seedlings or vegetative matter that may sprout will be disposed of at a licensed waste management facility.
 - Specific measures shall be undertaken to control and manage flora species within the Project area that have been identified to be invasive (i.e., Spathodea campanulata, Cecropia pachystachya, Falcataria moluccana). The Ecologist shall be consulted when managing Falcataria moluccana groves as tall trees may serve as nesting sites for birds of prey. The Ecologist shall also be consulted for other weed and invasive species that may also provide important foraging resources. Material imported into the Project area shall be checked for contamination from weeds/invasive species seeds/vegetative matter at source. This is particularly important for imported building materials, such as clay and soil. Source site shall be inspected to determine presence of weeds/invasive species. Where weeds or invasive species

are identified, alternative supply sources or decontamination shall occur before the material is transported to site.

- C. Reforestation Planting Palette and Plant Salvaging for Reforestation and Landscaping
 - The planting palette including all flora and grasses used for reforestation and other landscape planting shall be from native indigenous stock or non-native species that are not listed as weeds or invasive species or have a low seeding rate.
 - All trees transplanted into the Project area shall have local provenance or will be from within the
 Johor region for all SRDB and IUCN listed species. Other species shall be obtained within the
 larger Sunda region. Due diligence shall be conducted on suppliers to ensure that the trees are
 obtained by legal means and are able to be exported/imported to Singapore. All imported trees
 shall be inspected and/or undergo quarantine if required to reduce the chance of transmission
 of weeds and soil pathogens.
 - Specifically, enhancement planting should be conducted at the affected native forest patch prior to construction works at Sites I to III a small section of the mitigated worksite is situated at the native-dominated secondary forest patch at Site II, which will shrink the width of the forest strip by one-third and introduce more edge effects. To avoid potential habitat fragmentation and maintain ecological connectivity, it is recommended to enhance the existing shrubland patches within the strip by planting trees and shrubs (Figure 13-4). The planting scheme should be as similar to forest composition to adjacent forest, if not as native as possible.
 - The success of planting within landscape features shall be monitored. Where a planting strategy is not working, an alternative planting strategy shall be developed suitable for the location. Temporary measures shall be employed to reduce stress on planted individuals. The removal of sources of stress (such as dust) may also be required. If disease outbreaks are present, methods shall be used to control the outbreak or remove the diseased individual.
 - The flora specialist shall also identify other plant material, including ferns, epiphytes, orchids, shrubs, grasses, etc. that are of conservation value and work with NParks for the extraction of these plants by NParks to other sites. This includes the nationally Vulnerable pitcher plants, Nepenthes rafflesiana and Nepenthes ampullaria, and the uncommon hybrid Nepenthes × trichocarpa at the affected scrubland in Site V, if any. The pitcher plants are to be transplanted to the created freshwater marsh area or other suitable areas, in consultation with NParks.
 - The flora specialist shall formulate a salvaging protocol in consultation with NParks if salvaging
 of plant material is being carried out on site.



Figure 13-4 Proposed enhancement planting of scrubland patches at Turf City

The flora specialists, arborists and the arboriculture contractor engaged should meet the expected qualifications as described in Section 13.4.4.4, Section 13.4.4.2 and Section 13.4.4.3, respectively.

Additionally, the Contractor should fulfil the following:

- The Contractor and the attending arborist shall complete the 'Verification of Tree Protection Checklist' prior to the start of site clearance (refer to Appendix W: Annex A); and
- The Contractor shall instil discipline and raise awareness amongst all personnel on measures and mitigations to prevent damage to retained and protected trees throughout construction by including reminders on tree conservation guidelines within their daily toolbox briefings to workers and crane/excavator operators

13.6.1.3 Fauna Monitoring Programme

Fauna monitoring surveys should comprise of transect surveys and site inspection surveys conducted together, at within and outside of hoarded areas. The programme should include the conducting of monthly diurnal and nocturnal fauna and site inspection surveys beginning one month prior to construction.

This should also include monitoring of proposed species specific mitigation measures as follows:

Specific Mitigation Measures to be Implemented

The specific mitigation measures mentioned here are to be implemented prior to work commencement on site at CR14 Turf City.

- Road Calming Measures Road signages and/or speed limitation and/or road humps to be constructed
 along planned road works (replacing part of Turf Club Road), remaining Turf Club Road, Fairways Drive
 Road and small roads in the vicinity (including golf course areas). Besides, arrangement of trucks shall
 be optimised as such number of truck trips (e.g. using tri-axle truck, conveying truck in two or three rather
 than individually) can be minimised.
- Road barrier installation along planned road works (part of Turf Club Road) all roads with planned road works should be lined with hoarding, noise barriers, water barriers or road barriers (Figure 13-5), whichever applicable.
 - Where the road barriers/ water barriers are used, they should be at least 0.5 m to 1 m in height, with overhang and be made with a smooth material to prevent pangolin from scaling it (Figure 7-90). The barriers will also be useful in minimising roadkill of snakes. This measure should be done in tandem with the mitigation measures for concurrent works in the same area.
 - When the hoarding or noise barriers are used, they should follow requirement stated in Section 13.6.1.4 (Fauna Management Pre-Site Clearance, D).
- Colugo pole installation in large ECM tanks include climbing pole structures and nets in large ECM tanks
 (Figure 7-91) to ensure colugos can avoid drowning and safely climb out if they fall in. In the event colugos
 are found in the ECM tanks, the Fauna Response and Rescue Plan will be activated immediately.

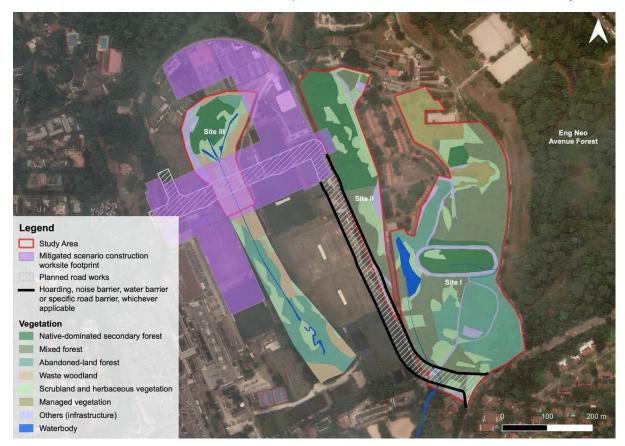


Figure 13-5 Proposed lining of planned road works at Turf City

The specific mitigation measures mentioned here are to be implemented prior to work commencement on site at CR15 Holland Plain.

- Road Calming Measures Road signages and/or speed limitation and/or road humps to be constructed
 along Old Holland Road. Besides, arrangement of trucks shall be optimised as such number of truck trips
 (e.g. using tri-axle truck, conveying truck in two or three rather than individually) can be minimised.
- Extension of hoarding line hoarding should extend to include the road works section between Holland Plain and Clementi Forest to prevent roadkill, especially of ground-dwelling pangolin (detailed requirement of hoarding installation in Section 13.6.1.4).
- Created freshwater marsh monitoring Monitoring for the created freshwater marsh should be monthly for a duration of at least 5 years (following the end of the design contract for the new marsh) or till the end of construction of CR15 entrance 4, whichever is longer. Monitor fauna species richness (taxa should include minimally bees, odonates, birds, herpetofauna) and habitat establishment at the created freshwater marsh, to determine if the construction has damaged or affected it, as part of the EMMP. The presence of trapped/injured/dead fauna, fauna entrapments, usage of implemented measures shall also be noted during monthly faunistic surveys or site inspections. The Contractor shall make comparisons with the EIS findings at the existing marsh to determine fauna establishment, draw correlations with water quality parameters if any, make recommendations and perform maintenance works where necessary, in consultation with NParks and Contractor designing the marsh. Should assisted reintroduction of fauna be necessary, a proper assessment of its feasibility should be done. Monitoring location of the created marsh is subjected to further confirmation on its design.

Monitoring of Specific Mitigation Measures Implemented

Monthly inspections of specific mitigation measures implemented such as rope bridges and culverts (if any) should be included as part of the EMMP. The following shall be noted during inspections.

- Visual inspection of structure to determine if the construction has damaged or affected them.
- Presence of trapped/injured/dead fauna.
- · Potential fauna entrapments.
- Usage of implemented measures. This can be done as part of fauna surveys or site inspection. If necessary, camera traps should be used to help with monitoring.

Monthly Faunistic Surveys

Fauna monitoring surveys should comprise of transect surveys and site inspection surveys conducted together, at within and outside of hoarded areas. In addition, the fauna monitoring programme should be extended to the created freshwater marsh (at Sites IV and V only). The programme should include the conducting of monthly diurnal and nocturnal fauna and site inspection surveys beginning one month prior to construction.

Faunistic surveys are recommended to be conducted along terrestrial sampling routes and aquatic sampling points undertaken during the baseline studies (Figure 13-6 and Figure 13-7) and at the proposed location of the newly created freshwater marsh (at Sites IV and V). Monitoring location of the created marsh is subjected to further confirmation on its location and design. This will include diurnal and nocturnal surveys and terrestrial transect will have to be conducted in reverse direction on alternate months. All fauna encountered shall be identified to species, or the lowest taxonomic level possible. The locations of all fauna sightings shall be recorded using a handheld GPS. Important behavioural observations (e.g., displaying, guarding, mating, ovipositing) and plant species that the fauna was observed to be feeding, laying eggs, or nesting on, shall be recorded.

Subsequently, camera trap monitoring will also be installed and maintain camera traps together for the purpose of monitoring impacts to fauna species within the study site during construction phase. Camera traps will be situated as closely as possible to those deployed during baseline studies. In the event camera trap location falls within worksite, monitoring location would be removed. The camera traps will be deployed at approximately 20–30 cm above ground. They should be operational 24 hr a day and programmed to record a 10-s footage per trigger with a 10-s quiet period following each trigger. Camera trap maintenance and data retrieval should be carried out at least once a month.

All methodology for the faunistic surveys should closely follow that implemented for this EIS, so as to ensure that the data collected can be used to compare against the baseline data. Comparison of species presence can be made with the baseline studies, where appropriate, to provide an indication of the changes in fauna diversity. Details

of the surveys should be determined in consultation with NParks and should take into account construction phases, final construction footprint, final development hoarding plan, and baseline studies.

Surveys should target the following fauna groups detailed in Table 13-2.

Table 13-2 Summary of Survey Methods for Each Faunal Group at Turf City and Holland Plain

Faunal Group	Survey Timing (h)	Description
Odonates	0900– 1600	 Diurnal visual encounter surveys along three terrestrial sampling routes¹ and diurnal point counts at 14 aquatic sampling points²
Butterflies	0900–1600	 Diurnal visual encounter surveys along three terrestrial sampling routes¹
Freshwater Decapod Crustaceans And Fish	0900–1600, 2000–0000	 Diurnal point count surveys with tray-netting at 14 aquatic sampling points² Nocturnal point count surveys with spot-lighting at 14 aquatic sampling points² Minnow trapping at 10 strategic locations along waterbodies (for fish)²
Herpetofauna (Amphibians And Reptiles)	0700–1600, 2000–0000	 Diurnal and nocturnal visual and auditory encounter surveys along three terrestrial sampling routes¹ Diurnal and nocturnal point count surveys at 14 aquatic sampling points²
Birds	0700–1000, 2000–0000	Diurnal and nocturnal visual and auditory encounter surveys along three terrestrial sampling routes ¹
Non-Volant Mammals	0700–1000, 2000–0000	 Diurnal and nocturnal visual and auditory encounter surveys along three terrestrial sampling routes¹ Terrestrial camera traps at 10 locations³
Bats	2000–0000, 1830–2100	 Nocturnal visual and auditory encounter surveys along three terrestrial sampling routes¹ Visual roost emergence surveys conducted between 1830 h and 2100 h for nine bamboo clusters⁴ within 20 m of worksites and planned road works

For Sites IV and V,

¹ Part of the terrestrial sampling route should be altered from the EIS to accommodate for the monitoring of the created freshwater marsh, but exact route is subjected to further confirmation on its design

² Aquatic sampling points include a monitoring location at the created freshwater marsh, but exact location is subjected to further confirmation on its design

³ Affected terrestrial camera trap CT_21 to be shifted further south of the EIS location to avoid worksite

⁴ An additional one bamboo cluster on top of the EIS has been included as it lies within 20 m of the planned road works (Figure 13-8)

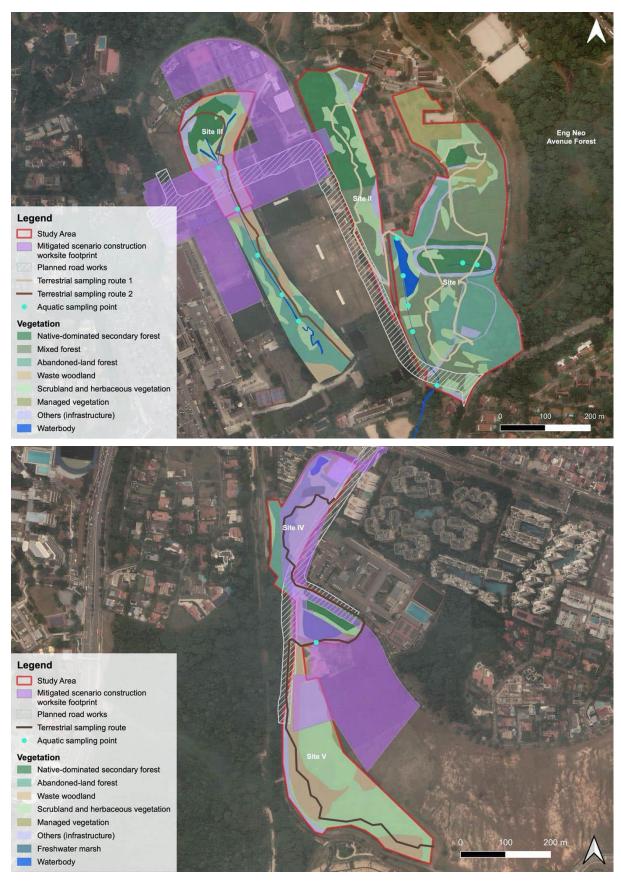


Figure 13-6 Locations of Terrestrial Sampling Routes and Aquatic Sampling Points at Turf City (above) and Holland Plain (below)



Figure 13-7 Locations of Terrestrial Camera Traps at Turf City (above) and Holland Plain (below)



Figure 13-8 Locations of Bamboo Clusters for Roost Emergence Surveys at Holland Plain

Site Inspections

Monthly fauna inspections shall be conducted by the Ecologist within the worksite boundary. The following shall be noted during the inspections (Figure 13-9):

- Visual inspection of sensitive habitats in the vicinity (e.g., streams, forests) to determine if the construction has damaged or affected them
- Presence of trapped/injured/dead fauna
- Potential fauna entrapments (e.g., ECBs, TPZs, pits, drains, ponds, trenches, tanks)
- Gaps in hoarding that may allow entry of ground-dwelling fauna
- Improperly disposed/stored food and food packaging
- Degradation of adjacent sensitive habitats (e.g., streams, forest)
- Daily roadkill surveys shall be conducted by the ECO along roads adjacent to the worksite, up to 500 m from the worksite boundary. A roadkill and investigation register shall be maintained. Appropriate mitigation measures shall be implemented where necessary.
- · Reporting and documentation of all findings and recommendations.



Figure 13-9 Photographs Showing Monthly Fauna Monitoring and Inspection On-site.

13.6.1.4 Fauna Management Programme

Fauna management will consist of managing fauna within and around all designated work areas. It consists of presite clearance inspections and continued biodiversity awareness training for the site team, tree felling inspections, and fauna response plan in event of animal encounters. The objectives of fauna management are as follows:

- Minimise negative impacts to fauna, particularly to species of conservation interest;
- Inspect hoarded areas for any compromises that may allow smaller-sized animals to enter;
- Prevent human-wildlife conflicts;
- Monitor presence of trapped/injured/dead fauna inside hoarded areas;
- Monitor and compare presence of targeted fauna groups within and outside of hoarded areas; and
- During each survey, fill out Fauna Inspection Form (Appendix V).

Biodiversity Awareness Training

The Ecologist shall conduct toolbox briefings on biodiversity awareness to inform site personnel of but not limited to the following:

- Ecological value of the site and its surrounding habitats
- Types of fauna present
- Biodiversity protection strategies
- Site personnel's responsibilities towards biodiversity
- How to respond to fauna encounters
- · No feeding of wildlife
- · Prevention of roadkill
- Inspection of trees before felling

All site personnel shall undergo biodiversity awareness training prior to commencing work at on-site, and regularly (every six months) throughout the duration of the construction. Documentation of such trainings and briefings shall be maintained.

Fauna Management Pre-Site Clearance

- A. The objective of fauna management pre-site clearance is to remove target fauna from the worksite before construction works begin to prevent fauna entrapment, injury and mortality, whilst minimising contact between human and wildlife.
- B. Target fauna species include ground-dwelling mammals such as the Wild Pig (*Sus scrofa*) and Sunda Pangolin (*Manis javanica*), as well as animals that may be implicated in human-wildlife conflicts (e.g., snakes) during passive wildlife shepherding.
- C. Sapling harvesting, if necessary, should be carried out prior to site clearance.
- D. Hoarding Installation
 - Hoarding installation shall be completed by the Contractor, leaving a 2–6-m wide gaps as the wildlife exit point. The wildlife exit point shall be located away from roads. The suitability of the exact location of the exit point shall be confirmed on-site by the Ecologist to ensure that shepherded fauna can exit into a forested area with ample cover to minimise stress and the possibility of roadkill.
 - Any wild boar must first be removed, before undertaking any other clearance on-site. There
 should be no 2-6m wide gaps within the hoarding at the boundary until all wild boars have been
 removed from the site. Following the removal of all wild boar, the site should be hoarded up
 completely to prevent wildlife re-entering."
 - The hoarding shall be at least 2.4-m high, with the surface facing the worksite coloured in white so that it is visually apparent to fauna.
 - The sequence of the hoarding installation shall be reviewed by the Ecologist to ensure that disturbance generated by the hoarding installation activities does not cause fauna to venture onto adjacent roads (i.e., it is to commence from the side of development nearest to the road first, moving inwards, so as to prevent any roadkill).
 - After hoarding installation is completed, the Ecologist shall inspect the hoarding to ensure its integrity and ability to prevent fauna entry/exit. The hoarding must not have any gaps between the panels and are to extend at least 300mm into the ground.
 - The access gates, when shut, must not have any gaps between the panels and must be flushed as closely to the ground, as possible.
- E. Pre-site Clearance Camera Trap Monitoring
 - Camera traps shall be deployed within the hoarded worksite at a density of approximately one camera trap per 1 ha over a period of at least seven days prior to site clearance. Additional camera traps may be needed on request from NParks or Ecologist.

- The camera traps shall be approximately evenly spaced throughout the worksite and targeted at strategic locations with signs of fauna use (e.g., clearings, burrows, nests).
- The camera traps and the data shall be retrieved one to two days before the day site clearance is slated to commence to determine the species that are likely to be encountered during the site clearance.
- Prior to site clearance, site clearance personnel shall be briefed by the Ecologist on species that
 are likely to be encountered during site clearance to prepare them for efficient response during
 encounters.

F. Pre-site Clearance Fauna Inspection

- Prior to site clearance, the Ecologist shall conduct a fauna inspection to identify active animal
 nests, hollows, other nesting structures, and any animals that may potentially get trapped/injured
 or die during site clearance (e.g., snakes, Sunda colugo, Sunda pangolin, bamboo bats). Animals
 that may be implicated in human-wildlife conflict (e.g., snakes) shall also be identified.
- Refer to Figure 13-10 for a sample of pre-felling inspection protocol. Refer to Appendix X for Pre-felling Inspection Form.
- The validity of the inspection shall be no more than seven days.
- Where fauna is found to be present on vegetation to be cleared, the affected vegetation shall be
 marked with coloured tags/tape. The fauna shall be allowed to leave on their own prior to
 vegetation clearance. Where eggs, chicks, or young fauna are found in nests, they shall be
 allowed to fledge or leave the nests on their own prior to vegetation clearance. The Ecologist
 shall conduct subsequent checks to ascertain that the fauna has left prior to vegetation
 clearance.
- Where it is not possible or ideal to allow the fauna to leave on its own (e.g., a stranded Sunda colugo that is unable to move away on its own, a venomous snake that is feasible to catch) relocation shall be considered and implemented by certified wildlife management contractors, in consultation with NParks and in accordance with the Fauna Response Plan.
- Where the Ecologist deems there is a risk of injury/death to fauna even though there were no
 immediately apparent findings during the inspection (e.g., nest in good condition but fauna
 activity not observed/visible), the Ecologist shall be present on-site during the removal of the
 affected vegetation to facilitate the implementation of the Fauna Response Plan where
 necessary.
- Elevating equipment shall be deployed where necessary and feasible to inspect nests, hollows and other nesting structures.
- Ecologist shall submit an inspection report indicating the date of the inspection, tree tag number (and/or location coordinates if untagged), observations, recommended mitigation measures, and photographic evidence within 24 h of the inspection.
- Where bamboo clusters are to be removed, the following steps shall be carried out:
- The Ecologist shall determine if the affected clusters are potential roosting sites for bamboo bats (*Tylonycteris sp.*).
 - (i) If determined to be a potential roosting site, the Ecologist shall carry out a bamboo bat roost emergence survey to determine the presence of bamboo bats. The roost emergence survey shall be carried out at least once for each bamboo cluster. The surveys shall occur between 1830–2100 h, during which two to three Ecologists shall be stationed around each bamboo cluster to observe for bamboo bat activity, and to identify slits in the bamboo stems that are used as roosts. Torches shall be used to aid in the detection. Stems bearing active slits shall be marked, and the number of bats residing within each slit shall be documented.
 - (ii) Bat detectors shall be deployed to detect the ultrasonic echolocation calls to aid in species identification.
 - (iii) If bamboo bats are determined to be present in the affected bamboo clusters, they should be rescued and released. Prior to the removal of the bamboo clusters, the Ecologist shall seal the slits of identified roosts with mesh and tape if feasible, and the section of the bamboo stem bearing the roost shall be cut with a chainsaw or hand saw and lowered in a controlled manner, ensuring that the section remains intact. The bamboo bats shall be held in the extracted bamboo stems if they are still intact. If not, the bamboo bats shall be vacated into individual cloth bags.
 - (iv) The remaining stems of the bamboo cluster shall be cut stem by stem manually (e.g., chainsaw, hand saw, parang) where feasible and deemed safe

to do so. Where manual cutting is not feasible, a grabber excavator may be used to remove the stems bit by bit from the base of the cluster. The stems shall be kept as intact as possible during felling. Each felled stem shall be inspected immediately by the Ecologist for holes that are possibly entrances to roosts of the bamboo bats. All bamboo bats found occupying the bamboo stems shall be held within the bamboo stems if they are still intact. Mesh and tape shall be used to seal the holes of the roosts. If bamboo stems are too damaged to be sealed, the bamboo bats shall be vacated into individual cloth bags.

- (v) If bamboo bats were not determined to be present during the roost emergence survey, the Ecologist may also recommend for the Ecologist to be present during the removal of the bamboo cluster to inspect each stem for roosting bamboo bats.
- (vi) After the bamboo clusters and felled stems have been completely removed from the worksite or destroyed, any rescued bamboo bats shall be released on the spot and tracked visually until out of sight. If the felling of a bamboo cluster cannot be completed by the end of the day (i.e., 1800 h), any rescued bats shall also be released.
- (vii) Should trapped/injured/dead bats be encountered, the Fauna Response Plan shall be activated.
- (viii) Bat handling shall be performed by experienced personnel properly trained in bat handling techniques.
- G. Passive wildlife shepherding involves directional site clearance within the hoarded worksite towards a forested wildlife refuge area. The disturbance generated by site clearance activities is expected to encourage target fauna to move out of the worksite on their own.
 - Where feasible, site clearance shall be scheduled to avoid the peak bird breeding season (March to July) as much as possible.
 - A camera trap shall be placed outside of the wildlife exit point throughout the duration of site clearance to monitor entry/exit of target fauna.
 - Site clearance shall begin furthest from the exit point and gradually move towards the exit point to flush fauna out of the worksite.
 - The wildlife exit point shall be opened by the Contractor before the start of site clearance works each day and closed at the end of each workday and during breaks to prevent fauna from returning to the worksite.
 - Horticultural waste shall be removed on the same day to prevent fauna from using it as shelter.

Fauna Management Post-Site Clearance

- After site clearance is completed, the Ecologist shall conduct a visual inspection of the cleared worksite for target fauna.
- If there are no trapped fauna, the wildlife exit point shall be sealed and the camera trap at the wildlife exit point shall be removed.
- If there are trapped fauna, the Ecologist shall formulate species-specific methods to remove them in consultation with NParks and in accordance with the Fauna Response Plan.

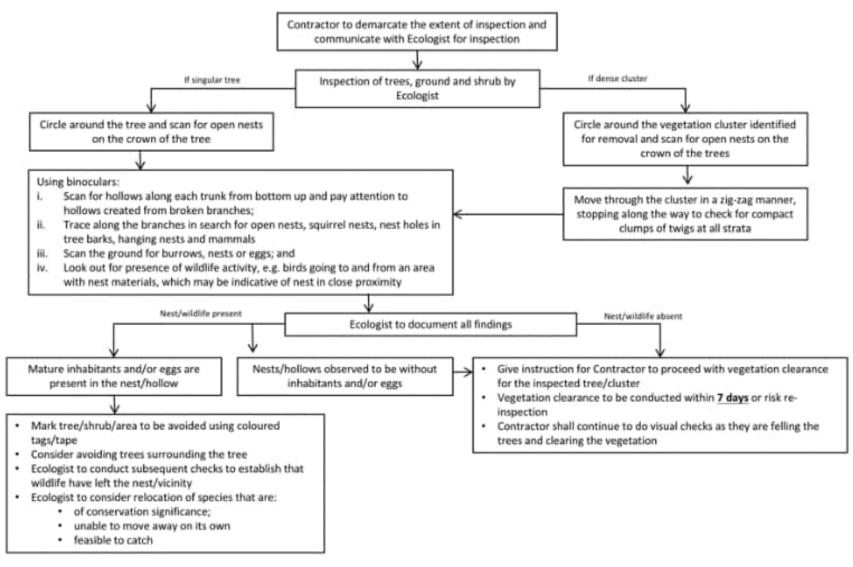


Figure 13-10 Pre-felling Inspection Protocol

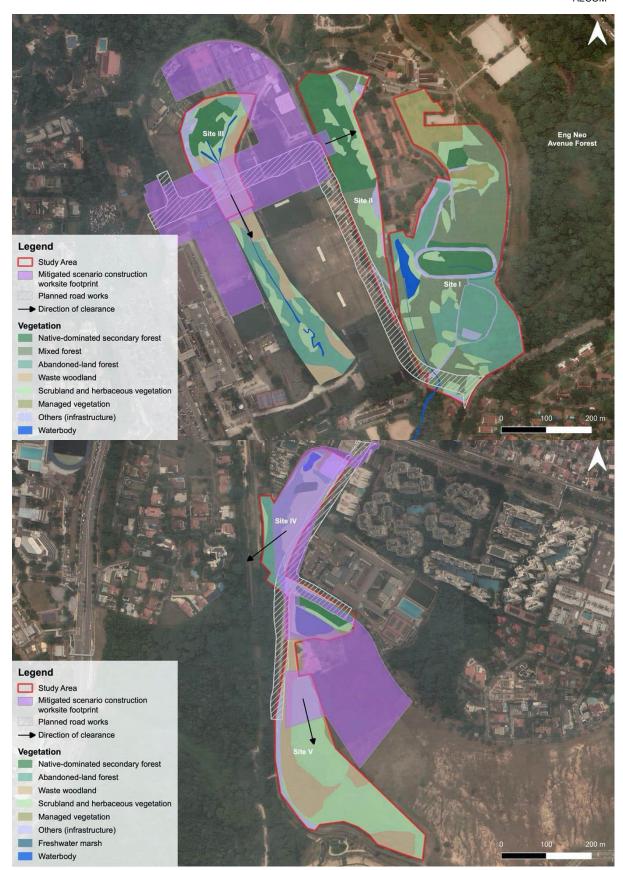


Figure 13-11 Directional site clearance at Turf City (above) and Holland Plain (below)

Fauna Response and Rescue Plan

The Fauna Response and Rescue Plan (Figure 13-13) should be enacted when a trapped/injured/dead/dangerous animal is encountered around or within the worksite. The objective of the wildlife response plan is to minimise animal injury and mortality by responding appropriately to the different scenarios in Figure 13-13. This should be

emphasised during the toolbox briefings. All wildlife encounters are to be documented within 24 h using the Wildlife Incident Form (Appendix U).

Where fauna is trapped on-site, options should be explored to remove them from site (e.g., partitioning worksite, use of one-way exit door) (Figure 13-12).

In scenarios where certain animal groups are encountered around or within the worksite, external specialists should be contacted to handle the animal. These scenarios are shown below:

- For encounters with snakes that require relocation/handling, a snake specialist should be contacted
- For animal carcasses that require disposal, an animal carcass disposal service should be contacted
- · For injured animals that require medical attention, a veterinarian should be contacted



Figure 13-12 Example of One-Way Flap Door to Allow Fauna to Exit Independently.

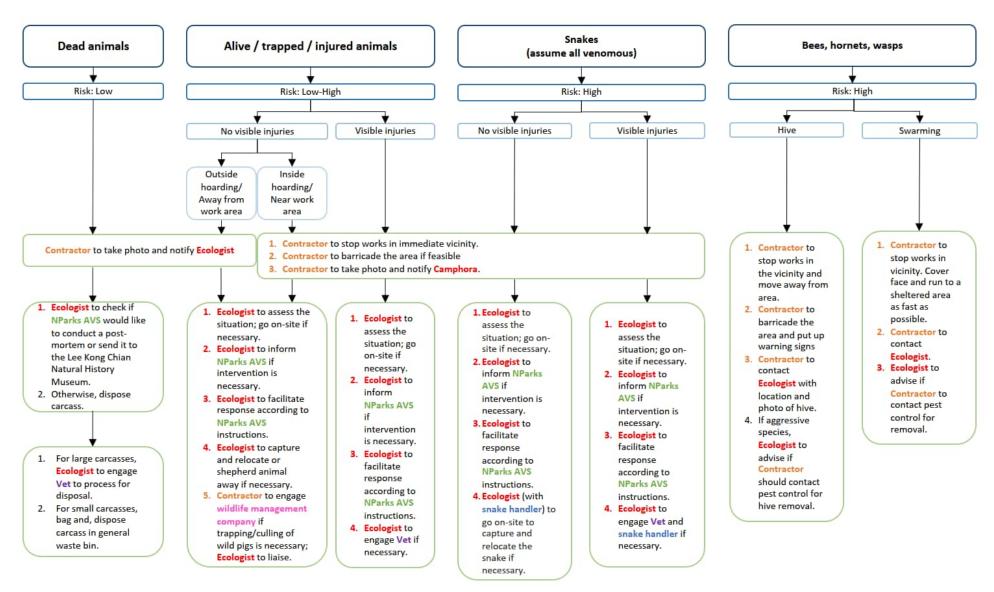


Figure 13-13 A Flowchart of the Wildlife Response Plan

Light Management

Night-time works should be avoided to prevent disturbance to nocturnal fauna. It is recommended to restrict working hours to 0700–1900h. Other light management measures include:

- The Contractor shall submit a site lighting plan (detailing the type of lights, specifications, numbers, locations, and direction) for all anticipated night works as part of the contract-specific EMMP.
- All lighting shall be directed away from adjacent forested areas. Upward and directional lighting into unintended areas shall be avoided.
- Where lighting is required to be installed for safety and security purposes, regulatory requirements shall be followed.
- Reduce the duration of nocturnal lighting sources by using a timer or movement-based sensor system to turn off lights.
- Lights that have a high UV component shall be avoided to reduce impacts on insects.
- Broad spectrum lights shall be avoided.
- Provide mitigation measures such as covers and shields where possible.
- The Ecologist shall conduct regular checks to ensure that lights are positioned as proposed.

Other General Fauna Management Measures

Besides, the Contractor shall be responsible in implementing the other general fauna management measures which include:

- The Contractor shall visually inspect the worksite for wildlife prior to the start of construction activities each day.
- The Contractor shall maintain the integrity of the worksite hoarding and repair any damages/breaches on a timely basis.
- Upon encountering trapped/injured/dead/dangerous fauna, the Contractor shall respond in accordance with the Fauna Response Plan.
- The Contractor shall not touch or handle any fauna unless instructed to do so.
- The Contractor shall implement all mitigation measures recommended by the Arborist, Flora Specialist, and Ecologist, as far as practicable.
- The Contractor shall ensure that all personnel and external visitors limit their movements and activities (including non-work activities such as resting and eating) to within the worksite boundary. There shall be strictly no movements into adjacent forested areas.
- Graphical representations of but not limited to the following shall be posted around the worksite:
 - No feeding of wildlife
 - No fishing
 - o No littering
 - No food or drinks (outside designated eating areas)
 - No cutting of trees or plants
 - No smoking (outside designated smoking areas)
- The Contractor shall deploy only 100% biodegradable wildlife friendly (e.g. loose weave, non-welded mesh, rectangle (elongated) mesh) ECBs.
- The Contractor shall provide designated sheltered eating areas that are wildlife-proof.
- The Contractor shall provide fully covered food storage areas that are wildlife-proof.
- The Contractor shall ensure that all pits, drains, ponds, trenches, tanks that are potential fauna entrapments are suitably covered (e.g., using plywood, mesh, tarpaulin) to prevent fauna from falling in.
- The Contractor shall trim overhanging vegetation above the worksite hoarding to prevent arboreal fauna from entering the worksite.
- Areas not used should be returned to earth ground and replanted if possible. Planting scheme should be
 as similar to forest composition to adjacent forest, if not as native as possible. Other than minimising
 edge effects, it can serve as a natural barrier to light, noise and dust to reduce disturbance. As a general
 guide, 400 trees should be replanted for every hectare to be reinstated

13.6.2 Commissioning Phase

At the commissioning phase, arboricultural services and management of flora and fauna are typically not expected. However, monthly flora and fauna monitoring for the duration of at least six months should still be conducted during the commissioning phase. Monitoring shall be extended for another six months if findings from the initial six month monitoring period is insufficient/non conclusive if required. This is to review the effectiveness of mitigation measures proposed during design phase and rectify biodiversity problems that arise due to operational works.

13.6.2.1 Flora Monitoring Programme

The flora monitoring aims to assess the impacts of operational works to adjacent forest and created freshwater marsh (Sites IV and V only), and rectify issues when identified. The programme should include the following:

- Assess impact of operational works on the physiological health and structural stability of vegetation and trees at proximity to the development;
- Determine whether there has been excessive and unauthorised removal of vegetation and trees beyond the development boundary;
- Monitor and assess potential edge effects (e.g., predictable failures, accelerated growth of climbers on canopy, change in species composition at the edge) within vegetation adjacent to the development;
- Determine if there was unauthorised dumping of rubbish (e.g., food materials), construction debris and materials, oil/chemical leakage that may contaminate soil watercourses, from post-construction waterbodies post-construction.

13.6.2.2 Fauna Monitoring Programme

The fauna monitoring aims to assess the impacts of operational works to fauna residing within adjacent forest and created freshwater marsh (Sites IV and V only) rectify issues when identified. The programme should include faunistic surveys. Faunistic surveys are recommended to be conducted along terrestrial sampling routes and aquatic sampling points, and should target the following fauna groups: odonates (dragonflies and damselflies), fish, decapoda, butterflies, herpetofauna (amphibians and reptiles), birds, and mammals. Comparison of species presence can be made with the baseline studies (Figure 13-6 and Figure 13-7), where appropriate, to provide an indication of the changes in fauna diversity.

The methodology for the faunistic surveys should closely follow that implemented for this EIS, so as to ensure that the data collected can be used to compare against the baseline data and data from construction monitoring (Table 13-2).

13.6.3 Operational Phase

At the operational phase, the Rail Operator shall ensure the recommended minimum controls stated in Section 7.7.2 are adhered. In addition, as a practice, disturbance should be kept to a minimum.

13.7 Hydrology and Surface Water Quality EMMP Requirements

13.7.1 Construction Phase

13.7.1.1 Monitoring Before Commencement of Site Clearance

For the naturalised stream D/S16 (in Site I and II) and earth drain D/S8 (Site III) at Turf City, one-time monitoring for hydrology and surface water quality should be conducted before the construction commencement as a baseline reference for the EMMP.

As described in the biodiversity compensation mitigation measures (refer to Section 7.9.1.2.4), the new freshwater marsh at Holland Plain will be allowed to establish first for 1.5 to 2 years, prior to the commencement of site clearance. Prior to the commencement of construction of the CR15 station entrance, one-time monitoring for hydrology and water quality will be conducted at the new freshwater marsh. This shall be the baseline reference for the EMMP.

Prior to construction, the hydrological conditions of the drainage system within the construction worksite and at its immediate vicinity should be monitored and inspected, especially during heavy storm events, to ensure flooding does not occur. For surface water quality, the baseline water quality parameters listed in Table 13-4 should be monitored. All the discharge points from construction worksites should follow NEA's Allowable Limits for Trade Effluent Discharge to Watercourse/ Controlled Watercourse. Meanwhile, the water quality of sensitive

streams/drains (i.e. naturalised stream D/S16, earth drain D/S8) and sensitive waterbodies (i.e. new freshwater marsh) shown in Figure 13-14, should also be recorded and compared with the water quality criteria for aquatic life as listed in Figure 13-14 to make sure their aquatic conditions will not be impacted by the construction activities.

Table 13-3 Water Quality Guidelines and Criteria

Parameter	NEA Trade Effluent Discharge Limits ^a	International Water Quality Criteria for Aquatic Life ^b	
рН	6 - 9	6.5 - 9	
Temperature (°C)	45	-	
Conductivity (µS/cm)	-	-	
Total Dissolved Solids, TDS (mg/L)	1,000	1,000	
Dissolved Oxygen, DO (mg/L)	-	> 4	
Turbidity (NTU)	-	50	
Total Suspended Solids, TSS (mg/L)	30 SDA: 50 ^f	50	
Biological Oxygen Demand, BOD ₅ (mg/L) ^c	≤ 20	3	
Chemical Oxygen Demand, COD (mg/L)	≤ 60	25	
Total Phosphorous, TP (mg/L)	-	Eutrophic limit: 0.075 mg/L	
Orthophosphate, PO ₄ -P (mg/L)	0.65 (equivalent to 2 as PO ₄)	0.033 (equivalent to 0.1 as PO ₄)	
Total Nitrogen, TN (mg/L)	-	Eutrophic limit: 1.5 mg/L	
Nitrate, NO ₃ -N (mg/L)	4.52 (equivalent to 20 as NO ₃)	10 (equivalent to 44 as NO ₃)	
Ammoniacal Nitrogen (NH ₄ -N)	-	0.5	
Total Organic Carbon (TOC)	-	-	
Total Alkalinity	-	-	
Oil & Grease - Total (mg/L)	1	0.14	
Oil & Grease - Hydrocarbon (mg/L)	-	-	
Lead, Pb (mg/L)	0.1	Acute LOELe: 82 Chronic LOELe: 3.2	
Zinc, Zn (mg/L)	0.5	0.0085	
Mercury, Hg (mg/L)	0.001	0.00016	
Enterococcus (cfu/100mL)d	-	-	
Note:			

Note:

- a) NEA Trade Effluent Discharge Limits for discharge into a controlled watercourse.
- b) The sources of international water quality criteria for aquatic life include United Nations Economic Commission for Europe [R-20], United States Environmental Protection Agency [R-21], Australian & New Zealand [R-28], Canada [R-29], Philippines [R-18], and Malaysia [R-30].
- c) BOD₅ is the amount of dissolved oxygen needed by aerobic biological organisms to break down organic material per litre of sample during 5 days of incubation at 20 °C.
- d) Enterococcus counts should follow the Singapore's Water Quality Guidelines for Recreational Beaches and Fresh Water Bodies (i.e. ≤ 200 cfu/100mL)
- e) LOEL Lowest Observed Effect Level
- f) The limit value is for TSS discharge into storm water drainage system (i.e. ECM discharge) which referred from Sewerage and Drainage (Surface Water Drainage) Regulations.

13.7.1.2 Monitoring Throughout Construction Period

In order to ensure that procedures are followed appropriately, the construction phase of the Project should be accompanied by an EMMP.

Water quality monitoring is essential as discharge of excess contaminants, especially pH, nutrients and heavy metals, may lead to severe consequences (e.g. algae blooms). Discharges via detention ponds/tanks and ECM tanks/ponds will take place during the construction phase, therefore monitoring of detention pond/tank discharge waters was recommended to be undertaken to complement surface water quality to ensure compliance with the relevant standards. In addition, due to the ecological importance and presence of aquatic life in streams/drains

such as D/S16 and D/S8 as shown in Figure 13-14, it was also recommended to monitor the water quality throughout the construction period to ensure minor construction impacts on the water quality. Furthermore, it is recommended that the ecologically important new freshwater marsh is monitored monthly for at least five (5) years or till the end of the construction of the CR15 Entrance 4 at Site V – whichever duration is longer – to ensure minor construction impacts on the water quality of this waterbody. For all discharge points from construction worksites, it is recommended to monitor water quality following Singapore NEA's Allowable Limits for Trade Effluent Discharge to Watercourse/Controlled Watercourse.

Furthermore, the water quality of the sensitive naturalised stream D/S16 and earth drain D/S8 as well as the new freshwater marsh should also be recorded and compared with the water quality criteria for aquatic life as listed in Table 13-4 to make sure the aquatic conditions will not be impacted by construction activities.

Table 13-4 Recommended Monitoring Program during Construction Phase (Surface Water Quality)

Test	Parameters	Monitoring Recommendation and Frequency
In-situ	Temperature pH Conductivity Total Dissolved Solids (TDS) Turbidity Dissolved Oxygen (DO)	 Online real time monitoring for turbidity at the discharge points at all the construction sites throughout the construction period; Monthly monitoring for temperature, pH, conductivity, TDS and DO at all the discharge points at the construction sites throughout out the construction period; Bi-weekly monitoring for all the in-situ parameters at sensitive naturalised stream D/S16 throughout the construction period; Monthly monitoring for all the in-situ parameters at the earth drain D/S8 throughout the construction period; and Monthly monitoring of the new freshwater marsh to be conducted for at least five (5) years or till the end of the construction of the CR15 Entrance 4 (whichever is longer).
Ex-situ	Total Suspended Solids (TSS) Biochemical Oxygen Demand (BOD ₅) Chemical Oxygen Demand (COD) Total Nitrogen (TN) Nitrate (NO ₃ -N) Ammoniacal Nitrogen (NH ₄ -N) Total Organic Carbon (TOC) Total Alkalinity Total Phosphorus (TP) Orthophosphate (PO ₄ -P) Oil & Grease (Total) Oil & Grease (Hydrocarbon) Lead (Pb) Zinc (Zn)	 Monthly monitoring for all the ex-situ parameters at the discharge points at all the construction sites during the construction period; Biweekly monitoring for all the ex-situ parameters at the sensitive naturalised stream D/S16 throughout the construction period; Monthly monitoring for all the ex-situ parameters at the earth drain D/S8 throughout the construction period; and Monthly monitoring of the new freshwater marsh to be conducted for at least five (5) years or till the end of the construction of the CR15 Entrance 4 (whichever is longer).

Beside the water quality monitoring, hydrological conditions of drainage system within construction site and at immediate vicinity should also be closely monitored during construction phase. Before draining to public drains or watercourses, surface runoff from the construction site should be drained to the treatment system to be filtered and to reduce peak runoff, as stipulated in the ECM Guidebook. The hoarding and perimeter drain of construction site should be inspected daily to ensure no surface runoff flowing out from the site untreated and no clogging which would affect the flow capacity of the drains/streams. During heavy storm event, site inspection should be carried out to ensure no flooding. The discharge of pumped dewatered groundwater or other wastewaters to sensitive aquatic habitats will be prohibited (e.g. naturalised stream D/S16 within Site I and II, earth drain D/S8 within Site III, and new freshwater marsh in Site V).

allowable limit for trade effluent discharge - in particular the limits for heavy metals (e.g. through monthly testing).

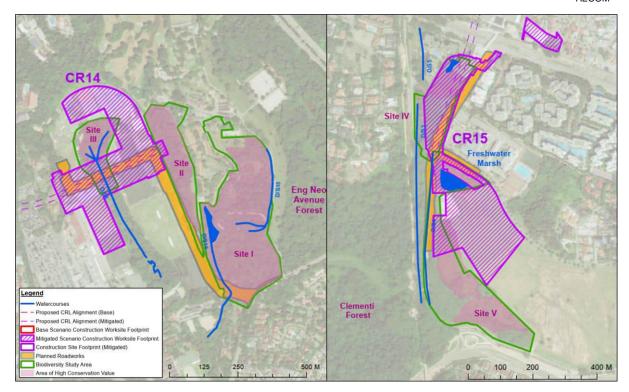


Figure 13-14 Watercourses at Turf City and Holland Plain (Note: the exact location of the newly created freshwater marsh is currently under a separated study carried out by LTA)

13.7.2 Commissioning Phase

The commissioning phase of the Project should be accompanied by an EMMP to ensure the proposed development will have minor impact on the surrounding watercourses. Water quality monitoring is essential as discharge of excess contaminants, especially pH and suspended solids may lead to severe consequences (e.g. water with less clearance) due to the commissioning activities. Hence, due to the ecological importance and presence of aquatic life in streams/drains D/S16 and D/S8, it was recommended to monitor their water quality during the first three (3) months of commissioning phase to ensure minor impacts on their water quality. For main outlets/drains (if any) of the Project site, it is recommended to monitor water quality following Singapore NEA's Allowable Limits for Trade Effluent Discharge to Watercourse/Controlled Watercourse. Meanwhile, the water quality of sensitive streams/drains (i.e. naturalised stream D/S16, earth drain D/S8) should also be recorded and compared with the water quality criteria for aquatic life as listed in Table 13-5 to make sure their aquatic conditions will not be impact by the commissioning activities.

Table 13-5 Recommended Monitoring Program during Commissioning Phase (Surface Water Quality)

Test	Parameters	Monitoring Recommendation and Frequency
In-situ	Temperature	Monthly monitoring for all the in-situ
	рН	parameters at the main outlets/drains (if any)
	Conductivity	of the Project site, as well as sensitive
	Total Dissolved Solids (TDS)	streams/drains, such as D/S16 and D/S8, during the first three (3) months of
	Turbidity	commissioning phase.
	Dissolved Oxygen (DO)	
Ex-situ	Total Suspended Solids (TSS)	 Monthly monitoring for all the ex-situ
	Biochemical Oxygen Demand (BOD ₅)	parameters at the main outlets/drains (if any)
	Chemical Oxygen Demand (COD)	of the Project site, as well as sensitive
	Total Nitrogen (TN)	streams/drains, such as D/S16 and D/S8, during the first three (3) months of
	Nitrate (NO ₃ -N)	commissioning phase.
	Ammoniacal Nitrogen (NH₄-N)	01
	Total Organic Carbon (TOC)	
	Total Alkalinity	
	Total Phosphorus (TP)	
	Orthophosphate (PO ₄ -P)	
	Enterococcus	

For the monitoring of hydrological changes during commissioning phase, drainage system within the site and at immediate vicinity should be inspected, especially during heavy storm events, to ensure no flooding. Routine audit on the site should be carried out by an independent EMMP consultant during the first three (3) months of commissioning phase.

13.7.3 Operational Phase

During operational phase, hydrology and water quality monitoring and audit is not required.

In general, the Rail Operator will ensure the implementation of minimum control measures according to the relevant legislations (e.g. PUB Code of Practice on Surface Water Drainage, Singapore Sewerage and Drainage (Trade Effluent) Regulations, SS 593: 2013 – Code of Practice for Pollution Control (COPPC), Environmental Protection and Management Act and its associated regulations etc., as listed in Section 15.1); as well as the proposed mitigation measures where the key ones are summarised in Section 13.13. General housekeeping and environmental management measures will be applied.

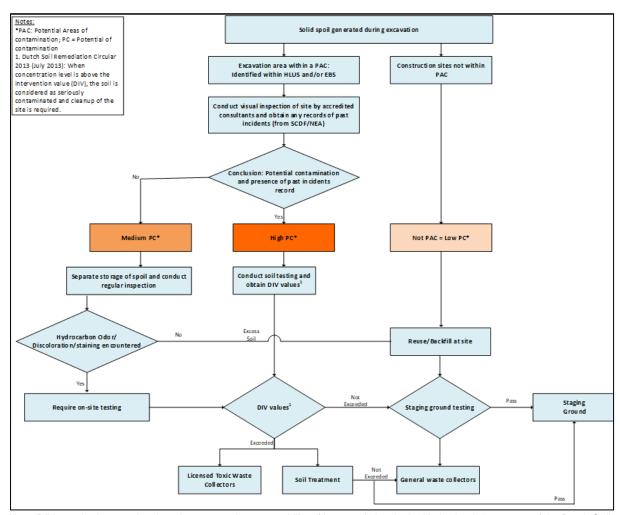
13.8 Soil and Groundwater EMMP Requirements

13.8.1 Construction Phase

A summary of the recommended monitoring for soil and groundwater during the construction phase is provided below in Table 13-6.

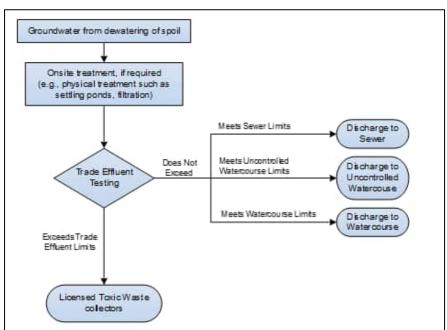
Table 13-6 Recommended Monitoring Program during Construction Phase (Soil and Groundwater)

Location	Parameters	Frequency and Duration
Within the development boundary	Groundwater level	Continuous monitoring of groundwater level throughout the lifetime of the
At locations within the Project site where excavated soil and extracted groundwater are generated and stored	Improper Management of Excavated Soil and Extracted Groundwater	construction phase as per the instrumentation and monitoring plan developed by the Qualified Professional (QP). • Visual monitoring of spoil generated by
At locations within the Project site where toxic chemical waste is generated/ stored	Toxic Chemical Waste Generation	the TBM to be conducted daily. Refer to Figure 13-15 and Figure 13-16 of suspected contaminated soils and groundwaters.
		 Records on chemical waste from the waste generator should be properly kept and records produced when requested.
At locations within the Project site where hazardous chemicals/ substances are used/ stored	Improper Handling of Hazardous Chemical/Substances	 Inspection of hazardous chemical/ substances storage condition weekly during construction phase. Routine environmental audit by independent EMMP Consultant during
		construction phase.



Note: DIV standards were developed to assess the acceptability of impacted sites in the Netherlands in support of the Dutch Soil Protection Act. Therefore, it is based on local Dutch ecotoxicology, soil (consisting of 10% organic clay or 25% clay) and climate conditions for residential usage which may not be applicable to conditions in Singapore.

Figure 13-15 Screening and Disposal of Excavated Soils



Note: DIVs for groundwater consider risks to human health and local ecosystems, whichever is more sensitive. When assessing risk to human health, a typical Dutch residential land use setting is considered which includes exposure via potable consumption of groundwater and consumption of home-grown produce which are not common exposure scenarios for Singapore.

Figure 13-16 Disposal of the Groundwater Generated Through Dewatering or Inflow Into Excavations

13.8.2 Commissioning Phase

A summary of the recommended monitoring for soil and groundwater during commissioning phase is provided below in Table 13-7.

Table 13-7 Recommended Monitoring Program during Commissioning Phase (Soil and Groundwater)

Location	Parameters	Frequency and Duration
At locations within the Project site where toxic chemical waste is generated/stored	Toxic Chemical Waste Generation	Monthly monitoring records of the amount and type of toxic chemical waste generated during the first three (3) months of commissioning
At locations within the Project site where hazardous chemicals/substances are used/stored	Improper Handling of Hazardous Chemical/Substances	phase. Monthly inspection of hazardous chemical/ substances storage conditions during the first three (3) months of commissioning phase.

13.8.3 Operational Phase

During operational phase of this Project, soil and groundwater monitoring and audit are not required.

It is assumed that the Rail Operator shall ensure the successful implementation of the recommended minimum control measures (see summary of key measures in Section 13.13.1.3 of this report). As the impact on soil and groundwater during the operational phase of this Project is assessed to be minor, no additional soil and groundwater mitigation measures are required in commissioning and operational phases.

13.9 Air Quality EMMP Requirements

13.9.1 Construction Phase

As part of the proposed mitigation measures (see summary of key measures in Section 13.3), dust monitoring shall be undertaken during the construction phase. Dust deposition monitoring is recommended due to the potential of High consequence dust impact conducted within the ecologically sensitive receptors during construction phase. Based on a review of sensitive receptors around the construction worksite areas, a continuous monitoring program as per Table 13-8 is proposed to be conducted during Project construction. The Contractor is also recommended to conduct air quality monitoring of PM_{10} and $PM_{2.5}$ for 1 week prior to site clearance for the re-establishment of latest baseline conditions around the Project area. Monitoring is to be conducted at locations as Table 13-8 and Figure 13-17.

No EMMP air monitoring is required to monitor the impact of CR13 retrieval shaft worksite and underpinning works with regards to ecological impact due to the distance of the worksites being >50 m from the ecological receptor and hence, outside of the Study Area as per the IAQM Guidance.

Table 13-8 Recommended Monitoring Program during Construction Phase (Air Quality)

Location	Parameters	Frequency and Duration	Triggers
Site I Site II Site III Site IV Site V	PM ₁₀ and PM _{2.5} in μg/m ³	Continuous monitoring of PM ₁₀ and PM _{2.5} for 1 week prior to site clearance averaged over 1-day period	-

Location	Parameters	Frequency and Duration	Triggers
	Dust Deposition in mg/m²/day	Continuous monitoring of dust deposition during construction phase averaged over 4-week period	 Investigation and corrective actions to be taken, when: Any of the following documentation are found inadequate / missing: Air Pollution Control Plan; Compliance certificate of an Off-Road Diesel engine; or Monitoring Log. If the monitored PM₁₀ and PM_{2.5} exceed Singapore long term air quality targets. If the dust deposition monitored exceeds 200 mg/m²/day averaged over 4-week If complaints are received due to Project activities. If visual non-compliance to any of the minimum control or mitigation measures are observed on-site.

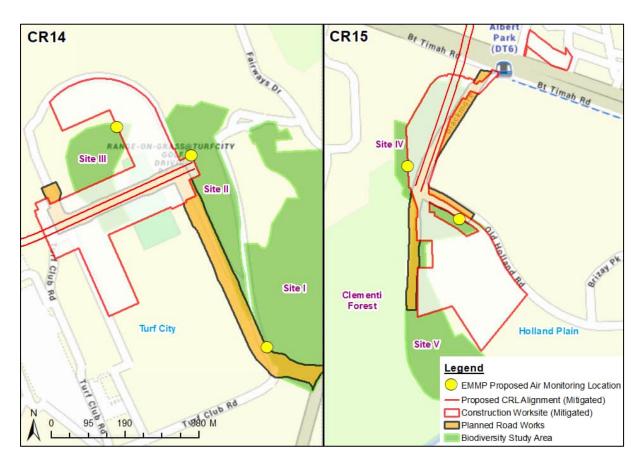


Figure 13-17 Proposed Air Monitoring Location Prior to Site Clearance and during Construction Period

13.9.2 Commissioning Phase

During commissioning phase, ambient air quality monitoring may not be required.

13.9.3 Operational Phase

During operational phase, ambient air quality monitoring may not be required. General housekeeping and environmental management measures shall be applied.

13.10 Airborne Noise EMMP Requirements

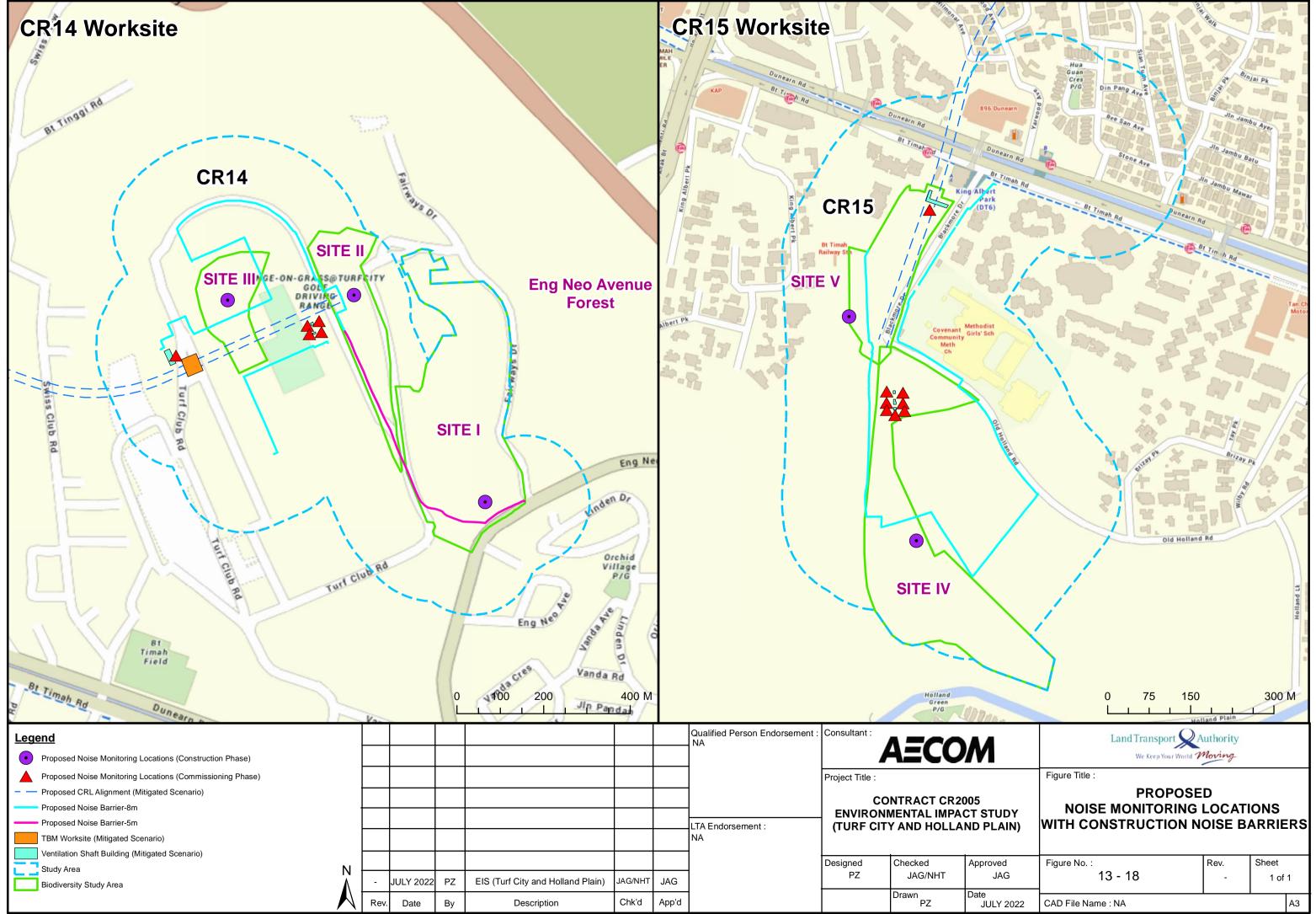
13.10.1 Construction Phase

Based on a review of sensitive receptors around the construction worksite areas, a continuous noise monitoring program as per Table 13-9 is proposed to be conducted during construction phase.

The proposed noise monitoring locations are presented in Figure 13-18, along with the noise barriers recommended as mitigation measures. Other key minimum control and key mitigation measures are summarised in Section 13.13.

Table 13-9 Recommended Monitoring Program during Construction Phase (Airborne Noise)

Location (see Figure 13-18)	Parameters	Frequency and Duration
Site I, Site II and Site III Three (3) monitoring locations at boundary of Site I, Site II and Site III which are closest to CR14 worksite	L _{Aeq(12 hour)} , L _{Aeq(1 hour)} , and L _{Aeq(5} min)	 Prior to site clearance: To conduct one-time (i.e. 1-week period) airborne noise monitoring at this location to re-establish the baseline noise levels for reference/comparison purposes before any construction works commence. Throughout construction period: Continuous monitoring at this location for the entire duration of construction.
Site IV and Site V: Two (2) monitoring locations at boundary of Site IV and Site V which are closest to CR15 worksite		 Prior to site clearance: To conduct one-time (i.e. 1-week period) airborne noise monitoring at this location to re-establish the baseline noise levels for reference/comparison purposes before any construction works commence. Throughout construction period: Continuous monitoring at this location for the entire duration of construction.



13.10.2 Commissioning Phase

During commissioning phase, continuous airborne noise monitoring ($L_{eq \, 5min \, and} \, L_{eq \, 1 \, hour}$) shall be conducted for the three (3) monitoring locations in Site I, Site II, Site III and two (2) monitoring locations in Site IV and Site V (as per Figure 13-18) for three (3) months of the commissioning phase.

Apart from that, five (5) additional airborne noise monitoring ($L_{eq\ 15min}$) will be required at the boundary of ventilation shaft at CR14 station and eight (8) additional airborne noise monitoring ($L_{eq\ 15min}$) will be required at the boundary of ventilation shaft at CR15 station for one (1) day (24 hours) within the commissioning phase, to monitor the potential airborne noise impact arising from the air conditioning and mechanical ventilation (ACMV) equipment which will be operating during commissioning phase. This indicates a total of eighteen (18) airborne noise monitoring locations during commissioning phase.

The airborne noise level monitored will comply with the *NEA's Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Building,* however, noise criteria for biodiversity will follow a "no worse off than baseline approach" will be complied. The current set of Project-specific noise criteria based on baseline noise monitoring in Year 2020 is provided in Table 13-10 below for reference and/or basis of comparison if there is no further update hereafter.

Table 13-10 Project-Specific Noise Criteria for Commissioning Phase (Baseline Measured in Year 2020)

No.	Types of Affected Receptors	L _{Aeq} (15 min), dB				
		7am-7pm	7pm-11pm	11pm-7am		
Site I (N05(S))	Ecologically sensitive receptors*	56	51	45		
Site II (N13)		53	51	46		
Site III (N03(S))		54	53	47		
Site IV (N14)		50	49	49		
SITE V (N15)		73	74	73		

*Notes:

- 1. Ecological receptor noise impact to be assessed against the baseline noise level as the noise criterion.
- 2. Criteria for ecological receptor is more stringent than human criteria.
- 3. If there are any noise monitoring works being conducted hereafter, i.e. during actual pre-construction phase (i.e. before actual site clearance) and/or pre-commissioning phase, this Project-specific noise criteria (no worse off than baseline approach) will be updated accordingly and be complied on site.

13.10.3 Operational Phase

During operational phase, airborne noise monitoring and audit is not required. General housekeeping and environmental management measures shall be applied.

In general, the Rail Operator shall ensure the implementation of minimum control measures according to the relevant legislations (i.e. *NEA's Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Building* and *Technical Guideline for Land Traffic Noise Impact Assessment* [R-53, R-54]), as well as the proposed mitigation measures where the key ones are summarised in Section 13.13.2.3. If there are any noise monitoring works to be carried out during operational phase in future, the same no worse-off than baseline noise criteria (see Section 13.10.2) shall be complied.

13.11 Ground-borne Vibration EMMP Requirements

This section details ground-borne vibration EMMP requirements during construction, commissioning and operational phases.

13.11.1 Construction Phase

Additional requirements are required during rock breaking and excavation and high vibratory compactors as outlined in Section 13.11.1.1 below.

13.11.1.1 EMMP for Structural Integrity of Burrows

The Contractor shall control construction vibration levels using the best available techniques (BAT). The construction activities include rock breaking and excavation for CR14 and high vibratory compactors for CR14 and CR15. The Contractor shall ensure that the vibration levels for any construction activities at Sites I to III and Eng Neo Avenue Forest (excluding the worksite area) do not exceed PPV, 8.0 mm/s.

Table 13-11 Recommended Monitoring Program during Construction Phase (Ground-borne Vibration)

Location (see Figure 13-20)	Parameters	Frequency and Duration
Site I, II, III: One location each within Sites I, II, III	Peak Particle Velocity, PPV, mm/s	 Prior to site clearance: To conduct one-time (i.e., 1-week period) continuous vibration monitoring (Triaxial with 3G remote communication) at these locations to reestablish the baseline noise levels for reference/comparison purposes before any construction works commence. Throughout construction period: Continuous monitoring at this location for the entire duration of construction.
Site IV and Site V: One (1) monitoring location each at boundary of Site IV and Site V which are closest to CR15 worksite	Peak Particle Velocity, PPV, mm/s	 Prior to site clearance: To conduct one-time (i.e., 1-week period) ccontinuous vibration monitoring (Triaxial with 3G remote communication) at these locations to reestablish the baseline noise levels for reference/comparison purposes before any construction works commence. Throughout construction period: Continuous monitoring at this location for the entire duration of construction.

Additionally, an Ecologist and Environmental Officer shall be present to survey for burrows before any construction activities. Camera traps should be deployed to assess fauna activity if burrows are detected within the Biodiversity Study Areas. Construction works can be continued if no burrows or fauna activity is detected.

13.11.1.2 EMMP for Behavioural Impacts of Ecologically Sensitive Species

During rock breaking and excavation (CR14), and high vibratory compactors (CR14 and CR15), bulldozing (CR15) Ecologist shall monitor for any fauna behaviour. For example, dashing onto the road) resulting in road-kill incidents for at least thirty (30) minutes after the event. In addition, during these construction activities, Ecologists will be present to observe fauna movements. Suppose fauna is seen trying to dash onto the road. In that case, construction activities will be immediately suspended, and mitigation measures should be applied to prevent such events from happening in the future.

Before the rock breaking and excavation commence (at Sites I to III and Eng Neo Avenue), a temporary barrier shall be set up along specific locations. Figure 13-20 shows a 1.2 km high temporary water-filled barrier along specific locations of Turf Club Road, Fairways Drive and Eng Neo Avenue. Noise barriers must also be present to double as barriers to prevent road kill.

Hoardings or noise barriers must be included at the worksites, and canvas sheets must be added onto existing railings (130 m long) along Fairways Drive to cover holes on the railings. These will mitigate road kills due to the impacted fauna trying to dash onto a road during the construction activities. This is shown in Figure 13-20

Barriers must not be implemented along a section of Site II (north of Site II as seen in Figure 13-20) to facilitate fauna connectivity. However, to ensure the safety of fauna, these conditions must be met:

- Turf Club Road north of CR14 and small roads nearby must remain to have limited access (closed if possible), even after lease is up; and
- Road calming measures must be extended to Turf Club Road north of CR14, small roads nearby and immediate areas within the gold course.

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Lastly, no night work should be conducted after 7 pm for all non-safety critical activities since the site is next to the sensitive receptors.

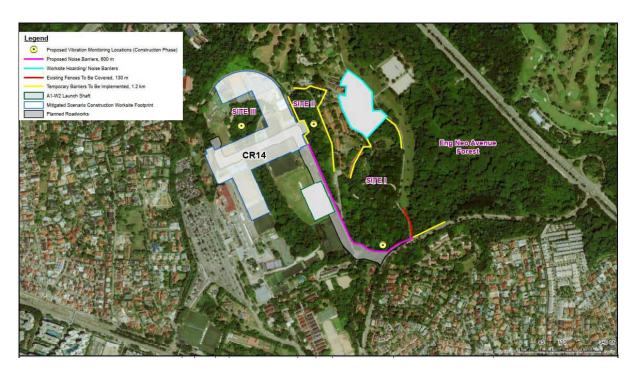


Figure 13-19 Proposed Barriers During Rock Breaking and Excavation with Proposed Vibration Monitoring Locations



Figure 13-20 Proposed Vibration Monitoring Locations

13.11.2 Commissioning Phase

During the commissioning phase, vibration monitoring is not required. General housekeeping and maintenance shall be applied.

13.11.3 Operational Phase

During the operational phase, vibration monitoring is not required. General housekeeping and maintenance shall be applied.

13.12 Environmental Audit

13.12.1 Construction Phase

13.12.1.1 Internal Site Inspection/Audit by EM/ECO

Site surveillance provides a direct means to assess and ensure the Project's environmental protection and pollution control measures are in compliance with the contract specifications and the EMMP. The EM/ECO should inspect the construction activities regularly and routinely to ensure that the appropriate environmental protection and pollution control mitigation measures are properly and timely implemented, based on the EMMP's recommendations. With well-defined pollution control and impact mitigation measures outlined, and a well-established efficient remedial action reporting system, the site inspection is an effective "tool" to ensure acceptable environmental performance at the construction site.

After consultation with Project's SO, the EM/ECO should prepare a procedure for the site inspections, deficiencies, remedial action, and reporting requirements. This documentation shall be agreed to by the RTO and Contractor representative, and approved by the Project Owner within 21 days of the commencement of the construction contract.

Weekly site inspections should be carried out by the EM/ECO to ensure the environmental, health and safety measures are properly implemented at all the work areas during the construction phase. The EM/ECO shall submit an Environmental Performance/Inspection Report which covers the onsite environmental situation, pollution control and mitigation measures to LTA fortnightly. Offsite environmental situations, which may be affected by onsite activities, (directly or indirectly) should also be reviewed.

13.12.1.2 External Environmental Audit by LTA's Independent EMMP Consultant

A third party independent EMMP consultant shall be engaged to perform routine environmental audit/ verification checks of the EMMP implementation by the Contractor (for all assessed environmental parameters in ecological perspectives) throughout the construction period. The routine audit includes but not limited to reviewing relevant documents prepared by Contractor's EMMP consultant, providing ad-hoc advice, assisting in resolving complaints with the Contractor, etc. largely for ecological perspective as LTA in house staff and project staff shall be able to resolve issues related to human impacts.

The external environmental audit exercise would also include the documentation review of on-site monitoring records against the proposed measures and findings in the approved site specific EMMP. This is to ensure proper implementation of minimum control measures, mitigation measures and EMMP proposed in this report, as well as to identify and/or resolve potential environmental incompliances and potential gaps with the findings in report, if any observed during the audit.

13.12.2 Commissioning Phase

It is suggested for the Contractor to engage an independent EMMP consultant to perform routine environmental audit in parallel to the biodiversity monitoring works. This is to inspect the effectiveness of biodiversity monitoring works and other on-site environmental implementations during commissioning phase before handing over to the rail operator.

13.12.3 Operational Phase

Environmental audit by an independent EMMP consultant may not be required during the operational phase of this Project. The EHS Officer and the rail operator shall manage the overall environmental performance and ensure implementation of minimum control measures and mitigation measures proposed in this report.

13.13 Summary of Proposed EMMP

The framework for the proposed EMMP is detailed below; however, it is important to note that this is not an exhaustive list of potential impacts, monitoring requirements, and triggers. This EMMP is intended to be a living document and should be reviewed thoroughly by the Client/ Project Owner/ rail operator and the Contractor (CT) prior to implementation. Development of the following inputs, that have not been addressed in this report, by the CT and/or rail operator are also required, including but not limited to:

- Stakeholder Communications Plan;
- Air Pollution Control Plan:
- Site log for all monitoring activities and complaints;
- Construction Logistics Plan;
- Standard Operating Procedures;
- Emergency Response Plan;
- Inventory of wastewater streams;
- Training protocols for staff, where appropriate; and
- Maintenance and Audit Schedules.

13.13.1 EMMP Summary for CR14 Worksite

13.13.1.1 Construction Phase

The EMMP for construction phase of the Project is summarised in the following table.

Table 13-12 Proposed Environmental Monitoring and Management Plan for Construction Phase

Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers ^{15,16}
General	Exclusion of the evaluation of certain environmental impacts where detailed design is not available for review at the time of writing this report	 The current preliminary worksite design used for this study excludes any inputs in terms of locations of piezometers, utilities/ road diversion areas, site elements (e.g. workers dormitory, detention tank, site office etc.). If this be available at later stage, the Contractor shall review the impact study findings based on the latest design inputs, then update the recommended EMMP (e.g. monitoring frequency/location) accordingly if necessary. 	N/A	N/A	N/A	N/A	СТ	N/A
Biodiversity	construction worksite would require an arborist to impacts to clearly mark out Tree Protection Zone flora/vegetation where no works are allowed. The Tree	worksite would require an arborist to clearly mark out Tree Protection Zones where no works are allowed. The Tree Protection Zones should be set up in	 Mark out site boundary Identification of locations, species and quantity of transplant candidates that are affected by construction Enhancement planting at affected native-dominated secondary forest patch to minimise risk of habitat degradation and fragmentation 	Flora and Arboriculture	Within development boundary	Prior to site clearance	CT, EM/ECO, Flora Specialist	N/A
			 Inspection of integrity of TPZ hoarding Assessment of tree physiological health and vigour Determination of presence of mechanical damage to trees that may impair stability Review of method statements of construction works in proximity to retained trees Identification of excessive or unauthorised tree removal Identification of trees that require management and maintenance such as tree care and pruning Determination of any unauthorised removal of flora within areas of conservation (if any) or beyond the demarcated worksite Identification of areas with soil erosion and degradation that have resulted from construction activities Determination of unauthorised dumping of waste material, 		Within development boundary and 15m beyond hoarding line	Monthly for duration of construction	CT, EM/ECO, Flora Specialist, Arborist	

¹⁵ Resident Technical Officer (RTO) and Site Officers (SO, WSHO and ECO) check the Project site for construction progress and implementation of environmental mitigation measures.

¹⁶ If there is trigger then all the mitigation and management measures should be audited in detail for compliance and corrective action must be taken in liaison with the Project Owner.

Parameter Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers ^{15,16}
		leakage that may contaminate the soil and waterbodies, and/or be detrimental to the vegetation Identification of areas that are responding poorly due to the development impacts.					
Minimisation of construction impacts to fauna Minimisation of construction impacts to flora/vegetation	Before vegetation removal, pre-felling fauna inspection should be conducted by an Ecologist to identify wildlife or nesting structures that are being actively used such as bird nests, tree hollows and burrows.	 Implementation of directional clearing Inspection for presence of trapped/injured/dead fauna, potential fauna entrapments and gaps in site hoarding Toolbox briefings on biodiversity awareness 	Fauna Flora and Arboriculture	Within development boundary	Prior to site clearance	CT, EM/ECO, Ecologist	N/A When fauna is encountered within development boundary
	 Soil erosion control measures are to be executed once vegetation has been removed and soil is exposed as described in Section 7 under Hydrology and Surface Water Quality Implement dust control measures as described in Section 10 under Air Quality Proper storage of materials that are likely to leech harmful chemicals and fuel-powered equipment away from waterbodies or sensitive habitats as described in Section 9 under Soil and Groundwater (and Waste) Ensure noise levels are within approved limits as described in Section 11 under Airborne Noise Ensure vibration levels are within approved limits as described in Section 12 under Ground-borne Vibration 	 Assessment of habitat quality (e.g., water quality, excessive vegetation removal, light management strategies) Implementation of only 100% biodegradable ECBs Establish a comprehensive waste management system and submit a contract-specific Waste Management Plan which details the types of waste generated, location and types of waste management facilities, frequency of disposal, as well as information of waste management contractors. This will act as the guidance for workers to ensure proper implementation of waste management and disposal on site, where the practices shall include but not limited to: Strictly prohibit illegal disposal of construction wastes into streams and storm water channels or other waterbodies Strictly prohibit littering of food waste and food packaging Provide sufficient fully covered food waste bins that are secured in a manner that is wildlife-proof Clear all food waste from the worksite at least once a day If fauna is found to be active around waste disposal areas, the Contractor shall implement measures to reduce the source of the attractant in consultation with the Ecologist Implementation of proper vector management strategies, where the hierarchy of vector control for 		Within development boundary	Monthly for duration of construction	CT, EM/ECO, Ecologist	

Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers ^{15,16}
			ecologically sensitive sites shall be as follows: (a) no thermal fogging to prevent unintended impacts to invertebrate fauna nearby; (b) no chemical insecticides, pesticides and rodenticides shall be used for pest control; (c) no sticky traps shall be used for pest control.					
		NA	 Conduct biodiversity survey to monitor construction impacts on fauna activity and presence. Conduct ground-borne and airborne noise monitoring to monitor behaviour of fauna to impacts from vibration. 		Adjacent to development boundary	Monthly for duration of construction	CT, EM/ECO, Ecologist	
		NA	Recording number of occurrences of human-wildlife conflict		Within development boundary	Daily monitoring and record- keeping	CT, EM/ECO	
		NA	 Line all planned road works (Turf Club Road) with hoarding, noise barriers, water barriers or specific road barriers to minimise roadkill, in tandem with related mitigation measures for concurrent works in the area Implementation of road calming measures such as road signages, speed limitation, road humps 		Adjacent to development boundary	Prior to site clearance	CT, EM/ECO	N/A
		Trees that are to be retained within worksite would require an arborist to clearly mark out Tree Protection Zones where no works are allowed. The Tree Protection Zones should be set up in accordance with NParks guidelines	 Mark out site boundary Identification of locations, species and quantity of transplant candidates that are affected by construction 		Within development boundary	Prior to site clearance	CT, EM/ECO, Flora Specialist	N/A
		N/A	 Inspection of integrity of TPZ hoarding Assessment of tree physiological health and vigour Determination of presence of mechanical damage to trees that may impair stability Review of method statements of construction works in proximity to retained trees Identification of excessive or unauthorised tree removal Identification of trees that require management and maintenance such as tree care and pruning Determination of any unauthorised removal of flora within areas of 		Within development boundary and 15m beyond hoarding line	Monthly for duration of construction	CT, EM/ECO, Flora Specialist, Arborist	N/A

Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers ^{15,16}
			conservation (if any) or beyond the demarcated worksite Identification of areas with soil erosion and degradation that have resulted from construction activities Determination of unauthorised dumping of waste material, construction debris or oil/chemical leakage that may contaminate the soil and waterbodies, and/or be detrimental to the vegetation Identification of areas that are responding poorly due to the development impacts.					
Hydrology and Surface Water Quality	 Solid & Toxic Waste Generation Liquid Effluent and stormwater run-off Generation 	 Key Minimum Controls 1. Solid & Toxic Waste Generation Effective ECM and monitoring implemented as recommended in the Code of Practice on Surface Water Drainage to ensure that discharge into the stormwater drainage system does not contain TSS in concentrations greater 	N/A	All water quality parameters identified in Table 13-4. And any flooding issues should be recorded and inspected.	Before every discharge outlet and at the sensitive stream and drain (i.e. D/S16, D/S8).	One time monitoring prior to site clearance	CT, EM/ECO	Investigation and corrective actions to be taken if there is a significant drawdown of groundwater level.
	Improper Management of Chemical Substances	than the prescribed limits under the Sewerage and Drainage (Surface Water Drainage) Regulations; Hazardous substances and toxic wastes should be stored on hard stand, under shelter with a kerb around the storage area; Implementation of CCTV including SIDS at the public drain to monitor the surface runoff discharges from the sites as per the Public Utilities Board of Singapore's (PUB) circular on Preventing Muddy Waters from the Construction Sites (October 2015); and All wastes will be disposed only in the designated waste disposal facilities and appropriately separated, i.e. by trained workers to properly sort and label the different types of waste (reusable and recyclable waste, toxic and non-toxic waste, etc.). Liquid Effluent Generation and Stormwater Runoff A full inventory of all anticipated wastewater streams and volumes should be finalised before the onset of the construction works; No unmanaged discharge of wastewater stream permitted; Reduce, reuse, and recycle hierarchy principle to be applied to wastewater onsite; Hazardous wastewater, such as oily water, thinners, solvents, or paints, should be stored on hard stand, under shelter with a kerb around the storage area. The wastewater should be removed for	The construction worksites and road works should not obstruct the flow of naturalised stream D/S16 and earth drain D/S8, so as to ensure the perennial flow is maintained. If diversion is required, the contractor shall provide diversion of affected sections of these watercourses prior to the start of construction. The diversion should follow PUB's Code of Practice on Surface Water Drainage. Discharge treated runoff into earth drain D/S8 (i.e. treated to meet NEA Trade Effluent Discharge Limits) to maintain its existing flow.	All water quality parameters identified in Table 13-4. And any flooding issues should be recorded and inspected.	Before every discharge outlet and at the sensitive stream and drain (i.e. D/S16, D/S8).	 Permanent turbidity monitor installed at every discharge outlet; Implementation of CCTV including a SIDS at every discharge outlet to monitor the surface run-off discharges from the sites; Monthly water quality monitoring for all discharge locations during construction phase; Bi-weekly water quality monitoring for D/S16 throughout construction period; Monthly water quality monitoring for D/S8 throughout construction period; Intensity of the laboratory analysis will be increased (e.g. fortnightly, weekly) if insitu measurements and/or monthly laboratory results indicate deterioration in the water quality. Intensified monitoring will be carried out until in-situ measurements and/or laboratory results indicate 'normality'/consistency with earlier monitored conditions; 	CT, EM/ECO	 Investigation and corrective actions to be taken, when: The following documentation are found inadequate/missing: ECM Plan; Monitoring Log; Training Log; Audit Reports; If the monitored parameters exceed applicable values of NEA Trade Effluent Discharge Limits at discharge point (refer to Table 13-3); If the monitored parameters exceed applicable values of Water Quality Criteria for Aquatic Life at

Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers ^{15,16}
		treatment and disposal off-site by an approved Waste Management Contractor. Hazardous liquids to be handled as Hazardous Waste; Containment pond/kerbs will be of impervious material and be designed with sufficient capacity to hold volumes of wastewater produced on-site and potential fire-fighting wastewater. Contractor will seek for comment and approval from relevant authorities (e.g. SCDF and NEA) on the treated wastewater to be used for firefighting purpose; Adequate drainage, cut-off drains, sump pit, road kerb, piping and toe wall will be designed for channelling of construction process wastewater streams (e.g. concrete batching, wash water, etc.) and stormwater runoff separately through detailed design for capture and treatment in the containment pond/kerbs. Where applicable (e.g. in the vicinity of liquid storage or refuelling areas), this infrastructure will include oil-water separators to capture inadvertent spills or leaked oils or greases; Temporary storage volumes should be provided for overflow situations. Temporary storage with sufficient capacity will capture any expected additional volumes to ensure untreated wastewater is not released to watercourses unless it complies with Singapore NEA Guidelines on trade effluent discharge concentrations. Contractor will need to seek approval from both relevant authorities (i.e. PUB & NEA) as per PUB Sewerage and Drainage (Trade Effluent) Regulations if the wastewater will be disposed to public sewer or NEA's Trade Effluent Discharge Limits to controlled watercourse if the treated trade effluent will be disposed to sensitive aquatic habitats will be prohibited (e.g. naturalised stream within Site I); Tunnel washing effluent should be discharged to a containment pond/kerbs that manually collected by operator assigned private wastewater reatment plant; Appropriate disposal of any waste listed in the Environmental Public Health (General Waste Collection) Regulations by licensed waste operator/collector by licensed waste operator/collector by licensed waste				Daily inspection on perimeter drains to ensure no surface runoff flowing out from the site untreated done by the site officer with routine audit done by independent EMMP consultant; and Daily inspection on perimeter drains and streams/drains including D/S16 at Site I & II and D/S8 at Site III to ensure no surface runoff flowing out from the site untreated done by the site officer with routine audit done by independent EMMP consultant.		natural stream (refer to Table 13-3); If any flooding or clogging issues observed; If complaints are received due to Project activities; and If visual noncompliance to any of the minimum control or mitigation measures are observed onsite.

Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers ^{15,16}
		away without causing flooding in the vicinity; • Appropriate permits for discharge to be obtained from relevant authority prior to discharge. No trade effluent other than that of a nature or type approved by NEA Director-General will be discharged into any watercourse or land; • Regular and dedicated procedures for the management of stormwater collection, settling, testing and eventual discharge of 'clean' water to watercourses. This should also include associated measures required to prevent high sediment concentration stormwater drainage to watercourses; and • Geotechnical aspect of site's slope stability (such as Earth Retaining and Stabilising structures (ERSS) to be included in detailed design engineering for the construction stage. 3. Improper Management of Chemical Substances • Development of SOP for safe handling, transfer and storage of toxic waste; housekeeping checks once a day to ensure all toxic waste is cleared from site; • Appropriate tests to ascertain the presence/absence of contamination of the excavated earth and sand; • Appropriate tests to ascertain the presence/absence of contamination of the excavated earth and sand; • Appropriate tests to ascertain the presence/absence of contamination of the accavated earth and sand; • Appropriate tests to ascertain the presence/absence of contamination of the excavated earth and sand; • Appropriate construction material for toxic waste storage containers with leak detection tests conducted periodically; • Provision of secondary containment for all toxic waste stored in bulk as per the requirements in the COPPC/SS593; • Preparation of an emergency response plan, training of the emergency response team (ERT) to be competent in the response mechanism and provision of response kits for any spillages;	Mitigation Measures	Monitoring Parameter				Triggers ^{15,16}
		 Consignment notification/tracking system and transport emergency response plan for transport of toxic waste; Appropriate disposal of toxic waste as per required in the Environmental Public Health (Toxic Industrial Waste) 						

Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers ^{15,16}
		Regulations by licensed waste						
		operator/collector.						
Soil and Groundwater	Decreased groundwater baseflow feeding into the streams	i) Install piezometers to monitor the changes in groundwater level in compliance with Building Control Regulations 2003 as part of its instrumentation and monitoring plan to be endorsed by the Qualified Professional (QP); and ii) Proper Earth Retaining Stabilising Structures (ERSS) should be selected and designed to limit groundwater settlement.	Not Applicable.	Groundwater Level	Actual monitoring location to be decided by QP.	To continuously monitor the groundwater level throughout the lifetime of the construction phase.	CT, EM/ECO	Investigation and corrective actions to be taken if there is a significant drawdown of groundwater level.
	Improper Management and Disposal of Excavated Soil and Groundwater	 Identify all types of solid waste (e.g. tunnelling waste) and implement comprehensive waste management system at the site in order to ensure proper disposal and prevent pollution to the environment. This Contractor should conduct a construction risk assessment and prepare a comprehensive construction health, safety and environment plan. If health impacts to workers are foreseen due to the handling of such waste, necessary precautionary measures as per the safety data sheets (SDS) including personal protective equipment should be implemented on site. Use approved materials, of the same or better quality as the surrounding area, for backfilling works. All backfilled material shall be free of debris, and of good material soil. Handle and dispose excavated soil following the procedure shown in the Figure 13-15. This flow chart explains how to handle excavated soils, and identify potential areas of contamination as well as potential of contamination (POC) in excavated soils. If the POC soils are tested for exceedance in DIVs, the soils can be disposed of to toxic waste collectors or undergo soil treatment. If contaminated soils were sent for treatment to an acceptable standard such as the DIV, the treated soil can be disposed in the staging ground or through a general waste collector, depending on the level of the 		Records on waste generated and hazardous chemicals used at the construction site should be properly kept and records produced when requested.	At locations where excavated soil and extracted groundwater are generated and stored. At locations where toxic chemical wastes are generated and stored. At locations where hazardous chemicals/sub stances are used and stored.	 Monitoring records of the amount and type of toxic chemical waste generated, once a week Inspection of hazardous chemical / substances storage conditions, once a week. Routine environmental audit during construction phase. 	CT, EM/ECO	 Investigation and corrective actions to be taken, when: There are no/ poor records of toxic chemical waste amount and type; and There is evidence of poor handling/storage of toxic chemical waste and hazardous chemical.

Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers ^{15,16}
		contaminants during the staging						
		ground testing.						
		 Upon receipt of results on the 						
		tested parameters (chemicals,						
		heavy metals) exceeding the						
		regulatory limits, the construction						
		Contractor should further assess						
		the potential inhalation and dermal						
		contact impacts of the exceeded						
		parameters to the site workers						
		exposed to areas where soil and/or						
		groundwater contamination is						
		identified. The risk assessment						
		should be conducted before the						
		commencement of construction						
		activities and the findings						
		incorporated into the Contractors'						
		construction risk assessment and						
		health, safety and environment						
		plan. If health impacts to workers						
		are foreseen, necessary						
		precautionary measures, as per the						
		respective chemical SDS, should be						
		implemented on site.						
		A site management plan should						
		include plans of safe handling,						
		transfer and storage of excavated						
		soils following the procedure in the						
		Figure 13-15.						
		 Discharge of extracted groundwater shall be to an area approved for 						
		such disposal by the NEA and the						
		proposed location as identified in						
		the Figure 13-15 and following the						
		process set out in the Figure 13-16.						
		Based on the results of the soil and						
		groundwater baseline study, the						
		detected concentrations of arsenic						
		in one soil sample taken at CR14						
		exceed the DIV. Therefore, it is						
		recommended that the construction						
		Contractor to be vigilant of site						
		conditions and extracted						
		groundwater to be tested at regular						
		intervals, especially for extracted						
		groundwater with oily sheens or						
		noticeable odour. If a contaminant						
		concentration in excess of the DIV						
		is detected, the Contractor shall						
		assess the potential inhalation and						
		dermal impacts of the chemical						
		identified and assess potential						
		health and safety considerations for						
		exposure to groundwater before						

Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers ^{15,16}
		commencement of construction activities. Such contaminated wastewater may need to be disposed of to a licenced toxic waste collector. • Bentonite slurry used in the TBM will be pumped into the slurry treatment plant for recycling, cleaning and removal of native cut material. Treatment methodologies in the slurry treatment plant will include de-sanding (e.g., cyclones) and filtration. Handling and disposal of spoils for disposal after the treatment shall follow the procedure in the Figure 13-15.						
	Toxic Chemical Waste Generation during Construction Phase	Identify all types of toxic chemical waste and implement comprehensive waste management system at the site in order to ensure proper disposal and prevent pollution to the environment. This Contractor should conduct a construction risk assessment and prepare a comprehensive construction health, safety and environment plan. If health impacts to workers are foreseen due to the handling of such waste, necessary precautionary measures as per the safety data sheets (SDS) including personal protective equipment should be implemented on site; Inspect all equipment prior to entering the site for fuel/hydraulic lines, leaking tanks, and other potential faulty parts that could potentially cause contamination to soil or groundwater;						
		Dispose all construction debris (under category C&D) at the gazetted Government dumping grounds or at such other sites or locations as directed by NEA; Store generated toxic chemical waste under shelter within concrete bund walls or in storage containers with good ventilation. Spill trays shall be provided for all waste containers Spill trays shall be regularly maintained to prevent rain from washing out the pollutive substances; Note that the Earth Control Measures (ECM) is for the containment and treatment of silty discharge due to the impact of rainwater. ECM is not meant for the treatment of wastewater due to construction activities (such as pipe-jacking and bore-piling works) which shall be treated to comply with the						

Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers ^{15,16}
		requirements under prevailing legislation;						
		and						
		The wastewater from tunnelling activities						
		should be stored and removed for treatment						
		and disposal off-site by an approved Waste						
		Management Contractor.						
		Contractor will need to seek approval from						
		both relevant authorities (e.g., PUB & NEA)						
		as per PUB Sewerage and Drainage (Trade						
		Effluent) Regulations if the wastewater will						
		be disposed to public sewer or NEA's Trade						
		Effluent Discharge Limits to controlled						
		watercourse if the treated trade effluent will						
		be disposed to surface watercourses. If such						
		discharges are not approved, the trade						
		effluent will be stored, treated, or recycled on						
		site and finally disposed of.						
	Improper Handling	Remove any hazardous substance or						
	of Hazardous Chemicals/Substa	chemical if there are safer alternatives;						
	nces during	Ensure all hazardous substance and						
	Construction	chemical containers are labelled its						
	Phase	movement is recorded and returned to the						
		designated storage areas when not in use; Assess the SDS of all the hazardous						
		substances and chemicals prior to its entry to						
		site for its suitability in terms of SHE hazards						
		and consider safer alternatives;						
		Ensure no trade effluent other than that of a						
		nature or type approved by NEA Director-						
		General shall be discharged into any						
		watercourse or land;						
		Ensure all activities involving repair,						
		servicing, engine overhaul works, etc. shall						
		be carried out on an area which is						
		appropriately contained (e.g. concreted area						
		and with proper containment/sumps) and all						
		wastes are channelled for appropriate						
		treatment or disposal to meet the						
		regulations;						
		Store chemicals stored under shelter within						
		concrete bund walls or in storage containers						
		with good ventilation. Spill trays shall be						
		provided for all drums, plants and machinery						
		and potential pollutive substances used on						
		site. Spill trays shall be regularly maintained to prevent rain from washing out the pollutive						
		substances; and						
		Provide emergency spill kits on site in the						
		event of any chemical spillages. The						
		emergency response team shall also be						
		competent in the use of these spill kits.						
Air Quality	Air quality impact	The construction footprint will be	General mitigation measures to be	Dust deposition in	Site I, II and III	Prior to site clearance:	CT, EM/ECO	Investigation and
223113	from dust nuisance from the	hoarded on all sides;	implemented throughout construction period.	mg/m²/day	J.C., a.ia iii	Conduct one-time air quality monitoring of PM ₁₀ and PM _{2.5}	3 1, 2, 200	corrective

Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers ^{15,16}
i didilietei	13306				Locations	Monitoring	Responsibility	
	construction activities and gaseous emissions from the construction equipment and vehicles	 No demolition of permanent structure is expected as part of the Project; and Road construction or expansion will be completed first and paved where possible before the construction of other development commences. Implement a wheel washing system for local access roads in all construction sites (with rumble grids to dislodge accumulated dust and mud prior to leaving the site where reasonably practicable). Ensure there is an adequate area of hard surfaced road between the wheel wash facility and the site exit, wherever site size and layout permits. 	Develop and implement a stakeholder communications plan that includes community engagement before work commences on site. Display the name and contact details of person(s) accountable for air quality and dust issues on the site boundary. This may be the environment manager/engineer or the site manager. Develop and implement an Air Pollution Control Plan (APCP) Site Management: Record all dust and air quality complaints, identify cause(s), take appropriate measures to reduce emissions in a timely manner, and record the measures taken. Make the complaints log available to the local authority when asked. Record any exceptional incidents that cause dust and/or air emissions, either onsite or off- site, and the action taken to resolve the situation in the log book. Hold liaison meetings with other high risk construction sites within 500m of the site boundary, if any, to ensure plans are co-ordinated and dust and particulate matter emissions are minimised. Monitoring: Undertake regular (daily frequency recommended) onsite and off-site inspections and record results. The log should be made available to the NEA or other Government Agencies if required. Inspections should include regular dust soiling checks of surfaces such as street furniture, cars and window sills within 100m of site boundary.			for 1 week at Site I, II and III for the establishment of baseline Throughout construction period: Continuous dust deposition monitoring, averaged over 4-week period Routine environmental audit by independent EMMP Consultant during construction phase.		actions to be taken, when 1. Any of the following documentation are found inadequate / missing: Air Pollution Control Plan; Compliance certificate of an Off-Road Diesel engine; or Monitoring Log. 2. If the monitored PM ₁₀ and PM _{2.5} exceed Singapore long term air quality targets. 3. If the dust deposition monitored exceeds 200 mg/m²/day averaged over 4-week 4. If complaints are received due to Project activities. 5. If visual noncompliance to any of the minimum control or mitigation measures are observed onsite.

Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers ^{15,16}
			Cleaning should be provided if necessary. Carry out regular site inspections to monitor and record compliance with the Air Pollution Control Plan. Increase the frequency of site inspections during prolonged dry or windy conditions. Conduct monitoring for dust deposition at suitable locations (refer to Section 13.9.1 for details) Preparing and maintaining the site: Plan site layout so that machinery and dust causing activities are located away from receptors, where possible. Erect hoarding around dusty activities and at the site boundary wherever possible. Boundary screens should be at least as high as any stockpiles or dust emission sources on site. Fully enclose specific activities where there is a known high potential for dust production and the site will be active for an extensive period of time. Keep site fencing, barriers, and scaffolding clean by cleaning regularly using wet methods (dry methods may give rise to fugitive dust). Remove materials that have the potential to produce dust from site as soon as possible, unless being re-used on-site, stockpiled material should be covered, seeded, fenced or enclosed to prevent fugitive dust formation. Operating vehicle/machinery and sustainable travel: Impose and signpost a maximum-speed-limit of 25 km/hr on paved or surfaced haul roads and 15 km/hr on unpaved haul roads and work					
			areas within worksite, as well					

Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers ^{15,16}
			as local access roads leading to worksite. Produce a Construction Logistics Plan to manage the sustainable delivery of goods and materials. Ensure all vehicles and engine powered equipment comply with the legislative requirements of Singapore Ensure all vehicles and equipment switch off their engines when stationary – i.e. no idling vehicles or engines. Clear signs will be erected at site entrance to inform all visitors. Where practicable, avoid the use of diesel- or petrol-powered generators and use mains electricity or battery powered equipment Construction: Only use cutting, grinding or sawing equipment fitted with, or in conjunction with, suitable dust suppression techniques such as water sprays or local extraction e.g. local exhaust ventilation system. Ensure an adequate water supply on the site for effective dust/particulate matter suppression/mitigation, using non-potable water where possible and appropriate. Use enclosed chutes and conveyors and covered skips wherever possible. Minimise drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate. A stringent "Clean as you go" Policy should be implemented on site to ensure no loose dry material is left exposed when not in use. Equipment should be readily available on site to clean and dry spillages, and cleaning should be conducted					

Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers ^{15,16}
			as soon as reasonably practicable after the event using wet cleaning methods. Waste Management: • Avoid burning of waste or other materials MITIGATION MEASURES FOR EARTHWORKS					
			 Re-vegetate earthworks and exposed areas/soil stockpiles to stabilise surfaces as soon as practicable. Use Hessian, mulches or soil tackifiers where it is not possible to re-vegetate or cover with topsoil, as soon as practicable. Only remove the cover in small areas during work and not all at once. 					
			 MITIGATION MEASURES FOR CONSTRUCTION Avoid scabbling (roughening of concrete surfaces) if possible. Ensure sand and other aggregates are stored in bunded areas and are not allowed to dry out, unless this is required for a particular process, in which case ensure that appropriate additional control measures are in place. Ensure bulk cement and other fine powder materials are delivered in enclosed tankers and stored in silos with suitable emission control systems to prevent escape of material and overfilling during delivery. For smaller supplies of fine powder materials ensure bags are sealed after use and stored appropriately to prevent dust. 					
			 MITIGATION MEASURES FOR TRACKOUT Use water-assisted dust sweeper(s) on the access and affected local roads, to remove, as necessary, any material tracked out of the site. This may require the sweeper being continuously in use. Avoid dry sweeping of large areas. Ensure vehicles entering and leaving sites are covered to prevent escape of materials during transport. Inspect on-site haul routes for integrity and instigate necessary repairs to the surface as soon as reasonably practicable. Record all inspections of haul routes and any subsequent action in a site log book. 					

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Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers ^{15,16}
Airborne Noise	Noise from construction	Minimum Controls:	 Install hard surfaced haul routes, which are regularly damped down with fixed or mobile sprinkler systems, or mobile water bowsers and regularly cleaned. Site access gates to be located at least 10m from receptors where possible MITIGATION MEASURES FOR GENERAL CONSTRUCTION NOISE 	Leq 12hours, Leq 1hour and Leg 5mins	Three (3) locations at	Before commencement of any construction works (including site	CT, EM/ECO	Investigation and corrective
	construction machines and equipment, especially rotational and vibratory equipment (e.g. dozers, cranes, excavators, trailers, generators, etc.) (see Appendix Z)	 Construction prohibition period should be followed, as per fourth schedule of Environment Protection and Management regulation; Prepare a Construction Noise Management Plan, to establish baseline monitoring prior to site clearance, plan for monitoring during the construction phase, and procedure for complaint handling; The Contractor shall review the equipment to be used on site and erect localised noise barriers prior to undertaking high noise generating work; Machines (such as trucks) that may be in intermittent use shall be shut down between work periods or shall be throttled down to a minimum; Only well-maintained plants shall be serviced regularly during the entire construction period; The number of PMEs shall be reduced as far as practicable when construction works are carried out at areas close to the noise sensitive receivers: Silencers or mufflers on construction equipment shall be utilised and shall be properly maintained during the construction programme; Behavioural practices including no shouting, no loud stereos/ radios on site, no dropping of materials from height, no throwing of metal items shall be ensured; Construction respite: Restrict high noise generating drilling activities only in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block, if possible; Periodic noise monitoring by an independent third party, to establish compliance with requirements and to advise on equipment causing concern, and additional potential mitigation measures; 	 GENERAL CONSTRUCTION NOISE CONTROL: Control of noise sources at the source from construction site – Analyse construction inventory list and check equipment causing high noise levels. The equipment with lower noise level hall be prioritised. Where controlling noise sources at the source is not feasible, acoustic enclosures or sheds are to be introduced to mitigate noise at the source. Typical acoustic enclosure covers the machine as fully as possible (with or without ventilation where applicable) to provide sound insulation. MITIGATION MEASURES FOR CONSTRUCTION NOISE: Noise Barrier of minimum STC 20 are proposed to be erected at all the locations presented in in the Section 13.10 and Figure 13-18 in order to mitigate the construction noise to the noise sensitive receptors. These locations are: 8m high noise barrier at the construction boundary of CR14 fronting noise sensitive receptors (Site I, Site II and Site III); and 5 m high noise barrier at the construction boundary of CR14 road construction worksite fronting noise sensitive receptors (Site I and Site II) No night works after 7pm for all non-safety critical activities since the site is next to Biodiversity Study Area. Where possible, this will be reduced to 6pm. Portable noise barrier were highly recommended close to the noisy equipment/ activities 	and Leq 5mins	locations at (Site I, Site II and Site III) boundary and closest to CR14 worksite (see Figure 13-18)	construction works (including site clearance) One-time airborne noise monitoring for 1 week at the proposed locations, for establishment of latest baseline. During Construction Phase Continuous monitoring at the proposed locations for the entire duration of construction. Records on noise levels from construction sites should be properly kept and produced when requested.		corrective actions to be taken, when: 1. Any of the following documentat ion are found inadequate / missing: • Construction Noise Management Plan; • Monitoring Log. 2. If the monitored parameters exceed applicable values of EPM regulations. 3. If complaints are received due to Project activities. 4. If visual noncompliance to any of the minimum control or mitigation measures are observed on-site. 5. If there are any cracks / leaks present on
			 For noisy machinery such as the Secant Pile Auger - that typically 					the noise

Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers ^{15,16}
		 Plan the layout of the site by considering using materials and other large structural equipment as noise barriers; Plant known to emit noise strongly in one direction shall, wherever possible, be orientated so that the noise is directed away from the nearby NSRs; and Material stockpiles and other structures shall be effectively utilised, wherever practicable, in screening noise from onsite construction activities. Acoustic sheds should be provided at the locations of the noise generating activity such as operation of hand-held breaker. All construction works should be conducted within the daytime period. TBM works are to be conducted in the daytime as much as possible. During high-noise events such as rock breaking and excavation, ecologists are to be onsite for at least the first seven rock breaking and excavation events and during the test runs in anticipation for fauna response (e.g., flee response behaviour). The ecologist is to monitor for any fauna behaviour (e.g., dashing onto road) resulting in roadkill incidents for at least 30 minutes after each rock breaking and excavation event. In addition, during rock breaking and excavation event. In addition, during rock breaking and excavation events, there shall be ecologists present to observe fauna movements, and the appointed Contractor should take note to restrict the entry of visitors into the trails of Biodiversity Study Area (Site I, Site II and Site III) 	operate for long period, the soundproof baffles can be mounted directly on the machine around the engine cowling					barrier erected.
Ground-borne Vibration	Ground-borne vibration from construction machines and equipment (e.g. tunnel boring machine, bulldozers, high amplitude vibratory compactors and rock breaking and excavation).	 Equipment Selection and Maintenance. Associated cut and cover tunnel plus the operation of the TBM. Works Scheduling and Respite Periods. Community Consultation. It is recommended that the surrounding community be notified before commencing TBM-related works, as a matter of good community relations. 	 smallest footprint within this area. Schedule rock breaking and excavation activities during the daytime. 	Peak Particle Velocity (PPV), mm/s	Site I, II, III: One location each within Sites I, II, III (see Figure 13-19)	Before commencement of any construction works (including site clearance) One-time continuous vibration monitoring for 1 week at the proposed locations, for establishment of latest baseline. During Construction Phase Continuous monitoring at the proposed locations for the entire duration of construction.		Investigation and corrective actions to be taken when: 1. The monitoring program log documentation is found inadequate/missi ng. 2. If the monitored parameters exceed applicable limits.

Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers ^{15,16}
			 Use of tri-axle trucks to reduce truck trips on the road. No night works should be conducted after 7 pm for all nonsafety critical activities. If there are justified complaints from the construction works, particularly from the rock breaking and excavation works, tunnel boring, high amplitude vibratory compactors and bulldozers, the operation may need to mitigate vibration levels to the most practical levels. Temporary barriers (i.e. 1.2 km long water barriers of 1 m height) should be implemented along Turf Club Road. Fairways Drive and Eng Neo Avenue as seen in Figure 13-20. Canvas sheets should also be used to cover the holes on the existing railings along Fairways Drive. Noise barriers must be implemented along Site II to double as temporary barriers. Hoardings must be ensured at the worksites and at the existing construction beside CR14. Turf Club Road north of CR14 and small roads nearby must remain to have limited access (closed if possible), even after lease is up; and Road calming measures must be extended to Turf Club Road north of CR14, small roads nearby and immediate areas within the gold course. Ecologist and Environmental Officer to identify burrows before the start of construction and monitoring burrow collapse during construction activities; During rock breaking and excavation stage, the Ecologist shall monitor for any fauna behaviour (e.g. dashing onto road) resulting in road-kill incidents, for at least thirty (30) minutes after the event. If fauna is seen trying to dash onto the road, construction activities will be immediately suspended, and mitigation measures should be applied to prevent such event from happening in the future. 			In the event of a valid complaint, until the complaint has been resolved. Monthly environmental audit by EMMP Consultant during the construction phase.		3. If complaints are received due to project activities. 4. If visual noncompliance to any of the minimum control or mitigation measures is observed onsite.

13.13.1.2 Commissioning Phase

The EMMP for commissioning phase of the Project is summarised in the following table. The key minimum control measures and key mitigation measures from the operational phase (see Table 13-13) are generally applicable where relevant.

Table 13-13 Proposed Environmental Monitoring and Management Plan for the Commissioning Phase

Environmental Parameter	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers ^{15,16}
Biodiversity	Flora and Arboriculture	Softscape of operational boundary	Monthly for duration of at least 6 months	CT, Floral Specialist, Arborist	NA
	Fauna	Adjacent forest to development boundary		CT, Ecologist	NA
Hydrology and Surface Water Quality	All parameters identified in Table 13-4. And any flooding issues should be recorded and inspected.	At the main outlets/drains of the Project site, as well as the sensitive streams/drains in the vicinity of proposed Project (i.e. D/S16, D/S8) during the first three (3) months of commissioning phase	Monthly inspection for the water quality and hydrology, especially during heavy storm event for hydrological conditions during first three (3) months of commissioning phase	CT, EM/ECO	 Investigation and corrective actions to be taken, when: If the monitored parameters of all discharge points exceed applicable values of NEA Trade Effluent Discharge Limits at discharge point (refer to Table 13-3); If the monitored parameters of natural streams exceed applicable values of Water Quality Criteria for Aquatic Life at natural stream (refer to Table 13-3); If any flooding issues observed; If complaints are received due to Project activities; and If visual non-compliance to any of the minimum control or mitigation measures are observed on-site.
Soil and Groundwater	Records on waste generated and hazardous chemicals used at the Project site should be properly kept and records produced when requested.	 At locations where toxic chemical waste are generated and store. At locations where hazardous chemicals/substances are used and stored. 	 Monitoring records of the amount and type of toxic chemical waste generated during first three (3) months of the commissioning phase Inspection of hazardous chemical/substances storage conditions during first three (3) months of the commissioning phase 	CT, EM/ECO	 Investigation and corrective actions to be taken, when: There are no/poor records of toxic chemical waste amount and type; and There is evidence of poor handling/storage of toxic chemical waste and hazardous chemical.
Airborne Noise	Leq 5min and Leq 1 hour	Three (3) noise monitoring locations at boundary of Site I, Site II and Site III (see Figure 13-18)	Continuous monitoring for three (3) months of the commissioning phase	CT, EM/ECO	Investigation and corrective actions to be taken, when: If complaints are received due to Project activities.
	Leq15 min	Five (5) noise monitoring locations at boundary of ventilation shaft (see Figure 13-18)	Continuous monitoring for one (1) day (24 hours) within the commissioning phase, as per NEA's Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Building		If visual non-compliance to any of the minimum control or mitigation measures are observed on-site.
Ground-borne Vibration	Peak Particle Velocity (PPV), mm/s	• N/A	• N/A	N/A	N/A

13.13.1.3 Operational Phase

A contract-specific EMMP is not required for operational phase. General housekeeping, environmental management and/or EHS measures as included as part of the minimum control measures and key mitigation measures proposed in this report and shall be implemented by the Rail Operator and other relevant personnel (refer to roles and responsibility in Section 13.5) during operational phase. The summary of key minimum control measures and key mitigation measures for operational phase are highlighted in table below.

Table 13-14 Summary of Key Minimum Control Measures and Mitigation Measures to Be Implemented during Operational Phase

Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Responsibility
Biodiversity	Minimisation of operational impacts to flora/vegetation	 The maintenance of the system should happen during engineering (0100h to 0400h) and non-engineering hours (operational hours of train line, 0600h to 2300h). As much as possible, systems that are crucial to daily operational basis will be carried out during non-engineering hours, while electrical services and signalling will be done during engineering hours except at the unlikely event of urgent work required due to failure in mainline. 	 Identify areas that are responding poorly due to operational activities Ensure that post-construction planting is responding well to development surrounding Ensure integrity of adjacent forest (if any) Identify signs of edge effects on new forest edge of adjacent forest (if any) 	Rail Operator
	Minimisation of operational impacts to fauna		 Assessment of habitat quality (e.g., water quality, excessive vegetation removal) Inspection for presence of trapped/injured/dead fauna, potential fauna entrapments and gaps in site hoarding Recording number of occurrences of human-wildlife conflict Conduct biodiversity survey to monitor construction impacts on fauna activity and presence 	Rail Operator
Hydrology and Surface Water Quality	Stormwater run-off generation	 Stormwater Quality: Adequate drainage, piping and/or channelling of stormwater run-off to be assured through detailed design [such as Active, Beautiful, Clean Water (ABC) Water Design approach] for capture and treatment before discharge into watercourses; Regular and dedicated procedures for the inspection and maintenance of stormwater collection, storage, and treatment infrastructure, such as pipes, oil water separation, silt screens, etc.; and Regular and dedicated procedures for the management of stormwater collection, settling, testing and eventual discharge of 'clean' water to watercourses. Hydrology: Potential increase of peak-flow due to the change in the land use at the new developments can be mitigated by providing detention tanks within the Study Area. Detention tanks can capture stormwater during heavy storm events to reduce the peak runoff. Stored water can then be discharged back to the system after the storm event. As required by PUB, the storage system needs to be in place to reduce the peak flow at the operational phase to be the same or less than that of the existing condition; Active, Beautiful, Clean Water (ABC) Water Design approach can be considered to reduce the peak-flow as well; and Geotechnical aspect of the site's slope stability (such as ERSS) shall be included in detailed design engineering for the operational stage. 	 Provision of flow diversion of affected sections of naturalised stream D/S16 and earth drain D/S8, so as to ensure the perennial flow is maintained. Discharge treated runoff into earth drain D/S8 (i.e. treated to meet NEA Trade Effluent Discharge Limits) to maintain its existing flow. 	- · · · · · · · · · · · · · · · · · · ·
Soil and Groundwater	Generation of small quantities of toxic chemical waste (used fluorescent bulbs, used lead-batteries, used maintenance chemical containers i.e. thinner, paints, lubricants, etc.) Improper handling of hazardous chemical/ substances	 Store all toxic chemical waste at designated sheltered area provided with access-controlled entrance and concrete bund walls or in storage containers with good ventilation. Spill trays shall be provided for all chemical drums, plants and machinery and potential pollutive substances used on site. Spill trays shall be regularly maintained to prevent rain from washing out the pollutive substances. Dispose all toxic waste chemicals off-site to licensed TIW collectors for treatment. Store all hazardous substances/chemicals at designated sheltered area provided with access-controlled entrance and concrete bund walls or in storage containers with good ventilation. Spill trays shall be provided for all chemical drums, plants and machinery and potential pollutive substances used on site. Spill trays shall be regularly maintained to prevent rain from washing out the pollutive substances. Ensure that all hazardous chemicals/substances are labelled its movement is recorded and returned to the designated storage areas when not in use. Ensure all activities including repair, servicing, engine overhaul works, etc. involving the use of hazardous chemicals/substances are carried out on an area which is appropriately contained (e.g. concreted area and with proper containment/sumps). 	Not Applicable	Rail Operator/ EHS Officer

Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Responsibility
		 Provide emergency spill kits on site in the event of any chemical spillages. The emergency response team shall also be competent in the use of these spill kits. Ensure no trade effluent other than that of a nature or type approved by NEA Director- 		
		General are discharged into any watercourse or land.		
Airborne Noise	Noise from facility building operation	 Minimum controls for ACMV noise: Minimum controls should be applied at the detailed design stage of the development by the appointed M&E consultants. An appointed Noise consultant should validate the noise in accordance with NEA's Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Building. Use low air-conditioning and mechanical ventilation system equipment; Ensure that any exhaust outlet or intake from the mechanical ventilation system is designed to be adequately set back as far as possible from the boundary line of the development; Acoustic treatment for equipment to meet noise level limit at site boundary where necessary; AC system to be designed with the AHU units placed at appropriate locations as set back from the boundary line of the development as possible; and Acoustic enclosures for outdoor equipment. Minimum controls for traffic noise: Due to the lack of information at this juncture of reporting, assessment, minimum controls and mitigation will be provided by the appointed Noise Consultant during the prelim design stage and in accordance with Technical Guideline for Land Traffic Noise Impact Assessment [R-54] 	 Noise attenuators and other BAT and BEP noise control measures shall be utilised Traffic noise at the drop-off points and parking areas shall be mitigated with low speed postings, humps and signage 	Rail Operator/ EHS Officer
Ground-borne Vibration	Ground-borne Vibration from the operation of trains	 Train, track and tunnel design; Maintenance of vertical track alignment at the relevant longitudinal wavelengths; Maintenance of roughness of the railhead and wheel thread at the relevant longitudinal and circumferential wavelengths; Maintenance of resilient elements of track construction, e.g. rail pads, sleeper pads and ballast mats; and Maintenance of rail joints, switches and crossings. 	General maintenance of the railway track and minimising of wheel defects.	Ground-borne Vibration from the operation of trains

CR2005

13.13.2 EMMP Summary for CR15 Worksite

13.13.2.1 Construction Phase

The EMMP for construction phase of the Project is summarised in the following table.

Table 13-15 Proposed Environmental Monitoring and Management Plan for Construction Phase

Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsib ility	Triggers ^{17,18}
General	Exclusion of the evaluation of certain environmental impacts where detailed design is not available for review at the time of writing this report	 The current preliminary worksite design used for this study excludes any inputs in terms of locations of piezometers, utilities/ road diversion areas, site elements (e.g. workers dormitory, detention tank, site office etc.). If this be available at later stage, the Contractor shall review the impact study findings based on the latest design inputs, then update the recommended EMMP (e.g. monitoring frequency/location) accordingly if necessary. 	N/A	N/A	N/A	N/A	СТ	N/A
Biodiversity	Minimisation of construction impacts to flora/vegetation	Trees that are to be retained within worksite would require an arborist to clearly mark out Tree Protection Zones where no works are allowed. The Tree Protection Zones should be set up in accordance with NParks guidelines	 Mark out site boundary. Identification of locations, species and quantity of transplant candidates that are affected by construction. 	Flora and Arboriculture	Within development boundary	Prior to site clearance	CT, EM/ECO, Flora Specialist	N/A
			 Inspection of integrity of TPZ hoarding Assessment of tree physiological health and vigour. Determination of presence of mechanical damage to trees that may impair stability Review of method statements of construction works in proximity to retained trees. Identification of excessive or unauthorised tree removal. Identification of trees that require management and maintenance such as tree care and pruning Determination of any unauthorised removal of flora within areas of conservation (if any) or beyond the demarcated worksite. Identification of areas with soil erosion and degradation that have resulted from construction activities. Determination of unauthorised dumping of waste material, construction debris or oil/chemical leakage that may contaminate the soil and waterbodies, and/or be detrimental to the vegetation. Identification of areas that are responding poorly due to the development impacts. 		Within development boundary and 15m beyond hoarding line	Monthly for duration of construction	CT, EM/ECO, Flora Specialist, Arborist	
	Minimisation of construction impacts to fauna Minimisation of construction	Before vegetation removal, pre-felling fauna inspection should be conducted by an Ecologist to identify wildlife or nesting structures that are being actively used such as bird nests, tree hollows and burrows.	 Implementation of directional clearing. Inspection for presence of trapped/injured/dead fauna, potential fauna entrapments and gaps in site hoarding. Toolbox briefings on biodiversity awareness. 	Fauna Flora and Arboriculture	Within development boundary	Prior to site clearance	CT, EM/ECO, Ecologist	N/A When fauna is encountered within development boundar

¹⁷ Resident Technical Officer (RTO) and Site Officers (SO, WSHO and ECO) check the Project site for construction progress and implementation of environmental mitigation measures.

¹⁸ If there is trigger then all the mitigation and management measures should be audited in detail for compliance and corrective action must be taken in liaison with the Project Owner.

Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsib ility	Triggers ^{17,18}
	impacts to flora/vegetation	 Soil erosion control measures are to be executed once vegetation has been removed and soil is exposed as described in Section 7 under Hydrology and Surface Water Quality Implement dust control measures as described in Section 10 under Air Quality Proper storage of materials that are likely to leech harmful chemicals and fuel-powered equipment away from waterbodies or sensitive habitats as described in Section 9 under Soil and Groundwater (and Waste) Ensure noise levels are within approved limits as described in Section 11 under Airborne Noise Ensure vibration levels are within approved limits as described in Section 12 under Ground-borne Vibration 	 Assessment of habitat quality (e.g., water quality, excessive vegetation removal, light management strategies) Implementation of only 100% biodegradable ECBs Establish a comprehensive waste management system and submit a contract-specific Waste Management Plan which details the types of waste generated, location and types of waste management facilities, frequency of disposal, as well as information of waste management contractors. This will act as the guidance for workers to ensure proper implementation of waste management and disposal on site, where the practices shall include but not limited to: Strictly prohibit illegal disposal of construction wastes into streams and storm water channels or other waterbodies Strictly prohibit littering of food waste and food packaging Provide sufficient fully covered food waste bins that are secured in a manner that is wildlife-proof Clear all food waste from the worksite at least once a day If fauna is found to be active around waste disposal areas, the Contractor shall implement measures to reduce the source of the attractant in consultation with the Ecologist Implementation of proper vector management strategies, where the hierarchy of vector control for construction worksites near ecologically sensitive sites shall be as follows: (d) no thermal fogging to prevent unintended impacts to invertebrate fauna nearby; (e) no chemical insecticides, pesticides and rodenticides shall be used for pest control; (f) no sticky traps shall be used for pest control; 		Within development boundary	Monthly for duration of construction	CT, EM/ECO, Ecologist	
		NA	 Conduct biodiversity survey to monitor construction impacts on fauna activity and presence. Conduct ground-borne and airborne noise monitoring to monitor behaviour of fauna to impacts from vibration. 		Adjacent to development boundary	Monthly for duration of construction	CT, EM/ECO, Ecologist	
		NA	Recording number of occurrences of human- wildlife conflict.		Within development boundary	Daily monitoring and record- keeping	CT, EM/ECO	
		NA	Implementation of road calming measures such as road signages, speed limitation, road humps		Adjacent to development boundary	Prior to site clearance	CT, EM/ECO	N/A
		Trees that are to be retained within worksite would require an arborist to clearly mark out Tree Protection Zones where no works are allowed. The Tree Protection Zones should be set up in accordance with NParks guidelines	Mark out site boundary		Within development boundary	Prior to site clearance	CT, EM/ECO, Flora Specialist	N/A

Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsib ility	Triggers ^{17,18}
			Identification of locations, species and quantity of transplant candidates that are affected by construction					
		N/A	 Inspection of integrity of TPZ hoarding Assessment of tree physiological health and vigour Determination of presence of mechanical damage to trees that may impair stability Review of method statements of construction works in proximity to retained trees Identification of excessive or unauthorised tree removal Identification of trees that require management and maintenance such as tree care and pruning Determination of any unauthorised removal of flora within areas of conservation (if any) or beyond the demarcated worksite Identification of areas with soil erosion and degradation that have resulted from construction activities Determination of unauthorised dumping of waste material, construction debris or oil/chemical leakage that may contaminate the soil and waterbodies, and/or be detrimental to the vegetation Identification of areas that are responding poorly due to the development impacts. 		Within development boundary and 15m beyond hoarding line	Monthly for duration of construction	CT, EM/ECO, Flora Specialist, Arborist	N/A
Hydrology and Surface Water Quality	 Solid & Toxic Waste Generation Liquid Effluent and stormwater run-off Generation Improper Management 	 Key Minimum Controls Solid & Toxic Waste Generation Effective ECM and monitoring implemented as recommended in the Code of Practice on Surface Water Drainage to ensure that discharge into the stormwater drainage system does not contain TSS in concentrations greater than the prescribed limits under the Sewerage and Drainage (Surface Water Drainage) Regulations; Hazardous substances and toxic wastes should be stored on hard stand, under shelter with a kerb around the storage area; 	N/A	All water quality parameters identified in Table 13-4. And any flooding issues should be recorded and inspected.	At new freshwater marsh.	One time monitoring prior to site clearance	CT, EM/ECO	Investigation and corrective actions to be taken if there is a significant drawdown of groundwater level.

Environmental Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsib ility	Triggers ^{17,18}
of Chemical Substances	 Implementation of CCTV including SIDS at the public drain to monitor the surface runoff discharges from the sites as per the Public Utilities Board of Singapore's (PUB) circular on Preventing Muddy Waters from the Construction Sites (October 2015); and All wastes will be disposed only in the designated waste disposal facilities and appropriately separated, i.e. by trained workers to properly sort and label the different types of waste (reusable and recyclable waste, toxic and non-toxic waste, etc.). Liquid Effluent Generation and Stormwater Runoff A full inventory of all anticipated wastewater streams and volumes should be finalised before the onset of the construction works; No unmanaged discharge of wastewater stream permitted; Reduce, reuse, and recycle hierarchy principle to be applied to wastewater, such as oily water, thinners, solvents, or paints, should be stored on hard stand, under shelter with a kerb around the storage area. The wastewater should be removed for treatment and disposal off-site by an approved Waste Management Contractor. Hazardous liquids to be handled as Hazardous Waste; Containment pond/kerbs will be of impervious material and be designed with sufficient capacity to hold volumes of wastewater produced on-site and potential fire-fighting wastewater. Contractor will seek for comment and approval from relevant authorities (e.g. SCDF and NEA) on the treated wastewater to be used for firefighting purpose; Adequate drainage, cut-off drains, sump pit, road kerb, piping and toe wall will be designed for channelling of construction process wastewater streams (e.g. concrete batching, wash water, etc.) and stormwater runoff separately through detailed design for capture and treatment in the containment pond/kerbs. Where applicable (e.g. in the vicinity of liquid storage or refuelling areas), this infrastructure will include oil-water separators to capture inadvertent spills or leaked oils or greases; Temporary stor	N/A	All water quality parameters identified in Table 13-4. And any flooding issues should be recorded and inspected.	Before every discharge outlet, at new freshwater marsh.	 Permanent online real-time turbidity monitor installed at every discharge outlet; Implementation of CCTV including a SIDS at every discharge outlet to monitor the surface run-off discharges from the sites; Monthly monitoring at all the discharge point locations at the construction sites throughout out the construction period; Monthly monitoring of the new freshwater marsh to be conducted for at least five (5) years or till the end of the construction of the CR15 Entrance 4 (whichever duration is longer) at Site V. Intensity of the laboratory analysis will be increased (e.g. fortnightly, weekly) if in-situ measurements and/or monthly laboratory results indicate deterioration in the water quality. Intensified monitoring will be carried out until in-situ measurements and/or laboratory results indicate 'normality'/consistency with earlier monitored conditions; Daily inspection on perimeter drains to ensure no surface runoff flowing out from the site untreated done by the site officer with routine audit done by independent EMMP consultant; and Daily inspection on perimeter drains, new freshwater marsh to ensure no surface runoff flowing out from the site untreated done by the site officer with routine audit done by independent EMMP consultant; and Daily inspection on perimeter drains, new freshwater marsh to ensure no surface runoff flowing out from the site untreated done by the site officer with routine audit done by independent EMMP consultant		Investigation and corrective actions to be taken, when: The following documentation are found inadequate/missing: ECM Plan; Monitoring Log; Training Log; Audit Reports; If the monitored parameters exceed applicable values of NEA Trade Effluent Discharge Limits at discharge point (refer to Table 13-3); If the monitored parameters exceed applicable values of Water Quality Criteria for Aquatic Life at natural stream (refer to Table 13-3); For newly created freshwater marsh - if the monitored parameters exceed the criteria set based on pre-site clearance baseline water quality. If any flooding or clogging issues observed; If complaints are received due to Project activities; and If visual non-compliance to any of the minimum control or mitigation measures are observed on-site.

Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsib ility	Triggers ^{17,18}
		will be stored, treated or recycled on-site and finally disposed off-site; The discharge of pumped dewatered groundwater or other wastewaters to sensitive aquatic habitats will be prohibited; Tunnel washing effluent should be discharged to a containment pond/kerbs that manually collected by						
		 operator assigned private wastewater collector to be transferred to wastewater treatment plant; Appropriate disposal of any waste listed in the Environmental Public Health (General Waste Collection) Regulations by licensed waste operator/collector; Runoff within, upstream of, and adjacent to the 						
		 worksite will be effectively drained away without causing flooding in the vicinity; Appropriate permits for discharge to be obtained from relevant authority prior to discharge. No trade effluent other than that of a nature or type approved by NEA Director-General will be discharged into any watercourse or land; 						
		 Regular and dedicated procedures for the management of stormwater collection, settling, testing and eventual discharge of 'clean' water to watercourses. This should also include associated measures required to prevent high sediment concentration stormwater drainage to watercourses; and 						
		 Geotechnical aspect of site's slope stability (such as Earth Retaining and Stabilising structures (ERSS) to be included in detailed design engineering for the construction stage. Improper Management of Chemical Substances 						
		 Development of SOP for safe handling, transfer and storage of toxic waste; housekeeping checks once a day to ensure all toxic waste is cleared from site; Appropriate tests to ascertain the presence/absence of contamination of the excavated earth and sand; Appropriate fully sheltered storage area with 						
		storage volume to be 110% of the largest volume of chemical substances to be stored (kerb up and enclosed on at least 3 sides, covered and with adequate ventilation) for hazardous substances; • Appropriate construction material for toxic waste storage containers with leak detection tests						
		 conducted periodically; Provision of secondary containment for all toxic waste stored in bulk as per the requirements in the COPPC/SS593; Preparation of an emergency response plan, 						
		training of the emergency response team (ERT) to be competent in the response mechanism and provision of response kits for any spillages; Consignment notification/tracking system and transport emergency response plan for transport of toxic waste;						

Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsib ility	Triggers ^{17,18}
		Appropriate disposal of toxic waste as per required in the Environmental Public Health (Toxic Industrial Waste) Regulations by licensed waste operator/collector.						
Soil and Groundwater	Decreased groundwater baseflow feeding into the streams	Minimum Controls: iii) Install piezometers to monitor the changes in groundwater level in compliance with Building Control Regulations 2003 as part of its instrumentation and monitoring plan to be endorsed by the Qualified Professional (QP); and iv) Proper Earth Retaining Stabilising Structures (ERSS) should be selected and designed to limit groundwater settlement.	v) Creation of Freshwater Marsh Habitat	Groundwater Level	Actual monitoring location to be decided by QP.	To continuously monitor the groundwater level throughout the lifetime of the construction phase.	CT, EM/ECO	Investigation and corrective actions to be taken if there is a significant drawdown of groundwater level.
	Improper Management and Disposal of Excavated Soil and Groundwater	 Identify all types of solid waste (e.g. tunnelling waste) and implement comprehensive waste management system at the site in order to ensure proper disposal and prevent pollution to the environment. This Contractor should conduct a construction risk assessment and prepare a comprehensive construction health, safety and environment plan. If health impacts to workers are foreseen due to the handling of such waste, necessary precautionary measures as per the safety data sheets (SDS) including personal protective equipment should be implemented on site. Use approved materials, of the same or better quality as the surrounding area, for backfilling works. All backfilled material shall be free of debris, and of good material soil. Handle and dispose excavated soil following the procedure shown in the Figure 13-15. This flow chart explains how to handle excavated soils, and identify potential areas of contamination as well as potential of contamination (POC) in excavated soils. If the POC soils are tested for exceedance in DIVs, the soils can be disposed of to toxic waste collectors or undergo soil treatment. If contaminated soils were sent for treatment to an acceptable standard such as the DIV, the treated soil can be disposed in the staging ground or through a general waste collector, depending on the level of the contaminants during the staging ground testing. Upon receipt of results on the tested parameters (chemicals, heavy metals) exceeding the regulatory limits, the construction Contractor should further assess the potential inhalation and dermal contact impacts of the exceeded parameters to the site workers exposed to areas where soil and/or groundwater contamination is identified. The risk assessment should be conducted before the commencement of construction activities and the findings 		Records on waste generated and hazardous chemicals used at the construction site should be properly kept and records produced when requested.	At locations where excavated soil and extracted groundwater are generated and stored. At locations where toxic chemical wastes are generated and stored. At locations where hazardous chemicals/substa nces are used and stored.	Monitoring records of the amount and type of toxic chemical waste generated, once a week Inspection of hazardous chemical /substances storage conditions, once a week. Routine environmental audit during construction phase.	CT, EM/ECO	Investigation and corrective actions to be taken, when: • There are no/ poor records of toxic chemical waste amount and type; and • There is evidence of poor handling/ storage of toxic chemical waste and hazardous chemical.

Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Triggers ^{17,18} Responsib ility
		incorporated into the Contractors' construction risk					
		assessment and health, safety and environment					
		plan. If health impacts to workers are foreseen, necessary precautionary measures, as per the					
		respective chemical SDS, should be implemented					
		on site.					
		A site management plan should include plans of					
		safe handling, transfer and storage of excavated					
		soils following the procedure in the Figure 13-15.					
		Discharge of extracted groundwater shall be to an					
		area approved for such disposal by the NEA and					
		the proposed location as identified in the Figure					
		13-15 and following the process set out in the					
		Figure 13-16. Based on the results of the soil and					
		groundwater baseline study, the detected					
		concentrations of lead in certain groundwater					
		samples exceeded the DIV. Therefore, it is recommended that the construction Contractor to					
		be vigilant of site conditions and extracted					
		groundwater to be tested at regular intervals,					
		especially for extracted groundwater with oily					
		sheens or noticeable odour. If a contaminant					
		concentration in excess of the DIV is detected, the					
		Contractor shall assess the potential inhalation					
		and dermal impacts of the chemical identified and					
		assess potential health and safety considerations					
		for exposure to groundwater before					
		commencement of construction activities. Such					
		contaminated wastewater may need to be					
		disposed of to a licenced toxic waste collector.					
		 Bentonite slurry used in the TBM will be pumped into the slurry treatment plant for recycling, 					
		cleaning and removal of native cut material.					
		Treatment methodologies in the slurry treatment					
		plant will include de-sanding (e.g., cyclones) and					
		filtration. Handling and disposal of spoils for					
		disposal after the treatment shall follow the					
		procedure in the Figure 13-15.					
	Toxic Chemical	 Identify all types of toxic chemical waste and 					
	Waste Generation	implement comprehensive waste management					
	during Construction	system at the site in order to ensure proper					
	Phase	disposal and prevent pollution to the environment.					
		This Contractor should conduct a construction risk					
		assessment and prepare a comprehensive construction health, safety and environment plan.					
		If health impacts to workers are foreseen due to					
		the handling of such waste, necessary					
		precautionary measures as per the safety data					
		sheets (SDS) including personal protective					
		equipment should be implemented on site;					
		Inspect all equipment prior to entering the site for					
		fuel/hydraulic lines, leaking tanks, and other					

Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Triggers ^{17,18} Responsib ility
		 potential faulty parts that could potentially cause contamination to soil or groundwater; Dispose all construction debris (under category C&D) at the gazetted Government dumping grounds or at such other sites or locations as directed by NEA; Store generated toxic chemical waste under shelter within concrete bund walls or in storage containers with good ventilation. Spill trays shall be provided for all waste containers Spill trays shall be regularly maintained to prevent rain from washing out the pollutive substances; Note that the Earth Control Measures (ECM) is for the containment and treatment of silty discharge due to the impact of rainwater. ECM is not meant for the treatment of wastewater due to construction activities (such as pipe-jacking and bore-piling works) which shall be treated to comply with the requirements under prevailing legislation; and The wastewater from tunnelling activities should be stored and removed for treatment and disposal off-site by an approved Waste Management Contractor. Contractor will need to seek approval from both relevant authorities (e.g., PUB & NEA) as per PUB Sewerage and Drainage (Trade Effluent) Regulations if the wastewater will be disposed to public sewer or NEA's Trade Effluent Discharge Limits to controlled watercourse if the treated trade effluent will be disposed to surface watercourses. If such discharges are not approved, the trade effluent will be stored, treated, 					
	Improper Handling of Hazardous Chemicals/Substa nces during Construction Phase	or recycled on site and finally disposed of.					

channelled for appropriate treatment or disposal to meet the regulations; Store chemicals stored under shelter within concrete bund walls or in storage containers with good ventilation. Spill trays shall be provided for all drums, plants and machinery and potential pollutive substances used on site. Spill trays shall be regularly maintained to prevent rain from washing out the pollutive substances; and		
Air Quality Air quality impact from dust in all also be completed in the use of these spill kits. Air Quality Air quality impact from dust manufactor into additional content of the protect and shall also be completed in the use of these spill kits. **No defending of protect and shall also be completed in activities and galeaus emissions from the construction of manufactor in the construction of supprient and whites and galeaus emissions from the construction of superior and whites and galeaus emissions from the construction of subtractive of the spill kits. **No defending of protect and construction or supprient and whites and galeaus emissions from the construction of subtractive or expansion will be completed first and protection sizes (with number grids to the six where the seanch grids for the six where the seanch grids for the six where the seanch grids and the protection of the development commences on site. **Implement and white propriet and where possible before the community or gragograment before work commences on site. **Implement and white propriet and construction plane that includes community or gragograment before work commences on site. **Implement and white propriet and construction sites (with number grids to the six where the construction sites with number of the seanch grids to the six where the seanch grids and surfaced mond between the wheel wash facility and the site was the seanch grid of the six where the six subject to th	od t by	Investigation and corrective actions to be taken, when 1. Any of the following documentation are found inadequate / missing: Air Pollution Control Plan; Compliance certificate of an Off-Road Diesel engine; or Monitoring Log. 2. If the monitored PM ₁₀ and PM _{2.5} exceed Singapore long term air quality targets. 3. If the dust deposition monitored exceeds 200 mg/m²/day averaged over 4-week 4. If complaints are received due to Project activities. 5. If visual non-compliance to any of the minimum control or mitigation measures are observed on-site.

Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsib ility	Triggers ^{17,18}
			 Carry out regular site inspections to monitor and record compliance with the Air Pollution Control Plan. Increase the frequency of site inspections during prolonged dry or windy conditions. Conduct monitoring for dust deposition at suitable locations (refer to Section 13.9.1 for details) Preparing and maintaining the site: Plan site layout so that machinery and dust causing activities are located away from receptors, where possible. Erect hoarding around dusty activities and at the site boundary wherever possible. Boundary screens should be at least as high as any stockpiles or dust emission sources on site. Fully enclose specific activities where there is a known high potential for dust production and the site will be active for an extensive period of time. Keep site fencing, barriers, and scaffolding clean by cleaning regularly using wet methods (dry methods may give rise to fugitive dust). Remove materials that have the potential to produce dust from site as soon as possible, unless being re-used on site. If they are being re-used on-site, stockpiled material should be covered, seeded, fenced or enclosed to prevent fugitive dust formation. Operating vehicle/machinery and sustainable travel: Impose and signpost a maximum-speed-limit of 25 km/hr on paved or surfaced haul roads and 15 km/hr on unpaved haul roads and work areas within worksite, as well as local access roads leading to worksite. Produce a Construction Logistics Plan to manage the sustainable delivery of goods and materials. Ensure all vehicles and engine powered equipment comply with the legislative requirements of Singapore Ensure all vehicles and equipment switch off their engines when stationary – i.e. no idling vehicles or engines. Clear signs will be er					

Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsib ility	Triggers ^{17,18}
			 Only use cutting, grinding or sawing equipment fitted with, or in conjunction with, suitable dust suppression techniques such as water sprays or local extraction e.g., local exhaust ventilation system. Ensure an adequate water supply on the site for effective dust/particulate matter suppression/mitigation, using non-potable water where possible and appropriate. Use enclosed chutes and conveyors and covered skips wherever possible. Minimise drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate. A stringent "Clean as you go" Policy should be implemented on site to ensure no loose dry material is left exposed when not in use. Equipment should be readily available on site to clean and dry spillages, and cleaning should be conducted as soon as reasonably practicable after the event using wet cleaning methods. Waste Management: Avoid burning of waste or other materials MITIGATION MEASURES FOR EARTHWORKS Re-vegetate earthworks and exposed areas/soil stockpiles to stabilise surfaces as soon as practicable. Use Hessian, mulches or soil tackifiers where it is not possible to re-vegetate or cover with topsoil, as soon as practicable. Only remove the cover in small areas during work and not all at once. MITIGATION MEASURES FOR CONSTRUCTION Avoid scabbling (roughening of concrete surfaces) if possible. Ensure sand and other aggregates are stored in bunded areas and are not allowed to dry out, unless this is required for a particular process, in which case ensure that appropriate additional control measures are in place. Ensure bulk cement and other fine powder materials are delivered in enclosed tankers and stored in silos with suitable emission control systems to prevent escape of material and overfilling during delivery. For smaller supplies of fine powder materials					

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Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsib ility	Triggers ^{17,18}
Airborne Noise	Noise from construction machines and equipment, especially rotational and vibratory equipment (e.g. dozers, cranes, excavators, trailers, generators, etc.) (see Appendix Z)	 Minimum Controls: Construction prohibition period should be followed, as per fourth schedule of Environment Protection and Management regulation; Prepare a Construction Noise Management Plan, to establish baseline monitoring prior to site clearance, plan for monitoring during the construction phase, and procedure for complaint handling; The Contractor shall review the equipment to be used on site and erect localised noise barriers prior to undertaking high noise generating work; Machines (such as trucks) that may be in intermittent use shall be shut down between work periods or shall be throttled down to a minimum; Only well-maintained plants shall be utilised onsite and plants shall be serviced regularly during the entire construction period; The number of PMEs shall be reduced as far as practicable when construction works are carried out at areas close to the noise sensitive receivers: Silencers or mufflers on construction equipment shall be utilised and shall be properly maintained during the construction programme; Behavioural practices including no shouting, no loud stereos/ radios on site, no dropping of materials from height, no throwing of metal items shall be ensured; Construction respite: Restrict high noise generating drilling activities only in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block, if possible; Periodic noise monitoring by an independent third party, to establish compliance with requirements and to advise on equipment causing concern, and additional potential mitigation measures; Plan the layout of the site by considering using materials and other large structural equipment as noise barriers; 	any material tracked out of the site. This may require the sweeper being continuously in use. Avoid dry sweeping of large areas. Ensure vehicles entering and leaving sites are covered to prevent escape of materials during transport. Inspect on-site haul routes for integrity and instigate necessary repairs to the surface as soon as reasonably practicable. Record all inspections of haul routes and any subsequent action in a site log book. Install hard surfaced haul routes, which are regularly damped down with fixed or mobile sprinkler systems, or mobile water bowsers and regularly cleaned. Site access gates to be located at least 10m from receptors where possible MITIGATION MEASURES FOR GENERAL CONSTRUCTION NOISE CONTROL: Control of noise sources at the source from construction site – Analyse construction inventory list and check equipment causing high noise levels. The equipment with lower noise level hall be prioritised. Where controlling noise sources at the source is not feasible, acoustic enclosures or sheds are to be introduced to mitigate noise at the source. Typical acoustic enclosure covers the machine as fully as possible (with or without ventilation where applicable) to provide sound insulation. MITIGATION MEASURES FOR CONSTRUCTION NOISE: Noise Barrier of minimum STC 20 are proposed to be erected at all the locations presented in in the Section 13.10 and Figure 13-18 in order to mitigate the construction noise to the noise sensitive receptors. These locations are: 12 m high noise barrier at the construction boundary of CR15 fronting noise sensitive receptors (Site IV, Site V and human receptors).	Leq 12hours, Leq 1hour and Leq 5mins	Two (2) locations at (Site IV and Site V) boundary and closest to CR15 worksite (see Figure 13-18) For all monitoring locations	construction works (including site clearance) One-time airborne noise monitoring for 1 week at the proposed locations, for establishment of latest baseline. During Construction Phase Continuous monitoring at the proposed locations for the entire duration of construction.	CT, EM/ECO	Investigation and corrective actions to be taken, when: 1. Any of the following documentation are found inadequate / missing: • Construction Noise Management Plan; • Monitoring Log. 2. If the monitored parameters exceed applicable values of EPM regulations. 3. If complaints are received due to Project activities. 4. If visual noncompliance to any of the minimum control or mitigation measures are observed on-site. 5. If there are any cracks / leaks present on the noise barrier erected.

Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsib ility	Triggers ^{17,18}
Ground-borne Vibration	Ground-borne vibration from construction machines and equipment (e.g. tunnel boring machine, bulldozers, high amplitude vibratory compactors and rock breaking and excavation).	 Plant known to emit noise strongly in one direction shall, wherever possible, be orientated so that the noise is directed away from the nearby NSRs; and Material stockpiles and other structures shall be effectively utilised, wherever practicable, in screening noise from on-site construction activities. Acoustic sheds should be provided at the locations of the noise generating activity such as operation of hand-held breaker. All construction works should be conducted within the daytime period. TBM works are to be conducted in the daytime as much as possible. Equipment Selection and Maintenance. Associated with cut and cover tunnel plus the operation of the TBM. Works Scheduling and Respite Periods. Community Consultation. It is recommended that the surrounding community be notified before commencing TBM related works, as a matter of good community relations. 	The Contractor shall control construction vibration levels using the best available techniques (BAT) for high amplitude vibratory compactors. Restrict high amplitude vibratory compactors and rock breaking below the vibration threshold, PPV, 8.0 mm/s. Ecologist and Environmental Officer to identify burrows before the start of construction and monitoring burrow collapse during construction activities. No night works should be conducted after 7 pm for all non-safety critical activities.	Velocity	One (1) monitoring location each at (Site IV and Site V) boundary and closest to CR15 worksite (see Figure 13-20)	Before commencement of any construction works (including site clearance) One-time continuous vibration monitoring for 1 week at the proposed locations, for establishment of latest baseline. During Construction Phase Continuous monitoring at the proposed locations for the entire duration of construction. In the event of a valid complaint, until the complaint has been resolved. Environmental audit by EMMP Consultant, monthly during construction phase.	CT, EM/ECO	Investigation and corrective actions to be taken, when: 1. The monitoring program log documentation is found inadequate/missing. 2. If the monitored parameters exceed applicable limits. 3. If complaints are received due to project activities. 4. If visual non-compliance to any of the minimum control or mitigation measures are observed on-site.

13.13.2.2 Commissioning Phase

The EMMP for commissioning phase of the project is summarised in the following table and tabulated in Appendix A. The minimum control measures and mitigation measures from the operational phase (see Table 13-16) are generally applicable where relevant.

Table 13-16 Proposed Environmental Monitoring and Management Plan for the Commissioning Phase

Environmental Parameter	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers ^{15,16}
Biodiversity	Flora and Arboriculture	Softscape of operational boundary	Monthly for duration of at least 6 months	CT, Floral Specialist, Arborist	NA
	Fauna	Adjacent forest to development boundary		CT, Ecologist	NA
Hydrology and Surface Water Quality	All parameters identified in Table 13-5. And any flooding issues should be recorded and inspected.	At the main outlets/drains of the Project site in the vicinity of the proposed Project	Monthly inspection for the water quality and hydrology, especially during heavy storm event for hydrological conditions during first three (3) months of commissioning phase	CT, EM/ECO	 Investigation and corrective actions to be taken, when: If the monitored parameters of all discharge points exceed applicable values of NEA Trade Effluent Discharge Limits at discharge point (refer to Table 13-3); If the monitored parameters of natural streams exceed applicable values of Water Quality Criteria for Aquatic Life at natural stream (refer to Table 13-3); If any flooding issues observed; If complaints are received due to Project activities; and If visual non-compliance to any of the minimum control or mitigation measures are observed on-site.
Soil and Groundwater	Records on waste generated and hazardous chemicals used at the Project site should be properly kept and records produced when requested.	 At locations where toxic chemical waste are generated and store. At locations where hazardous chemicals/substances are used and stored. 	 Monitoring records of the amount and type of toxic chemical waste generated during first three (3) months of the commissioning phase Inspection of hazardous chemical/substances storage conditions during first three (3) months of the commissioning phase 	CT, EM/ECO	 Investigation and corrective actions to be taken, when: There are no/poor records of toxic chemical waste amount and type; and There is evidence of poor handling/storage of toxic chemical waste and hazardous chemical.
Airborne Noise	Leq 5min and Leq 1 hour	Two (2) noise monitoring locations at boundary of Site IV and Site V (see Figure 13-18)	Continuous monitoring for three (3) months of the commissioning phase	CT, EM/ECO	Investigation and corrective actions to be taken, when: If complaints are received due to Project activities.
	Leq15 min	Eight (8) noise monitoring locations at boundary of ventilation shaft (see Figure 13-18)	Continuous monitoring for one (1) day (24 hours) within the commissioning phase, as per NEA's Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Building		If visual non-compliance to any of the minimum control or mitigation measures are observed on-site.
Ground-borne Vibration	Peak Particle Velocity (PPV), mm/s	N/A	• N/A	N/A	N/A

13.13.2.3 Operational Phase

A contract-specific EMMP is not required for operational phase. General housekeeping, environmental management and/or EHS measures as included as part of the minimum control measures and key mitigation measures proposed in this report and shall be implemented by the Rail Operator and other relevant personnel (refer to roles and responsibility in Section 13.5) during operational phase. The summary of key minimum control measures and key mitigation measures for operational phase are highlighted in table below.

Table 13-17 Summary of Key Minimum Control Measures and Mitigation Measures to Be Implemented during Operational Phase

Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Responsibility
Biodiversity	 Minimisation of operational impacts to flora/vegetation The maintenance of the system should happen during engineering (0100h to 0400h) and non-engineering hours (operational hours of train line, 0600h to 2300h). As much as possible, systems that are crucial to daily operational basis will be carried out during non-engineering hours, while electrical services and signalling will be done during engineering hours except at the unlikely event of urgent work required due to failure in mainline. 		 Identify areas that are responding poorly due to operational activities Ensure that post-construction planting is responding well to development surrounding Ensure integrity of adjacent forest (if any) Identify signs of edge effects on new forest edge of adjacent forest (if any) 	Rail Operator
	Minimisation of operational impacts to fauna		 Assessment of habitat quality (e.g., water quality, excessive vegetation removal) Inspection for presence of trapped/injured/dead fauna, potential fauna entrapments and gaps in site hoarding Recording number of occurrences of human-wildlife conflict Conduct biodiversity survey to monitor construction impacts on fauna activity and presence 	Rail Operator
Hydrology and Surface Water Quality	Stormwater run-off generation	 Stormwater Quality: Adequate drainage, piping and/or channelling of stormwater run-off to be assured through detailed design [such as Active, Beautiful, Clean Water (ABC) Water Design approach] for capture and treatment before discharge into watercourses Regular and dedicated procedures for the inspection and maintenance of stormwater collection, storage, and treatment infrastructure, such as pipes, oil water separation, silt screens, etc.; and Regular and dedicated procedures for the management of stormwater collection, settling, testing and eventual discharge of 'clean' water to watercourses. Hydrology: Potential increase of peak-flow due to the change in the land use at the new developments can be mitigated by providing detention tanks within the Study Area. Detention tanks can capture stormwater during heavy storm events to reduce the peak runoff. Stored water can then be discharged back to the system after the storm event. As required by PUB, the storage system needs to be in place to reduce the peak flow at the operational phase to be the same or less than that of the existing condition; Active, Beautiful, Clean Water (ABC) Water Design approach can be considered to reduce the peak-flow as well; and Geotechnical aspect of the site's slope stability (such as ERSS) shall be included in detailed design engineering for the operational stage. 	Not Applicable	Rail Operator/ EHS Officer
Soil and Groundwater	Generation of small quantities of toxic chemical waste (used fluorescent bulbs, used lead-batteries, used maintenance chemical containers i.e. thinner, paints, lubricants, etc.) Improper handling of hazardous chemical/ substances	 Store all toxic chemical waste at designated sheltered area provided with access-controlled entrance and concrete bund walls or in storage containers with good ventilation. Spill trays shall be provided for all chemical drums, plants and machinery and potential pollutive substances used on site. Spill trays shall be regularly maintained to prevent rain from washing out the pollutive substances. Dispose all toxic waste chemicals off-site to licensed TIW collectors for treatment. 	Not Applicable	Rail Operator/ EHS Officer
		 Ensure no trade effluent other than that of a nature or type approved by NEA Director-General are discharged into any watercourse or land. 		

Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Responsibility
Airborne Noise	Noise from facility building operation	 Minimum controls for ACMV noise: Minimum controls should be applied at the detailed design stage of the development by the appointed M&E consultants. An appointed Noise consultant should validate the noise in accordance with NEA's Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Building. Use low air-conditioning and mechanical ventilation system equipment; Ensure that any exhaust outlet or intake from the mechanical ventilation system is designed to be adequately set back as far as possible from the boundary line of the development; Acoustic treatment for equipment to meet noise level limit at site boundary where necessary; AC system to be designed with the AHU units placed at appropriate locations as set back from the boundary line of the development as possible; and Acoustic enclosures for outdoor equipment. Minimum controls for traffic noise: Due to the lack of information at this juncture of reporting, assessment, minimum controls and mitigation will be provided by the appointed Noise Consultant during the prelim design stage and in accordance with Technical Guideline for Land Traffic Noise Impact Assessment [R-54] 	 Noise attenuators and other BAT and BEP noise control measures shall be utilised Traffic noise at the drop-off points and parking areas shall be mitigated with low speed postings, humps and signage 	Rail Operator/ EHS Officer
Ground-borne Vibration	Ground-borne Vibration from the operation of trains	 Train, track and tunnel design Maintenance of vertical track alignment at the relevant longitudinal wavelengths Maintenance of roughness of the railhead and wheel thread at the relevant longitudinal and circumferential wavelengths, respectively. Maintenance of resilient elements in track construction, e.g. rail pads Maintenance of rail joints, switches and crossings. 	General maintenance of the railway track and minimising of wheel defects.	Rail Operator

14. Conclusion

In conclusion, the summary of unmitigated impact significance and potential residual impact significance of the assessed environmental aspects for both construction and operational phases are presented in the following tables. The recommended Environmental Monitoring and Management Program (EMMP) measures are summarised in Section 13.11.2.

The assessment findings of this report demonstrated that the design optimisation measures, which are the mitigated scenarios for CR14 and CR15 worksites with optimised construction footprint, can minimise environmental impacts to the ecologically sensitives sites as well as to the nearby human receptors.

Table 14-1 Summary of Potential Residual Impact Significance during Construction Phase

Sensitive Receptor	Environmental Parameter	Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)
Site I	Biodiversity	Mostly Major/ Moderate	Minor to Major
	Hydrology and Surface Water Quality	Negligible to Major	Minor to Moderate (see note 6)
	Soil and Groundwater	Minor	Minor (see Note 4)
	Air Quality	Moderate to Major	Minor
	Airborne Noise	Minor to Major	Minor to Major (see Note 1)
	Ground-borne Vibration	Negligible to Moderate (see Note 2)	Negligible to Moderate (see Note 2)
Site II	Biodiversity	Mostly Major/ Moderate	Minor to Major
	Hydrology and Surface Water Quality	Negligible to Major	Minor to Moderate (see note 6)
	Soil and Groundwater	Minor	Minor (see Note 4)
	Air Quality	Moderate to Major	Minor
	Airborne Noise	Minor to Major	Minor to Major (see Note 1)
	Ground-borne Vibration	Negligible to Moderate (see Note 2)	Negligible to Major ^(see Note 3)
Site III	Biodiversity	Mostly Major/ Moderate	Minor to Major
	Hydrology and Surface Water Quality	Minor to Moderate	Minor to Moderate (see note 6)
	Soil and Groundwater	Minor	Minor (see Note 4)
	Air Quality	Moderate to Major	Minor
	Airborne Noise	Minor to Major	Moderate to Major (see Note 1 and 5)
	Ground-borne Vibration	Negligible to Moderate (see Note 2)	Negligible to Major (see Note 3)
Site IV	Biodiversity	Minor to Major	Minor to Major
	Hydrology and Surface Water Quality	Negligible to Minor	Negligible to Minor
	Soil and Groundwater	Minor	Minor (see Note 4)
	Air Quality	Moderate to Major	Minor

Sensitive Receptor	Environmental Parameter	Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)
	Airborne Noise	Minor to Major	Minor
	Ground-borne Vibration	Negligible – Minor	Negligible – Minor (see Note 4)
Site V	Biodiversity	Minor to Major	Minor to Major
	Hydrology and Surface Water Quality	Minor	Minor
	Soil and Groundwater	Minor to Moderate	Minor to Moderate (see note 7)
	Air Quality	Moderate to Major	Minor
	Airborne Noise	Major	Minor- Major (see Note 1)
	Ground-borne Vibration	Negligible – Minor (see Note 4)	Negligible – Minor ^(see Note 4)

Note:

- 1. Due to surrounding extremely low ambient noise levels, sensitive receptor in the close proximity, and undulant terrain with high elevation difference which cannot be blocked by the proposed noise barrier/ multiple barriers, further mitigation of noise levels are challenged. The area of "Major" impact significance during the residual impact significance with mitigation measures are expected to be reduced significantly than base scenario.
- 2. Construction activities such as bulldozing produce high PPV levels at the biodiversity sensitive receptors. It is essential to implement EMMP measures to reduce the impact significance to Moderate.
- Construction activities such as rock breaking and excavation is only required in the mitigated scenario, which
 produces high PPV levels and impact significance at the biodiversity sensitive receptors. It is essential to
 implement EMMP measures to reduce the impact significance to Moderate.
- 4. The initial impact assessment with minimum controls was considered insignificant (Negligible to Minor), no residual impact assessment was undertaken, hence the impact significance remained the same. Note that this does not indicate that impacts are completely eliminated.
- 5. The area of moderate impact significance is less than 0.1 hectares and this is due to close proximity of Site III with station entrance worksite during Post-Mitigated Scenario than Base Scenario.
- 6. Water Quality impacts at Site I and Site III was assessed to be Moderate impact significance, as the proposed road under study will cross existing major stream in Site I and the proposed CR14 worksite likewise for earth drain in Site III, even with diverted drain or culvert, the impact cannot be reduced further mainly due to the watercourses are in the immediate vicinity of the construction site.
- 7. Construction of entrance of CR15 will occupied the freshwater marsh, and its impact on groundwater drawdown in the vicinity cannot be avoided.

Table 14-2 Summary of Potential Residual Impact Significance during Operational Phase

Sensitive Receptor	Environmental Parameter	Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)
Site I	Biodiversity	Mostly Moderate	Mostly Minor
	Hydrology and Surface Water Quality	Negligible to Major	Minor
	Soil and Groundwater	Minor	Minor (see Note 1)
	Air Quality	Minor	Minor (see Note 1)
	Airborne Noise	Negligible	Negligible (see Note 1)
	Ground-borne Vibration	Minor (see Note 1)	Minor (see Note 1)

Sensitive Receptor	Environmental Parameter	Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)	
Site II	Biodiversity	Mostly Moderate	Mostly Minor	
	Hydrology and Surface Water Quality	Negligible to Major	Minor	
	Soil and Groundwater	Minor	Minor (see Note 1)	
	Air Quality	Minor	Minor (see Note 1)	
	Airborne Noise	Negligible	Negligible (see Note 1)	
	Ground-borne Vibration	Minor (see Note 1)	Minor (see Note 1)	
Site III	Biodiversity	Mostly Moderate	Mostly Minor	
	Hydrology and Surface Water Quality	Minor to Moderate	Minor	
	Soil and Groundwater	Minor	Minor (see Note 1)	
	Air Quality	Minor	Minor (see Note 1)	
	Airborne Noise	Negligible	Negligible (see Note 1)	
	Ground-borne Vibration	Minor (see Note 1)	Minor (see Note 1)	
Site IV	Biodiversity	Mostly Moderate/Minor	Mostly Minor	
	Hydrology and Surface Water Quality	Negligible to Minor	Negligible to Minor	
	Soil and Groundwater	Minor	Minor (see Note 1)	
	Air Quality	Minor	Minor (see Note 1)	
	Airborne Noise	Negligible	Negligible (see Note 1)	
	Ground-borne Vibration	Minor (see Note 1)	Minor (see Note 1)	
Site V	Biodiversity	Mostly Moderate/Minor	Mostly Minor	
	Hydrology and Surface Water Quality	Minor	Minor	
	Soil and Groundwater	Minor	Minor (see Note 1)	
	Air Quality	Minor	Minor (see Note 1)	
	Airborne Noise	Negligible	Negligible (see Note 1)	
	Ground-borne Vibration	Minor (see Note 1)	Minor (see Note 1)	

Note:

The initial impact assessment with minimum controls was considered insignificant (Negligible to Minor), no
residual impact assessment was undertaken, hence the impact significance remained the same. Note that this
does not indicate that impacts are eliminated.

14.1 Way Forward

This EIS Report presents the impact assessment on the environmental parameters from the preliminary design stage only, where the assessed worksite areas exclude detailed design elements such as locations of piezometers, utilities/ road diversion areas, site elements (e.g., workers dormitory, detention tank, site office etc.), utilities/ road diversion. Shall there be any changes to the design of the Project elements in this report during actual construction phase, the Contractor shall take note of the design exclusions and update the findings of this EIS accordingly.

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