Contract CR2005
Provision of Services to Conduct Environmental Impact Study

Environmental Impact Study (Clementi Forest and Maju Forest)

Study Stage: Final

Volume 3 of 5

Submitted by:
AECOM Singapore Pte Ltd

Submitted to:
Land Transport Authority

06 October 2022

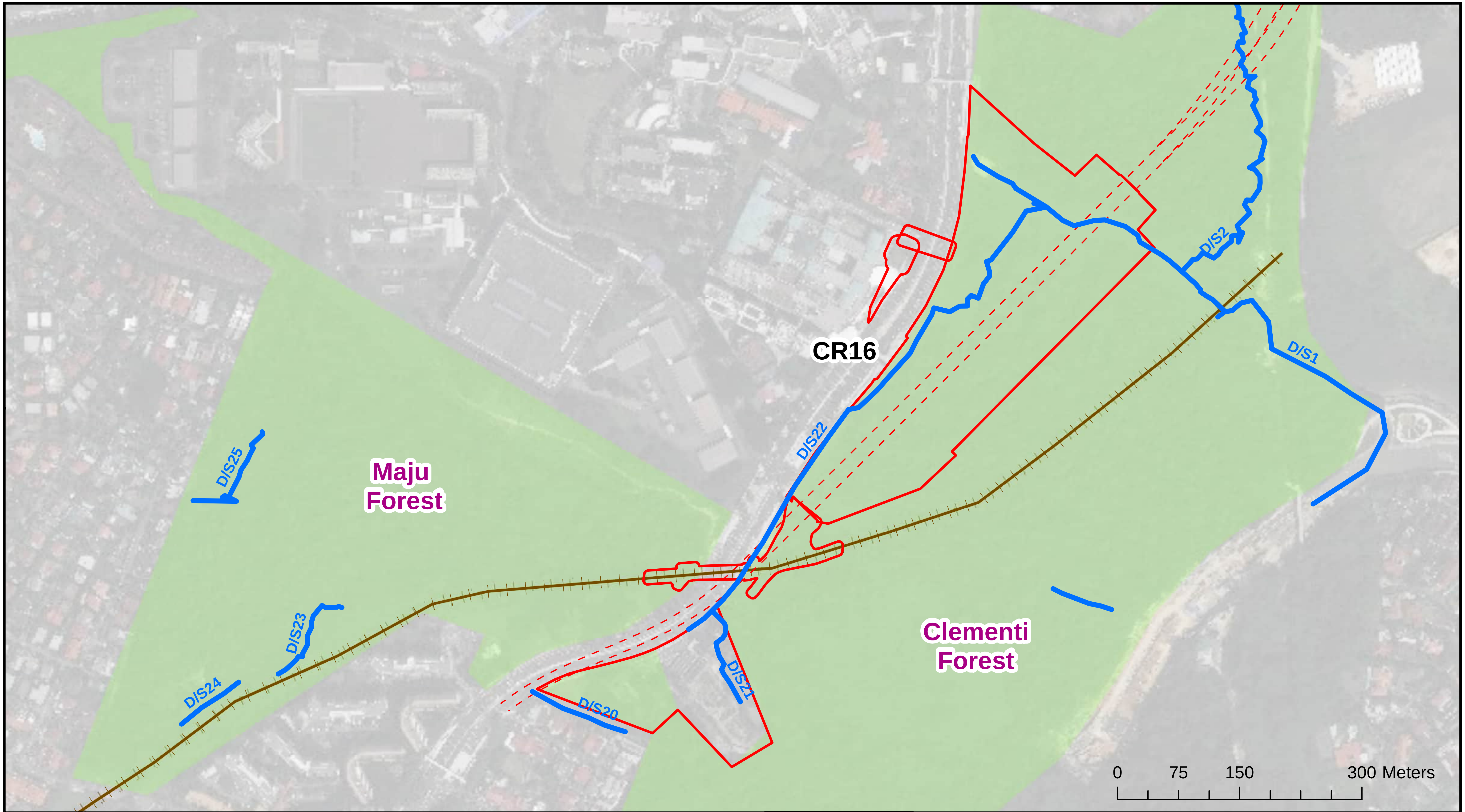
8. Hydrology and Surface Water Quality

8.1 Introduction

This section includes the assessment of hydrology and surface water quality within the Study Area, as well as the prediction and evaluation of the impacts from the Project's construction and operational phases on the hydrology of the Study Area and the water quality of the impacted watercourses (refer to Figure 8-1). Results from the site surveys were analysed and used to establish the baseline conditions to assess the subsequent changes due to construction and operational activities associated with the Project. Sensitive receptors were identified and classified according to the sensitivity categorisation defined in Section 6.2.2. Potential sources of impact from the Project that could affect the identified sensitive receptors and the minimum controls put in place to reduce them were also described to allow for impact prediction. Thereafter, an impact evaluation was carried out to assign significance to predicted impacts and where necessary, mitigation measures were proposed. An EMMP was also developed to specify methods and measures to be included during construction, commissioning and operation of the Project which is necessary to reduce the environmental impacts to minimal levels (see Section 13).

The scope of work of the hydrological and surface water quality impact assessment consisted of:

- Reviewing of data provided by the Client to understand the topographic characteristics of the Study Area;
- Conducting site reconnaissance survey for a better understanding of the Study Area's topography, hydrology, land cover and existing watercourses with their properties (i.e., locations, water flow conditions and bank characteristics);
- Identifying sampling locations for in-situ and ex-situ water quality analysis of existing watercourses located within the Study Area;
- Carrying out hydrological and surface water quality impact analysis to assess the potential impacts of the Project during construction and operational phases; and
- Proposing EMMP to mitigate potential impacts of the Project during construction, commissioning and operational phases.



Legend

- Watercourses
- Proposed CRL Alignment (Base)
- Base Scenario Construction Worksite Footprint
- Biodiversity Study Area
- Old Jurong Railway Corridor

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Rev.	Date	By	Description	Chk'd	App'd
-	MAY 2022	JAC	Final Report	NHT	JAG

Qualified Person Endorsement : NA

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Consultant : AECOM

Land Transport Authority
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Project Title :
CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(CLEMENTI FOREST AND
MAJU FOREST)

Figure Title :
STUDY AREA FOR THE HYDROLOGY AND SURFACE WATER QUALITY IMPACT ASSESSMENT

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	Drawn JAC	Date MAY 2022	CAD File Name :		A3

Note: Source of basemap - Google Earth Map

8.2 Methodology and Assumption

8.2.1 Baseline Hydrology and Surface Water Quality Study

The activities performed as part of the baseline assessment included the following:

- To assess the accessibility of the watercourses within the Study Area;
- To verify the information collected from the available topographic survey and satellite images;
- To identify and map out the location of existing watercourses within the Study Area;
- To determine the drain and stream flow conditions and bank characteristics; and
- To assess current surface water quality conditions in existing watercourses within the Study Area.

8.2.1.1 Desktop Assessment

Desktop research aided in determining the location of existing watercourses within the Study Area. The topographic survey data provided by LTA as well as the catchment map (i.e. defines the areas which contributes water flow to existing reservoirs) from PUB website [W-26] were used to support the findings of the hydrological survey. The information used for the desktop assessment, comprised of publicly available data from government and technical Agencies, existing publicly available data (e.g. online satellite images), as well as published books, relevant articles, and other online sources.

8.2.1.2 Hydrological Baseline Assessment

The hydrological survey was conducted by casual exploration methods to identify and outline existing major watercourses within the Study Area. The existing conditions of the watercourses such as stream bank characteristics (e.g. natural bank or artificial bank), were identified based on visual observations and professional experience. Using the topography survey data provided by the Client, ArcGIS was used to overlay with this Project alignment and worksites to support the hydrological survey. Catchment analysis based on topographic data and catchment map from PUB website [W-26] was carried out to identify the water sources and to ascertain the runoff flow direction within the site.

A Global Positioning System (GPS) device was used to track the hydrology survey route. The GPS data were then synchronised with the photos taken on-site to identify the exact location of identified watercourses.

8.2.1.3 Water Quality Baseline Assessment

As mentioned in the section above, major watercourses present in the Study Area were identified during site surveys. Suitable locations were selected within the identified watercourses for collection of water samples in order to assess the baseline in-situ and ex-situ water quality of existing watercourses within the Study Area.

The water quality sampling locations were subsequently identified based on preliminary hydrological findings during site reconnaissance. The surface water samples were collected at twelve (12) water quality stations along the streams or roadside drains from Clementi Forest and Maju Forest as detailed in Figure 8-2 and Table 8-1.

In Clementi Forest, water quality sampling stations of WQ1, WQ2, WQ20, WQ19, WQ18 and WQ17 were selected to capture the water quality along the natural stream D/S1 within the Clementi Forest, which receives water from the construction worksite CR16, as well as corresponding Project operational footprint. The midstream of D/S1 is the natural stream which supports an ecosystem of high biodiversity conservation significance in the Clementi Forest, as described in Section 7. Station WQ2 was selected to capture the water from stream D/S2 before flowing to midstream of stream D/S1. Station WQ16 was selected to capture the upstream water quality of drain D/S22 running to the natural stream D/S1 in Clementi Forest. Stations WQ14 and WQ15 were selected to capture the water quality within roadside drain D/S20 and D/S21, respectively, which receive water from southwest of the worksite footprint. In Maju Forest, water quality sampling stations of WQ33, WQ34 and WQ35 were selected to capture the water quality along the natural streams of D/S23, D/S24 and D/S25.

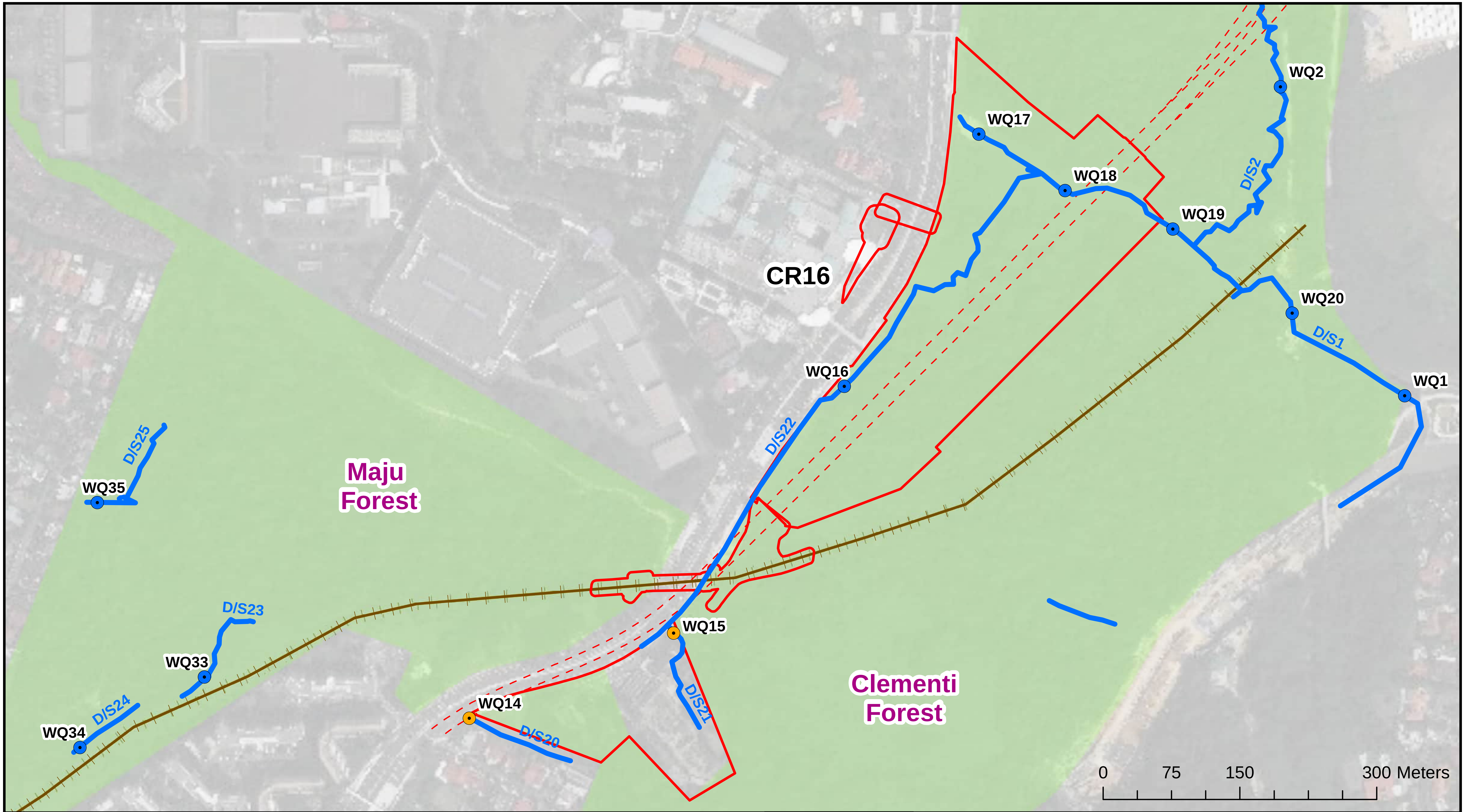
Two (2) dry weather (normal conditions) and one (1) wet weather (after a storm event) samples were collected from each water quality station. However, some of the watercourses in the Study Area were sampled during storm event only due to no flow or mostly dry during dry weather condition. Hence, only wet weather samples were collected at WQ14 and WQ15. Dry weather conditions are defined as after a continuous 48-hour period of no rain, while wet weather conditions are defined as a rainfall event having more than 10mm of rainfall, with samples to be collected within 3 hours after the rain stops.

In-situ water quality parameters assessed in this Study were all measured using a calibrated multi-parameter digital sensor (YSI ProDSS) with USEPA approved testing methods for water quality parameters and included:

- Temperature;
- pH;
- Conductivity;
- Total Dissolved Solids (TDS); and
- Dissolved Oxygen (DO).

The ex-situ parameters analysed by Marchwood Laboratory Services Pte Ltd (MLS) are listed as below:

- Turbidity;
- Total Suspended Solids (TSS);
- Biochemical Oxygen Demand (BOD_5);
- Chemical Oxygen Demand (COD);
- Total Nitrogen (TN);
- Nitrate (NO_3-N);
- Total Phosphorus (TP); and
- Orthophosphate (PO_4-P).



Legend

Water Quality Sampling Locations
- Dry and Wet
- Wet
- Watercourses
- Proposed CRL Alignment (Base)
- Base Scenario Construction Worksite Footprint
- Biodiversity Study Area
- Old Jurong Railway Corridor

N

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Project Title :
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ENVIRONMENTAL IMPACT STUDY
(CLEMENTI FOREST AND
MAJU FOREST)

Figure Title :
WATER QUALITY SAMPLING
LOCATIONS WITHIN
THE STUDY AREA

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JAC	NHT	JAG	8 - 2	-	1 of 1
	Drawn JAC	Date MAY 2022	CAD File Name :		A3

Note: Source of basemap - Google Earth Map

Table 8-1 Rationale for the Selection of Water Quality Sampling Locations

S/N	Sampling Location[7]	Nearest Construction Worksite Area/Operational Footprint	Justification (refer to Figure 8-2)
WQ17	Upstream of stream D/S1	CR16 (construction worksite area) CR16 (operation stage)	To capture the baseline water quality right at the downstream of the concrete canal before water flows into the stream without any contribution from CR16 proposed construction and operational footprints. The stream discharge will ultimately flow to Pandan Reservoir, which is a reservoir that serves as a raw water source for treated drinking water supply. Stream D/S1 in Clementi Forest supports an ecosystem of biodiversity conservation significance (Section 7.5.2).
WQ18	Midstream of stream D/S1	CR16 (construction worksite area) CR16 (operation stage)	To capture the baseline water quality at midstream at the CR16 proposed construction and operational footprints. The stream discharge will ultimately flow to Pandan Reservoir, which is a reservoir that serves as a raw water source for treated drinking water supply. Stream D/S1 in Clementi Forest supports an ecosystem of biodiversity conservation significance (Section 7.5.2).
WQ19	Midstream of stream D/S1	CR16 (construction worksite area) CR16 (operation stage)	To capture the baseline water quality right at the downstream of the CR16 proposed construction and operational footprints. The stream discharge will ultimately flow to Pandan Reservoir, which is a reservoir that serves as a raw water source for treated drinking water supply. Stream D/S1 in Clementi Forest supports an ecosystem of biodiversity conservation significance (Section 7.5.2).
WQ20	Downstream of stream D/S1	CR16 (construction worksite area) CR16 (operation stage)	To capture the baseline water quality at downstream of stream D/S1 which receives discharge from earth drain D/S2 and the water from the CR16 proposed construction and operational footprints. The stream discharge will ultimately flow to Pandan Reservoir, which is a reservoir that serves as a raw water source for treated drinking water supply. It is not really supporting an ecosystem of biodiversity conservation significance. But as it is located at downstream of sites of ecological values, samples were collected to assure quality of water flowing from Biodiversity Study Area.
WQ1	Downstream of stream D/S1	CR16 (construction worksite area) CR16 (operation stage)	To capture the baseline water quality at downstream of stream D/S1 which receives water from CR16 proposed construction and operational footprints. The stream discharge will ultimately flow to Pandan Reservoir, which is a reservoir that serves as a raw water source for treated drinking water supply. It is not really supporting an ecosystem of biodiversity conservation significance (Section 7.5.2). But as it is located at downstream of sites of ecological values, samples were collected to reassure the quality of water flowing from Biodiversity Study Area.
WQ2	Midstream of natural stream D/S2	CR16 (construction worksite area)	To capture the baseline water quality within stream D/S2 which receives water from forested area to north of CR16 footprints before discharge to stream D/S1. Presence of aquatic life based on site observations and it is supporting an ecosystem of biodiversity conservation significance

[7] The sampling locations are shown in Figure 8-2.

S/N	Sampling Location[7]	Nearest Construction Worksite Area/Operational Footprint	Justification (refer to Figure 8-2)
		CR16 (operation stage)	(Section 7.5.2). The discharge will ultimately flow to Pandan Reservoir, which is a reservoir that serves as a raw water source for treated drinking water supply.
WQ14	Downstream of drain D/S20	CR16 (construction worksite area) CR16 (operation stage)	To capture the baseline water quality within roadside drain D/S20 which receives storm runoff from southwest area of CR16 worksite. No water was observed at drain during dry weather and it is not supporting an ecosystem of biodiversity conservation significance. Samples were collected during wet weather to understand existing water quality condition of discharge from forest. The discharge will ultimately flow to Pandan Reservoir, which is a reservoir that serves as a raw water source for treated drinking water supply.
WQ15	Downstream of drain D/S21	CR16 (construction worksite area) CR16 (operation stage)	To capture the baseline water quality at downstream of earth drain D/S21 which receives water from southwest area of CR16 worksite. No water was observed at drain during dry weather and it is not supporting an ecosystem of biodiversity conservation significance. Samples were collected during wet weather to understand existing water quality condition of discharge from forest. The discharge will ultimately flow to Pandan Reservoir, which is a reservoir that serves as a raw water source for treated drinking water supply.
WQ16	Midstream of stream D/S22	CR16 (construction worksite area) CR16 (operation stage)	To capture the midstream baseline water quality of stream D/S22 before the water flowing further downstream of its natural stream portion in forested area. The water of D/S22 ends up to the natural stream D/S1 in Clementi Forest. The water is running along the upstream roadside drain and flowing to the downstream natural stream in the forested area. The downstream natural stream D/S22 supports an ecosystem of biodiversity conservation significance (Section 7.5.2).
WQ33	Downstream of stream D/S23	CR16 (construction worksite area) CR16 (operation stage)	To capture the baseline water quality at downstream of stream D/S23 which receives water within eastern forested area of Maju Forest. The discharge will ultimately flow to Pandan Reservoir, which is a reservoir that serves as a raw water source for treated drinking water supply. Presence of aquatic life based on site observations and it is supporting an ecosystem of biodiversity conservation significance (Section 7.5.1).
WQ34	Downstream of stream D/S24	CR16 (construction worksite area) CR16 (operation stage)	To capture the baseline water quality at downstream of stream D/S24 which receives water within southern forested area of Maju Forest. The discharge from the stream is flowing to a concrete drain and ultimately drain to the Pandan Reservoir which served as source of drinking water. Presence of aquatic life based on site observations and it is supporting an ecosystem of biodiversity conservation significance (Section 7.5.1).

S/N	Sampling Location[7]	Nearest Construction Worksite Area/Operational Footprint	Justification (refer to Figure 8-2)
WQ35	Downstream of stream D/S25	CR16 (construction worksite area) CR16 (operation stage)	To capture the baseline water quality at downstream of stream D/S25 receiving water within the western forested area of Maju Forest. The discharge from the stream is flowing to a concrete drain and ultimately drain to the Pandan Reservoir which served as source of drinking water. Presence of aquatic life based on site observations and it is supporting an ecosystem of biodiversity conservation significance (Section 7.5.1).

8.2.2 Water Quality Baseline Assessment Criteria

During construction phase, the locations of the construction worksites can potentially impact the hydrology and water quality of existing watercourses. During operational phase, increased urbanised area and human activities may lead to increased surface runoff and improper waste management practices (such as littering). Hence, any watercourses that are directly impacted by the proposed development were included in the impact assessment.

The baseline water quality of the watercourses located within the Study Area was analysed against the NEA Trade Effluent Discharge limits for controlled watercourses [W-18]. This comparison could be used to determine whether the existing baseline water quality of the watercourses within the Study Area complies with NEA limits or has already exceeded these limits. However, the NEA Trade Effluent Discharge limits does not provide criteria for the preservation and growth of aquatic life locally. To assess whether the water quality along the identified streams is suitable for aquatic life, certain parameters were compared to the water quality criteria for aquatic life from other countries including United Nations Economic Commission for Europe [R-18], United States Environmental Protection Agency [R-19], Australian & New Zealand [R-26], Canada [R-27], Philippines [R-16], and Malaysia [R-28], which provide guidelines for the protection of aquatic life. The relevant limits and guidelines for water quality parameters were summarised in Table 8-2; however, where no guidelines exist, the monitored results would be considered as the minimum criteria.

Table 8-2 Water Quality Guidelines and Criteria

Parameter	NEA Trade Effluent Discharge Limits[a]	Water Quality Criteria for Aquatic Life from other countries[b]
pH	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)	-	> 4.0
Turbidity (NTU)	-	50
Total Suspended Solids, TSS (mg/L)	30 SDA: 50[d]	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)

Note:

a. NEA Trade Effluent Discharge Limits for discharge into a controlled watercourse [W-18].

b. The sources of water quality criteria for aquatic life include United Nations Economic Commission for Europe [R-18], United States Environmental Protection Agency [R-19], Australian & New Zealand [R-26], Canada [R-27], Philippines [R-16], and Malaysia [R-28].

Parameter	NEA Trade Effluent Discharge Limits[a]	Water Quality Criteria for Aquatic Life from other countries[b]
c. BOD_5 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. 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.		

8.2.3 Prediction and Evaluation of Impact Assessment

Qualitative and analytical methods were applied to assess hydrological and water quality impacts of the development construction and operational phases.

The hydrological impact study will provide an understanding of the impact of construction/operational activities on hydrological conditions of the site, such as the potential land use changes of the site which can lead to an increase in peak flow discharge, a reduction in dry weather flow or even a change in the stream alignment of the impacted watercourse.

The water quality impact study will provide an understanding of potential impact of construction/operational activities on the water quality of the existing watercourses within/surrounding the site using analytical methods.

8.3 Potential Sources of Hydrology and Surface Water Quality Impacts

This section discusses the potential environmental impacts arising from the construction and operational phases of the Project.

8.3.1 Construction Phase

Nearby watercourses can be potentially exposed to contamination due to the activities taking place during the Project's construction phase. The sources that could potentially impact on the nearby freshwater quality and quantity include, but are not limited to, those listed in Table 8-3.

Table 8-3 Potential Hydrology and Water Quality Impacts during the Construction Phase

Activity	Potential Source of Impacts	Potential Associated Impacts
Site clearance, earthworks and general construction activities at launch/retrieval shafts, the open cut and the C&C works (e.g. clearing and preparation, trench excavation, backfill, soil mixing, compaction, concrete batching plant, spoil handling and transport, building of permanent structures, utilities diversion including diversion of water pipes and stormwater drains along the Project, etc.)	• Runoff from exposed soil surface, earth work areas, utilities diversion, soil stockpiles; • Stormwater/groundwater pumped out from excavated areas; • Release of grouting and cement materials; • Runoff from dust suppression sprays; • Wastewater generated from concrete batching plant; • Elevated suspended solids (e.g. silt and sediment) in site runoff due to heavy rain; • Spoil generation, handling and transport; and • Heavy rain during construction; and • Wastewater generated from tunnelling activities.	Hydrology: • Increased stormwater peak flow contributions to the channel can lead to increased water levels and subsequently flood to the surrounding areas adjacent to the stream/drain due to the land use change from land clearance; • Alteration of dry weather flow of the watercourse can impact downstream aquatic habitats; • Stormwater runoff from exposed and unstable slopes may cause soil erosion; and • Potential groundwater drawdown due to dewatering process during tunnelling activities (its impact will be assessed in Section 9 – soil and groundwater). Water contamination: • Wastewater from construction activities can contain elevated levels of suspended solids which can lead to increased turbidity and sedimentation rates in the watercourses, etc; • Wastewater from construction activities can contain high levels of oil, grease, and other chemical substances (e.g. calcium hydroxide) therefore contaminating the watercourses;

Activity	Potential Source of Impacts	Potential Associated Impacts
Storage and disposal of solid wastes	• Improper handling, transfer, storage, and disposal of spoil and solid waste (e.g. TBM spoil, excavated earth, construction debris).	• Alteration of pH due to runoff generated from concrete batching plant; • Inappropriate storage and disposal of wastewater will generate contaminated runoff and pollute nearby watercourses (e.g. improper discharge of tunnelling wastewater, concrete batching plant wastewater and domestic sewage); • Solid waste generated can lead to elevated levels of suspended solids entering watercourses via runoff or improper handling/disposal. It can also block the temporary drains which can lead to localised flooding and mosquito breeding; • Improper storage, handling, disposal or leakage of toxic waste generated at temporary work areas can lead to water contamination; • Contaminated stormwater due to improper storage/disposal/transport of chemical materials handled and stored on site leading to an increase in the levels of oil, grease and other chemical substances (e.g. calcium hydroxide) in the nearby watercourses; and • Fuel and lubricants spillage from maintenance of construction vehicles and mechanical equipment can also lead to elevation in levels of oil and grease in the nearby watercourses.
Storage and disposal of liquid wastes	• Improper management of sewage effluents from on-site; and • Inappropriate discharge of domestic sewage and poor maintenance of the portable chemical toilet, storage tanks and septic tanks (e.g. overflow or overload). • Inappropriate discharge of wastewater generated from tunnelling activities	
Use and storage of chemical substances, and refuelling activities	• Improper handling, transfer, and storage of chemical substances; • Accidental spill and leaks; and • Fuel and lubricants spillage from maintenance of construction vehicles and mechanical equipment.	

8.3.2 Operational Phase

Watercourses can potentially be exposed to contamination due to the activities taking place during the Project's operational phase. The sources that could potentially impact on nearby surface water quality and quantity include but are not limited to the ones listed in Table 8-4.

Table 8-4 Potential Hydrology and Water Quality Impacts during the Operational Phase

Activity	Potential Source of Impacts	Potential Associated Impacts
Stormwater Runoff Generation	• Heavy rain and stormwater wash-off pollutants built-up in the new development area and discharge to the streams; • Increase of runoff peak flow draining to the stream or drain during storm events due to the increase in urbanised area; • Accidental events (e.g. fires); and • Reduce the baseflow (sub-surface water discharge) due to the change in land use of the new development	Hydrology: • Increased stormwater peak flow contributions to the channel and blockage of channel can lead to increased water level and subsequent flooding of surrounding areas adjacent to the stream/drain; • Alteration of dry weather flow of the watercourse can lead to impacts on downstream aquatic habitats; and • Stormwater runoff from exposed and unstable slopes may cause soil erosion. Stormwater Quality: Elevated suspended solids (e.g. silt and sediment) and pollutants in the watercourses (e.g. heavy metals and nutrients from human activities including accidental events).

8.4 Identification of Hydrology and Surface Water Quality Sensitive Receptors

Receptor screening for surface water was conducted within Biodiversity Study Area for both construction and operational phases (Figure 8-1). Based on site observations, the sensitive receptors for surface water were same for both construction and operational phases. The criteria detailed in Table 6-1 were used to determine the sensitivity of the surface water receptors presented in Table 8-5.

Table 8-5 Classification of Hydrology and Water Quality Sensitive Receptors Identified within the Study Area for Both Construction and Operational Phases

Sensitive Receptor	Description	Water Use	Sensitivity Classification
Natural stream D/S1	The natural stream is a freshwater stream that discharges into public canal in Clementi Forest. Observations from the site walkover included presence of aquatic life.	The surface watercourse is supporting ecosystems of biodiversity conservation significance (refer to Section 7.5.2). The surface water eventually will be discharged into Pandan Reservoir and to be treated for drinking supply.	Priority 1
Natural stream D/S2	The natural stream is a freshwater stream that discharges into stream D/S1 in Clementi Forest. Observations from the site walkover included presence of aquatic life.	The surface watercourse is supporting ecosystems of biodiversity conservation significance (refer to Section 7.5.2). The surface water eventually will be discharged into Pandan Reservoir and to be treated for drinking supply.	Priority 1
Concrete drain D/S20	The concrete drain is a freshwater public drain in Clementi Forest. Observations from the site walkover did not include presence of aquatic life due to its dry condition during dry days.	The runoff eventually will be discharged into Pandan Reservoir and to be treated for drinking supply.	Priority 1
Earth drain D/S21	The earth drain is the freshwater public drain in Clementi Forest. Observations from the site walkover did not include presence of aquatic life due to its dry condition during dry days.	The runoff eventually will be discharged into Pandan Reservoir and to be treated for drinking supply.	Priority 1
Natural stream D/S22	Upstream of the stream is concrete channel of roadside drain and its downstream is natural watercourse aligned in Clementi Forest. The natural stream is a freshwater stream that discharges into stream D/S1. Observations from the site walkover included presence of aquatic life.	The surface water eventually will be discharged into Pandan Reservoir and to be treated for drinking supply.	Priority 1
Natural stream D/S23	The natural stream is a freshwater stream in Maju Forest. Observations from the site walkover included presence of aquatic life.	The surface watercourse is supporting ecosystems of biodiversity conservation significance (refer to Section 7.5.1). The surface water eventually will be discharged into Pandan Reservoir and to be treated for drinking supply.	Priority 1

Sensitive Receptor	Description	Water Use	Sensitivity Classification
Natural stream D/S24	The natural stream is a freshwater stream in Maju Forest. Observations from the site walkover included presence of aquatic life.	The surface watercourse is supporting ecosystems of biodiversity conservation significance (refer to Section 7.5.1). The surface water eventually will be discharged into Pandan Reservoir and to be treated for drinking supply.	Priority 1
Natural steam D/S25	The natural stream is a freshwater stream in Maju Forest. Observations from the site walkover included presence of aquatic life.	The surface watercourse is supporting ecosystems of biodiversity conservation significance (refer to Section 7.5.1). The surface water eventually will be discharged into Pandan Reservoir and to be treated for drinking supply.	Priority 1

8.5 Baseline Hydrology and Surface Water Quality

As mentioned in Table 6-2, this Report presents the hydrology and water quality findings of the field assessments collected till April 2022.

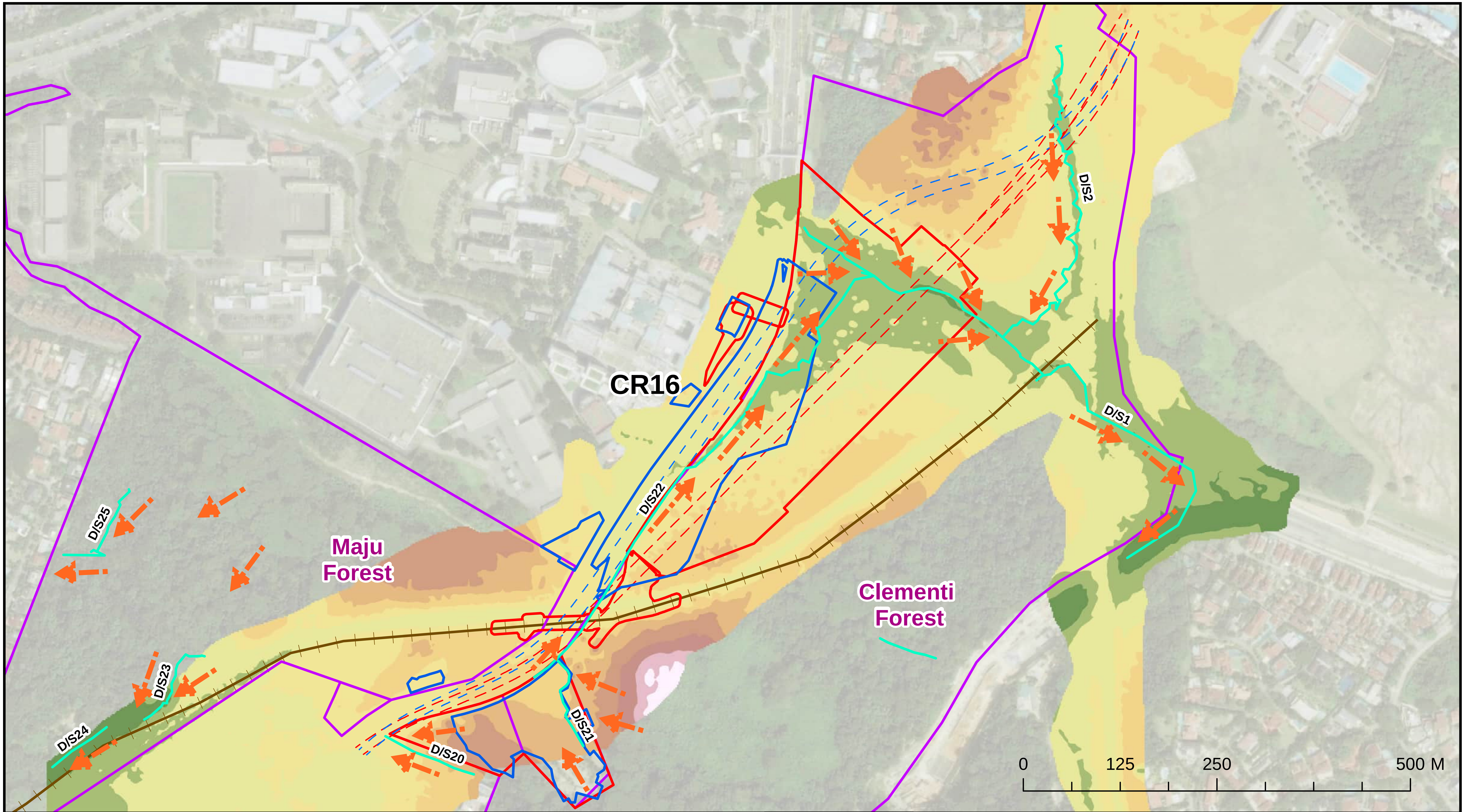
8.5.1 Baseline Monitoring Results

8.5.1.1 Hydrological Conditions in the Study Area

During site reconnaissance, a few major streams and drains were identified in the Study Area. The baseline hydrological conditions in the Study Area were analysed based on site observations and the topographic survey data received from Client, and then were recorded with site photos in Table 8-6. Three (3) natural streams (D/S1, D/S2 and D/S22), one (1) concrete drain (D/S20), one (1) earth drains (D/S21) have been identified in Clementi Forest and three (3) natural streams (D/S23, D/S24 and D/S25) have been identified in Maju Forest accordingly. In the southwest area of Clementi Forest (refer to Figure 8-3), drain D/S20 and drain D/S21 are aligned along the boundary of Worksite at Nursery and receiving surface runoff from the Worksite at Nursery and southwest of the Clementi Forest. Both drains D/S20 and D/S21 have ephemeral flows and the surface runoff from drain D/S21 flows to northwest and subsequently discharges to stream D/S22. The perennial flow of stream D/S22 will flow towards northeast in the Clementi Forest, connecting to the upstream of stream D/S1. The surface water of stream D/S2 also flows perennially towards south and end up to the midstream of stream D/S1. The surface water along D/S1 flows perennially and ends up to the concrete canal at its downstream. In Maju Forest, streams D/S23 and D/S25 are collecting water from the north of forested area while stream D/S24 receives water from south of forested area, with water flowing towards the southwest direction as shown in Figure 8-3.

The surveyed topographic data were used to generate elevation and slope maps, and subsequently overlaid with surface watercourses using ArcGIS software as shown in Figure 8-3 and Figure 8-4. It should be noted that the catchment map was not generated for the Study Area due to insufficient topography data set.

CR16 worksites mostly will be located in relatively higher overall elevation and hilly terrain with uneven slopes in the Clementi Forest based on the elevation data (Figure 8-3 and Figure 8-4).The highest point within the CR16 worksite is located at the southwest in the Clementi Forest, at 39.4 mSHD. The southwestern hill near to drain D/S20 in the CR16 footprint decreases in elevation towards the northwest direction of the site and the deceasing elevation leads the flow of D/S22 towards the upstream of stream D/S1. It can be observed that stream D/S1 was formed along a valley between the areas with higher elevation (not more than 15 mSHD) and steep slopes on either bank (Figure 8-4). The smaller CR16 worksites are located at the northeast of Maju Forest and outside of west Clementi Forest with relatively minor undulating terrain of ranging from 15 mSHD – 27 mSHD. The Old Jurong Railway Corridor is located at lower elevation level between the areas with higher elevation across the Maju Forest and Clementi Forest. And significant steep slopes (more than 60%) can be observed along the Old Jurong Railway Corridor. For the proposed based scenario CR16 worksite that will be located in the Maju Forest and the mitigated scenario CR16 worksite that will locate at the flat turf area near the Maju Forest, the stormwater generated from the worksites will tend to flow towards the low-lying area near the Old Jurong Railway Corridor and proposed CRL alignment instead of towards the identified natural streams that located in southwest of Maju Forest.



Legend

- Watercourses
- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint (Combined)
- Biodiversity Study Area
- Old Jurong Railway Corridor

Elevation (mSHD)

- <10
- 10 - 15
- 15 - 20
- 20 - 25
- 25 - 30
- 30 - 35
- 35 - 40
- 40 - 45
- 45 - 50
- > 50

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAY 2022	JAC	EIS (Clementi Forest and Maju Forest)	NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

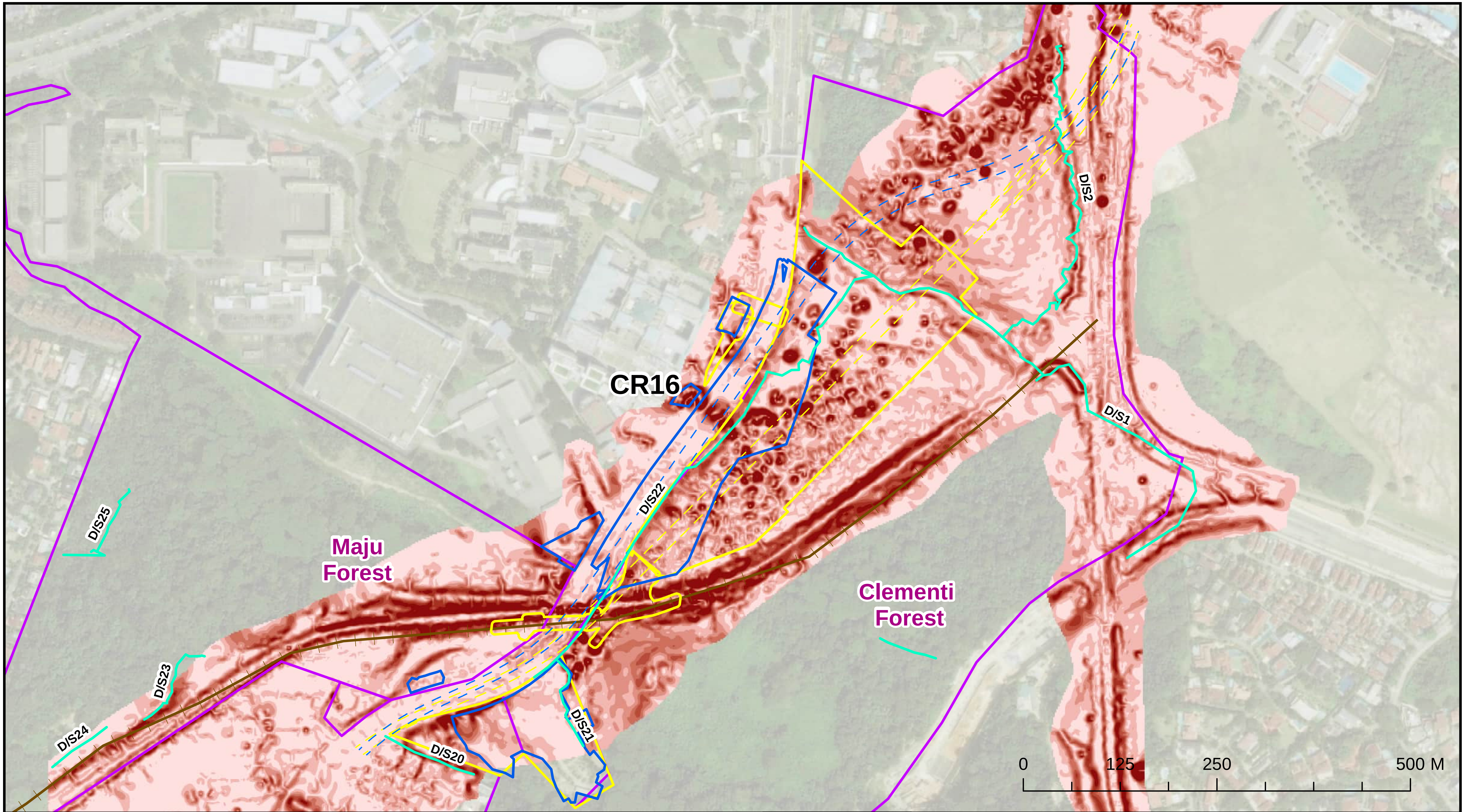
Land Transport Authority We Keep Your World Moving

Project Title :
CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(CLEMENTI FOREST AND
MAJU FOREST)

Figure Title :
ELEVATION MAP OF THE CR16 WORKSITE

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
JAC	NHT	JAG	8 - 3	-	1 of 1
	Drawn JAC	Date MAY 2022	CAD File Name :		A3

Note: Source of basemap - Google Earth Map



Legend

- Watercourses
- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint
- Biodiversity Study Area
- Old Jurong Railway Corridor

Slope (%)

- < 10
- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- > 60

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAY 2022	JAC	EIS (Clementi Forest and Maju Forest)	NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title :
CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(CLEMENTI FOREST AND
MAJU FOREST)

Figure Title :
SLOPE MAP OF
THE CR16 WORKSITE

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
JAC	NHT	JAG	8 - 4	-	1 of 1
	Drawn JAC	Date MAY 2022	CAD File Name :		A3

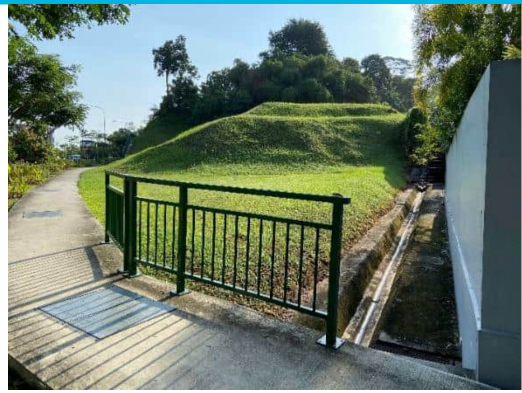
Note: Source of basemap - Google Earth Map

Table 8-6 Description of Watercourses with its Water Quality Sampling Points within the Study Area

Watercourses	Bank Characteristics	Water Flow Conditions	Photos
D/S1	Upstream of stream D/S1 (WQ17) is a closed culvert followed by a concrete drain with artificial banks. The midstream of stream D/S1 (WQ18, WQ19) is a natural stream with dense vegetation. The downstream and near the outlet (WQ20 and WQ1) of stream D/S1 is a wide concrete drain. Estimated stream length is 800 m.	• Originates from stream D/S2, stream D/S22, upstream urban area and Study Area • Perennial flow **During dry weather condition:** Upstream (WQ17): slow water flow velocity (estimated at 0.25 m/s) • Willow water with approximate water depth of 3 - 4 cm and an approximate water width of 95 cm, at time of survey Midstream (WQ18, WQ19): almost stagnant flow observed in the natural stream • At WQ18, approximate water depth of 10 - 20 cm and water width of 100 - 200 cm, at time of survey • At WQ19, approximate water depth of 50-60 cm and water width of 100 - 200 cm, at time of survey Downstream (WQ20 and WQ1): slow water flow velocity (estimated at 0.26 m/s) • At WQ20, the water depth was approximately 2 - 3 cm with an approximate water width of 140 - 150 cm, at time of survey • At WQ1: slow water flow observed of approximately 0.25 m/s	**WQ17 (Upstream)** During Dry Weather  During Wet Weather  **WQ18 (Midstream)** During Dry Weather  During Wet Weather  **WQ19 (Midstream)** During Dry Weather During Wet Weather

Watercourses	Bank Characteristics	Water Flow Conditions	Photos	
		• Approximately 1 - 2 cm in water depth with water width of 300 cm, at time of survey • Water was clear and had no odour **During wet weather condition:** <u>Upstream (WQ17)</u>: fast water flow velocity (estimated at 1 m/s) • Willow water with approximate depth of 6 - 7 cm and an approximate width of 760 cm at the mouth of the drain, at time of survey <u>Midstream</u> (WQ18, WQ19): slow water flow velocity (estimated at 0.17 m/s) for both points • At WQ18, approximate water depth of 25 - 30 cm and water width of 300 - 400 cm, at time of survey • At WQ19, approximate water depth of 50 - 60 cm and water width of 300 - 400 cm, at time of survey <u>Downstream</u> (WQ20, WQ1): fast water flow velocity (estimated 1.42 m/s at WQ20 and 1.23 m/s at WQ1) • At WQ20, the water depth was approximately 15 cm with an approximate water width of 200 - 400 cm, at time of survey • At WQ1, approximately 19 cm in water depth with water width of 160 cm, at time of survey • Water was clear and had no odour		
			WQ20 (Downstream)	
			During Dry Weather 	During Wet Weather 
			WQ1 (Downstream)	
			During Dry Weather	During Wet Weather

Watercourses	Bank Characteristics	Water Flow Conditions	Photos	
				
D/S2	Natural stream covered by dense vegetation. Estimated stream length is 550 m.	• Originates from forested area in the north of Clementi Forest, located to the west of Old Bukit Timah Railway Station • Perennial flow **During dry weather condition:** • Stagnant flow was observed • Approximate water depth of 10 cm and an approximate water width of 100 - 150 cm, at time of survey • Water had low turbid but no odour **During wet weather condition** • Slow water flow velocity was observed (estimated 0.05 m/s) • Approximate water depth of 13 -14 cm and an approximate water width of 100 - 200 cm, at time of survey • Water was clear and had no odour	**WQ2** During Dry Weather 	During Wet Weather 
D/S20	Concrete drain with artificial banks. Estimated length of the drain is about 130 m.	• Originates from runoff from surrounding forested and residential area, and • Ephemeral flow towards west during wet weather condition only	**WQ14** During Dry Weather	During Wet Weather

Watercourses	Bank Characteristics	Water Flow Conditions	Photos	
		During dry weather condition: • Almost no flow **During wet weather condition:** • Slow water flow velocity (estimated at 0.20 m/s) • Approximate water depth of 2 - 3 cm and an approximate water width of 10 - 15 cm, at time of survey • Water was clear and had no odour		
D/S21	Earth drain D/S21 is likely to be old drains with broken concrete banks and slabs observed. It is covered by dense vegetations.	• Originates from runoff from forested area and the nearby plant nursery • Ephemeral flow during wet weather condition only **During dry weather condition:** • Almost no flow **During wet weather condition:** • Slow water flow velocity (estimated at 0.29 m/s) • Approximate water depth of 2 - 3 cm and an approximate water width of 80 cm, at time of survey • Water was clear and had no odour	**WQ15** During Dry Weather 	During Dry Weather 
D/S22		• Originates from runoff from Clementi Forest and surrounding urban area	**WQ16 (Upstream)** During Dry Weather	During Wet Weather

Watercourses	Bank Characteristics	Water Flow Conditions	Photos	
	Upstream of D/S22 is a close culvert followed by open concrete drain. Downstream is natural stream covered by dense vegetations. Estimated drain length is 700 m.	• Perennial flow towards the natural stream D/S1 of Clementi Forest in the north-eastern direction **During dry weather condition at the concrete drain:** • Slow water flow velocity (estimated at 0.27 m/s) • Approximate water depth of 2 - 3 cm and an approximate water width of 25 cm, at time of survey • Water was clear and had no odour **During wet weather condition:** • Fast water flow velocity (estimated at 0.34 m/s) • Approximate water depth of 14 cm and an approximate water width of 25 cm, at time of survey • Water was clear and had no odour		
			Downstream	
			 	
D/S23	Natural stream with earth banks, covered by dense vegetation. Estimated stream length is 150 m.	• Originates from forest area of Maju Forest • Ephemeral flow • Water flow towards a concrete drain at southwest direction during dry and wet weather at time of survey • The stream could be partially dried at some sections of it (with many sections having no or low water levels) occasionally based on	**WQ33**	
			During Dry Weather	During Wet Weather

Watercourses	Bank Characteristics	Water Flow Conditions	Photos	
		biodiversity findings (section 7.3.2.2.6) **During dry weather condition:** • Slow water flow velocity (estimated at 0.05 – 0.08 m/s) • Approximate water depth of 5 - 20 cm and an approximate water width of 110 - 130 cm, at time of survey • Water was clear and had no odour **During wet weather condition:** • Fast water flow velocity (estimated at 0.5 - 1 m/s) • Approximate water depth of 13 - 25 cm and an approximate water width of 120 - 190 cm, at time of survey • Water was less turbid and had no odour		
D/S24	Natural stream with earth banks, covered by dense vegetation. Estimated stream length is 90 m.	• Originates from forest area of Maju Forest • Ephemeral flow • Water flow towards a concrete drain at southwest direction during dry and wet weather at time of survey • The stream could be partially dried at some sections of it (with many sections having no or low water levels) occasionally based on biodiversity findings (section 7.3.2.2.6) **During dry weather condition:** • Stagnant to slow water flow velocity (estimated at 0.01 m/s) • Approximate water depth of 6 - 10 cm and an approximate water width of 40 - 50 cm, at time of survey	**WQ34** During Dry Weather 	During Wet Weather 

Watercourses	Bank Characteristics	Water Flow Conditions	Photos	
		• Observed stagnant water had a layer of oil and no odour • Observed slow water flow was clear and had no odour **During wet weather condition:** • Slow water flow velocity (estimated at 0.05 m/s) • Approximate water depth of 8 - 10 cm and an approximate water width of 50 - 100 cm, at time of survey • Water was less turbid and had no odour		
D/S25	Natural stream with earth banks, covered by dense vegetation. Estimated stream length is 130 m.	• Originates from forest area of Maju Forest • Ephemeral flow • Water flow towards a concrete drain at southwest direction during dry and wet weather at time of survey • The stream could be partially dried at some sections of it (with many sections having no or low water levels) occasionally based on biodiversity findings (section 7.3.2.2.6) **During dry weather condition:** • Stagnant to slow water flow velocity (estimated at 0.1 m/s) • Approximate water depth of 20 - 25 cm and an approximate water width of 20 - 230 cm, at time of survey • Observed water had a layer of oil and had no odour **During wet weather condition:** • Slow water flow velocity (estimated at 0.2 m/s)	**WQ35** During Dry Weather 	During Wet Weather 

Watercourses	Bank Characteristics	Water Flow Conditions	Photos	
		• Approximate water depth of 20 - 30 cm and an approximate water width of 140 - 350 cm, at time of survey • Water was less turbid and had no odour		

8.5.1.2 Water Quality Conditions in the Study Area

From February 2020 to April 2022, the water quality sampling was conducted in the Study Area during dry and wet weather conditions as shown in Table 8-7. Only stations located at perennial streams/drains (i.e. WQ1, WQ2, WQ16, WQ17, WQ18, WQ19 and WQ20) were sampled during dry and wet weather conditions, while stations located at ephemeral streams/drains (i.e. WQ14 and WQ15) were sampled during rainy days. Due to water flow observed at the stations of ephemeral streams such as WQ33, WQ34 and WQ35 at the time of survey during both dry and wet weather, so these streams were sampled for both dry and wet weather conditions. A total of thirty-two (32) samples has been collected for the Study. A total of thirty-two (32) samples has been collected for the Study.

The water quality results are presented in Table 8-8 with photos shown in Table 8-9, and were assessed against guidelines listed in Table 8-2. The laboratory results for surface water quality parameters were also included in Appendix L. This comparison supports the impact assessment as the streams/drains within the Study Area were found to flow into area of ecological conservation values and public watercourses, and it allows for an assessment of whether the existing water quality is in compliance with the identified limits. If there are no guidelines defined for any of the water quality parameters, the monitored results were considered as the minimum criteria. It should be noted that the water quality of any water generated from the Project's activities during both construction and operational phases should be treated to comply with the NEA allowable limits for discharge into a controlled watercourse prior to discharge.

Table 8-7 Water Quality Monitoring Schedule

Sampling Event / Sampling Location	Dry Weather				Wet Weather		
	4 or 5 February 2020	17 March 2020	28 March 2022	6 April 2022	22 June 2020	13 August 2020	11 April 2022
WQ1 (D/S1)	Sampled	Sampled	-	-	-	Sampled	-
WQ2 (D/S2)	Sampled	Sampled	-	-	-	Sampled	-
WQ14 (D/S20)	-	-	-	-	Sampled	-	-
WQ15 (D/S21)	-	-	-	-	Sampled	-	-
WQ16 (D/S22)	Sampled	Sampled	-	-	Sampled	-	-
WQ17 (D/S1)	Sampled	Sampled	-	-	Sampled	-	-
WQ18 (D/S1)	Sampled	Sampled	-	-	Sampled	-	-
WQ19 (D/S1)	Sampled	Sampled	-	-	Sampled	-	-
WQ20 (D/S1)	Sampled	Sampled	-	-	-	Sampled	-
WQ33 (D/S23)	-	-	Sampled	Sampled	-	-	Sampled
WQ34 (D/S24)	-	-	Sampled	Sampled	-	-	Sampled
WQ35 (D/S25)	-	-	Sampled	Sampled	-	-	Sampled
Note: "-" indicates the sampling was not conducted on the corresponding date.							

Table 8-8 Surface Water Quality Results

Parameter		WQ1 (D/S1)	WQ17 (D/S1)	WQ18 (D/S1)	WQ19 (D/S1)	WQ20 (D/S1)	WQ2 (D/S2)	WQ14 (D/S20)	WQ15 (D/S21)	WQ16 (D/S22)	WQ33 (D/S23)	WQ34 (D/S24)	WQ35 (D/S25)	Average	NEA Trade Effluent Discharge Limits[a]	Criteria for Aquatic Life[b]
Site		**Clementi Forest**									**Maju Forest**					
Watercourse type		**Perennial, concrete**	**Perennial, natural**				**Perennial, earth drain**	**Ephemeral, concrete**	**Ephemeral, earth drain**	**Perennial, natural**	**Ephemeral, natural**					
pH	Dry Average	7.6	6.8	6.8	6.8	7.1	6.7	-	-	7.2	6.6	5.4	5.0	6.6	6 - 9	6.5 - 9
	Wet	7.1	6.8	6.7	6.7	6.6	6.7	6.7	6.6	6.8	6.6	5.4	5.5	6.5		
Temperature (˚C)	Dry Average	28.4	27.4	26.7	26.8	27.1	26.3	-	-	27.0	26.6	26.4	27.1	27.0	45	-
	Wet	26.7	27.2	26.9	26.8	26.7	25.9	27.1	26.4	27.0	25.4	25.4	25.4	26.4		
Conductivity (µS/cm)	Dry Average	246	227	231	228	233	288	-	-	223	193	51	66	165.5	-	-
	Wet	71	286	278	271	70	214	341	234	257	111	49	53	186.3		
Total Dissolved Solids, TDS (mg/L)	Dry Average	151	141	145	144	145	183	-	-	140	121	33	41	103.7	1,000	1,000
	Wet	44	179	174	170	44	137	213	148	160	72	32	34	117.3		
Dissolved Oxygen, DO (mg/L)	Dry Average	9.4	8.0	2.0	1.1	4.4	1.1	-	-	7.4	5.1	0.4	3.0	4.2	-	> 4.0
	Wet	5.6	7.0	5.2	3.7	5.2	3.4	8.7	6.8	8.2	7.7	3.5	7.2	6.0		
Turbidity (NTU)	Dry Average	5	3	11	7	6	45	-	-	4	5	97	4	18.7	-	50
	Wet	7	4	8	7	7	24	3	14	9	70	60	40	21.1		
Total Suspended Solids, TSS (mg/L)	Dry Average	3.7	2.7	5.5	15.5	8.3	36.8	-	-	2.8	3.0	84.5	5.7	16.9	30	50
	Wet	3.4	2.3	3.7	6.0	3.6	20.0	11.0	4.0	14.7	25.9	16.2	6.7	9.8		
Biochemical Oxygen Demand, BOD_5 (mg/L)	Dry Average	1.7	1.8	2.5	2.0	1.7	2.9	-	-	1.3	1.8	< 1	< 1	1.6	20	3
	Wet	< 1	1.5	1.8	2.3	< 1	2.4	2.7	2.3	2.6	< 1	< 1	< 1	1.3		
Chemical Oxygen Demand, COD (mg/L)	Dry Average	7.0	4.0	9.5	9.0	7.0	15.5	-	-	3.0	5.0	41.5	< 5	10.2	60	25
	Wet	7.9	7.0	7.0	8.0	13.0	19.0	14.0	23.0	12.0	83.0	48.0	35.0	23.1		
Total Phosphorus, TP (mg/L)	Dry Average	0.084	0.105	0.110	0.122	0.105	0.115	-	-	0.074	0.065	0.193	0.111	0.108	-	Eutrophic Limit: 0.075
	Wet	0.024	0.100	0.078	0.092	0.031	0.051	0.120	0.083	0.053	0.039	0.040	0.034	0.062		
Orthophosphate, PO_4-P (mg/L)	Dry Average	0.065	0.072	0.071	0.069	0.067	0.065	-	-	0.048	0.046	0.039	0.047	0.049	0.65	0.033
	Wet	0.012	0.057	0.051	0.049	0.012	0.032	0.040	0.055	0.044	0.037	0.034	0.033	0.038		
Total Nitrogen, TN (mg/L)	Dry Average	0.6	1.1	1.0	0.8	0.7	1.0	-	-	1.1	0.4	0.8	0.4	0.8	-	Eutrophic Limit: 1.5
	Wet	0.5	1.1	0.8	0.8	0.6	1.4	0.7	2.6	0.7	1.6	1.3	1.6	1.1		
Nitrate, NO_3-N (mg/L)	Dry Average	0.1	0.4	0.4	0.09	0.07	0.003	-	-	0.5	0.2	0.3	0.3	0.2	4.52	10
	Wet	0.4	0.8	0.6	0.5	0.4	0.8	0.1	1.0	0.6	1.5	1.3	1.5	0.8		

Note:
- a. NEA Trade Effluent Discharge Limits are for controlled watercourses.
- b. The sources of water quality criteria for aquatic life include United Nations Economic Commission for Europe [R-18], United States Environmental Protection Agency [R-19], Australian & New Zealand [R-26], Canada [R-27], Philippines [R-16], and Malaysia [R-28].
- c. Red values mean data exceeding the NEA limits; Purple values mean data exceeding the aquatic life criteria; Blue values mean data exceeding both NEA limits and aquatic life criteria.
- d. "-" indicates samples were only collected for wet weather conditions, thus dry weather data were not available.
- e. < 1 means lower than 1 mg/L of level of detection limit, etc.

Table 8-9 Water Quality Photos at Each Sampling Station

Water Sampling Station	During Dry weather	During Wet weather
Clementi Forest		
WQ1		
WQ2		
WQ14		
WQ15		

Water Sampling Station	During Dry weather	During Wet weather
WQ16		
WQ17		
WQ18		
WQ19		

Water Sampling Station	During Dry weather	During Wet weather
WQ20		
	Maju Forest	
WQ33		
WQ34		
WQ35		

As described in Section 8.5.1.1, some drains/streams in the Study Area had ephemeral flow and it is unlikely that such ephemeral drains/streams (i.e. WQ14 and WQ15) will have any aquatic life. Hence, water quality of all stations was compared with NEA guidelines, while those stations located along perennial watercourses (i.e. WQ1, WQ2, WQ16, WQ17, WQ18, WQ19, WQ20 and WQ33, WQ34 and WQ35) were compared against the criteria for aquatic life.

8.5.1.2.1 *Clementi Forest*

At Clementi Forest, a total of nine (9) water quality stations were sampled. These stations are located along the stream D/S2 (WQ2), drain D/S20 (WQ14), drain D/S21 (WQ15), drain D/S22 (WQ16) and natural stream D/S1 (WQ1, WQ17, WQ18, WQ19 and WQ20). Generally, the surface water quality parameters such as pH, temperature, total dissolved solids (TDS), turbidity, chemical oxygen demand (COD), biochemical oxygen demand (BOD_5), total nitrogen (TN) and nitrate (NO_3-N) met the NEA guideline and aquatic life criteria at all water quality stations as shown in Table 8-8.

Dissolved Oxygen (DO) levels at stream D/S2 and midstream of stream D/S1 during both dry and/or wet weather conditions did not meet the limit of 4 mg/L for aquatic life. Decomposition of organic matter from forest vegetation in low flowing natural streams surrounded by vegetation, can usually result in depletion of DO in the natural streams. These reasons seem valid for lower DO levels observed at stream D/S2 and midstream of D/S1 (i.e. near stagnant natural stream conditions during dry weather and covered by dense vegetation). However, previous study [P-5] has shown that DO lower than 4 mg/L was normal in natural streams of Singapore, which is consistent with the Study.

The total suspended solids (TSS) level at the stream D/S2 exceeded the NEA guideline of 30 mg/L during dry weather. This indicated the high concentration of sediments existing in the stagnant water as observed during time of survey (refer to Table 8-9).

Compared with water quality criteria for aquatic life, during dry weather, (TP) concentration at the stations within perennial stream of D/S1 and stream D/S2 exceeded the eutrophication limit (i.e. 0.075 mg/L), while the orthophosphate (PO_4-P) concentration at all the perennial watercourses had exceeded the aquatic life criteria limit (i.e. 0.033 mg/L). The PO_4-P at all the watercourses were within NEA guideline limit (i.e. 0.65 mg/L). Phosphorus data show high eutrophication potential in natural streams which had slow flow velocity, which is consistent with the site observation of greenish watercourses with algae and dense vegetations (refer to photos of all the sampling stations in Table 8-9). In Clementi Forest, stream D/S1 have high phosphorus from its upstream with increasing concentration till its downstream. This has indicated the source of phosphorus might come from both upstream residential area (e.g. fertiliser from tree plantation, food wastes, etc.) as well as organic decomposition from dead plants within the Study Area. During wet weather, the phosphorus concentrations within all the perennial natural streams slightly reduced due to dilution effect from storm.

The overall baseline water quality of the perennial watercourses was likely to be suitable for aquatic life. This supports the biodiversity findings in Section 7.4.2.1, especially the natural stream D/S1 of high ecological value.

8.5.1.2.2 *Maju Forest*

At Maju Forest, a total of three (3) water quality stations were sampled along three (3) natural streams D/S23, D/S24, and D/S25 in the forested area. The water quality parameters such as temperature, biochemical oxygen demand (BOD_5) and nitrate (NO_3-N) met the NEA guideline and aquatic life criteria at all water quality stations as shown in Table 8-8.

The pH found at stream D/S24 and stream D/S25 during dry and wet weather conditions were not within than the range of NEA guideline (i.e. pH 6 – pH 9) and aquatic life criteria (i.e. pH 6.5 – pH 9). This might be due to the higher concentration of humic acid from decomposing forest debris from the surrounding vegetation during dry weather.

DO levels were found to be depleted at stream D/S24 and stream D/S25 during both dry and/or wet weather conditions. Decomposition of organic matter from forest vegetation in natural streams with slow flow velocity and surrounded by vegetation, can usually result in depletion of DO in the natural streams.

The turbidity at stream D/S23 and stream D/S24 (i.e. 70 NTU and 60 NTU, respectively) during wet weather and turbidity at drain D/S23 (i.e. 97 NTU) during dry weather have exceeded the aquatic life criteria (i.e. 50 NTU). The TSS levels at the water quality stations were within the NEA guideline of 30 mg/L and aquatic life criteria of 50 mg/L, except at stream D/S24 during dry weather conditions. The elevated TSS at stream D/S24 could be attributed to the relatively very low velocity flow and low turbid observed at the time of survey.

For chemical oxygen demand (COD), the streams in the Maju Forest (i.e. D/S23, D/S24 and D/S25) exceeded the NEA guideline (i.e. 60 mg/L) and/or aquatic life criteria limits (i.e. 25 mg/L) during wet weather and it might be due to the flushing of stormwater from upstream consisted of high concentration of COD. Elevated COD at stream D/S24 during dry weather has also exceeded the aquatic life criteria and this indicated a large proportion of non-biodegradable organics (given the low BOD_5 observed) in the water of stream D/S24 during dry and wet weather conditions.

During wet weather, total phosphorus (TP) concentration among all three (3) water samples ranged from 0.034 mg/L to 0.040 mg/L, which was below the eutrophication limit (i.e. 0.075 mg/L) of the aquatic life criteria. During dry weather, TP concentration at streams D/S24 and D/S25 (i.e. WQ34 and WQ35) exceeded the eutrophication limit, while the orthophosphate (PO_4-P) concentration at all the sampled stations exceeded the aquatic life criteria limit (i.e. 0.033 mg/L). The PO_4-P levels at streams D/S23 and D/S24 (i.e. 0.037 mg/L and 0.034 mg/L) during wet weather also exceeded the aquatic life criteria (i.e. 0.033 mg/L). Hence, phosphorus data show high eutrophication potential in natural streams which had slow flow velocity, which is consistent with the site observation of greenish watercourses with algae and dense vegetations (refer to photos of all the sampling stations in Table 8-9).

TN levels at streams D/S23 and D/S25 slightly exceeded the eutrophic limit during wet weather. The elevated TN could be due to water flushing from surroundings dense vegetation contained of high nitrogen level during storm event.

As such, it can be concluded that the baseline water quality of the natural streams in Maju Forest suggesting possible unfavourable conditions for aquatic life. However, the aquatic life could have adapted to such existing conditions based on biodiversity findings in Section 7.4.1.1, which consider the natural streams to be of high ecological value.

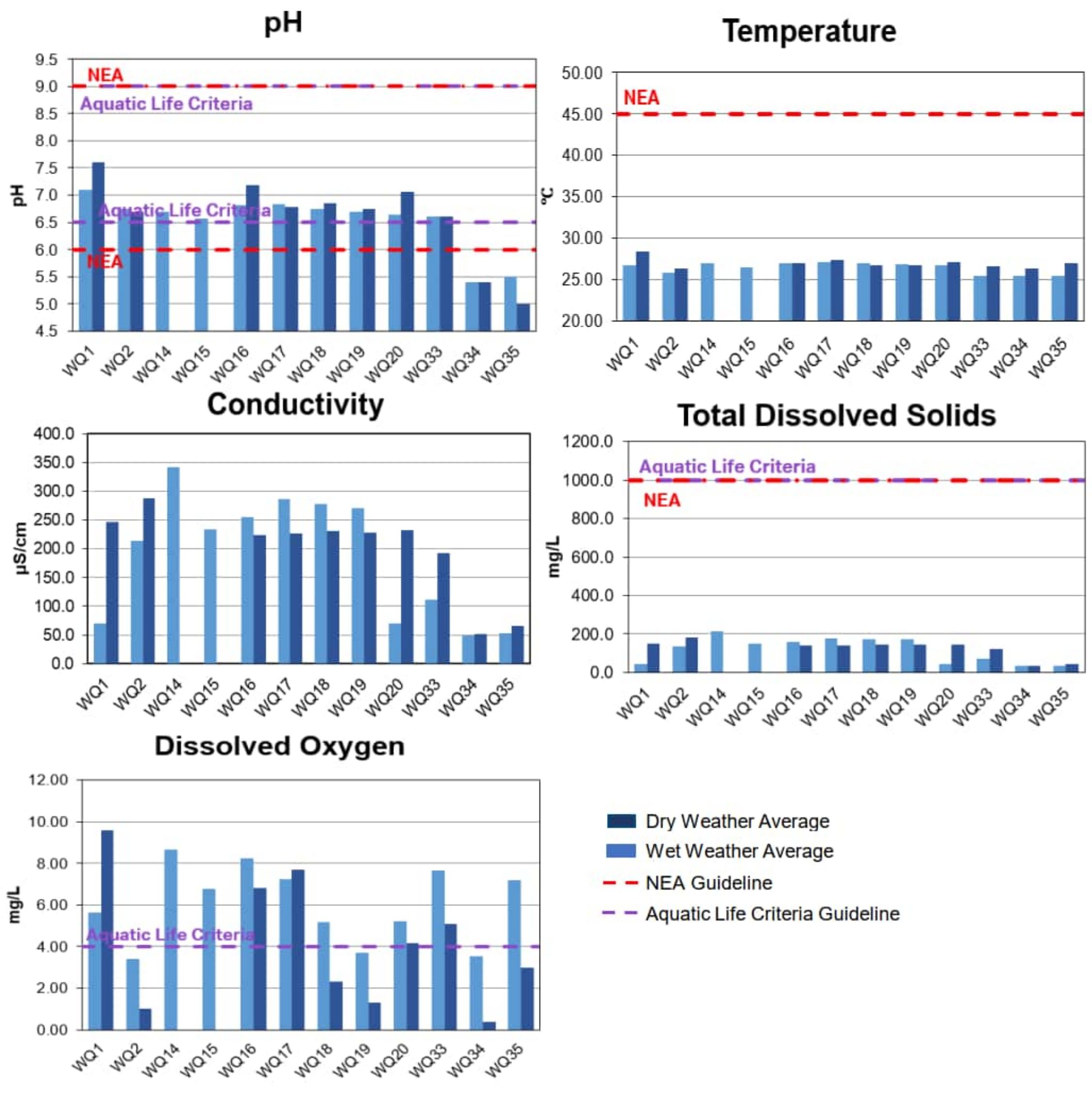


Figure 8-5 Average Monitoring Results of In-situ Parameters for Dry and Wet Weather Conditions

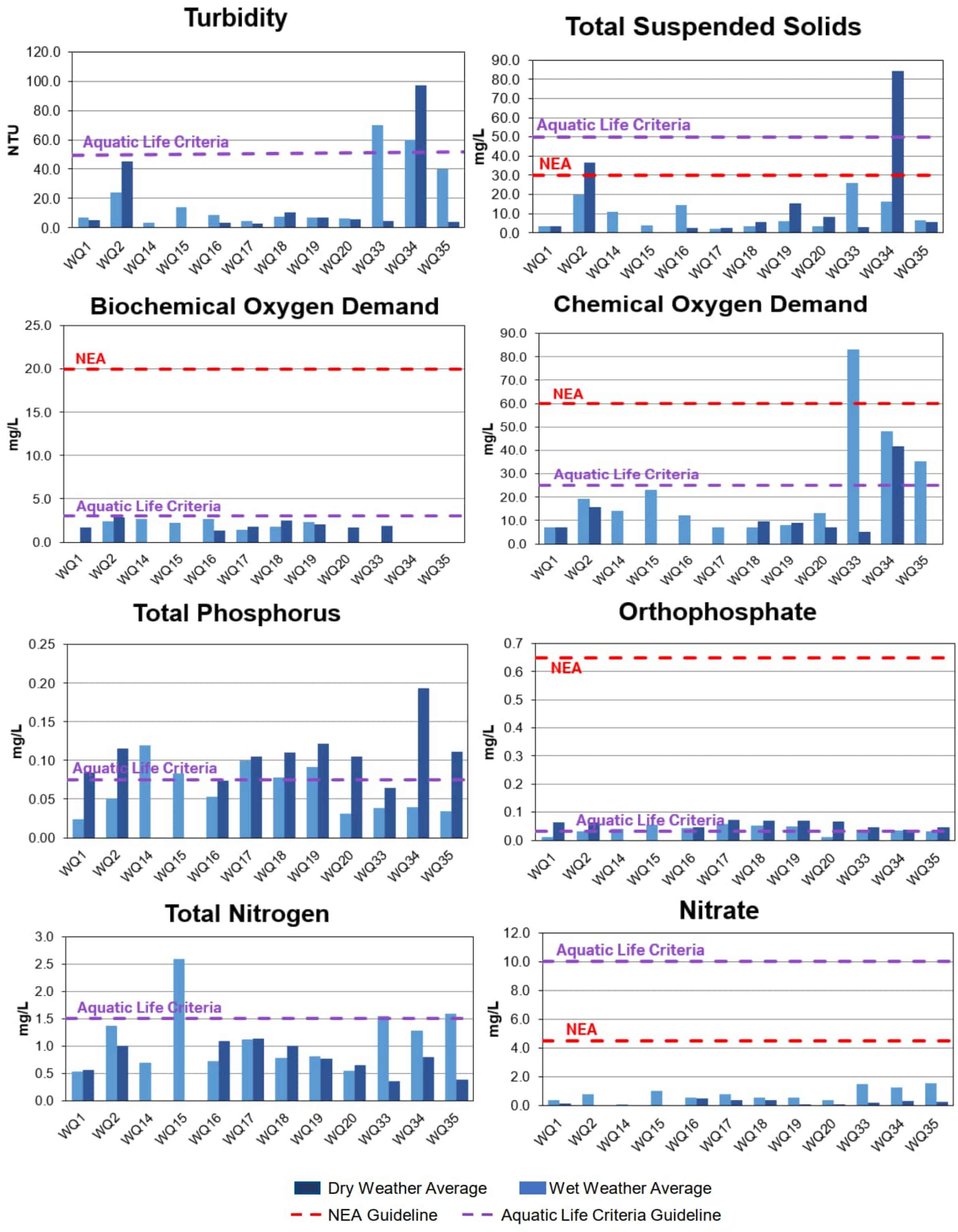


Figure 8-6 Average Monitoring Results of Ex-situ Parameters for Dry and Wet Weather Conditions

8.6 Minimum Control for Potential Impacts

This section proposes minimum controls, or standard practices, commonly implemented in Singapore for similar construction and operational activities, that have been assumed to be implemented for the purposes of impact assessment.

8.6.1 Construction Phase

Table 8-10 has a non-exhaustive list of minimum controls for each potential impact identified in Section 8.3.1 for construction phase.

Table 8-10 Minimum Controls during the Construction Phase Applicable to Hydrology and Water Quality Impact Assessment

Environmental Parameter	Activity	Minimum Control
Solid & Toxic Waste Generation	Site clearance, earthworks and general construction activities at launch/retrieval shafts, the open cut and the C&C works (e.g. clearing and preparation, trench excavation, backfill, soil mixing, compaction, spoil handling and transport, building of permanent structures, utilities diversion including diversion of water pipes and stormwater drains along the Project, etc.)	• Development of a Standard Operation Procedure (SOP) for safe handling, transfer, storage and disposal of solid waste; • 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; • ECM measures include but are not limited to minimisation of formation of bare soil, coverage of all bare/erodible surfaces, slope stability, concrete cut-off drains, silt fences/traps along the perimeter cut-off drain, turbidity curtains for works adjacent to watercourses, etc.; • 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); • Provision of enclosed bins and waste disposal facilities cleared up as often as necessary to prevent build-up. Housekeeping checks will be carried out once a day to ensure all litter is cleared from site; • Hazardous substances and toxic wastes should be stored on hard stand, under shelter with a kerb around the storage area; • 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.); and • Appropriate disposal of any waste listed in the Environmental Public Health (General Waste Collection) Regulations by licensed waste operator/collector.
Liquid Effluent Generation and Stormwater Runoff	Construction wastewater resulting from site clearance, excavation, tunnelling, etc.	• 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 on-site; • Regular audits on environmental management procedures will be carried out on-site; • No hazardous liquids to be sent to the detention pond/tank; • 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 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;

Environmental Parameter	Activity	Minimum Control

		• ECM tanks/ponds will be designed in sufficient capacity to hold the turbid stormwater prior to treatment at the ECM facility;
		• Temporary storage volumes should be provided for overflow situations of untreated wastewater. Temporary storage with sufficient capacity will capture any expected additional volumes ensure untreated wastewater is not released to watercourses unless it complies with Singapore NEA Guidelines on trade effluent discharge concentrations;
		• A responsible person (e.g. ECO) to be assigned to oversee the efficient operation of the containment pond/kerbs where 'Good Housekeeping' practices would be adhered to. Also, the area would be carefully managed to avoid spills, leaks, and odour issues, with the containment pond/kerbs checked at least daily to ensure proper functionality;
		• Daily record volume of wastewater, as well as volumes of sludge and other produced wastes;
		Contractor will need to seek approval from 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 surface watercourses. If such discharges are not approved, the trade effluent will be stored, treated or recycled on site and finally disposed off-site;
		• Contractor will seek for comment and approval from relevant authorities (e.g. SCDF and NEA) on the treated wastewater to be used for firefighting purposes.
		• The discharge of pumped dewatered groundwater or other wastewaters to sensitive aquatic habitats will be prohibited (e.g. natural streams within Clementi Forest and Maju Forest);
		• Tunnel washing effluent should be discharged to containment pond/kerbs that are manually collected by operator assigned private wastewater collector to be transferred to wastewater treatment plant;
		• The containment pond/kerbs, as well as wastewater generating areas on-site, to be equipped with spill clean-up kits;
		• 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;
		• Implement a construction EMMP and ensure full preparation of associated plans and procedures including the following:
		  • EMMP to include SOPs, an Emergency Response Plan (ERP), an inventory of wastewater streams, training of staff as well as an inspection, maintenance and audit schedule; and
		  • Full development of EMMP Wastewater Management Procedures to include dedicated management and monitoring procedures that covers all eventualities related to the proper operation of containment pond/kerbs, or any other wastewater discharge location/equipment.
		• Regular and dedicated procedures for the inspection and maintenance of wastewater (i.e. trade effluent) collection, storage, and treatment infrastructure, such as pipes, oil water separators, silt screens, etc.;
		• Regular and dedicated procedures for the management of stormwater collection, settling, testing and eventual discharge of 'clean' water to watercourse; and
		• A training programme for all on-site workers, including sub-contractors, in relation to their obligations for ensuring proper water quality management.

Environmental Parameter	Activity	Minimum Control
	Storage and disposal of domestic liquid wastes	• Provision of portable toilets and on-site septic tank; • Regular cleaning of the portable toilets and clearing of sanitary waste; • Appropriate location of toilet facilities away from any nearby watercourse; • Inspections and audits to ascertain the hygienic conditions on-site; • The toilet facilities will be placed at least 30 m away from any nearby watercourse; • Training of workers on the best practices to contribute to environmental protection; and • Appropriate disposal of any waste listed in the Environmental Public Health (General Waste Collection) Regulations by licensed waste operator/collector regardless the wastes to be disposed off-site or discharged to public sewer.
	Storage and disposal of construction solid wastes	• Surface Water Drainage, to be endorsed by a QECP and submitted to PUB; • Implementation of the ECM plan before the start of any construction work; • Effective ECM and monitoring implemented as recommended in the Code of Practice on Surface Water Drainage to ensure that discharge into stormwater drainage system does not contain TSS in concentrations greater than the prescribed limits under the Sewerage and Drainage (Surface Water Drainage) Regulations; • ECM measures include but are not limited to minimisation of formation of bare soil, coverage of all bare/erodible surfaces, concrete cut-off drains, silt fences/traps along the perimeter cut-off drain, turbidity curtains for works adjacent to water bodies (canals, drains, streams), etc. • Implementation of CCTV including a SIDS at the public drain to monitor the surface runoff discharges from the sites as per the PUB circular on Preventing Muddy Waters from the Construction Sites (October 2015); • Runoff within, upstream of, and adjacent to the work site will be effectively drained away without causing flooding in the vicinity; • Manholes should always be adequately covered and temporarily sealed; • Protection of stockpiles with erosion blanket coverage and proper scheduling of the demolition and earthworks to reduce the quantity of stockpiles to be stored on-site; • Coverage of temporary/open storage of excavated materials; • All vehicles should run via wheel washing process before leaving the site to ensure no earth, mud, debris, etc., is deposited on roads; and the wastewater hence generated should be stored and removed for treatment and disposal off-site by an approved Waste Management Contractor; and • 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.
	Stormwater Runoff Generation	Stormwater Quality: • ECM measures include but are not limited to minimisation of formation of bare soil, coverage of all bare/erodible surfaces, concrete cut-off drains, silt fences/traps along the perimeter cut-off drain, turbidity curtains for works adjacent to watercourses (canals, drains, streams), etc.; • Adequate drainage, piping and/or channelling of stormwater runoff to be assured through detailed design for capture and treatment at ECM tanks/ponds before discharge into watercourses; • Regular and dedicated procedures for the inspection and maintenance of stormwater collection, storage, and treatment

Environmental Parameter	Activity	Minimum Control
		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. This should also include associated measures required to prevent high sediment concentration stormwater drainage to watercourses. Hydrology: • Runoff within, upstream of, and adjacent to the work site will be effectively drained away without causing flooding in the vicinity; • Potential increase of peak-flow due to the change in the land use at the worksite can be mitigated by providing detention tanks or ponds within the Study Area. Detention tanks or ponds can capture stormwater during heavy storm events to reduce the peak runoff; • 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; and • The design engineers for detailed design may need to ensure that Earth Retaining Stabilisation structures (ERSS) are proposed when the site is cleared and excavated. Concurrently the ECO must ensure that these measures are implemented in the construction phase, as cutting of slopes may result in slope instability.
Improper Management of Chemical Substances	Use, storage and disposal of chemical substances Refuelling activities	• 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); • 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; and • Appropriate disposal of toxic waste as per required in the Environmental Public Health (Toxic Industrial Waste) Regulations by licensed waste operator/collector.

8.6.2 Operational Phase

Table 8-11 has a non-exhaustive list of minimum controls for each potential impact identified in Section 8.3.2 for operational phase.

Table 8-11 Minimum Controls during the Operational Phase Applicable for Hydrology and Water Quality Impact Assessment

Environmental Parameter	Activity	Minimum Control
Stormwater Runoff	Stormwater Runoff Generation	Stormwater Quality: • Adequate drainage, piping and/or channelling of stormwater runoff 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 site's slope stability (such as ERSS) to be included in detailed design engineering for the operational stage.

8.7 Prediction and Evaluation of Hydrology and Surface Water Quality Impacts

8.7.1 Construction Phase

As described in Sections 8.3 and 8.6, three (3) major sources of hydrology and surface water quality impacts were identified, including solid & toxic waste generation, liquid effluent and stormwater runoff, as well as management of chemical substances. Among them, liquid effluent and stormwater runoff may have impact on both hydrology and surface water quality in the vicinity of Study Area, while the other two (2) sources tend to have more impact on surface water quality. Following sections present the prediction and evaluation of hydrology and surface water quality impacts during construction phase.

8.7.1.1 Solid & Toxic Waste Generation (Water Quality)

In Clementi Forest, five (5) sensitive receptors were identified as Priority 1 (i.e. stream D/S1, drain D/S2, drain D/S20, drain D/S21 and stream D/S22). The quantity of solid and toxic waste stored on-site (e.g. chemical waste, construction debris, etc.) was expected to be limited and will be periodically disposed of by licensed waste management contractors as provided for in the minimum controls. However, during the construction phase, stream D/S1, drain D/S21 and stream D/S22 are located within the construction worksites. Hence, the impact intensity of water quality impact on stream D/S1, drain D/S21 and stream D/S22 would be High due to potential contamination could be significant at the watercourses and some of watercourses has supported high ecological value (refer to Section 7.4.2.1). As the watercourses are Priority 1 sensitive receptors, the water quality impact consequence on the watercourses would be High based on the Impact Consequence Matrix as in Table 6-6. Water soluble parameters such as TDS, nutrients, heavy metals, etc. will be monitored and treatment for these parameters will be put in place before the stormwater runoff releases into the stream D/S1, drain D/S21 and stream D/S22. As some portions of watercourses of stream D/S1, drain D/S21 and stream D/S22 will be within the worksite areas, so even all minimum control measures detailed in Table 8-10 are provided, the likelihood of occurrence would be Regular for stream D/S1, drain D/S21 and stream D/S22. According to Table 6-8, the impact significance on stream D/S1, drain D/S21 and stream D/S22 would be Major. For drain D/S20 in Clementi forest, it is located near to the Worksite at Nursery so the impact intensity on drain D/S20 would be Medium and the consequence on drain D/S20 would be Medium also based on the Impact Consequence Matrix as in Table 6-6. The impact significance on drain

D/S20 was assessed to be Minor with Rare likelihood of occurrence by providing the minimum controls as mentioned in Table 8-10. For drain D/S2, the construction worksites are not located within the catchment areas of drain D/S2 and the existing land use of drain D/S2 will not be changed, so the impact intensity of solid and toxic waste contamination on drain D/S2 would be Negligible and the consequence would be Very Low as the watercourse is Priority 1 sensitive receptors based on the Impact Consequence Matrix as in Table 6-6. Once effective ECM and monitoring are implemented as required in the Code of Practice on Surface Water Drainage, the impact likelihood on drain D/S2 would be Rare and the impact significance would be Negligible according to Table 6-8.

In Maju Forest, the construction worksites are not located within the catchment areas of the natural streams. It is unlikely that spills or runoff from the waste stored on site will reach the watercourses and the impact intensity on the natural streams in Maju Forest would be Negligible. The impact consequence would be Very Low as the watercourses are Priority 1 sensitive receptors based on the Impact Consequence Matrix as in Table 6-6. In addition, the suspended solids discharge from the construction worksite to the nearby watercourse is kept to minimum with the ECM tanks/ponds. Therefore, the likelihood of occurrence was expected to be Rare for the natural streams. Hence, the impact significance would be Negligible for the natural streams in Maju Forest according to Table 6-8.

8.7.1.2 Liquid Effluent and Stormwater Runoff Generation (Hydrology and Water Quality)

8.7.1.2.1 *Hydrology*

Land use modification due to land clearing during construction phase may affect existing hydrology condition of Study Area. Due to the land use changes with less vegetation and exposed earth, it may lead to increased surface runoff volume and water level in existing channel, and subsequent flooding of surrounding areas adjacent to the streams and drains. With minimum controls as mentioned in Table 8-10, installation of temporary storage can prevent overflow situations at site. Temporary storage with sufficient capacity will capture any additional volumes that may be expected due to proposed construction site. Flooding can be minimised at streams and drains if they will not be occupied as CCTV will be implemented at existing drain to monitor the surface runoff discharges from the sites.

At Clementi Forest, the existing forest and natural streams could be impacted by construction activities of CR16 worksite. The drain D/S21, stream D/S22 and upstream-midstream of stream D/S1 will be occupied by the proposed construction worksite. The catchment area could be changed due to land use change of construction worksite. Less vegetation on the land due to forest clearing in the worksite will also lead to potentially increased amount of surface runoff during storm event. Dry weather flow might be altered as well, which in turn might have adverse impact on the sensitive aquatic habitat of the natural stream D/S1 and downstream of D/S22 (refer to biodiversity findings in Section 7.4.2.1. Hence, drain D/S21, stream D/S22 and stream D/S1 would have High impact intensity. As the watercourses are Priority 1 sensitive receptors, the impact consequence on drain D/S21, stream D/S22 and stream D/S1 would be High based on Table 6-6. The likelihood of occurrence would be Regular for the drains and stream with a Major impact significance based on Table 6-8. The hydrology of drain D/S20 which near the Worksite at Nursery will be potentially altered due to the land use change of construction worksite so drain D/S20 could have Medium impact intensity. Drain D/S20 is Priority 1 sensitive receptor and the impact consequence would be Medium based on Table 6-6. With minimum controls as provided in Table 8-10, the occurrence likelihood would be Rare for drain D/S20 and the impact significance was assessed to be Minor based on the Table 6-8. For drain D/S2, the construction worksites are not located within the catchment areas of drain D/S2 and the existing land use of drain D/S2 will not be changed, the hydrology impact intensity on drain D/S2 would be Negligible and the consequence would be Very Low as the watercourse is Priority 1 sensitive receptors based on the Impact Consequence Matrix as in Table 6-6. The impact likelihood of occurrence on drain D/S2 would be Rare and the impact significance was assessed to be Negligible according to Table 6-8.

In Maju Forest, the construction worksites are not located within the catchment areas of the natural streams, so flooding was not expected to occur at the natural streams. Thus, the impact intensity on the natural streams in Maju Forest would be Negligible. The impact consequence would be Very Low as the watercourses are Priority 1 sensitive receptors based on the Impact Consequence Matrix as in Table 6-6. The likelihood of occurrence would be Rare for the natural streams. Hence, the impact significance would be Negligible for the natural streams in Maju Forest according to Table 6-8.

8.7.1.2.2 *Water Quality*

Liquid effluents generated from the construction activities commonly include extracted groundwater, sanitary discharges, and stormwater runoff from exposed and unstable slopes. For sanitary discharges, portable toilets will be installed as part of the minimum control provided by the Project and sanitary effluents from portable toilets will be collected regularly by the appointed contractor for disposal. Management controls are also expected to be implemented, such as regular inspection and housekeeping. To avoid additional stormwater runoff flowing from site’s unstable slope to adjacent forested slopes during construction phase, it is also recommended that soil nailing should be done along the cut slope and geotextile should be used for fill slope along the worksite boundary before construction.

In Clementi Forest, five (5) sensitive receptors were identified as Priority 1 (i.e., stream D/S1, drain D/S2, drain D/S20, drain D/S21 and stream D/S22). During the construction phase, stream D/S1, drain D/S21 and stream D/S22 are located within the construction worksite. Hence, the impact intensity of impact water quality on stream D/S1, drain D/S21 and stream D/S22 would be High due to potential contamination could be significant at the watercourses and some of watercourses has supported high ecological value (refer to Section 7.4.2.1). With proper application of the minimum controls described in Table 8-10, such as the implementation of containment pond/kerbs to hold wastewater produced during construction, impacts to the surface water quality from the construction site surface runoff can be reduced. Stormwater runoff generated from construction activities will be channelled to containment ponds/kerbs and treated before treatment. For the extracted groundwater as part of tunnelling wastewater, contractor will need to seek approval from both relevant authorities (i.e., PUB & NEA) prior to any discharge of treated trade effluent generated 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 extracted groundwater is approved to be discharged into surface watercourses, in the event that exceedance of the Trade Effluent Discharge Limits of Controlled Watercourse was detected during monthly monitoring, NEA and PUB should be immediately notified. If such discharges are not approved, the trade effluent will be stored, treated or recycled on site and finally disposed off-site. The turbid stormwater runoff generated from construction site will be channelled to ECM tanks/ponds. As the watercourses are Priority 1 sensitive receptors, the water quality impact consequence on the watercourses would be High based on the Impact Consequence Matrix as in Table 6-6. Even other controls such as regular and dedicated procedures for inspection and the maintenance of wastewater collection and storage are provided accordingly, the occurrence likelihood would be Regular for stream D/S1, drain D/S21 and stream D/S22. According to Table 6-8, the impact significance on stream D/S1, drain D/S21 and stream D/S22 would be Major. For drain D/S20, it is located near to the Worksite at Nursery so the impact intensity on drain D/S20 would be Medium and the consequence would be Medium also based on based on the Impact Consequence Matrix as in Table 6-6. The impact significance on drain D/S20 was assessed to be Minor with Rare likelihood of occurrence by providing the minimum controls as mentioned in Table 8-10. For drain D/S2, since the construction worksites are not located within the catchment areas of drain D/S2 and the existing land use of drain D/S2 will not be changed, the impact intensity of liquid effluent contamination on drain D/S2 would be Negligible. The impact consequence would be Very Low as the watercourse is Priority 1 sensitive receptors based on the Impact Consequence Matrix as in Table 6-6. The impact likelihood of occurrence on drain D/S2 would be Rare and the impact significance would be Negligible according to Table 6-8.

In Maju Forest, the construction worksites are not located within the catchment areas of the natural streams. It is unlikely that liquid effluent and stormwater generated from the construction worksite will reach the watercourses. Thus, the impact intensity on the natural streams in Maju Forest would be Negligible. The impact consequence would be Very Low as the watercourses are Priority 1 sensitive receptors based on the Impact Consequence Matrix as in Table 6-6. By given the likelihood of occurrence is expected to be Rare for the natural streams, the impact significance would be Negligible for the natural streams in Maju Forest according to Table 6-8.

8.7.1.3 Improper Management of Chemical Substances (Water Quality)

Chemical substances will be stored on concrete surfaces with containment bunds or on spill control palettes. Moreover, SOP is expected to be developed to ensure the proper handling, transfer and storage of these substances, which will also contribute to reduce the frequency and impact of chemical spillage.

In the vicinity of Clementi Forest, five (5) sensitive receptors were identified as Priority 1 (i.e., stream D/S1, drain D/S2, drain D/S20, drain D/S21 and stream D/S22). During the construction phase, stream D/S1, drain D/S21 and drain D/S22 are located within the construction worksite. The impact intensity of impact water quality on stream D/S1, drain D/S20, drain D/S21 and stream D/S22 would be High due to potential contamination could be significant at the watercourses and some of watercourses has supported high ecological value (refer to Section 7.4.2.1). As the watercourses are Priority 1 sensitive receptors, the water quality impact consequence on the watercourses would also be High based on the Impact Consequence Matrix as in Table 6-6. Even provided that all minimum control measures detailed in Table 8-10 are in place such as periodically conducting leak detection tests, the likelihood of occurrence would be Regular for stream D/S1, drain D/S21 and stream D/S22. According to Table 6-8, the impact significance on stream D/S1, drain D/S21 and stream D/S22 would be Major. For drain D/S20, it is located near to the Worksite of Nursery so the impact intensity on drain D/S20 would be Medium and the consequence on drain D/S20 would be Medium also based on based on the Impact Consequence Matrix as in Table 6-6. The impact significance on drain D/S20 was assessed to be Minor with Rare likelihood of occurrence by providing the minimum controls as mentioned in Table 8-10. For drain D/S2, since the construction worksites are not located within the catchment areas of drain D/S2 and the existing land use of drain D/S2 will not be changed, the impact intensity due to improper management of chemical substances on drain D/S2 would be Negligible. The consequence would be Very Low as the watercourse is Priority 1 sensitive receptors based on the Impact Consequence Matrix as in Table 6-6. The impact likelihood on drain D/S2 would be Rare and the impact significance would be Negligible according to Table 6-8.

In Maju Forest, the construction worksites are not located within the catchment areas of the natural streams. It is unlikely that liquid effluent and stormwater generated from the construction worksite will reach the watercourses. Thus, the impact intensity on the natural streams in Maju Forest would be Negligible. The impact consequence would be Very Low as the watercourses are Priority 1 sensitive receptors based on the Impact Consequence Matrix as in Table 6-6. Given the likelihood of occurrence was expected to be Rare for the natural streams, the impact significance would be Negligible for the natural streams in Maju Forest according to Table 6-8

Table 8-12 Summary of Impact Evaluation during Construction Phase

Potential Source of Impact	Receptor Sensitivity[1]	Biodiversity Study Area	Impact Intensity	Consequence	Likelihood	Significance
Solid & Toxic Waste Generation (Water Quality)	Priority 1 (D/S1)	Clementi Forest	High	High	Regular	Major
	Priority 1 (D/S2)		Negligible	Very Low	Rare	Negligible
	Priority 1 (D/S20)		Medium	Medium	Rare	Minor
	Priority 1 (D/S21)		High	High	Regular	Major
	Priority 1 (D/S22)		High	High	Regular	Major
	Priority 1 (Natural streams in Maju Forest)	Maju Forest	Negligible	Very Low	Rare	Negligible
Liquid Effluent Generation and Stormwater Runoff (Hydrology)	Priority 1 (D/S1)	Clementi Forest	High	High	Regular	Major
	Priority 1 (D/S2)		Negligible	Very Low	Rare	Negligible
	Priority 1 (D/S20)		Medium	Medium	Rare	Minor
	Priority 1 (D/S21)		High	High	Regular	Major
	Priority 1 (D/S22)		High	High	Regular	Major
	Priority 1 (Natural streams in Maju Forest)	Maju Forest	Negligible	Very Low	Rare	Negligible
Liquid Effluent Generation and Stormwater Runoff (Water Quality)	Priority 1 (D/S1)	Clementi Forest	High	High	Regular	Major
	Priority 1 (D/S2)		Negligible	Very Low	Rare	Negligible
	Priority 1 (D/S20)		Medium	Medium	Rare	Minor
	Priority 1 (D/S21)		High	High	Regular	Major
	Priority 1 (D/S22)		High	High	Regular	Major
	Priority 1 (Natural streams in Maju Forest)	Maju Forest	Negligible	Very Low	Rare	Negligible
Improper Management of Chemical Substances (Water Quality)	Priority 1 (D/S1)	Clementi Forest	High	High	Regular	Major
	Priority 1 (D/S2)		Negligible	Very Low	Rare	Negligible
	Priority 1 (D/S20)		Medium	Medium	Rare	Minor
	Priority 1 (D/S21)		High	High	Regular	Major
	Priority 1 (D/S22)		High	High	Regular	Major
	Priority 1 (Natural streams in Maju Forest)	Maju Forest	Negligible	Very Low	Rare	Negligible

Note:
1. Receptor locations are shown in Figure 8-2.

8.7.2 Operational Phase

As described in Sections 8.3 and 8.6, the major source of hydrology and surface water quality impact from the operational footprint is stormwater runoff generation. Following sections present the prediction and evaluation of hydrology and surface water quality impact during operational phase. Drain D/S21 is not applicable to be assessed for impact assessment of operational phase due to there being no permanent structures proposed for Worksite at Nursery during the operational phase.

8.7.2.1 Stormwater Runoff Generation (Hydrology and Water Quality)

8.7.2.1.1 *Hydrology*

The stormwater runoff peak flow will be increased, and soil erosion may occur due to land use change of Study Area during operation stage. Due to the land use changes with less vegetation and low pervious area, it may lead to increased surface runoff volume and water level in existing channel, and subsequent flooding of surrounding areas adjacent to the streams and drains.

In Clementi Forest, proposed CR16 station will encroach the upstream of D/S22 as shown in Figure 8-7. This will lead to potential hydrology change on streams D/S1 and D/S22 which support high ecological value based on biodiversity findings (refer to Section 7.4.2.1). Even with proper implementation of the minimum controls as described in Table 8-11 such as the drainage installation to direct stormwater runoff and potential spillages, providing detention tanks, etc., the impact intensity on streams D/S1 and D/S22 would be Medium as the hydrology of the watercourses will be permanently changed. As both streams D/S1 and D/S22 are Priority 1 sensitive receptors, the impact consequence on both streams D/S1 and D/S22 would be Medium according to Table 6-6. Given the likelihood of such hydrological impact on streams D/S1 and D/S22 would be Regular, the impact significance of the hydrological modification on streams D/S1 and D/S22 was assessed to be Moderate based on Table 6-8. For other watercourses in Clementi Forest such as drains D/S2 and D/S20, it is expected the no land use change on the watercourses due to the proposed CR16 station during operational phase. Thus, the impact intensity on drains D/S2 and D/S20 would be Negligible and the impact consequence on the watercourses would be Very Low since the watercourses are Priority 1 sensitive receptors based on the Impact Consequence Matrix as in Table 6-6. The impact significance on drains D/S2 and D/S20 would be Negligible according to Table 6-8.

In Maju Forest, the CR16 station will not locate within the catchment areas of the natural streams. It is unlikely that the existing land use of natural streams would be modified, and stormwater generated from the CR16 station will flow into the watercourses during operational phase. Thus, the impact intensity on the natural streams in Maju Forest would be Negligible. The impact consequence would be Very Low as the watercourses are Priority 1 sensitive receptors based on the Impact Consequence Matrix as in Table 6-6. Given the likelihood of occurrence was expected to be Rare for the natural streams, the impact significance would be Negligible for the natural streams in Maju Forest according to Table 6-8.

8.7.2.1.2 *Water Quality*

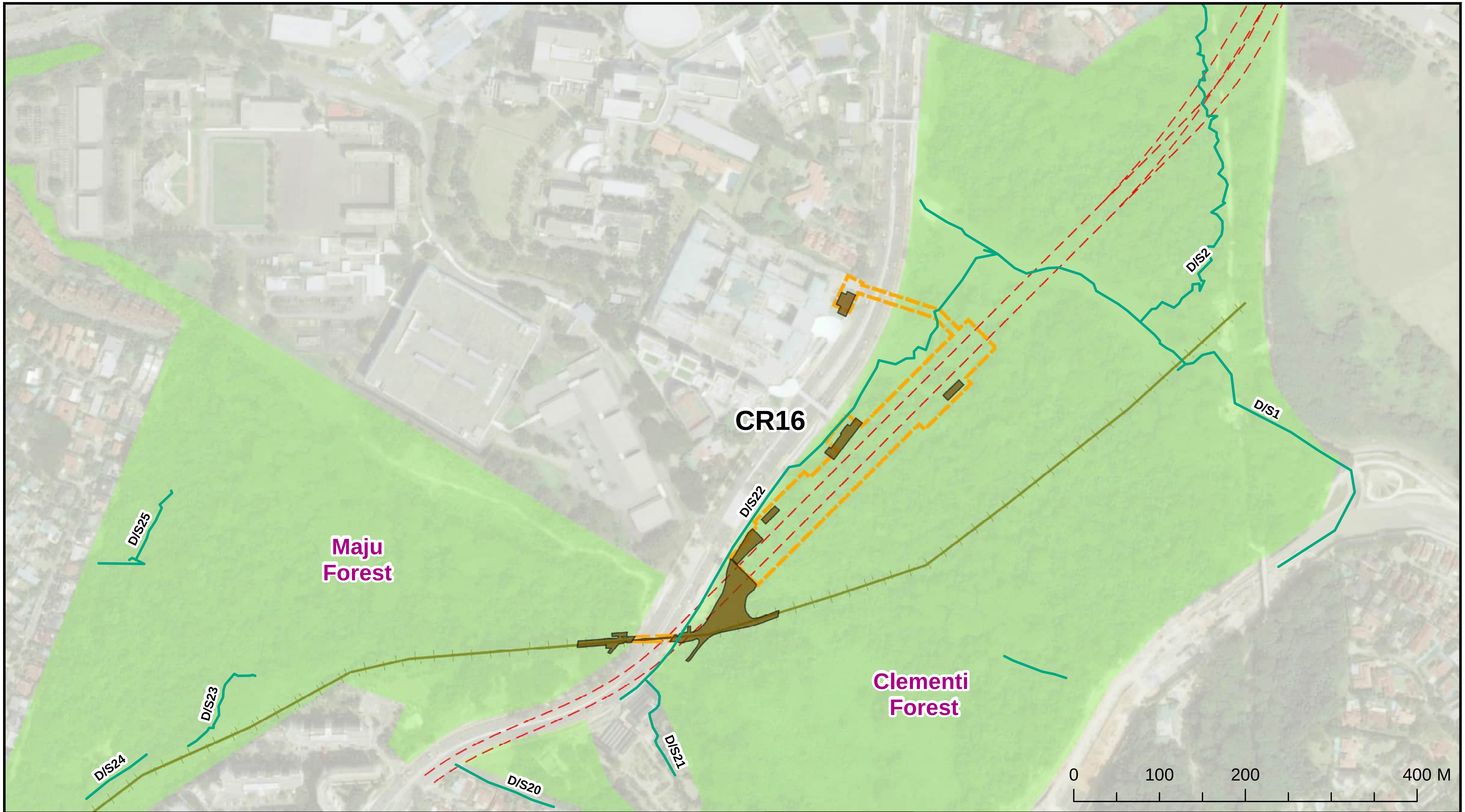
In Clementi Forest, the proposed above-ground CR16 station will encroach the upstream of D/S22 as shown in Figure 8-7. This will lead to potential water quality on streams D/S1 and D/S22 which support high ecological value based on biodiversity findings (refer to Section 7.4.2.1). Even with proper application of the minimum controls described in Table 8-11, such as the ABC water design approach for capture and treatment before discharge into watercourses and regular dedicated procedures for the inspection and maintenance of stormwater drainage systems, the impact intensity on stream D/S1 and drain D/S22 would be Medium. As streams D/S1 and D/S22 are Priority 1 sensitive receptors, the impact consequence on both streams D/S1 and D/S22 would be Medium according to Table 6-6. Given the likelihood of such water quality impact on streams D/S1 and D/S22 would be Regular, the impact significance of the potential water quality contamination on streams D/S1 and D/S22 was assessed to be Moderate based on Table 6-8. For drains D/S2 and D/S20, the proposed CR16 station will not locate within the catchment areas of drains D/S2 and D/S20. Thus, the impact intensity on drains D/S2 and D/S20 would be Negligible and the impact consequence on the watercourses would be Very Low since the watercourses are Priority 1 sensitive receptors based on the Impact Consequence Matrix as in Table 6-6. The impact significance on drains D/S2 and D/S20 would be Negligible according to Table 6 8.

In Maju Forest, CR16 station will not locate within the catchment areas of the natural streams. It is unlikely that the water quality of natural streams would be potentially affected by CR16 station during operational phase. Thus, the impact intensity on the natural streams in Maju Forest would be Negligible. The impact consequence would be Very Low as the watercourses are Priority 1 sensitive receptors based on the Impact Consequence Matrix as in Table 6-6. Given the likelihood of occurrence was expected to be Rare for the natural streams, the impact significance would be Negligible for the natural streams in Maju Forest according to Table 6-8.

Table 8-13 Summary of Impact Evaluation during Operational Phase

Potential Source of Impact	Receptor Sensitivity[1]	Biodiversity Study Area	Impact Intensity	Consequence	Likelihood	Significance
Stormwater Runoff (Hydrology)	Priority 1 (D/S1)	Clementi Forest	Medium	Medium	Regular	Moderate
	Priority 1 (D/S2)	Clementi Forest	Negligible	Very Low	Rare	Negligible
	Priority 1 (D/S20)	Clementi Forest	Negligible	Very Low	Rare	Negligible
	Priority 1 (D/S21)	Clementi Forest	N.A.			
	Priority 1 (D/S22)	Clementi Forest	Medium	Medium	Regular	Moderate
	Priority 1 (Natural streams in Maju Forest)	Maju Forest	Negligible	Very Low	Rare	Negligible
Stormwater Runoff (Water Quality)	Priority 1 (D/S1)	Clementi Forest	Medium	Medium	Regular	Moderate
	Priority 1 (D/S2)	Clementi Forest	Negligible	Very Low	Rare	Negligible
	Priority 1 (D/S20)	Clementi Forest	Negligible	Very Low	Rare	Negligible
	Priority 1 (D/S21)	Clementi Forest	N.A.			
	Priority 1 (D/S22)	Clementi Forest	Medium	Medium	Regular	Moderate
	Priority 1 (Natural streams in Maju Forest)	Maju Forest	Negligible	Very Low	Rare	Negligible

Note:
1. Receptor locations are shown in Figure 8-2.
2. N.A. – Not applicable as in base scenario, during construction phase, the Worksite at Nursery (base scenario) will occupy D/S21. Due to such occupancy, DS21 will no longer exist during operational phase, and D/S21 was not assessed for operational phase.



Legend

- Watercourses
- Proposed CRL Alignment (Base)
- CR16 Underground Structures
- CR16 Above-ground Structures
- Biodiversity Study Area
- Old Jurong Railway Corridor

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAY 2022	JAC	EIS (Clementi Forest and Maju Forest)	NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

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Project Title :
CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (CLEMENTI FOREST AND MAJU FOREST)

Figure Title :
SENSITIVE RECEPTORS OF WATERCOURSES IN THE VICINITY OF CR16 STATION (BASE SCENARIO) DURING OPERATION

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
JAC	NHT	JAG	8 - 7	-	1 of 1
	Drawn JAC	Date MAY 2022	CAD File Name :		A3

Note: Source of basemap - Google Earth Map

8.8 Recommended Mitigation Measures

In this section, mitigation measures are proposed to further minimise the adverse impacts on the environment where impact significance were assessed to be Moderate or Major.

8.8.1 Construction Phase

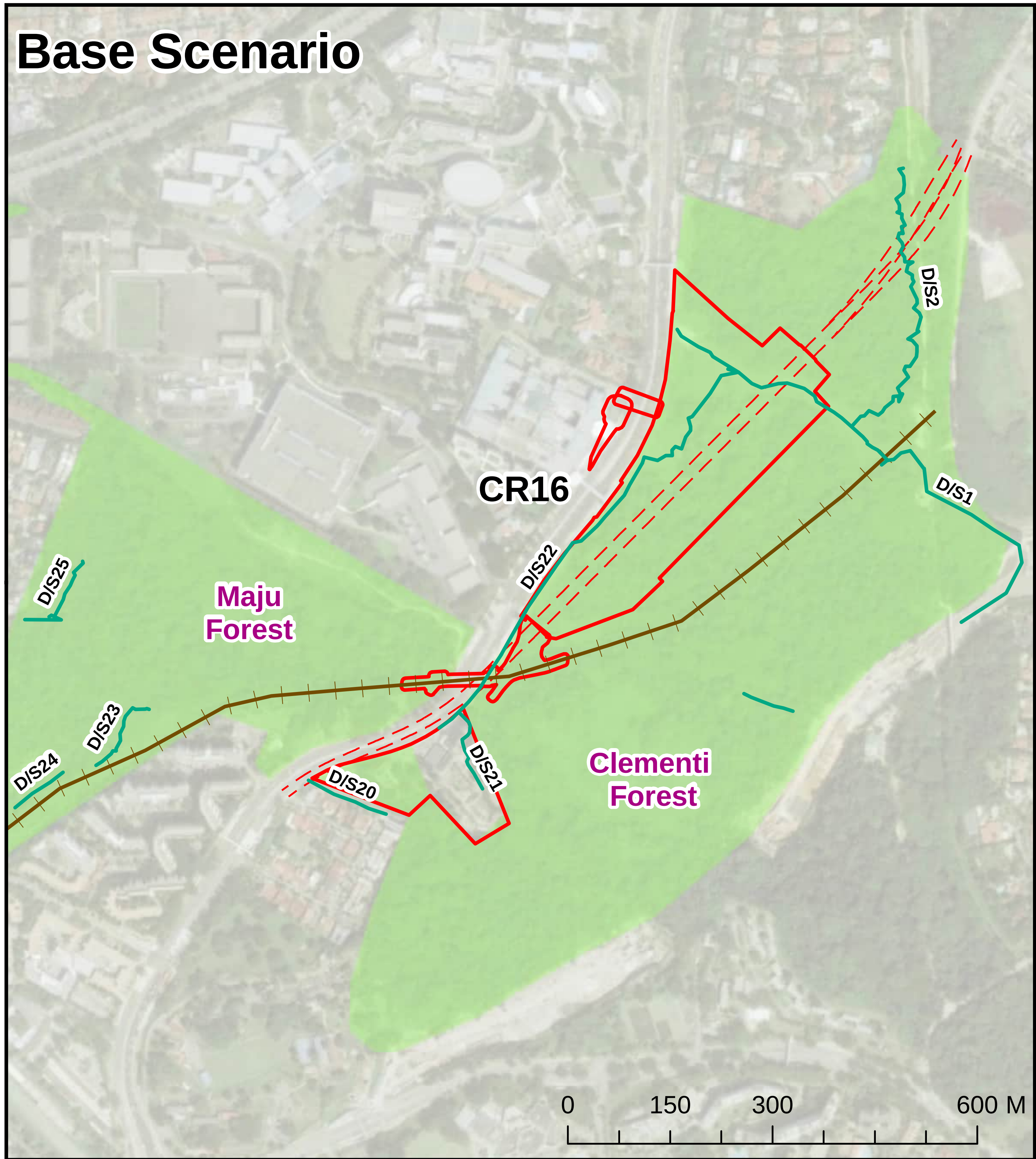
8.8.1.1 Elimination/Substitution

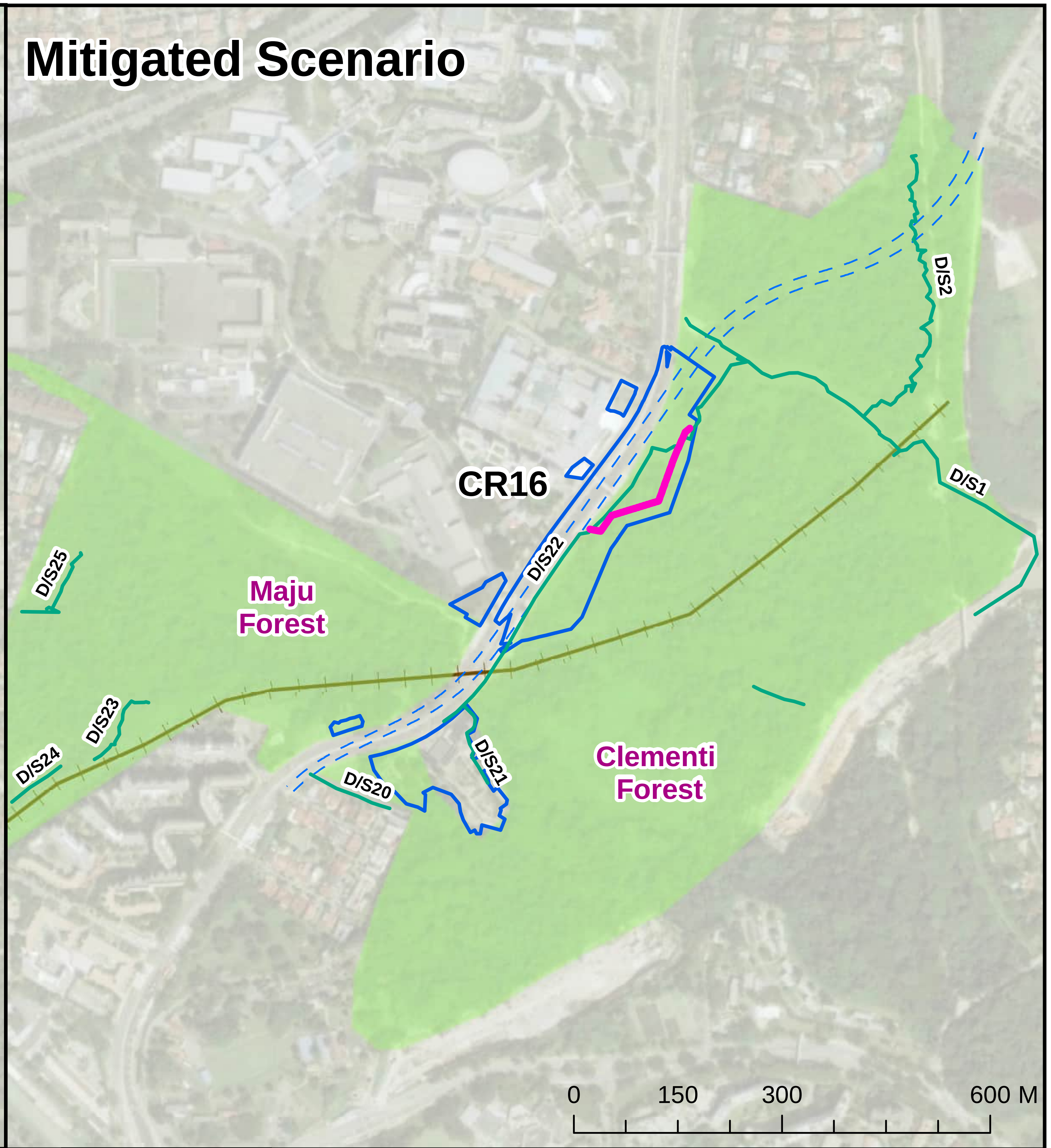
As shown in Table 8-12, the proposed construction activities were assessed to have Major impacts on the water quality and hydrology in watercourses D/S1, D/S21 and D/S22, although with implemented minimum controls. In addition, the biodiversity findings from Section 7 shows that the natural stream (i.e. whole stream of D/S1) has high ecological value to support aquatic life. Hence, it was recommended to divert the flow in D/S21 and downstream of D/S22 during construction period, while the natural stream D/S1 should be conserved. To conserve the natural stream D/S1, no construction activities will be allowed in the vicinity of D/S1 (i.e. 30m buffer from both embankments of the stream). In addition, no disturbance from construction activities of the CR16 worksite on existing hydrological and water quality conditions of D/S1 during construction stage as any diversion may create further adverse major impact on the surrounding ecological system. In order to conserve stream D/S1 and no encroachment on drain D/S21, LTA minimised the CR16 worksite, which is the optimised “CR16 Mitigated Scenario” as shown in Figure 8-8.

The stream D/S22 were proposed to be diverted. It is understood that LTA would propose ground levelling at CR16 worksite, thus the final alignment and design of diverted D/S22 will be subject to detailed design. To minimise diversion impact of unstable soil and land sliding, it was recommended that the proposed diverted drains will be designed properly to have adequate flow capacity to cater changes in land uses from the existing conditions and will avoid any negative impact to any slope foundations of existing road structures. Slope stability analysis should be included in detailed design for the drain diversion at a later stage. The proposed diverted drain will also remain existing hydrology capacity to ensure no flooding occurrence. The flow diversion should obtain PUB’s approval and the drains design will follow PUB’s Code of Practice on Surface Water Drainage [R-21] to ensure the proposed diversion caters for sufficient flow capacity during construction phase. Any storm discharge from the worksites to the diverted drain requires to meet the guideline of NEA Trade Effluent Discharge Limits if applicable. In addition, diverted stream D/S22 should provide continuous flow as in the existing condition of it downstream (especially during dry days) to maintain any ecological water habitats at downstream (i.e. the natural stream D/S1).

With the above-mentioned mitigation measures, both hydrology and water quality can be reduced to Minor impacts.

The hydrology and water quality impacts on the rest of the watercourses were assessed as Minor with minimum controls. Hence, no additional management or mitigation measures other than the minimum controls identified and those incorporated in the construction plans are required.





Legend

- Watercourses
- Temporary Drain Diversion
- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint
- Biodiversity Study Area
- Old Jurong Railway Corridor

N

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Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

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Project Title :
CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (CLEMENTI FOREST AND MAJU FOREST)

Figure Title :
COMPARISON BETWEEN BASE AND MITIGATED SCENARIOS OF CR16 FOOTPRINT DURING CONSTRUCTION PHASE

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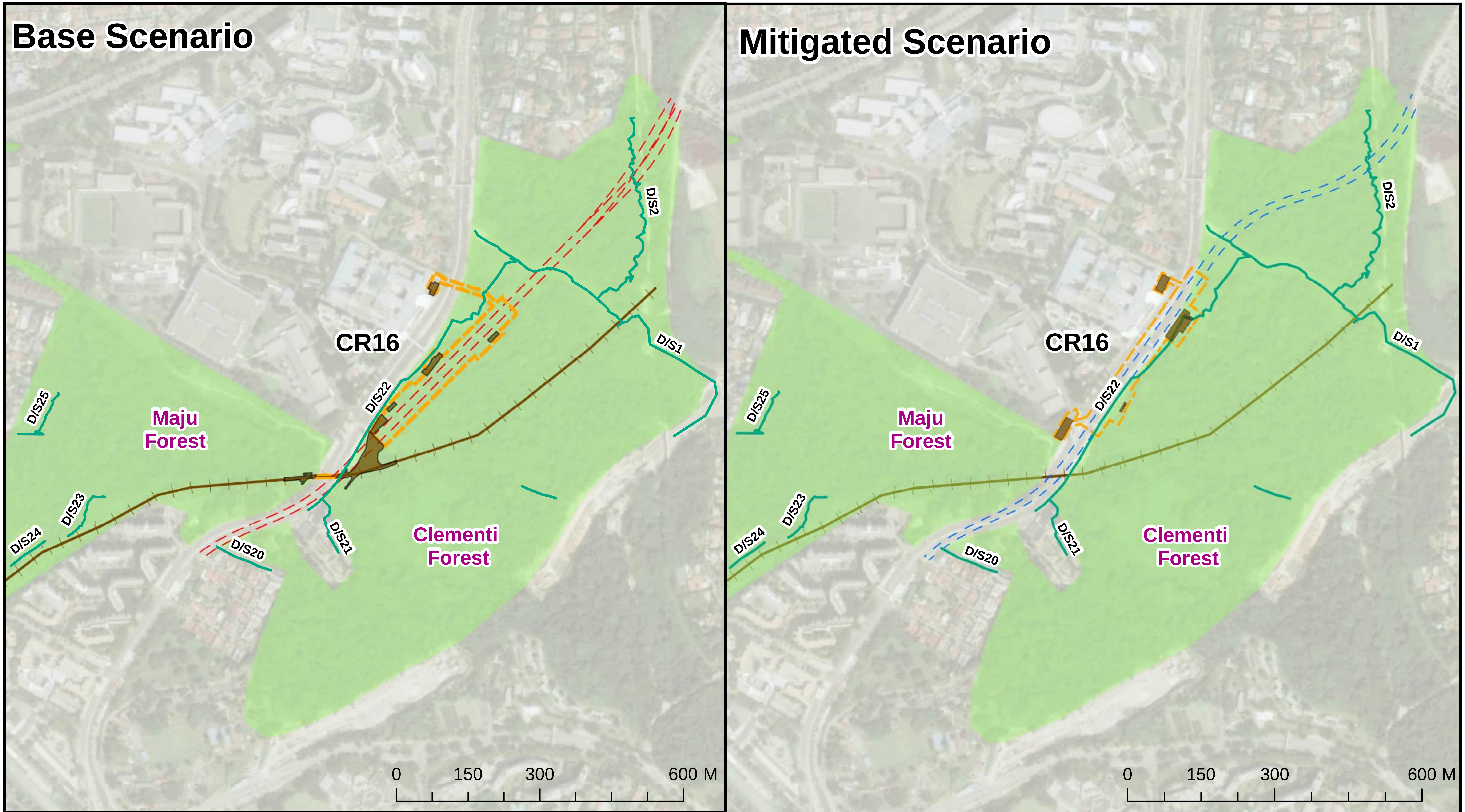
8.8.2 Operational Phase

8.8.2.1 Elimination/Substitution

As shown in Table 8-13, the proposed operational activities would have Major impacts on the hydrology in watercourses D/S1 and D/S22 although with implemented minimum controls. The proposed CR16 above-ground structure areas have been redesigned and reduced as shown in mitigated scenario of Figure 8-9 and it could help to reduce the potential impacts on hydrology and water quality of the watercourses. The biodiversity findings from Section 7.4.2.1 shows that the streams D/S1 and D/S22 have high ecological value. However, stream D/S1 habitat appears to be better at supporting a diversity of species compared to stream D/S22 based on biodiversity findings (Section 7.9.1.2.1). Hence, it is recommended to divert the affected sections of stream D/S22 permanently during operational phase and to conserve the natural stream D/S1 as any diversion on stream D/S1 may create further adverse major impact on the surrounding ecological system. To minimise diversion impact of unstable soil and land sliding, it was recommended that the proposed diverted watercourses will be designed properly to have adequate flow capacity to cater changes in land uses from the existing conditions and will avoid any negative impact to any slope foundations of existing road structures. Slope stability analysis will be included in detailed design for the drain diversion at a later stage. The flow diversion design should comply with PUB Code of Practice on Surface Water Drainage to ensure minimal scouring effect on its downstream. Diverted D/S22 will also remain existing hydrology capacity to ensure no flooding occurrence. The water from diverted D/S22 will be monitored during first three (3) months period of operational phase. In addition, diverted D/S22 should provide continuous flow as in the existing condition to downstream (especially during dry days) to maintain any ecological water habitats at its downstream (i.e. the natural stream D/S1).

Besides the recommendation of permanent drain diversion, the proposed footprint areas will be reinstated in accordance with agencies' requirements with greenery provisions to reduce the runoff coefficient, would help to reduce the peak-flow and flood risk at downstream area. With the above-mentioned mitigation measures, the Major hydrology impact can be reduced to Minor.

The hydrology and water quality impacts on the rest of the watercourses were assessed Minor with minimum controls. Hence, no additional management or mitigation measures other than the minimum controls identified and those incorporated in the operational plans are required.



Legend

- Watercourses
- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- CR16 Underground Structures
- CR16 Above-ground Structures
- Biodiversity Study Area
- Old Jurong Railway Corridor

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Land Transport Authority
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Project Title :
CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(CLEMENTI FOREST AND
MAJU FOREST)

Figure Title :
COMPARISON BETWEEN BASE AND MITIGATED SCENARIOS OF CR16 FOOTPRINT DURING OPERATIONAL PHASE

Designed	Checked	Approved	Drawn	Date
JAC	NHT	JAG	JAC	MAY 2022

Figure No.	Rev.	Sheet
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Note: Source of basemap - Google Earth Map

8.9 Residual Impacts

A residual impact assessment has been undertaken assuming the mitigation measures recommended in the previous section are implemented.

The diverted stream D/S22 and the conserved stream D/S1 could continue providing freshwater supply to the aquatic life and forest. With the implementation of the recommended mitigation measures in conjunction with the identified minimum controls, the intensity of the hydrological and water quality residual impact on the drains/streams can be reduced to Low for both construction and operational phases. Thereafter, the impact significance is hence reduced to **Minor** with Occasional likelihood of occurrence.

Table 8-14 Summary of Residual Impacts and its Mitigation Measures during Construction Phase

Activity	Receptor Sensitivity	Biodiversity Study Area	Impacts	Impact Significance (without Mitigation Measures)	Mitigation Measures	Significance of Residual Impact (with Mitigation Measures)
• Land clearing, earthworks and excavation activities; • Storage and disposal of solid, liquid and toxic wastes; and • Use and storage of chemical substances, and refuelling activities	Stream D/S1 (Priority 1)	Clementi Forest	• Increased stormwater peak flow, increased water level and subsequent flooding of surrounding as D/S1 will be blocked by the construction worksite. • Reduction of baseflow due to land use change. • Contaminants from the worksite will direct deteriorate the water quality. • Habitat disruption of flora and fauna along the stream.	Major on both hydrology and water quality	Conserve D/S1, no construction/blockage on top of it or in its vicinity, and with no disturbance on its water quality and hydrology (i.e. 30m buffer from both embankments of the stream)	Minor
	Drain D/S21 (Priority 1)	Clementi Forest	• Increased stormwater peak flow, increased water level and subsequent flooding of surrounding as D/S21 will be occupied by the construction worksite. • Contaminants from the worksite will direct deteriorate the water quality.	Major on both hydrology and water quality	Minimise the CR16 worksite to avoid worksite encroachment on D/S21.	Minor
	Stream D/S22 (Priority 1)	Clementi Forest	• Increased stormwater peak flow, increased water level and subsequent flooding of surrounding as D/S22 will be occupied by the construction worksite. • Reduction of baseflow due to land use change. • Contaminants from the worksite will direct deteriorate the water quality. • Habitat disruption of flora and fauna along the stream.	Major on both hydrology and water quality	Flow diversion of D/S22 and discharge water to the main natural stream D/S1. The flow diversion of drains will require PUB's approval and the drain design will follow PUB's Code of Practice on Surface Water Drainage. Any storm discharge from the worksites to the diverted drain requires to meet the guideline of NEA Trade Effluent Discharge Limits if applicable.	Minor

Table 8-15 Summary of Residual Impacts and its Mitigation Measures during Operational Phase

Activity	Receptor Sensitivity	Biodiversity Study Area	Impacts	Impact Significance (without Mitigation Measures)	Mitigation Measures	Significance of Residual Impact (with Mitigation Measures)
Stormwater runoff generation	Stream D/S1 (Priority 1)	Clementi Forest	• Slightly increased stormwater peak flow, increased water level and subsequent flooding of surrounding due to flooding from D/S22. • Reduction of baseflow due to land use change. • Habitat disruption of flora and fauna along the stream	Moderate on hydrology and water quality	Redesign and reduce proposed footprint areas. Divert D/S22 permanently and discharge water to the main natural stream D/S1. Area reinstatement with greenery provisions to reduce the runoff coefficient which will help to reduce the peak-flow and reduce flood risk at downstream area.	Minor
	Stream D/S22 (Priority 1)	Clementi Forest	• Slightly increased stormwater peak flow, increased water level and subsequent flooding of surrounding as D/S22 will be occupied by the operational footprint. • Reduction of baseflow due to land use change. • Habitat disruption of flora and fauna along the stream	Moderate on hydrology and water quality	Redesign and reduce proposed footprint areas. Divert D/S22 permanently and discharge water to the natural stream D/S1. Area reinstatement with greenery provisions to reduce the runoff coefficient which will help to reduce the peak-flow and reduce flood risk at downstream area.	Minor

8.10 Cumulative Impacts from Other Major Concurrent Developments

This section focuses on assessing cumulative impacts of the construction and operational activities from identified concurrent developments on the watercourses. It should be noted that as the details of construction and operational activities were not available at the time of writing this Report, only qualitative cumulative impact assessment was carried out.

8.10.1 Construction Phase

There are five (5) nearby concurrent developments such as PUB Deep Tunnel Sewerage System Phase 2 (DTSS2) link sewer with manholes along Clementi Road, proposed Brookvale Drive development, Clementi Nature Trail, Old Jurong Line Nature Trail and CR15 footprints (i.e., worksite and station).

The concurrent development of PUB DTSS2 will be constructed along Clementi Road with manholes and pipelines located in the vicinity of the existing Old Jurong Railway Corridor. For the PUB DTSS2 development, it was envisaged that its construction worksite will be located at the proposed manhole locations as the underground DTSS alignment will be constructed through pipe jacking method, which will start before the construction of CR16 worksite at Maju Forest (Q1 2023) as described in Project schedule (Section 3.4.1). Similar as CR16 worksite, the terrain at the Old Jurong Railway Corridor has relatively lower elevation in the Maju Forest, thus stormwater generated at the DTSS worksite during construction phase tends to flow into the low-lying area near the Old Jurong Railway Corridor (only if there is no water control measure to be taken place) instead of the main watercourses in the southwest of Maju Forest. Hence, the DTSS development is unlikely to increase the impact extent of hydrology and water quality on the watercourses within Maju Forest or Clementi Forest as long as best management practices and minimum controls are in place during its construction.

The concurrent development of proposed road construction along the Brookvale Drive at north of Maju Forest. The existing vegetation of Maju Forest will be cleared prior to construction and will cause some use change at north of Maju Forest. However, if the proposed road construction activities have best management practices and minimum controls in place to minimise both hydrology and water quality impacts, it is unlikely to increase the hydrology and water quality impact extent on Maju Forest. And the proposed road construction will also be completed before the construction of CR16 worksites based on Project schedule (Section 3.4.1).

The concurrent developments of proposed Clementi Nature Trail and Old Jurong Nature Trail will align across the Clementi Forest and Maju Forest. The construction of the trails will commence during construction of CR16 worksites. Since only minor construction activities such as levelling to be involved, the concurrent developments are unlikely to increase the hydrology and water quality impact extent on Clementi Forest and Maju Forest as long as the best management practices and minimum controls are in place during their construction.

Proposed CR15 construction worksite will be constructed near the north of Clementi Forest and its construction will commence before CR16 worksite construction. The proposed construction worksite will occupy large area and cause major change for existing land use near the Clementi Forest. However, since the concurrent development of CR15 construction worksite will not locate within the catchment area of the watercourses, it is unlikely to increase the hydrology and water quality impact extent on the watercourses of Clement Forest if the best management practices and minimum controls are in place during its construction. The CR15 operational footprint will be located at Old Holland Road and near the north of Clementi Forest after the completion of the CR16 construction (estimated year 2023). The CR15 operational footprint is unlikely to increase the hydrology and water quality impact extent on the watercourses of Clementi Forest if the best management practices and minimum controls are in place during construction phase.

8.10.2 Operational Phase

There are five (5) nearby concurrent developments such as PUB Deep Tunnel Sewerage System Phase 2 (DTSS2) manholes and pipeline along Clementi Road, proposed Brookvale Drive Project, Clementi Nature Trail, Old Jurong Line Nature Trail and CR15 footprints (i.e., worksite and station).

For the PUB DTSS2 concurrent development, only manholes will be the project footprint, which will occupy relatively small area along the roadside. Besides, it was envisaged that maintenance works will be restricted at the manhole area, and any contamination (e.g., chemical spills, leaking, etc.) will be minimised given best management practices and minimum controls are in place. Hence, the PUB DTSS2 development is not likely to increase the impact extent on hydrology and water quality of watercourses within Clementi Forest and Maju Forest.

The concurrent development of proposed road along the Brookvale Drive at the north of Maju Forest will be operated before operational phase of CR16 footprint based on Project Schedule (Section 3.4.1). The permanent clearance of existing vegetation of Maju Forest will cause minor use change at the north of Maju Forest but no catchment changes for the identified watercourses. Hence, it is unlikely to increase the hydrology and water quality impact extent on Maju Forest as long as the best management practices and minimum controls are in place during its construction.

The concurrent developments of proposed Clementi Nature Trail and Old Jurong Nature Trail will align across the Clementi Forest and Maju Forest. The proposed trails will be operated before operational phase of CR16 footprint. Since the catchment area of watercourses will not change permanently due to the concurrent development, the concurrent development is unlikely to increase the hydrology and water quality impact extent on Clementi Forest and Maju Forest as long as the best management practices and minimum controls are in place.

Proposed CR15 station is located at Old Holland Road and near the north of Clementi Forest and the operation of CR15 station will commence during the operational phase of CR16 footprint (after year 2023). The proposed CR15 station will occupy large area and cause permanent change for existing land use near the north of Clementi Forest. Since the concurrent development of CR15 station are located outside of catchment areas of identified watercourses in Clementi Forest, it is unlikely to increase the hydrology and water quality impact extent on the watercourses of Clement Forest if the best management practices and minimum controls are put in place during operational phase.

8.11 Summary of Key Findings

The hydrological baseline study aimed to identify watercourses present in the Study Area including their locations, water flow conditions and bank characteristics. Based on topographic survey data, site survey as well as PUB water catchment map, eight (8) major watercourses were identified in Clementi Forest and Maju Forest. In Clementi Forest, the identified watercourses are three (3) streams (D/S1, D/S2 and D/S22), one (1) earth drain (D/S21) and one (1) concrete drain (D/S20). Three (3) natural streams (D/S23, D/S24 and D/S25) have been identified in Maju Forest. In the southwest area of Clementi Forest, drain (D/S20) and drain D/S21 are aligned along the boundary of Worksite at Nursery and receiving surface runoff from the Worksite at Nursery and southwest of Clementi Forest. Both drains D/S20 and D/S21 have ephemeral flows and the surface runoff from drain D/S21 flows to northwest and subsequently discharges to stream D/S22. The perennial flow of stream D/S22 will flow towards northeast in the Clementi Forest, connecting to the upstream of stream D/S1. The surface water of stream D/S2 also flows perennially towards south and end up at the midstream of stream D/S1. In Maju Forest, streams D/S23, D/S24 and D/S25 are collecting water from the forested area, with water flowing towards the southwest direction. Water from the identified drains/streams will eventually flow into Sungei Pandan. Water from Sungei Pandan is pumped into Pandan Reservoir for drinking water purpose. Besides, some of the watercourses in Clementi Forest (i.e., D/S1, D/S2 and D/S22) and Maju Forest (i.e. D/S23, D/S24 and D/S25) are located within the areas of high ecological values and supporting biodiversity life. Hence, it is very important to understand potential environmental impacts those drains/streams.

To study the water quality within the identified drains/streams, two (2) dry and one (1) wet weather samples were collected from twelve (12) water quality stations at the watercourses in Clementi Forest and Maju Forest. Water samples were tested for both physical and chemical parameters relevant or sustenance of aquatic life including temperature, pH, conductivity, total dissolved solids (TDS), dissolved oxygen (DO), turbidity, total suspended solids (TSS), biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), total phosphorus (TP), orthophosphate (PO_4-P), total nitrogen (TN), and nitrate (NO_3-N). Analysis of the water quality results have shown that the water quality of the watercourses is relatively consistent with its ecological significance.

In Clementi Forest, the water quality was good for aquatic life in terms of temperature, pH, TDS, turbidity, TSS, BOD_5, COD, TN, and NO_3-N in perennial watercourses. DO level at most of the stations met aquatic life criteria, except for stream D/S2 and midstream of stream D/S1 (lower than 4 mg/L) during dry and/or wet weather, due to their stagnant conditions. However, previous study also showed that at DO below 4 mg/L in Singapore natural streams, freshwater aquatic life may have adapted and therefore found to thrive in these conditions in Singapore. Elevated TSS found at stream D/S2 indicated high sediments existing in the stagnant water. Relatively high phosphorus concentrations (i.e., TP and PO_4-P) were detected from all the tested water samples. This suggests that existing watercourses have high eutrophication potential, which is consistent with the site observation of greenish watercourses with algae. The overall baseline water quality of the perennial watercourses was likely to be suitable for aquatic life. This supports the biodiversity findings in Section 7.4.2.1, especially the natural stream D/S1 of high ecological value. In Maju Forest, temperature, BOD_5, and NO_3-N at the natural streams met the limits of NEA guideline and aquatic life criteria. Lower pH and DO were found at streams D/S24 and D/S25 during dry and/or wet weather conditions. High TSS level was observed at stream D/S24 during dry weather and elevated turbidity was found at streams D/S23 and D/S24 during dry and/or wet weather conditions. COD levels at the natural streams during wet weather exceeded the limits of NEA guideline and aquatic life criteria. High phosphorus nutrient was found in the natural streams in Maju Forest, and this indicated high eutrophication potential all the time. It can be concluded that the overall baseline water quality of the natural streams in Maju Forest is poor and suggests possible unfavourable conditions for aquatic life. However, the aquatic life could have adapted to such existing conditions based on biodiversity findings in Section 7.4.1.1, which considers the natural streams to be of high ecological value.

Based on the assessment of the hydrology and water quality related impacts on the various sensitive receptors, the assessment findings have been summarised in Table 8-12 and Table 8-13. The proposed construction footprint (base scenario) was assessed to cause Major impact on stream D/S1 and stream D/S22 while the operational footprint was assessed to cause Moderate impact on streams D/S1 and D/S22 in term of hydrology and water quality, even with implemented minimum controls. Hence, proposed mitigation measures included temporary diversion of the affected sections of stream D/S22, and absolute conservation of stream D/S1 with no disturbance on its hydrology and water quality within 30m buffer from both embankments of the stream, during construction phase in order to reduce impact from the worksites. Flow diversion of drains will require PUB's approval and the drain design will follow PUB's Code of Practice on Surface Water Drainage. Any storm discharge from worksites to the diverted drain requires to meet NEA Trade Effluent Discharge Limits if applicable. For operational footprint, the mitigation measures included redesign and reduce proposed footprint areas, permanent diversion of the affected section of stream D/S22, and area reinstatement by providing greenery provisions to reduce the peak runoff resulting in reduction of flood risk at downstream area. Should these recommendations be successfully implemented during both construction and operational phases, the impact significance would be reduced to Minor.

For other watercourses in these forested areas which the construction or operational footprint are not within their catchment areas, they were assessed to have only Minor to Negligible impacts on hydrology and water quality during both construction and operational phases. Thus, apart from the minimum controls identified and those incorporated in the construction and operational plans, no additional management or mitigation measures are required.

Therefore, given that the minimum controls and mitigation measures for the CRL 2 construction and operational activities will be implemented, the significance of residual impacts from the potential hydrology and water quality impacts on the sensitive water receptors was assessed to be **Minor to Negligible** as shown in Table 8-16.

The cumulative impacts from concurrent developments identified in the vicinity of the CRL2 were assessed. It was concluded that the concurrent developments including PUB Deep Tunnel Sewerage System Phase 2 (DTSS2) manholes and pipeline along Clementi Road, proposed Brookvale Drive development, Clementi Nature Trail, Old Jurong Line Nature Trail and CR15 footprints (i.e. worksite and station) are unlikely to increase the impact extent on hydrology and water quality of identified watercourses in Clementi Forest and Maju Forest, given best management practices and minimum controls provided by its developer are in place during both construction and operational phases.

Table 8-16 Summary of Hydrology and Water Quality Impact Assessment

Sensitive Receptor		Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)
Construction Phase			
Clementi Forest	Natural Steam D/S1	Major	**Minor**
	Earth Drain D/S2	Negligible	**Negligible**
	Concrete Drain D/S20	Minor	**Minor**
	Earth Drain D/S21	Major	**Minor**
	Natural Stream D/S22	Major	**Minor**
Maju Forest	Natural Streams (i.e. D/S23, D/S24 and D/S25)	Negligible	**Negligible**
Operational Phase			
Clementi Forest	Natural Steam D/S1	Moderate	**Minor**
	Earth Drain D/S2	Negligible	**Negligible**
	Concrete Drain D/S20	Negligible	**Negligible**
	Earth Drain D/S21	**N.A.**	**Negligible**
	Natural Stream D/S22	Moderate	**Minor**
Maju Forest	Natural Streams (i.e. D/S23, D/S24 and D/S25)	Negligible	**Negligible**

Note:

1. N.A. - Not applicable as in base scenario, during construction phase, the Worksite at Nursery (base scenario) will occupy D/S21. Due to such occupancy, DS21 will no longer exist during operational phase, and D/S21 was not assessed for operational phase.

9. Soil and Groundwater

9.1 Introduction

Construction and operational activities, if not managed properly, can lead to potential contamination of soil and groundwater. Furthermore, during the land preparation and excavations for construction works there is also a potential to encounter historically contaminated soils. This section presents the assessment undertaken to define the nature and scale of the potential impacts on soil and groundwater associated with the construction and operational phase of the Project. The section will also outline appropriate control and mitigation measures.

9.2 Methodology and Assumption

This section outlines the methodology adopted for the soil and groundwater baseline analysis as well as for impact assessment for both construction and operational phases. The purpose of soil and groundwater baseline study was to determine the soil profile of the Study Area, hydrogeological conditions of the aquifer, soil and groundwater chemistry which may potentially have adverse impacts on the identified sensitive receptors. Furthermore, the baseline study should ascertain the presence of possible historical pollutants in the underlying soil that may also cause adverse impacts during construction and operational phases. Baseline conditions were established based on available secondary data, primarily Historical Land Use Survey (HLUS) report and previous soil and/ or groundwater investigation studies as detailed in Section 9.2.1 and Section 9.2.2, respectively.

9.2.1 Historical Land Use

Historical land use information of the Study was extracted from the LTA's Historical Land Use Survey (HLUS) report [R-4] for the purpose of this Report. The HLUS identifies potentially counterinitiative land uses and areas where deep excavation would occur due to the Project works. This information is analysed to produce an environmental borehole and monitoring well location plan.

9.2.2 Soil and Groundwater Baseline

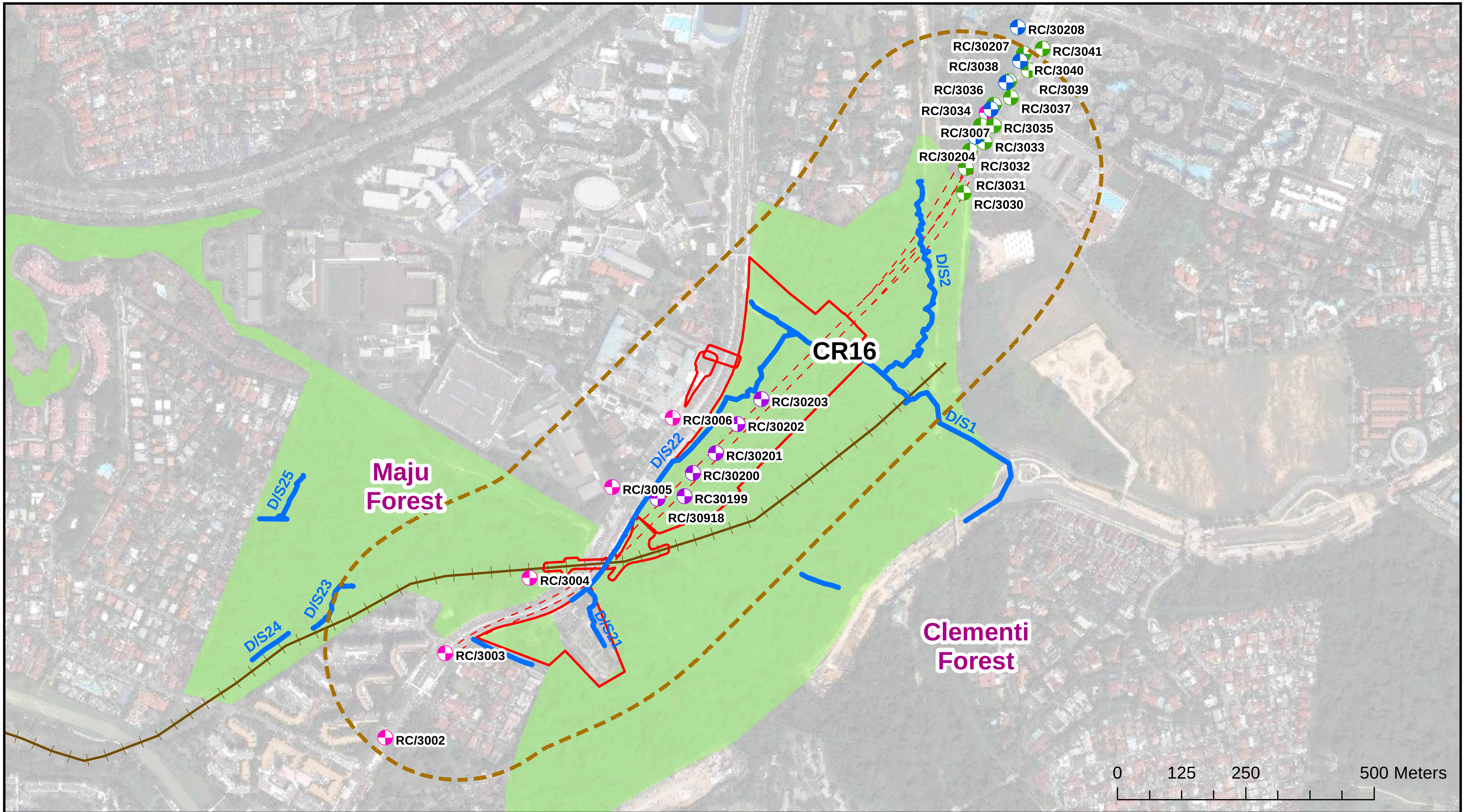
Besides the HLUS and publicly available secondary data, as a part of soil and groundwater baseline study, AECOM also reviewed previous soil and/ or groundwater investigation studies carried out within the Study Area. These included both Soil Investigation (SI) reports (focusing on geotechnical characteristics of soil) [R-69] [R-70] and soil and groundwater baseline studies (focusing on physicochemical parameters of soil and groundwater) [R-71] [R-75] (refer to Figure 9-1).

9.2.2.1 Soil and Groundwater Baseline Assessment Criteria

The Dutch Intervention Values (DIV) in the Dutch Environmental Guidelines Soil Remediation Circular [R-42] were adopted in this Study for screening of the 12 priority pollutant metals, inorganic compounds, aromatic compounds, polycyclic aromatic hydrocarbons (PAHs), chlorinated hydrocarbons, pesticides and other pollutants in soil and groundwater. The DIV is referenced in the latest Code of Practice for Pollution Control [R-7] (COPPC) by the National Environmental Agency (NEA).

The DIVs are related to spatial parameters and define soil as being seriously contaminated if the mean soil/ sediment concentration of at least one substance in at least 25 cubic metres (m^3) of soil-volume, or groundwater concentration in at least 100 m^3 of pore-saturated soil-volume, exceeds the DIV. It is noted that the intervention values for groundwater are not based on a separate risk assessment with regards to the contaminants present in the groundwater but are calculated based on partitioning of chemicals at concentrations equivalent to the intervention values in soil/sediment.

It is recognised that the Dutch Guidelines were developed to assess the acceptability of impacted soil and groundwater at housing estates in the Netherlands and is based on local Dutch ecotoxicology and soil condition (that is, soil made of 10% organic clay or 25% clay), without reference to commercial or industrial general, or similar land uses in Singapore. On that basis, exceedances of the DIVs should not necessarily be interpreted as conclusive regarding the need for remediation. Conversely, if the concentrations of COPCs were below these criteria, it would be reasonable to conclude that the concentrations are not of concern.



Legend

- Study Area
- Watercourses
- Base Scenario Construction Worksite Footprint
- Proposed CRL Alignment (Base)
- Biodiversity Study Area
- Old Jurong Railway Corridor

Previous Studies

- 1W05
- 1W34
- 1W91
- 1W92

-	JUL 2022	SAG	Final Report	NHT	JAG
Rev.	Date	By	Description	Chk'd	App'd

Qualified Person Endorsement :
NA

LTA Endorsement :
NA

Consultant :
AECOM

Land Transport Authority
We Keep Your World Moving

Project Title :
CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(CLEMENTI FOREST AND
MAJU FOREST)

Figure Title :
LOCATION OF BOREHOLES
FROM PREVIOUS STUDIES

Designed	Checked	Approved
SAG	NHT	JAG
	Drawn SAG	Date JUL 2022

Figure No. :	Rev.	Sheet
9 - 1	-	1 of 1

CAD File Name : A3

Note: Source of basemap - Google Earth Map

9.2.3 Prediction and Evaluation of Impact Assessment

The Study Area adopted for the assessment followed the HLUS Study Area of 250 m from both sides of the alignment/ station and other construction sites footprint. Furthermore, where applicable, impact assessment was also based on the soil and groundwater baseline data collected as part of previous soil and/ or groundwater investigations.

9.3 Identification of Soil and Groundwater Sensitive Receptors

The receptor screening for groundwater was conducted within the 250 m Study Area and classified based on methodology defined in Table 6-1.

It is understood that presently groundwater in Singapore is not directly extracted for beneficial use (i.e. as a source for potable water, industrial water or irrigation purposes), and hence should be considered as Priority 3, as shown in Table 9-1 below. Streams with biodiversity conservation significance where groundwater flow partially supporting the stream ingress from the Project is also shown in Table 9-1 as a Priority 2 receptor for the purpose of this Report.

Table 9-1 Classification of Receptor Sensitivity

Sensitive Receptor	Description	Receptor Sensitivity	Sensitivity Classification
Soil and Groundwater within the Project Site	The soil and groundwater within the Project site were expected not to pose unacceptable risks to future workers and human receptors.	Not sensitive groundwater (i.e. not directly extracted for any purposes such as drinking or commercial/industrial use).	Priority 3
Watercourses with biodiversity conservation significance where groundwater flow partially supporting the stream ingress from the construction worksite and operational footprint	Groundwater baseflow to the stream near construction worksite and operational footprint to the streams was expected to be affected.	Groundwater partially supporting the stream with biodiversity conservation significance (refer to Figure 8-1).	Priority 2

9.4 History of Land Contamination

The historical land use within the Study Area (250 m from both sides of the alignment) was reviewed in detail in the HLUS report.

According to HLUS, the potential site with contaminating historical land uses which differs from the current land uses, were identified and summarised in Table 9-2.

Table 9-2 Historical Land Use within the Study Area

Current Land Uses/Venue	Historical Land Uses/Venue	Description/Remark
Old Jurong Railway Corridor (as biodiversity, recreational and heritage venues by NParks, namely Rail Corridor)	Jurong Railway (1960s – 1990s) (as transport facility)	• Accidental spills and leaks of fuel from stopping and/or passing trains. • Contamination severity level from HLUS: Low
Note: The contamination severity level was extracted from the HLUS reports where it categorises using a Contamination Severity Matrix, which considers the degree of toxicity of contaminants present on site (with		

Current Land Uses/Venue	Historical Land Uses/Venue	Description/Remark
respect to dermal contact and inhalation) and the spatial extent of potential contamination within HLUS's Study Area whether it is localised (1-5%), medium (6-40%) or pervasive (>40%).		

Potentially contaminating activities can be deduced to have occurred based on the land use at a site, noting possible contamination at some point during the history of the land usage. Based on the HLUS reports, the hotspots and contamination severity are shown in Table 9-3 below with the respective Project worksites where HLU denotes historical land use.

Table 9-3 Land Use Hotspots

No.	Hotspot	Type	Severity of Contamination
1	Clementi Road	Existing Road	Low
2	Ngee Ann Polytechnic Substation	Utility Facilities	Low
3	Clementi Crescent Substation	Utility Facilities	Low
4	Blk 114A Substation	Utility Facilities	Low
5	Blk 113A Substation	Utility Facilities	Low
6	Aquatic Science Research Centre Substation	Utility Facilities	Low
7	Blk 379 Substation	Utility Facilities	Low
8	Corona Florist & Nursery Pte Ltd	Agricultural/Horticultural Sites	Low
9	• Central Medical Clinic (Blk 109) • The Dublin Clinic (Blk 109) • Toronto Dental Care Singapore (Blk 109) • Mount Pleasant Animal Care (Blk 105) The Animal Clinic (Blk 109) • The Cat Clinic (Blk 109)	Medical Facilities	Low
10	Orange Valley Nursing Home	Medical Facilities	Low
11	Wee HealthFirst Medical Clinic	Medical Facilities	Low
12	Bukit Timah Railway (HLU)	Transport Facilities	Low
13	Jurong Railway (HLU)	Transport Facilities	Low
14	Bukit Timah Railway Station (HLU)	Transport Facilities	Medium
15	Protective Security Command ProCom, former Mowbray Camp	Defence Facilities	Low
16	Extension of Brookvale Walk to Clementi Road	Future Developments	Medium
17	Upgrading of Ulu Pandan Park Connector	Future Developments	Medium
18	Sian Tuan Avenue Substation	Utility Facilities	Low
19	Hua Guan Garden Substation	Utility Facilities	Low

Note:
1. HLU denotes historical land use.
2. The contamination severity level was extracted from the HLUS reports where it categorises using a Contamination Severity Matrix, which considers the degree of toxicity of contaminants present on site (with respect to dermal contact and inhalation) and the spatial extent of potential contamination within HLUS's Study Area whether it is localised (1-5%), medium (6-40%) or pervasive (>40%).

9.5 Soil and Groundwater Baseline Findings

9.5.1 Soil Profile

Based on the information obtained from the soil and groundwater investigation studies carried out within the Study Area, the encountered soil profile generally consisted of sandy silt. Besides sandy silt, layers of silty sand, clay and sandy clay were observed, mostly in western parts of the Study Area. At majority of the soil sampling locations, a backfill layer was observed.

9.5.2 Soil Baseline Results

As most of the available soil and groundwater investigation studies within Study Area were carried out with focus on geotechnical characteristics of soil, the available data regarding soil and groundwater baseline quality are limited.

Review of the findings of soil and groundwater baseline study, carried out along the future alignment and proposed CR16 construction worksite area [R-75], showed that none of the parameters tested in soil samples exceeded their respective DIVs. Photoionization Detector (PID) readings recorded were between 0.1 and 1.0 parts per million (ppm), indicating negligible concentration of VOCs. No visual or olfactory evidence of contamination of soil was noted during the field activities.

Metals, including arsenic, antimony, barium, cadmium, chromium, copper, lead, molybdenum, nickel and zinc were detected in majority of soil samples at concentrations above their respective levels of reporting (LOR). Cobalt and mercury were detected in only certain locations and depths. Total Petroleum Hydrocarbons (TPH) were detected in some soil samples. All of the abovementioned detections of metals and TPH were below their respective DIVs.

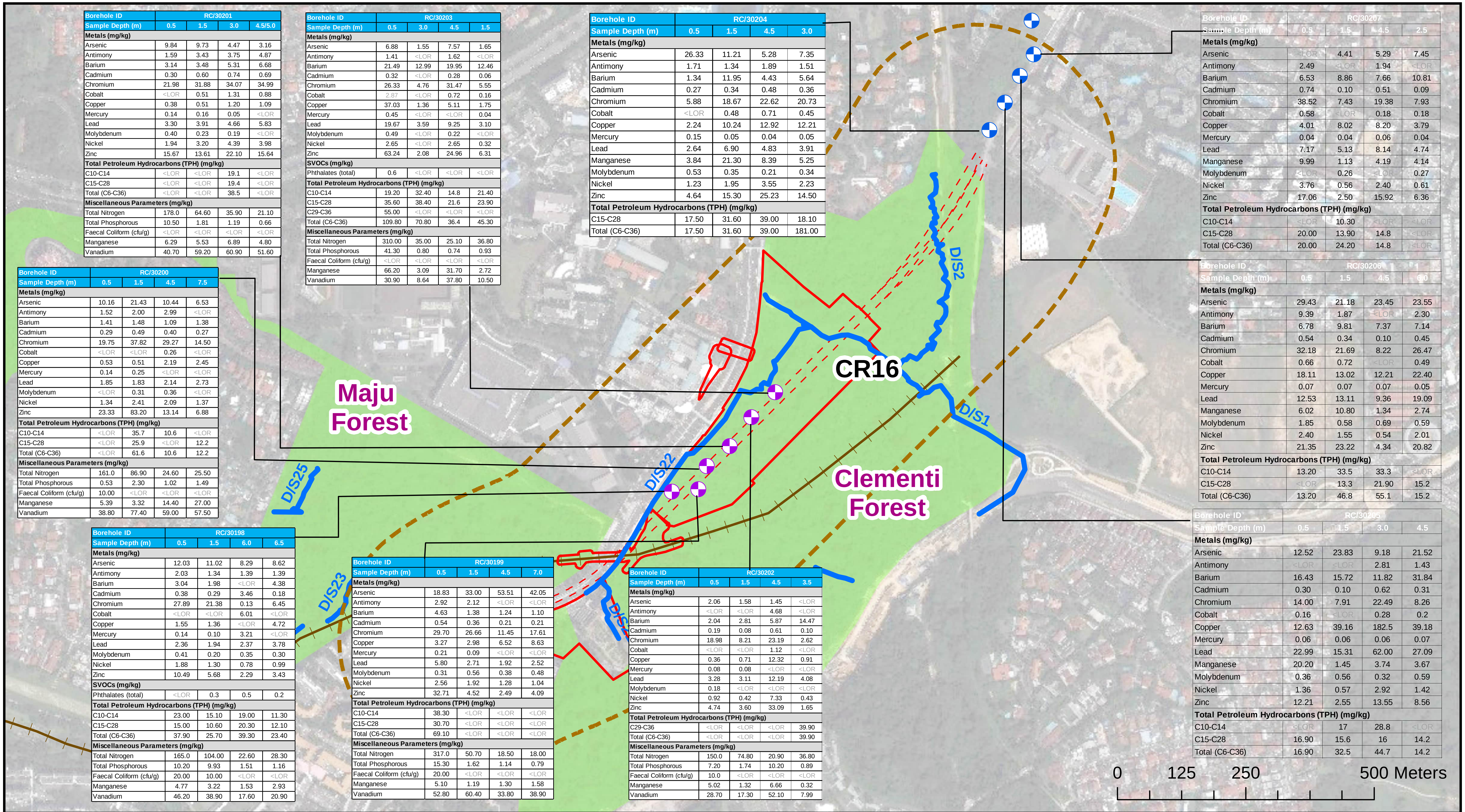
Vanadium has been detected in all the collected soil samples, with concentrations ranging between 7.99 mg/kg and 77.44 mg/kg. These values are below the indicative levels for severe soil contamination as per Dutch Environmental Guidelines Soil Remediation Circular [R-40].

Other than that, detections of faecal coliforms and manganese were also reported. Total Nitrogen (TN), Total Phosphorous (TP), chloride and sulphate contents were also analysed in soil samples.

The remaining parameters analysed for the soil samples were below their respective LORs.

Review of the findings of the soil and groundwater baseline study, carried out at the eastern part of the Study Area [R-71], also showed that none of the parameters tested in soil samples exceeded their respective DIVs. Similar detections were reported, including metals (i.e. arsenic, antimony, barium, cadmium, chromium, cobalt, copper, mercury, lead, molybdenum, nickel, zinc), TPHs and manganese.

The source(s) of parameters detected above their respective LORs in soil samples could not be conclusively ascertained. Presence of metals, heavy metals and TPH is a common and well-documented occurrence in urban soils that are exposed to anthropogenic activities. Besides, many of the detected parameters (i.e. metals, phosphorus, nitrogen) are naturally occurring elements in the environment. However, currently there are no comprehensive studies that provide the information on the background concentrations of these parameters in soil in Singapore. The concentration of faecal coliforms is commonly used parameter to indicate the pollution of the analysed media with the faecal material of humans and/ or other animal species. Considering the proximity of Clementi and Maju Forests, it is possible that the faecal matter originating from the surrounding fauna leaching into the soil. QA/ QC analysis shows that the RPD results for soil duplicate samples were at the acceptable level of precision, and trip and equipment blanks did not show any detections.



Borehole ID	RC/30201			
Sample Depth (m)	0.5	1.5	3.0	4.5/5.0
Metals (mg/kg)				
Arsenic	9.84	9.73	4.47	3.16
Antimony	1.59	3.43	3.75	4.87
Barium	3.14	3.48	5.31	6.68
Cadmium	0.30	0.60	0.74	0.69
Chromium	21.98	31.88	34.07	34.99
Cobalt	<LOR	0.51	1.31	0.88
Copper	0.38	0.51	1.20	1.09
Mercury	0.14	0.16	0.05	<LOR
Lead	3.30	3.91	4.66	5.83
Molybdenum	0.40	0.23	0.19	<LOR
Nickel	1.94	3.20	4.39	3.98
Zinc	15.67	13.61	22.10	15.64
Total Petroleum Hydrocarbons (TPH) (mg/kg)				
C10-C14	<LOR	<LOR	19.1	<LOR
C15-C28	<LOR	<LOR	19.4	<LOR
Total (C6-C36)	<LOR	<LOR	38.5	<LOR
Miscellaneous Parameters (mg/kg)				
Total Nitrogen	178.0	64.60	35.90	21.10
Total Phosphorous	10.50	1.81	1.19	0.66
Faecal Coliform (cfu/g)	<LOR	<LOR	<LOR	<LOR
Manganese	6.29	5.53	6.89	4.80
Vanadium	40.70	59.20	60.90	51.60

Borehole ID	RC/30203			
Sample Depth (m)	0.5	3.0	4.5	1.5
Metals (mg/kg)				
Arsenic	6.88	1.55	7.57	1.65
Antimony	1.41	<LOR	1.62	<LOR
Barium	21.49	12.99	19.95	12.46
Cadmium	0.32	<LOR	0.28	0.06
Chromium	26.33	4.76	31.47	5.55
Cobalt	2.87	<LOR	0.72	0.16
Copper	37.03	1.36	5.11	1.75
Mercury	0.45	<LOR	<LOR	0.04
Lead	19.67	3.59	9.25	3.10
Molybdenum	0.49	<LOR	0.22	<LOR
Nickel	2.65	<LOR	2.65	0.32
Zinc	63.24	2.08	24.96	6.31
SVOCs (mg/kg)				
Phthalates (total)	0.6	<LOR	<LOR	<LOR
Total Petroleum Hydrocarbons (TPH) (mg/kg)				
C10-C14	19.20	32.40	14.8	21.40
C15-C28	35.60	38.40	21.6	23.90
C29-C36	55.00	<LOR	<LOR	<LOR
Total (C6-C36)	109.80	70.80	36.4	45.30
Miscellaneous Parameters (mg/kg)				
Total Nitrogen	310.00	35.00	25.10	36.80
Total Phosphorous	41.30	0.80	0.74	0.93
Faecal Coliform (cfu/g)	<LOR	<LOR	<LOR	<LOR
Manganese	66.20	3.09	31.70	2.72
Vanadium	30.90	8.64	37.80	10.50

Borehole ID	RC/30204			
Sample Depth (m)	0.5	1.5	4.5	3.0
Metals (mg/kg)				
Arsenic	26.33	11.21	5.28	7.35
Antimony	1.71	1.34	1.89	1.51
Barium	1.34	11.95	4.43	5.64
Cadmium	0.27	0.34	0.48	0.36
Chromium	5.88	18.67	22.62	20.73
Cobalt	<LOR	0.48	0.71	0.45
Copper	2.24	10.24	12.92	12.21
Mercury	0.15	0.05	0.04	0.05
Lead	2.64	6.90	4.83	3.91
Manganese	3.84	21.30	8.39	5.25
Molybdenum	0.53	0.35	0.21	0.34
Nickel	1.23	1.95	3.55	2.23
Zinc	4.64	15.30	25.23	14.50
Total Petroleum Hydrocarbons (TPH) (mg/kg)				
C15-C28	17.50	31.60	39.00	18.10
Total (C6-C36)	17.50	31.60	39.00	181.00

Borehole ID	RC/30207			
Sample Depth (m)	0.5	1.5	4.5	2.5
Metals (mg/kg)				
Arsenic	<LOR	4.41	5.29	7.45
Antimony	2.49	<LOR	1.94	<LOR
Barium	6.53	8.86	7.66	10.81
Cadmium	0.74	0.10	0.51	0.09
Chromium	38.52	7.43	19.38	7.93
Cobalt	0.58	<LOR	0.18	0.18
Copper	4.01	8.02	8.20	3.79
Mercury	0.04	0.04	0.06	0.04
Lead	7.17	5.13	8.14	4.74
Manganese	9.99	1.13	4.19	4.14
Molybdenum	<LOR	0.26	<LOR	0.27
Nickel	3.76	0.56	2.40	0.61
Zinc	17.06	2.50	15.92	6.36
Total Petroleum Hydrocarbons (TPH) (mg/kg)				
C10-C14	<LOR	10.30	<LOR	<LOR
C15-C28	20.00	13.90	14.8	<LOR
Total (C6-C36)	20.00	24.20	14.8	<LOR

Borehole ID	RC/30200			
Sample Depth (m)	0.5	1.5	4.5	7.5
Metals (mg/kg)				
Arsenic	10.16	21.43	10.44	6.53
Antimony	1.52	2.00	2.99	<LOR
Barium	1.41	1.48	1.09	1.38
Cadmium	0.29	0.49	0.40	0.27
Chromium	19.75	37.82	29.27	14.50
Cobalt	<LOR	<LOR	0.26	<LOR
Copper	0.53	0.51	2.19	2.45
Mercury	0.14	0.25	<LOR	<LOR
Lead	1.85	1.83	2.14	2.73
Molybdenum	<LOR	0.31	0.36	<LOR
Nickel	1.34	2.41	2.09	1.37
Zinc	23.33	83.20	13.14	6.88
Total Petroleum Hydrocarbons (TPH) (mg/kg)				
C10-C14	<LOR	35.7	10.6	<LOR
C15-C28	<LOR	25.9	<LOR	12.2
Total (C6-C36)	<LOR	61.6	10.6	12.2
Miscellaneous Parameters (mg/kg)				
Total Nitrogen	161.0	86.90	24.60	25.50
Total Phosphorous	0.53	2.30	1.02	1.49
Faecal Coliform (cfu/g)	10.00	<LOR	<LOR	<LOR
Manganese	5.39	3.32	14.40	27.00
Vanadium	38.80	77.40	59.00	57.50

Borehole ID	RC/30206			
Sample Depth (m)	0.5	1.5	4.5	6.0
Metals (mg/kg)				
Arsenic	29.43	21.18	23.45	23.55
Antimony	9.39	1.87	<LOR	2.30
Barium	6.78	9.81	7.37	7.14
Cadmium	0.54	0.34	0.10	0.45
Chromium	32.18	21.69	8.22	26.47
Cobalt	0.66	0.72	<LOR	0.49
Copper	18.11	13.02	12.21	22.40
Mercury	0.07	0.07	0.07	0.05
Lead	12.53	13.11	9.36	19.09
Manganese	6.02	10.80	1.34	2.74
Molybdenum	1.85	0.58	0.69	0.59
Nickel	2.40	1.55	0.54	2.01
Zinc	21.35	23.22	4.34	20.82
Total Petroleum Hydrocarbons (TPH) (mg/kg)				
C10-C14	13.20	33.5	33.3	<LOR
C15-C28	<LOR	13.3	21.90	15.2
Total (C6-C36)	13.20	46.8	55.1	15.2

Borehole ID	RC/30198			
Sample Depth (m)	0.5	1.5	6.0	6.5
Metals (mg/kg)				
Arsenic	12.03	11.02	8.29	8.62
Antimony	2.03	1.34	1.39	1.39
Barium	3.04	1.98	<LOR	4.38
Cadmium	0.38	0.29	3.46	0.18
Chromium	27.89	21.38	0.13	6.45
Cobalt	<LOR	<LOR	6.01	<LOR
Copper	1.55	1.36	<LOR	4.72
Mercury	0.14	0.10	3.21	<LOR
Lead	2.36	1.94	2.37	3.78
Molybdenum	0.41	0.20	0.35	0.30
Nickel	1.88	1.30	0.78	0.99
Zinc	10.49	5.68	2.29	3.43
SVOCs (mg/kg)				
Phthalates (total)	<LOR	0.3	0.5	0.2
Total Petroleum Hydrocarbons (TPH) (mg/kg)				
C10-C14	23.00	15.10	19.00	11.30
C15-C28	15.00	10.60	20.30	12.10
Total (C6-C36)	37.90	25.70	39.30	23.40
Miscellaneous Parameters (mg/kg)				
Total Nitrogen	165.0	104.00	22.60	28.30
Total Phosphorous	10.20	9.93	1.51	1.16
Faecal Coliform (cfu/g)	20.00	10.00	<LOR	<LOR
Manganese	4.77	3.22	1.53	2.93
Vanadium	46.20	38.90	17.60	20.90

Borehole ID	RC/30199			
Sample Depth (m)	0.5	1.5	4.5	7.0
Metals (mg/kg)				
Arsenic	18.83	33.00	53.51	42.05
Antimony	2.92	2.12	<LOR	<LOR
Barium	4.63	1.38	1.24	1.10
Cadmium	0.54	0.36	0.21	0.21
Chromium	29.70	26.66	11.45	17.61
Copper	3.27	2.98	6.52	8.63
Mercury	0.21	0.09	<LOR	<LOR
Lead	5.80	2.71	1.92	2.52
Molybdenum	0.31	0.56	0.38	0.48
Nickel	2.56	1.92	1.28	1.04
Zinc	32.71	4.52	2.49	4.09
Total Petroleum Hydrocarbons (TPH) (mg/kg)				
C10-C14	38.30	<LOR	<LOR	<LOR
C15-C28	30.70	<LOR	<LOR	<LOR
Total (C6-C36)	69.10	<LOR	<LOR	<LOR
Miscellaneous Parameters (mg/kg)				
Total Nitrogen	317.0	50.70	18.50	18.00
Total Phosphorous	15.30	1.62	1.14	0.79
Faecal Coliform (cfu/g)	20.00	<LOR	<LOR	<LOR
Manganese	5.10	1.19	1.30	1.58
Vanadium	52.80	60.40	33.80	38.90

Borehole ID	RC/30202			
Sample Depth (m)	0.5	1.5	4.5	3.5
Metals (mg/kg)				
Arsenic	2.06	1.58	1.45	<LOR
Antimony	<LOR	<LOR	4.68	<LOR
Barium	2.04	2.81	5.87	14.47
Cadmium	0.19	0.08	0.61	0.10
Chromium	18.98	8.21	23.19	2.62
Cobalt	<LOR	<LOR	1.12	<LOR
Copper	0.36	0.71	12.32	0.91
Mercury	0.08	0.08	<LOR	<LOR
Lead	3.28	3.11	12.19	4.08
Molybdenum	0.18	<LOR	<LOR	<LOR
Nickel	0.92	0.42	7.33	0.43
Zinc	4.74	3.60	33.09	1.65
Total Petroleum Hydrocarbons (TPH) (mg/kg)				
C29-C36	<LOR	<LOR	<LOR	39.90
Total (C6-C36)	<LOR	<LOR	<LOR	39.90
Miscellaneous Parameters (mg/kg)				
Total Nitrogen	150.0	74.80	20.90	36.80
Total Phosphorous	7.20	1.74	10.20	0.89
Faecal Coliform (cfu/g)	10.0	<LOR	<LOR	<LOR
Manganese	5.02	1.32	6.66	0.32
Vanadium	28.70	17.30	52.10	7.99

Borehole ID	RC/30205			
Sample Depth (m)	0.5	1.5	3.0	4.5
Metals (mg/kg)				
Arsenic	12.52	23.83	9.18	21.52
Antimony	<LOR	<LOR	2.81	1.43
Barium	16.43	15.72	11.82	31.84
Cadmium	0.30	0.10	0.62	0.31
Chromium	14.00	7.91	22.49	8.26
Cobalt	0.16	<LOR	0.28	0.2
Copper	12.63	39.16	182.5	39.18
Mercury	0.06	0.06	0.06	0.07
Lead	22.99	15.31	62.00	27.09
Manganese	20.20	1.45	3.74	3.67
Molybdenum	0.36	0.56	0.32	0.59
Nickel	1.36	0.57	2.92	1.42
Zinc	12.21	2.55	13.55	8.56
Total Petroleum Hydrocarbons (TPH) (mg/kg)				
C10-C14	<LOR	17	28.8	<LOR
C15-C28	16.90	15.6	16	14.2
Total (C6-C36)	16.90	32.5	44.7	14.2

Legend

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Previous Studies

- 1W91
- 1W92

N

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Qualified Person Endorsement : NA

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Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title : CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (CLEMENTI FOREST AND MAJU FOREST)

Figure Title : SOIL ANALYTICAL RESULTS FROM PREVIOUS STUDIES

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Note: Source of basemap - Google Earth Map

9.5.3 Groundwater Baseline Results

9.5.3.1 Groundwater Elevation

Based on groundwater elevation data collected as part of previous soil and/ or groundwater investigations carried out within the Study Area, the average groundwater level ranged from 9.91 mRL (in western part of Study Area) to the 21.75 mRL (in eastern part of Study Area). Based on the measured data, average groundwater level within the construction footprint ranges from 1.18 m below ground level (m bgl) to 9.84 m bgl. Overall, groundwater levels are expected to fluctuate as a result of rainfall percolating into the ground and due to seasonal variations.

9.5.3.2 Groundwater Flow Direction and Velocity

The hydraulic gradient was calculated using the EPA On-Line Tools for Site Assessment. Subsequently, the linear velocity of groundwater flow was calculated based on the Darcy's Equation as follows:

$$V = \frac{(Ki)}{n}$$

Where	V =	Groundwater flow velocity;
	K =	Theoretical Hydraulic Conductivity;
	n =	Effective porosity; and
	i =	Hydraulic gradient.

The average hydraulic gradient of groundwater within Study Area was calculated to be 0.10425 meter / meter (m/m). Theoretical hydraulic conductivity and effective porosity of the dominant soil type (i.e. sandy silt) were assumed to be 1 x 10^{-5} cm/s and 0.43, respectively. Therefore, the calculated velocity of groundwater is 0.76 m per year. It should be noted that the groundwater seepage velocity varies depending on the varying clay, silt and sand contents at a specific location and should be used as a general guide only. Based on groundwater level data collected during gauging and / or sampling events, the inferred groundwater flow direction is generally towards northeast, and it follows surrounding topography.

9.5.3.3 Groundwater Quality

Review of the groundwater analytical results, as presented in soil and groundwater investigation studies [R-70, R-71], showed that majority of the parameters tested in groundwater samples do not exceed their respective DIVs. In groundwater samples collected from the area that corresponds to the proposed construction worksite, detections of antimony, barium, lead and zinc were reported above their respective levels of reporting (LOR). However, the concentrations of these metals were all below their respective DIVs. In the eastern portion of the Study Area, detections of barium, chromium, lead and zinc were reported above their respective LOR, and most of these detections were below their respective DIVs. Exceedances of lead were reported in RC/30204 and RC/30205 (i.e. 75.2 µg/kg and 95.4 µg/kg, respectively).

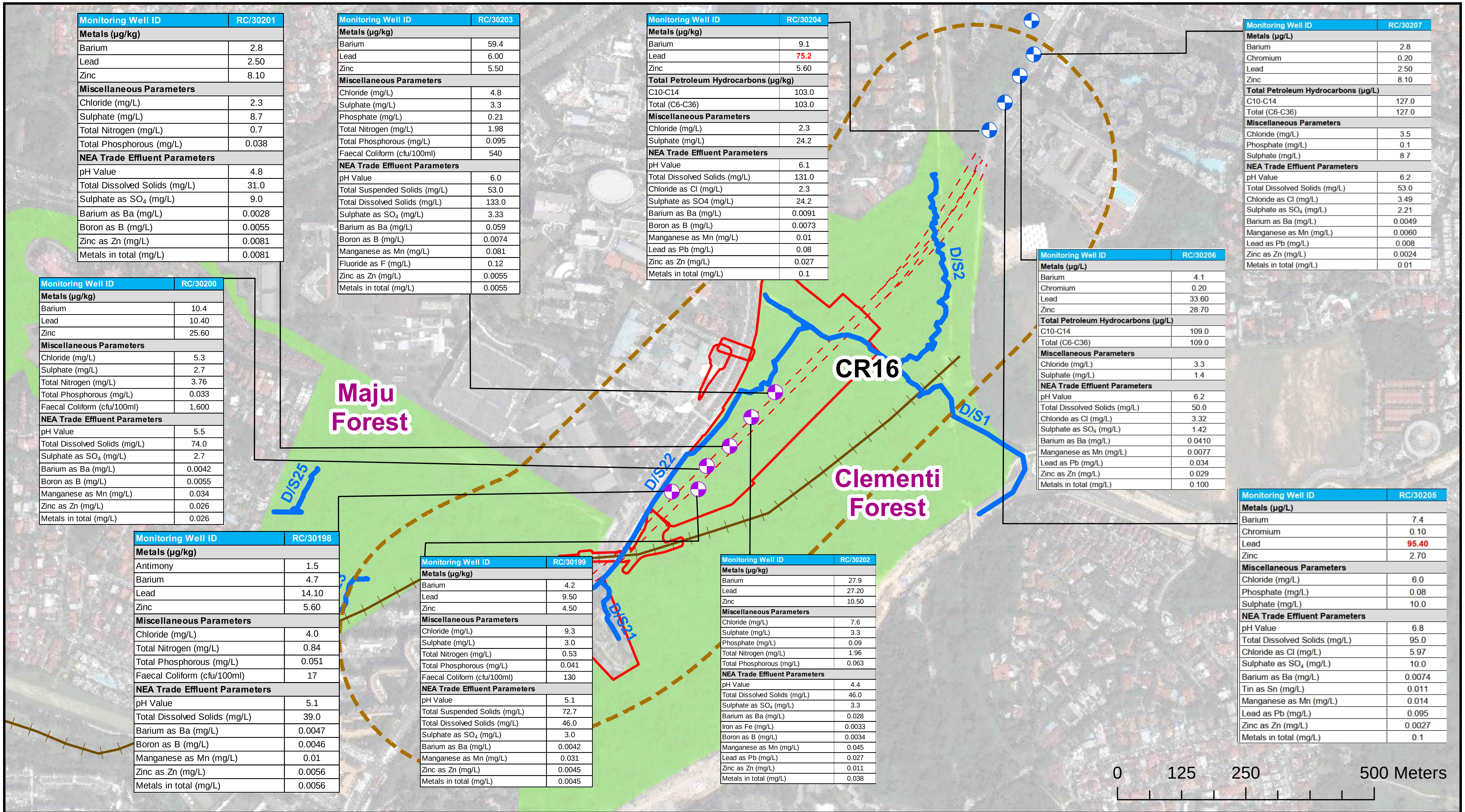
Chloride was detected in concentrations ranging between 2.3 mg/L to 9.3 mg/L. Phosphate was detected in some samples, at concentrations from 0.09 mg/L to 0.21 mg/L. Concentrations of detected sulphate ranged from 2.7 mg/L to 24.2 mg/L.

Faecal coliforms were detected in some groundwater samples collected from the area which corresponds to future construction site, with concentrations ranging from 17 to 1,600 cfu/100ml.

The remaining parameters analysed for the groundwater samples were below their respective LORs.

The source(s) of parameters detected above their respective LORs in groundwater samples could not be conclusively ascertained. Presence of metals, chloride and phosphates is a common occurrence in groundwaters due to the naturally-occurring processes (e.g. leachate and migration from soil) and anthropogenic activities. The presence of faecal coliforms in certain groundwater samples is possible to have originated from faecal matter of faunal species from the surrounding environment (e.g. Maju Forest and Clementi Forest). As mentioned earlier, reported concentration of lead in RC/30204 and RC/30205 showed exceedances of DIV. Therefore, Tier 1 Risk Assessment [R-71] was carried out which identified that the construction workers could potentially be exposed to groundwater via dermal contact and incidental ingestion. However, further analysis (i.e. by using American Society for Testing and Material [ASTM] Standard Guide for Risk-Based Corrective Action and USEPA Screening Levels) showed that the concentration of lead is well-below screening level and therefore does not present unacceptable risk to human health for future construction workers. QA/ QC analysis show that the RPD results for groundwater duplicate sample were at the acceptable level of precision and trip blanks did not show any detections.

Based on physicochemical measurements of groundwater during the field activities carried out as part of soil and groundwater investigation [R-70, R-71], the groundwater beneath the Clementi Forest and its surroundings can be described as generally acidic. Furthermore, during well development and sampling event, presence of non-aqueous phase liquid (NAPL) was not observed.



Monitoring Well ID	RC/30201
Metals (µg/kg)	
Barium	2.8
Lead	2.50
Zinc	8.10
Miscellaneous Parameters	
Chloride (mg/L)	2.3
Sulphate (mg/L)	8.7
Total Nitrogen (mg/L)	0.7
Total Phosphorous (mg/L)	0.038
NEA Trade Effluent Parameters	
pH Value	4.8
Total Dissolved Solids (mg/L)	31.0
Sulphate as SO_4 (mg/L)	9.0
Barium as Ba (mg/L)	0.0028
Boron as B (mg/L)	0.0055
Zinc as Zn (mg/L)	0.0081
Metals in total (mg/L)	0.0081

Monitoring Well ID	RC/30203
Metals (µg/kg)	
Barium	59.4
Lead	6.00
Zinc	5.50
Miscellaneous Parameters	
Chloride (mg/L)	4.8
Sulphate (mg/L)	3.3
Phosphate (mg/L)	0.21
Total Nitrogen (mg/L)	1.98
Total Phosphorous (mg/L)	0.095
Faecal Coliform (cfu/100ml)	540
NEA Trade Effluent Parameters	
pH Value	6.0
Total Suspended Solids (mg/L)	53.0
Total Dissolved Solids (mg/L)	133.0
Sulphate as SO_4 (mg/L)	3.33
Barium as Ba (mg/L)	0.059
Boron as B (mg/L)	0.0074
Manganese as Mn (mg/L)	0.081
Fluoride as F (mg/L)	0.12
Zinc as Zn (mg/L)	0.0055
Metals in total (mg/L)	0.0055

Monitoring Well ID	RC/30204
Metals (µg/kg)	
Barium	9.1
Lead	75.2
Zinc	5.60
Total Petroleum Hydrocarbons (µg/kg)	
C10-C14	103.0
Total (C6-C36)	103.0
Miscellaneous Parameters	
Chloride (mg/L)	2.3
Sulphate (mg/L)	24.2
NEA Trade Effluent Parameters	
pH Value	6.1
Total Dissolved Solids (mg/L)	131.0
Chloride as Cl (mg/L)	2.3
Sulphate as SO4 (mg/L)	24.2
Barium as Ba (mg/L)	0.0091
Boron as B (mg/L)	0.0073
Manganese as Mn (mg/L)	0.01
Lead as Pb (mg/L)	0.08
Zinc as Zn (mg/L)	0.027
Metals in total (mg/L)	0.1

Monitoring Well ID	RC/30207
Metals (µg/L)	
Barium	2.8
Chromium	0.20
Lead	2.50
Zinc	8.10
Total Petroleum Hydrocarbons (µg/L)	
C10-C14	127.0
Total (C6-C36)	127.0
Miscellaneous Parameters	
Chloride (mg/L)	3.5
Phosphate (mg/L)	0.1
Sulphate (mg/L)	8.7
NEA Trade Effluent Parameters	
pH Value	6.2
Total Dissolved Solids (mg/L)	53.0
Chloride as Cl (mg/L)	3.49
Sulphate as SO_4 (mg/L)	2.21
Barium as Ba (mg/L)	0.0049
Manganese as Mn (mg/L)	0.0060
Lead as Pb (mg/L)	0.008
Zinc as Zn (mg/L)	0.0024
Metals in total (mg/L)	0.01

Monitoring Well ID	RC/30200
Metals (µg/kg)	
Barium	10.4
Lead	10.40
Zinc	25.60
Miscellaneous Parameters	
Chloride (mg/L)	5.3
Sulphate (mg/L)	2.7
Total Nitrogen (mg/L)	3.76
Total Phosphorous (mg/L)	0.033
Faecal Coliform (cfu/100ml)	1,600
NEA Trade Effluent Parameters	
pH Value	5.5
Total Dissolved Solids (mg/L)	74.0
Sulphate as SO_4 (mg/L)	2.7
Barium as Ba (mg/L)	0.0042
Boron as B (mg/L)	0.0055
Manganese as Mn (mg/L)	0.034
Zinc as Zn (mg/L)	0.026
Metals in total (mg/L)	0.026

Monitoring Well ID	RC/30206
Metals (µg/L)	
Barium	4.1
Chromium	0.20
Lead	33.60
Zinc	28.70
Total Petroleum Hydrocarbons (µg/L)	
C10-C14	109.0
Total (C6-C36)	109.0
Miscellaneous Parameters	
Chloride (mg/L)	3.3
Sulphate (mg/L)	1.4
NEA Trade Effluent Parameters	
pH Value	6.2
Total Dissolved Solids (mg/L)	50.0
Chloride as Cl (mg/L)	3.32
Sulphate as SO_4 (mg/L)	1.42
Barium as Ba (mg/L)	0.0410
Manganese as Mn (mg/L)	0.0077
Lead as Pb (mg/L)	0.034
Zinc as Zn (mg/L)	0.029
Metals in total (mg/L)	0.100

Monitoring Well ID	RC/30205
Metals (µg/L)	
Barium	7.4
Chromium	0.10
Lead	95.40
Zinc	2.70
Miscellaneous Parameters	
Chloride (mg/L)	6.0
Phosphate (mg/L)	0.08
Sulphate (mg/L)	10.0
NEA Trade Effluent Parameters	
pH Value	6.8
Total Dissolved Solids (mg/L)	95.0
Chloride as Cl (mg/L)	5.97
Sulphate as SO_4 (mg/L)	10.0
Barium as Ba (mg/L)	0.0074
Tin as Sn (mg/L)	0.011
Manganese as Mn (mg/L)	0.014
Lead as Pb (mg/L)	0.095
Zinc as Zn (mg/L)	0.0027
Metals in total (mg/L)	0.1

Monitoring Well ID	RC/30198
Metals (µg/kg)	
Antimony	1.5
Barium	4.7
Lead	14.10
Zinc	5.60
Miscellaneous Parameters	
Chloride (mg/L)	4.0
Total Nitrogen (mg/L)	0.84
Total Phosphorous (mg/L)	0.051
Faecal Coliform (cfu/100ml)	17
NEA Trade Effluent Parameters	
pH Value	5.1
Total Dissolved Solids (mg/L)	39.0
Barium as Ba (mg/L)	0.0047
Boron as B (mg/L)	0.0046
Manganese as Mn (mg/L)	0.01
Zinc as Zn (mg/L)	0.0056
Metals in total (mg/L)	0.0056

Monitoring Well ID	RC/30199
Metals (µg/kg)	
Barium	4.2
Lead	9.50
Zinc	4.50
Miscellaneous Parameters	
Chloride (mg/L)	9.3
Sulphate (mg/L)	3.0
Total Nitrogen (mg/L)	0.53
Total Phosphorous (mg/L)	0.041
Faecal Coliform (cfu/100ml)	130
NEA Trade Effluent Parameters	
pH Value	5.1
Total Suspended Solids (mg/L)	72.7
Total Dissolved Solids (mg/L)	46.0
Sulphate as SO_4 (mg/L)	3.0
Barium as Ba (mg/L)	0.0042
Manganese as Mn (mg/L)	0.031
Zinc as Zn (mg/L)	0.0045
Metals in total (mg/L)	0.0045

Monitoring Well ID	RC/30202
Metals (µg/kg)	
Barium	27.9
Lead	27.20
Zinc	10.50
Miscellaneous Parameters	
Chloride (mg/L)	7.6
Sulphate (mg/L)	3.3
Phosphate (mg/L)	0.09
Total Nitrogen (mg/L)	1.96
Total Phosphorous (mg/L)	0.063
NEA Trade Effluent Parameters	
pH Value	4.4
Total Dissolved Solids (mg/L)	46.0
Sulphate as SO_4 (mg/L)	3.3
Barium as Ba (mg/L)	0.028
Iron as Fe (mg/L)	0.0033
Boron as B (mg/L)	0.0034
Manganese as Mn (mg/L)	0.045
Lead as Pb (mg/L)	0.027
Zinc as Zn (mg/L)	0.011
Metals in total (mg/L)	0.038

Legend

- Study Area
- Watercourses
- Base Scenario Construction Worksite Footprint
- Proposed CRL Alignment (Base)
- Biodiversity Study Area
- Old Jurong Railway Corridor

Previous Studies

- 1W91
- 1W92

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Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title :
CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (CLEMENTI FOREST AND MAJU FOREST)

Figure Title :
GROUNDWATER ANALYTICAL RESULTS FROM PREVIOUS STUDIES

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	Drawn SAG	Date JUL 2022	CAD File Name :		A3

Note: Source of basemap - Google Earth Map

9.6 Potential Sources of Soil and Groundwater Impacts

Soil and groundwater can be potentially exposed to contaminants due to activities during the construction and operational phases of the Project.

9.6.1 Construction Phase

Soil and groundwater can be potentially exposed to contaminants due to the activities during the construction phase of the Project, especially within and around the cut and cover areas. The activities which could lead to contamination of the soil and groundwater during the construction phase are listed in Table 9-4.

Table 9-4 Potential Sources of Soil and Groundwater Impacts (Construction Phase)

Activity	Potential Sources of Impacts	Potential Associated Impacts
• Site Clearance, levelling and land grading works • Construction of station boxes and other infrastructures	• Increased runoff from hard standing surface resulting in decreased infiltration into the ground • Disposal of wastewater generated from tunnelling activities • Groundwater from dewatering from excavated areas	• Decreased groundwater baseflow feeding into potential streams • Potential groundwater drawdown due to dewatering process
• Excavation of cut and cover areas • Stockpiling of excavated soil from cut and cover areas and tunnel boring activities • Improper management and disposal of excavated soils and/ or groundwater during excavations and tunnel boring activities	• Exposure of land and stockpiles from the various construction activities • Contaminated excavated soils (if encountered), if not stored, handled, transported and disposed properly, can lead to direct or indirect contamination • Wastewater generated from tunnelling activities	• Soil erosion of exposed soil from excavation and stockpiles • Potential for direct soil and/ or groundwater contamination within the Study Area • Potential pollution to the adjacent areas within the immediate vicinity of the Project due to migration of soil and groundwater contamination, off-site • Potential contamination to the surface watercourses located in the vicinity of the construction site (its impact will be assessed in Section 8)
• Improper handling, transfer and storage of toxic chemical waste	• Discharge of toxic chemical waste due to spillage or leakage during storage, handling and transfer • Inappropriate or inadequate design parameters for storage containers	• Potential for direct soil and/ or groundwater contamination within the Study Area • Potential pollution to the adjacent areas within the immediate vicinity of the Project due to migration of soil and groundwater contamination, off-site
• Improper handling, transfer, refuelling and storage of chemicals (e.g. diesel, bentonite, lubricants, oils, grease, paints, solvents, waste treatment chemicals, etc.) generated during construction activities.	• Discharge of chemical due to spillage or leakage during storage, handling, transfer and refuelling (oil, grease or other chemical substance release) • Inappropriate or inadequate design parameters for storage containers	

The proposed minimum controls or stand practices commonly implemented in Singapore are discussed in Section 9.7.

9.6.2 Operational Phase

It is anticipated that there will be limited sources of impacts to soil and groundwater during the operational phase as use of chemicals and generation of toxic chemical waste are expected to be of limited quantities. Hazardous waste generated during the operational phase are associated to maintenance works on the alignment and station while non-hazardous waste generations are expected to be generated from the site office staff’s general waste within the station.

The activities which could lead to contamination of the soil and groundwater during the operational phase are listed in Table 9-5.

Table 9-5 Potential Sources of Soil and Groundwater Impacts (Operational Phase)

Activity	Potential Sources of Impacts	Potential Associated Impacts
• Maintenance works on the alignment and station	• Small quantities of toxic chemical waste generated during maintenance works and operational phase (used fluorescent bulbs, used lead-batteries, used maintenance chemical containers i.e. thinner, paints, lubricants, etc.) • Operation of trains resulting in diesel oil leakage	• For maintenance activities within the alignment, hazardous waste leakage could occur and seep into the wastewater drainage within the alignment and/or into the soil and groundwater • For general maintenance for the station, hazardous waste from equipment could potentially leak into drainage systems and/or into the soil and groundwater
	• Improper handling of hazardous chemicals/substances during operation phase	• Potential pollution within the Study Area where toxic chemicals are stored

The proposed minimum controls or stand practices commonly implemented in Singapore are discussed in Section 9.7.

9.7 Minimum Control for Potential Impacts

This section proposes minimum controls or standard practices commonly implemented in Singapore for similar developments that have been assumed to be implemented for the purpose of impact assessment during the construction and operational phases.

9.7.1 Construction Phase

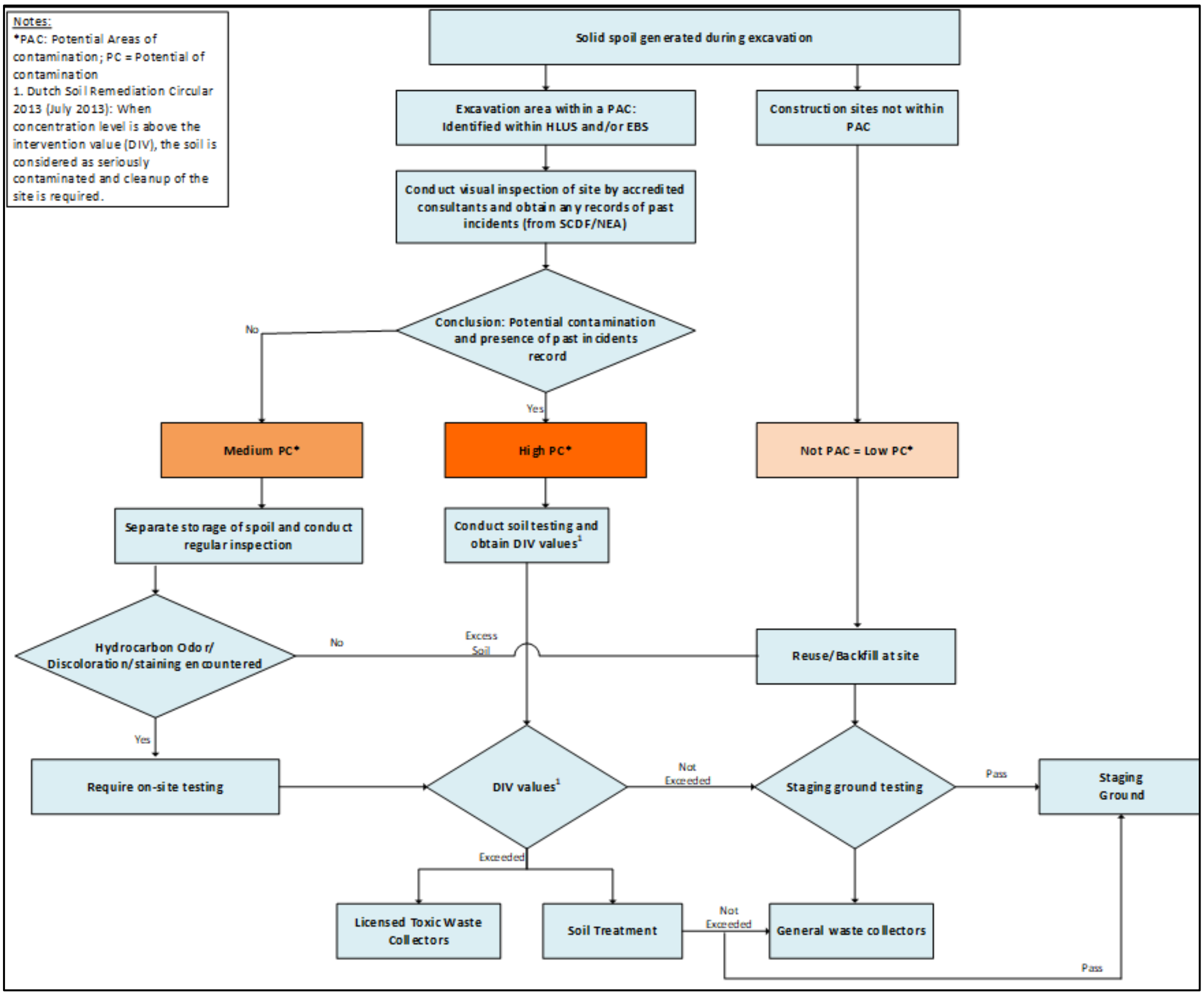
Table 9-6 sets out the minimum controls that have been identified for the Project during construction phase. Regular inspection and workers training must be conducted to ensure these measures are inculcated in the behaviour and practice of all the site staff on site.

Table 9-6 Minimum Controls During Construction Phase (Soil and Groundwater)

Potential Sources of Impacts	Minimum Controls
Decreased groundwater baseflow feeding into the streams	• 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). • Proper Earth Retaining Stabilising Structures (ERSS) should be selected and designed to limit groundwater settlement.
Improper management and disposal of excavated soils and/or groundwater during excavations and tunnel boring activities	• Identify all types of solid 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 will be free of debris, and of good material soil. • Handle and dispose excavated soil following the procedure shown in Figure 9-4. 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 via 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

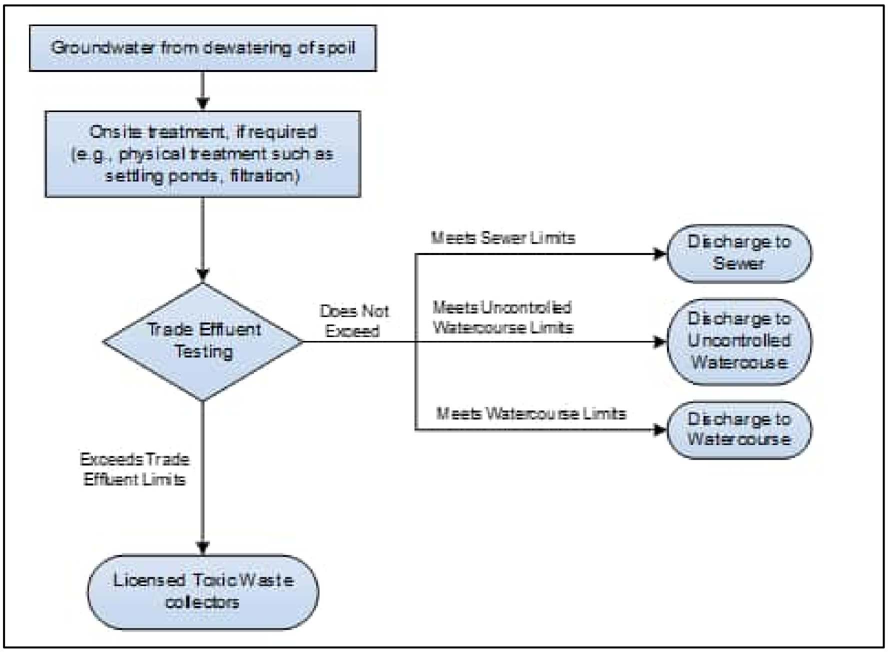
Potential Sources of Impacts	Minimum Controls
	parameters to the site workers exposed to areas where soil and/or groundwater contamination is identified. The risk assessment should be conducted before the commencement of construction activities and the findings incorporated into the Contractors' construction 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 Figure 9-4. • Discharge of extracted groundwater will be to an area approved for such disposal by the NEA and the proposed location as identified in Figure 9-4 and following the process set out in Figure 9-5. Based on the results of the soil and groundwater baseline study, the detected concentrations in groundwater do not exceed the DIVs**.** However, 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 will 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. • Contractor will need to seek approval from relevant authorities (e.g., PUB & NEA) as per NEA's Trade Effluent Discharge Limits if the treated groundwater will be disposed to controlled watercourse If such discharges are not approved, the trade effluent will be stored, treated, or recycled on site and finally disposed of. The extracted groundwater to be discharged should be tested in regular intervals, especially if oily sheens or odour are observed. • 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 will follow the procedure in Figure 9-4.
Toxic Chemical Waste and Wastewater 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 will be provided for all waste containers Spill trays will 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 will be treated to comply with the requirements under prevailing legislation. • Contractor will need to seek approval from 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.

Potential Sources of Impacts	Minimum Controls
Improper Handling of Hazardous Chemicals/Substances during Construction Phase	• Remove any hazardous substance or chemical if there are safer alternatives. • Ensure all hazardous substance and chemical containers are labelled its 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 will be discharged into any watercourse or land. • Ensure all activities involving repair, servicing, engine overhaul works, etc. will 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 will be provided for all drums, plants and machinery and potential pollutive substances used on site. Spill trays will be regularly maintained to prevent rain from washing out the pollutive substances. • Provide emergency spill kits on site in the event of any chemical spillages. The emergency response team will also be competent in the use of these spill kits.



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 9-4 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 9-5 Disposal of the Groundwater Generated through Dewatering or Inflow into Excavations

9.7.2 Operational Phase

Table 9-7 sets out the minimum controls that have been identified for the Project during operation phase.

Table 9-7 Minimum Controls During Operational Phase (Soil and Groundwater)

Potential Sources of Impacts	Minimum Controls
Small quantities of toxic chemical waste generated during maintenance works (used fluorescent bulbs, used lead-batteries, used maintenance chemical containers i.e. thinner, paints, lubricants, etc.)	• 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 will be provided for all chemical drum and potentially pollutive substances. Spill trays will be regularly maintained to prevent rain from washing out the pollutive substances. • Dispose all toxic waste chemicals to licensed TIW collectors for treatment
Improper handling and storage of hazardous chemicals/substances during operation phase	• 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 will be provided for all chemical drums, plants and machinery and potential pollutive substances used on site. Spill trays will be regularly maintained to prevent rain from washing out the pollutive substances. • Ensure 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). • Provide emergency spill kits on site in the event of any chemical spillages. The emergency response team will also be competent in the use of these spill kits.

Potential Sources of Impacts	Minimum Controls
	• Ensure no trade effluent other than that of a nature or type approved by NEA Director-General will be discharged into any watercourse or land.

9.8 Prediction and Evaluation of Soil and Groundwater Impacts

9.8.1 Construction Phase

9.8.1.1 Decreased Groundwater Baseflow Feeding into the Streams

The pre-construction activities (e.g. site clearance, levelling and land grading works) and main construction activities of shaft, station boxes and other infrastructures of this Project which include deep excavations and dewatering process, could lead to potential groundwater drawdown and decreased baseflow into the watercourses. Based on the information provided by LTA, the groundwater drawdown for proposed CR16 station box was assessed to be 3 m during construction phase. Based on construction timeline (refer to Section 3.4.1), the Project will be constructed phase by phase instead of whole area together, which further reduces its construction footprint by phases and reduce the potential impact on groundwater baseflow due to dewatering process. Overall, such amount of groundwater drawdown will not significantly decrease the groundwater baseflow during construction phase. Furthermore, based on the inferred groundwater flow direction, the construction footprint is located downgradient and therefore will most likely not impact the source of groundwater flowing through the Study Area. Hence, the impact intensity was considered **Low** on groundwater baseflow reduction.

Hydrological baseline study (refer to the Section 8.5.1.1) showed that there are five (5) watercourses at Clementi Forest (i.e. D/S1, D/S2, D/S20, D/S21 and D/S22). Streams D/S1, D/S2 and D/S22 have been identified to support biodiversity of conservation significance (refer to the Section 7) and me be partly supported by the groundwater baseflow. Therefore, they have been categorised as Priority 2 sensitive receptors. Based on the sensitivity of these receptors and assessed impact intensity, the impact consequence was **Very Low** (as per Table 6-6). Given that the occurrence of the expected decreased baseflow is probably during the dry season (i.e. **Occasional**), the impact significance of the decreased groundwater baseflow to the streams was **Minor** and no further mitigation measures were required.

In Maju Forest, identified watercourses are located away from the construction worksite. Although the watercourses (i.e. D/S23, D/S24 and D/S25) support the biodiversity of conservation significance, based on the inferred groundwater flow the proposed developments are **Unlikely** to affect the groundwater baseflow feeding into the watercourses. Therefore, the impact significance was assessed to be **Negligible**.

9.8.1.2 Improper Management and Disposal of Excavated Soil and Groundwater

The construction method is expected to generate large amounts of spoil material. The quantity of solid waste stored on site (e.g. excavated soil, construction debris, etc.) is expected to be limited given the periodical disposal by licenced general and toxic waste Contractors as part of minimal controls (as shown in Section 9.7).

In the event that contaminated soils or groundwater are encountered during excavations, implementation of the measures detailed in Figure 9-4 and Figure 9-5 will ensure that the contaminated soil and/ or groundwater is properly managed and disposed.

The overall sensitivity of the soil and groundwater receptors in the Study Area is considered as Priority 3, as specified in Section 9.3. Based on the HLUS report [R-4], the contamination severity level from the majority of past land uses within Study Area was estimated to be low and the impact intensity was considered **Low**. Hence, the impact consequence of improper management and disposal of excavated soil and groundwater was estimated to be **Very Low** (based on the Impact Consequence Matrix as shown in Table 6-6With the implementation of minimum controls, the likelihood of occurrence was expected to be **Occasional** during construction phase.

Therefore, the overall environmental of improper management and disposal of excavated soil and groundwater during construction phase was assessed to be **Minor**. Hence, no further mitigation measures were required.

9.8.1.3 Toxic Chemical Waste Generation

The quantity of toxic chemical waste stored on site is expected to be limited with the assumption that waste generated on-site will be periodically removed and disposed off-site by licensed Toxic Industrial Waste (TIW) contractors during the construction phase. Based on HLUS report, the contamination severity level was expected to be low from most of the land uses within the Study Area (refer to Table 9-3), and the impact intensity was considered **Low** (localised soil and groundwater impacts which is not likely to extend beyond the Project site and possible to remediate), with the impact consequence of soil and/or groundwater contamination was assessed to be **Very Low.**

Based upon implementation of the minimum controls and that the controls are approved by the relevant agency, where applicable, it is unlikely that discharge, spillage or leakage from toxic waste in a quantity that may adversely impact the environment will regularly occur during the construction phase. Mandatory worker trainings regarding environmental management and spill management and regular site inspections serve as preventative measure for such occurrences. On this basis, the likelihood of occurrence during construction phase was expected to be **Occasional**.

Overall, based upon an assessment of the likelihood and consequences, and considering the routine, standard industry practices implemented during the construction phase, the potential impact of toxic chemical waste spillage or leakage to soil and/or groundwater was assessed to be **Minor**. Therefore, no further mitigation measures were required.

9.8.1.4 Improper Handling of Hazardous Chemicals/Substances

Chemicals used during the construction phase will be stored at designated sheltered area provided with access-controlled entrance and concrete bund walls or in storage containers with good ventilation or on spill pallets. In the event of chemical spillage, spill kits will be available on site to be operated by an emergency response team competent in their use. Based on HLUS report, the contamination severity level is low to most of the land uses within the Study Area (refer to Table 9-3). Hence, the impact consequence of potential contamination (**Low** impact intensity) from chemical spillage was considered to be **Very Low** during the construction phase.

With the minimum controls implemented and listed in Section 9.7, the likelihood of occurrence of a chemical spill leading to soil and/or groundwater contamination was assessed to be **Occasiona**l during construction phase. Therefore, the overall environmental impact of chemical spillage to soil and/or groundwater likely to occur during the construction phase was assessed to be **Minor**. Therefore, no further mitigation measures were required.

9.8.2 Operational Phase

9.8.2.1 Toxic Chemical Waste Generation during Maintenance Work

For the periodic maintenance work to be conducted along the alignment, entrances and vent shafts, it can be expected that toxic chemical waste might be generated in the form of used fluorescent bulbs, used lead-batteries, used maintenance chemical containers i.e., thinner, paints, lubricants, etc. These toxic wastes were expected to be of limited quantities and disposed of periodically by licensed TIW contractors during the operational phase.

The impact intensity was considered **Low** (localised soil and groundwater impacts which is not likely to extend beyond the Project site and possible to remediate), with the impact consequence of soil and/or groundwater contamination was assessed to be **Very Low.**

Based upon implementation of the minimum controls and that the controls are approved by the relevant agency, where applicable, it is unlikely that discharge, spillage or leakage from toxic waste in a quantity that may adversely impact the environment and will only occur during the operational phase as often as maintenance is scheduled. Mandatory worker trainings regarding environmental management and spill management and regular site inspections serve as preventative measure for such occurrences. For example, in the event where spillage occurs during the maintenance of rail infrastructure, toxic chemicals could possibly enter the drainage system of the alignment and cause pollution downstream with the potential to impact the soil and groundwater. It is imperative to have preventative measures from the source to prevent pollution downstream of the drainage process. On this basis, the likelihood of occurrence during operational phase was expected to be **Occasional**.

Overall, based upon an assessment of the likelihood and consequences, and considering the routine, standard industry practices implemented during the operational phase, the potential impact of toxic chemical waste spillage or leakage to soil and/ or groundwater was assessed to be **Minor**. Therefore, no further mitigation measures were required.

9.8.2.2 Improper Handling of Hazardous Chemicals/Substances

Chemicals used during the operational phase will be stored at designated maintenance area provided with access-controlled entrance and concrete bund walls or in storage containers with good ventilation or on spill pallets. In the event of chemical spillage, spill kits will be available on site to be operated by an emergency response team (maintenance team) competent in their use. Based on HLUS report, the contamination severity level is low to most of the land uses within the Study Area (refer to Table 9-3). Hence, the impact consequence of potential contamination (Low impact intensity) from chemical spillage was considered to be **Very Low** during the operational phase.

With the minimum controls implemented and listed in Section 9.7, the likelihood of occurrence of a chemical spill leading to soil and/or groundwater contamination was assessed to be **Occasional** during operational phase.

Therefore, the overall environmental impact of chemical spillage to soil and/or groundwater likely to occur during the construction phase was assessed to be **Minor**. Therefore, no further mitigation measures were required.

9.9 Recommended Mitigation Measures

In this section, no mitigation measures are proposed to further minimise the adverse impacts on the environment as there is no impact significance on sensitive receptors were assessed to be Moderate or Major.

However, it is noted that mitigation scenario has been developed mainly due to their major adverse impact on surrounding biodiversity (refer to Section 7). Proposed two-stage development will most likely help to further reduce the impacts on groundwater.

9.10 Cumulative Impacts with Other Major Concurrent Developments

9.10.1 Construction Phase

In Maju Forest, two (2) concurrent developments have been identified to occur concurrently with the proposed Cross Island Line development, namely PUB's DTSS2 link sewer project and road construction along Brookvale Drive.

For the PUB DTSS2 project, it was envisaged that its construction worksite will be located at the proposed manhole locations as the underground DTSS alignment will be constructed through pipe-jacking. The overall duration of this project is 3 years, and it will mostly overlap with proposed CRL2 development. The underground works of DTSS project might slightly increase the impact on soil and groundwater within Maju Forest due to the pipe-jacking during its construction. Hence, proper mitigation measures should be proposed to deal with the excavated groundwater and soil to minimise its adverse impact.

The proposed construction of the new road along Brookvale Drive is planned to be carried out at the north of Maju Forest, overlapping with the CIL development for approximately 1 year. Although the proposed development will change the current land use at the north of Maju Forest (and therefore alter the percolation into the soil), with the implementation of minimum control measures it was expected that the impact on soil and groundwater of Maju Forest will not be significant.

In Clementi Forest there will be two (2) concurrent developments during the development of CRL2. These are Clementi Nature Trail and proposed CR15 worksite.

The Clementi Nature Trail is a proposed development along Clementi Stream which will eventually become part of Singapore's PCN. It is expected to overlap with CRL2 developments for approximately 1 year. As the development include mostly minor construction activities (e.g., cut and cover for trail levelling) and as it is located downgradient (based on the inferred groundwater flow), this development is unlikely to increase the soil and groundwater impact.

The proposed CR15 worksite will be constructed in the vicinity of the northern parts of Clementi Forest. As the proposed development will alter the current land use, changes in hydrological cycle (e.g., seepage into the soil, surface runoff, etc.) are expected. However, under the assumption that the minimum control measures and best management practices will be implemented during the construction, and taking into consideration the inferred flow of the groundwater in this area (i.e., towards northeast) it is unlikely that the project will increase the impact on soil and groundwater in Clementi Forest.

Similar as the Clementi Nature Trail, the proposed Jurong Line Nature Trail will include construction activities for the purposes of development of PCN along the Old Jurong Line ridge spanning through both Maju Forest and Clementi Forest. As the construction works will mostly include minor construction activities, the development is unlikely to increase soil and groundwater impact.

9.10.2 Operational Phase

For the PUB DTSS2 project, only manholes will be the project footprint, which will occupy relatively small area along the roadside. Besides, it was envisaged that maintenance works will be restricted at the manhole area, and any contamination (e.g. chemical spills, leaking, etc.) will be minimised given best management practices and minimum controls are in place. Hence, the DTSS project might not increase the impact on soil and groundwater within Maju Forest.

The proposed Brookvale Drive Project, Old Jurong Line Nature Trail and Clementi Nature Trail will occupy relatively small area and it is expected that after some time the groundwater levels will find a new equilibrium. Under the assumption that the minimum control measures and best management practices have been implemented, the proposed developments are unlikely to increase the impact on soil and groundwater.

As the CR15 station will be located downgradient based on the inferred groundwater flow, it is unlikely that it will increase the impact on underlying soil and groundwater.

9.11 Summary of Key Findings

The potential impacts on soil and groundwater of historical and current/potential land uses associated with the construction and operational phases of the Project was discussed with reference to LTA's HLUS reports, previously carried out soil and/ or groundwater studies, construction waste information and other best available data.

The soil and groundwater within the Project site were identified as Priority 3 sensitive receptors, as they were not expected for direct sensitive uses (e.g., agricultural/irrigation/drinking water purposes) and not directly extracted for industrial uses, therefore not posing unacceptable risks. Streams that support habitats and/or species of high conservation significance and which are partly supported by groundwater were identified as Priority 2 sensitive receptors.

The potential sources of soil and groundwater impact during construction were expected to be mainly from pre-construction activities (e.g. site clearance, levelling, land grading works) and main construction activities of this Project such as tunnelling activities, which may cause decreased groundwater baseflow feeding into the streams, potential contamination from improper management of excavated soil and groundwater, potential contamination from toxic chemical waste used or generated on site, as well as potential leakage from improper handling of hazardous chemical/substances on site.

The potential sources of soil and groundwater impact during operational phase are expected to be mainly from maintenance of the rail infrastructure, vent buildings and stations with potential contamination from toxic chemical waste used or generated, as well as potential leakage from improper handling of hazardous chemical/substances within the operational footprint of the Project. According to preliminary planning at the time of writing this Report, this Project is assumed to have maintenance works for each station and rails within the tunnels to be carried out once a week. These activities could lead to generation of small quantities of toxic chemical waste (e.g. used fluorescent bulbs, used lead-batteries, used maintenance chemical containers i.e. thinner, paints, lubricants, etc.) as well as accidental leakages of hazardous chemicals/ substances due to improper handling/ management. Those may seep into the wastewater drainage systems and/ or into the soil and groundwater, potentially impacting their quality. Furthermore, there is a potential for contamination of soil and/ or groundwater due to accidental spills and leaks in the storage areas of maintenance chemicals.

Minimum control measures for soil and groundwater which are commonly implemented in Singapore have been included in this section. Regular inspection and workers training must be conducted to ensure these measures are inculcated in the behaviour and practice of all the site staff on site. Hence, the significance from potential sources of soil and groundwater impacts during construction and operational phases such as decreased groundwater baseflow feeding into the streams, improper management of excavated soil and extracted water, toxic chemical waste generation and improper handling of hazardous chemicals/ substances was assessed to be Negligible to Minor to the sensitive receptors and no further mitigation measures were required for CRL2 Project.

Cumulative impacts from concurrent developments identified in the vicinity of the CR2005 Project during both construction and operational phases were assessed. It was concluded that the concurrent development of PUB DTSS sewer pipe construction along Clementi Road might increase the impact during construction phase only. Hence, appropriate mitigation measures should be proposed to minimise these adverse impacts by the project developer to avoid accidental spillage of chemicals for impacting on the quality of soil and groundwater, and to ensure surface water streams are diverted with an equivalent capacity of stream if impacted and to minimise groundwater drawdown in line with best practice measures. The impact from the other concurrent developments might not increase soil and groundwater impact in their construction or operational phases given best management practices and minimum controls are in place as the development might only have significant changes on the land use.

Table 9-8 Summary of Soil and Groundwater Impact Assessment

Sensitive Receptor	Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)
Construction Phase		
Clementi Forest	Minor	Minor
Maju Forest	Negligible to Minor	Negligible to Minor
Operational Phase		
Clementi Forest	Minor	Minor
Maju Forest	Minor	Minor

10. Air Quality

10.1 Introduction

This section presents the air quality impact assessment for the construction and operational phases of the Project. The key steps for conducting the air quality impact assessment are as follows:

- Review baseline monitoring data to evaluate the existing air quality in the Study Area;
- Identify and classify sensitivity of the area around the construction worksite or Project footprint;
- Conduct an impact assessment to qualitatively assess air quality impacts during construction and operation of the Project;
- Evaluate qualitative air quality impacts against nominated assessment criteria;
- Specify mitigation measures to be implemented; and
- Determine the overall significance of the residual air quality impacts after implementation of mitigation measures.

10.2 Methodology

The sections below outlined the methodology used in the air quality impact assessment for both construction and operational phase, including the determination of the Study Area and baseline collection methodology.

10.2.1 Study Area

The Study Area for air quality impact assessment is recommended as 50 m from the construction worksite areas (station and vent shafts) for impact during construction phase in accordance with UK IAQM guidance [R-45] and 250m around the Project footprint for operational phase. It should be noted that the operational footprint considered in air quality impact assessment also includes existing operational roads outside or nearby the Project site, if any. During the scoping phase for this EIS, an initial screening of receptors in the Study Area was conducted in order to determine the areas which are sensitive to potential construction and operational impacts.

10.2.2 Baseline Air Quality Study

Baseline air quality monitoring includes primary data collection in the form of baseline ambient air quality monitoring in the Study Area. Of the criteria pollutants generally measured as part of ambient air monitoring, such as CO, NO_2, SO_2, PM_{10} and $PM_{2.5}$, this baseline monitoring only focuses on dust levels i.e. PM_{10} and $PM_{2.5}$, since these are the major pollutants that are likely to have the most significant impact on the ambient air quality as a result of the Project. The purpose of the baseline monitoring is to understand what the natural conditions of these air quality parameters are, so that in the event that a repeat monitoring event is to be conducted during the construction and/or operational phases of the Project, this monitoring data can be used as a reference of the existing baseline prior to any disturbance in the Study Area. Primary monitoring data include monitoring equipment to be setup at the site for at least a week; while simultaneous data recorded are from nearest NEA's monitoring station from web resources. The observed site data and NEA's monitored data are compared to provide confidence in the collected data.

Air quality has both short-term and long-term targets which vary from a 1-hr target to an annual target. Owing to the timeframe of the Project, annual monitoring cannot be accommodated in this Study; however, a short-term monitoring baseline was established. With varying seasonal fluctuations, it is understandable that wind flow and direction will vary throughout the year, and hence short-term baselines will also fluctuate. However, a correlation, be it direct or indicative between the site baseline and NEA's western area monitoring data, will be useful for future monitoring as it provides a reliable context for any future comparisons based on the relation between the two datasets. Hence, secondary data, such as NEA's long-term air quality data, hourly Pollution Standard Index (PSI), and meteorological data observed in the vicinity of the Study Area were collected from publicly available sources.

10.2.2.1 Secondary Data Collection (Review of Background Data)

Desktop research consists of a review of secondary data (including existing land use and development activities, satellite images, etc.) which aids in determining the baseline air quality monitoring location. The information retrieved during the desktop research comprised of publicly available data from government and technical Agencies, existing available data, relevant articles, and other online sources.

10.2.2.1.1 *NEA Long Term Ambient Air Quality*

NEA carries out routine monitoring of ambient air quality through the Telemetric Air Quality Monitoring and Management System (TAQMMS). This system comprises 22 monitoring stations (refer to Figure 10-1) which are located around Singapore and linked into a Central Control System (CCS). The air quality monitoring stations are distributed amongst urban, industrial, suburban, coastal, and roadside locations. General NEA ambient air monitoring results for Singapore over the period 2015 – 2019 have been presented and compared with Singapore Long Term Ambient Air Quality Targets in Section 10.5.1.1.1. Air pollution control in Singapore is governed by legislation listed in Section 4.

Figure 10-1 NEA Ambient Air Quality Monitoring Stations in Singapore [R-42].

10.2.2.1.2 *Hourly Pollution Standards Index (PSI) and 24-hour PM_{10} and $PM_{2.5}$ Concentrations*

PSI (Pollutant Standards Index) is an index to provide accurate and easily understandable information about daily levels of air quality. The concentration levels of particulate matter (PM_{10}), fine particulate matter ($PM_{2.5}$), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), and carbon monoxide (CO) monitored by air monitoring locations located in different parts of Singapore are used to determine the PSI. The PSI value gives an indication of the air quality as shown in Table 10-1. 24-hr $PM_{2.5}$ and PM_{10} PSI readings were available on data.gov.sg for the Western Region of Singapore during the primary data collection period, which was on 11 to 18 March 2020, and these are presented and discussed in Section 10.5.1.1.2.

Table 10-1 General Air Quality Descriptor Based on PSI value [W-43]

PSI Value	Air Quality Descriptor
0 – 50	Good
51 – 100	Moderate
101 -200	Unhealthy
201 – 300	Very unhealthy
Above 300	Hazardous

10.2.2.1.3 *Other Parameters (Rainfall, Temperature, Wind Speed)*

Rainfall, temperature, and wind speed can significantly affect the distribution of pollutants. Clementi is the nearest monitoring station to the Study Area, located approximately 660m from the Study Area. Clementi monitoring station recorded rainfall, temperature and wind speed data. These are discussed in Section 10.5.1.1.3.

Figure 10-2 NEA Weather Monitoring Stations in Singapore [W-44].

10.2.2.2 Primary Data Collection (Survey & Sampling)

Air quality monitoring services were provided by ALS Technichem (S) Pte. (ALS). A total of one (1) air monitoring location was proposed (at the Inception stage), based on the following considerations:

- Identification of ASRs (hospitals, schools, childcare facilities, old age homes, residences, flora and habitats of high ecological value) nearest to the construction worksite areas/ Project footprint boundary of the proposed station box and vent shafts;
- Other ASRs away from the construction worksite areas/ Project footprint were eliminated as these receptors are assumed to be barricaded by the first row of buildings;
- ASRs with areas having ongoing construction were avoided;
- Exclude areas where CCNR EIA has already established some air baseline in the past;
- The closest ASR to the construction worksite areas/Project footprint was selected; and
- ASRs where the owner denied permission during site walkover was excluded (e.g., past experience with terrace houses/bungalows, etc).

Air quality monitoring was conducted at the monitoring locations for one week to collect air quality samples for the following air quality parameters:

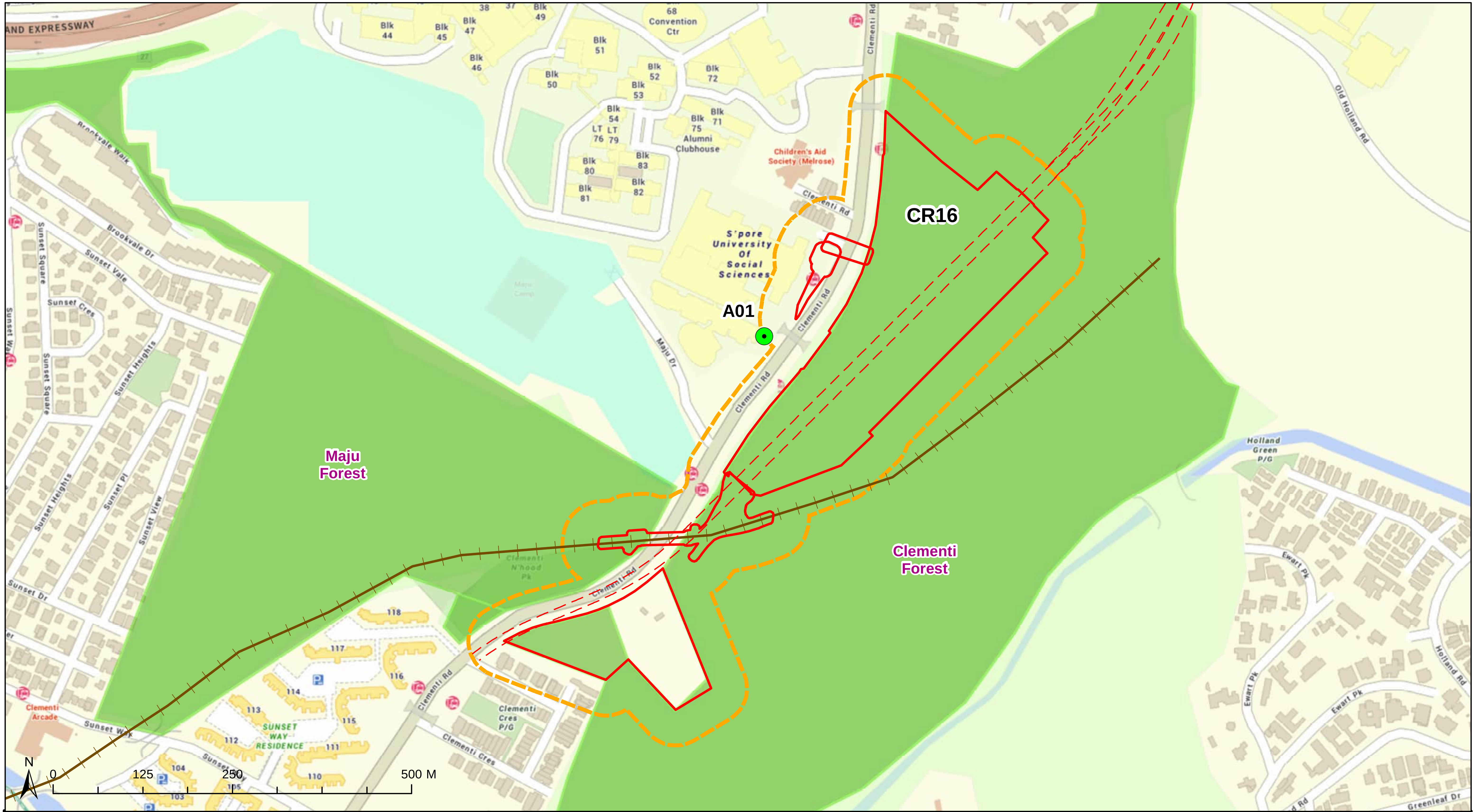
- Particulate matter smaller than 2.5µm, $PM_{2.5}$; and
- Particulate matter smaller than 10 µm, PM_{10}.

Air quality monitoring was conducted for 1 week within the Study Area in order to establish a baseline for existing air quality levels. Following the site survey conducted on 5-6 November 2019, 1 (one) monitoring location was identified to represent the site. This has been proposed and accepted in the inception report. The monitoring location was chosen so that the equipment was more than 1 metre from any buildings or structures, and not shaded by structures or trees. This is necessary to ensure adequate airflow. The indicative air quality monitor was installed at 1.8m from ground level in the breathing zone. Proposed air monitoring location is provided in Table 10-2 and Figure 10-3.

TSI Environmental DustTrak Monitoring System was used for the purpose of PM_{10} and $PM_{2.5}$ monitoring. Concentrations of PM_{10} and $PM_{2.5}$ were measured by the light scattering laser photometer principle using an Environmental DustTrak Monitoring System coupled with a heated inlet for 5-minute interval data logging over a 7-day continuous sampling period. The photometer uses an ellipsoidal reflector and simple optical components to collect the laser-scattered light and to focus it onto a photodiode array. The mass and particle size are determined by detecting how the particles scatter light. For further details of the Air Quality Monitoring, please refer to Appendix M.

Table 10-2 Baseline Air Quality Monitoring Location

Monitoring Location	Receptor Type	Nearest Construction Worksite Area/Project Footprint	Justification	Photo of Monitoring Location
A01: SUSS	Educational Institution	• CR16 Worksite (Construction) • CR16 Station (Operation)	CR16 is located within the Clementi Forest and in the proximity of Maju Forest. The ambient air quality in the vicinity of CR16 is expected to be affected by traffic along Clementi Road. The ambient air quality on both sides of Clementi Road is expected to be the same. It should also be noted that there are no feasible equipment access points to the Clementi Forest and Maju Forest for the air quality monitoring to be conducted within the Clementi Forest and Maju Forest. Hence, SUSS has been identified as representative monitoring location and this proposed monitoring location captured the ambient air quality levels in the vicinity of the worksite/station, the Maju Forest and the southern part of Clementi Forest.	



Legend

- Air Monitoring Location
- Proposed CRL Alignment (Base)
- Base Scenario Construction Worksite Footprint
- Old Jurong Railway Corridor
- Study Area (Air Quality)
- Biodiversity Study Area

Rev.	Date	By	Description	Chk'd	App'd
-	MAY 2022	HHL	EIS (Clementi Forest and Maju Forest)	NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title :
CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (CLEMENTI FOREST AND MAJU FOREST)

Figure Title :
BASELINE AIR QUALITY MONITORING LOCATION

Designed	Checked	Approved
ASH	NHT	JAG
	Drawn: HHL	Date: MAY 2022

Figure No. : 10-3 | Rev. : - | Sheet : 1 of 1

CAD File Name : | A3

Note: Source of basemap - OneMap

10.2.3 Prediction and Evaluation of Impact Assessment

The air quality impact assessment includes evaluation of air quality impacts from construction and operational activities.

10.2.3.1 Construction Phase

Air quality impacts were assessed using the methodology outlined in the document entitled “Guidance on the Assessment of Dust from Demolition and Construction” which was published by the UK IAQM in 2014 for impacts during construction phase. This methodology has been adapted to the general methodology outlined in this EIS.

10.2.3.1.1 *Identification of Potential Sources of Air Quality Impacts*

It is important to identify potential sources of air quality impact in the vicinity of the Study Area. While conducting the assessment, a typical construction machinery was assumed to be used during the construction equipment and activities. For air quality impacts, only above-ground areas were assessed. These have been detailed in Section 10.3.1.

10.2.3.1.2 *Identification of Sensitive Receptors*

Identification of Air Sensitive Receptors (ASRs) in the Study Area in the vicinity of above-ground construction footprint was subsequently undertaken. IAQM identifies an entire area around one continuous stretch of construction footprint as a category or sensitive receptor. It does not distinguish between each unit, household or block present in the area as a separate ASR but designates the whole area as same category of sensitivity based on an overall location, number, proximity and scale to the construction activity. This approach thereby adopts a conservative principle to air quality. Further discussion on Receptor Sensitivity is presented in Section 10.4.1.

Sensitive areas identified as Priority 1, Priority 2, and Priority 3 for air quality during the screening process have been examined in the Impact Assessment in this EIS in order to provide a more refined classification for Receptor Sensitivity. Sensitivity of the area has been determined based on the usage, number of receptors, distance from the construction footprint, and the current context of sensitive buildings in Singapore.

10.2.3.1.3 *Understanding of Baseline Air Quality*

Primary and secondary data were collected to understand the baseline air quality of the Study Area. NEA’s PSI data available from the nearest monitoring station were also reviewed for the Study Area. In addition, baseline air quality data were collected for representative location near the construction footprint. The baseline air quality review and data measured was discussed in Section 10.5.1.

10.2.3.1.4 *Impact Intensity Definition*

The impact intensity was determined by reviewing the scale of construction activities and classifying them as Low, Medium or High. The IAQM Guidance document provides example definitions for determining impact intensity for earthworks (based on construction footprint, heavy duty vehicles movement, formation of bunds, and material moved), for construction (based on total building volume, on-site concrete batching), for trackout (based on heavy duty vehicle outward movement, surface material, and unpaved road lengths), and for demolition (based on total demolition volume, construction material, on-site crushing of material, and height of demolition activity). The definition of parameters was defined in Table 6-5 in Section 6.4.2.1. It should be noted that in each case, not all criteria need to be met and that determination of magnitude is also based on the professional judgment of the air quality consultant. If the areas around the construction footprint are rated as High for one activity and Medium or Low for the other activities, the overall impact intensity result is classified as High for that site as those multiple activities may be occurring concurrently.

10.2.3.1.5 *Classification of Overall Consequence*

The dust impact assessment therefore evaluated the overall consequence prior to the implementation of mitigation. The worksite has been assessed by considering both the impact intensity and the Receptor Sensitivity to obtain an overall consequence rating. Since the definition of impact intensity is different for each activity, the overall consequence for each activity was explained in matrices shown in Table 10-3 to Table 10-6. Each activity for the worksite has been rated as being High, Medium, Low, or Imperceptible in terms of overall consequence based upon pre-mitigation measures but with incorporation of minimum controls.

Table 10-3 Overall Consequence of the Air Impact Analysis (Earthworks)

Receptor Sensitivity / Impact Intensity	Priority 3	Priority 2	Priority 1
Negligible	-	-	-
Low	Imperceptible	Low	Low
Medium	Low	Medium	Medium
High	Low	Medium	High

Table 10-4 Overall Consequence of the Air Impact Analysis (Construction)

Receptor Sensitivity / Impact Intensity	Priority 3	Priority 2	Priority 1
Negligible	-	-	-
Low	Imperceptible	Low	Low
Medium	Low	Medium	Medium
High	Low	Medium	High

Table 10-5 Overall Consequence of the Air Impact Analysis (Trackout)

Receptor Sensitivity / Impact Intensity	Priority 3	Priority 2	Priority 1
Negligible	-	-	-
Low	Imperceptible	Imperceptible	Low
Medium	Low	Low	Medium
High	Low	Medium	High

Table 10-6 Overall Consequence of the Air Impact Analysis (Demolition)

Receptor Sensitivity / Impact Intensity	Priority 3	Priority 2	Priority 1
Negligible	-	-	-
Low	Imperceptible	Low	Medium
Medium	Low	Medium	Medium
High	Medium	High	High

10.2.3.1.6 *Establishing Impact Significance*

Impact Significance was evaluated by considering both the overall Consequence and the Likelihood of occurrence of significant adverse impacts. The Likelihood of occurrence was defined as unlikely, rare, occasional, regular, and continuous as per criteria listed in Table 6-7. Impact Significance has been evaluated in accordance with the matrix presented below in Table 10-7. The IAQM methodology does not differentiate between imperceptible and very low Consequences, due to the nature of air impacts as perceived by humans. In order to align the IAQM methodology with the methodology of this Report, imperceptible and very low Consequences were consolidated.

Table 10-7 Impact Significance Matrix for Air Quality

Likelihood \ Consequence	Imperceptible/Very Low	Low	Medium	High
Unlikely	Negligible	Negligible	Negligible	Negligible
Rare	Negligible	Minor	Minor	Minor
Occasional	Minor	Minor	Moderate	Moderate
Regular	Minor	Moderate	Moderate	Major
Continuous	Minor	Moderate	Major	Major

10.2.3.1.7 *Mitigation Measures Recommendations*

Mitigation measures were proposed for implementation when the Impact Significance is predicted to be Moderate or Major. Where mitigation measures are required, specific mitigation measures have been proposed based on the level of overall Consequence (High, Medium, and Low) as per the IAQM guidance. This is the most efficient way of prescribing dust mitigation measures so that high Consequence areas have the most comprehensive mitigation measures implemented whilst avoiding unnecessary implementation of complex mitigation measures in low Consequence areas.

10.2.3.1.8 *Establishing Residual Impact Significance*

Following implementation of mitigation measures prescribed in the EIS at the proposed construction footprint, the residual Impact Significance was evaluated using the matrix outlined in Table 10-7. Ideally, the mitigation measures required should be specified within the conditions given for planning permission and should be stipulated in construction contracts.

10.2.3.2 Operational Phase

This methodology below has been used to assess the air quality impact during operational phase of the Project.

10.2.3.2.1 *Identification of Potential Sources of Air Quality Impacts*

It is important to identify potential sources of air quality impact in the vicinity of the Study Area. While conducting the assessment, an increase in traffic volume in the vicinity of the Project during operational phase was assumed. These have been detailed in Section 10.3.2.

10.2.3.2.2 *Identification of Sensitive Receptors*

Identification of Air Sensitive Receptors (ASRs) in the Study Area within 250m around the Project footprint was subsequently undertaken. Further discussion on Receptor Sensitivity is presented in Section 10.4.2.

Sensitive areas identified as Priority 1, Priority 2, and Priority 3 for air quality during the screening process have been examined in the Impact Assessment in this EIS in order to provide a more refined classification for Receptor Sensitivity. Sensitivity of the area has been determined based on the usage and the current context of sensitive buildings in Singapore.

10.2.3.2.3 *Understanding of Baseline Air Quality*

Primary and secondary data were collected to understand the baseline air quality of the Study Area. NEA's PSI data available from the nearest monitoring station were also reviewed for the Study Area. In addition, baseline air quality data were collected for representative location near the Project footprint. The baseline air quality review and data measured was discussed in Section 10.5.1.

10.2.3.2.4 *Impact Intensity Definition*

The impact intensity was determined by reviewing the scale of increase in air quality levels due to traffic volume increase in the vicinity of the Project footprint by comparing the baseline and predicted traffic volume. The impact intensity was then classified as Low, Medium or High.

10.2.3.2.5 *Classification of Overall Consequence*

The air quality impact assessment therefore evaluated the overall consequence prior to the implementation of mitigation. The worksite has been assessed by considering both the impact intensity and the Receptor Sensitivity to obtain an overall consequence rating. The overall consequence has been rated as being High, Medium, Low, or

Imperceptible in terms of overall consequence based upon pre-mitigation measures but after incorporation of minimum controls.

10.2.3.2.6 *Establishing Impact Significance*

Impact Significance was evaluated by considering both the overall Consequence and the Likelihood of occurrence of significant adverse impacts. The Likelihood of occurrence may be defined as unlikely, rare, occasional, regular, and continuous as per criteria listed in Table 6-7. Impact Significance has been evaluated in accordance with the matrix presented in Table 10-7.

10.2.3.2.7 *Mitigation Measures Recommendations*

Mitigation measures were proposed for implementation when for Moderate or Major Impact Significance.

10.2.3.2.8 *Establishing Residual Impact Significance*

Following implementation of mitigation measures prescribed in the EIS at the proposed Project footprint, the residual Impact Significance was evaluated using the matrix outlined in Table 10-7. Ideally, the mitigation measures required should be specified within the conditions given for planning permission and should be stipulated in construction contracts.

10.3 Potential Sources of Air Quality Impacts

Fugitive particulate emissions from construction and operational activities (base scenario) have the potential to result in adverse impacts on air quality and therefore, public and ecosystem health. Particulate emissions may also generate significant nuisance to receptors near the heavy use construction footprint.

10.3.1 Construction Phase

Dust generated during construction works can have adverse effects upon vegetation restricting photosynthesis, respiration and transpiration. Furthermore, it can lead to phytotoxic gaseous pollutants penetrating the plants. The overall effect can be a decline in plant productivity, which may then have indirect effects on the quality of the affected habitats and associated fauna. Table 10-8 listed potential sources of air quality impact during construction phase of the Project.

Table 10-8 Potential Air Quality Impacts during the Construction Stage

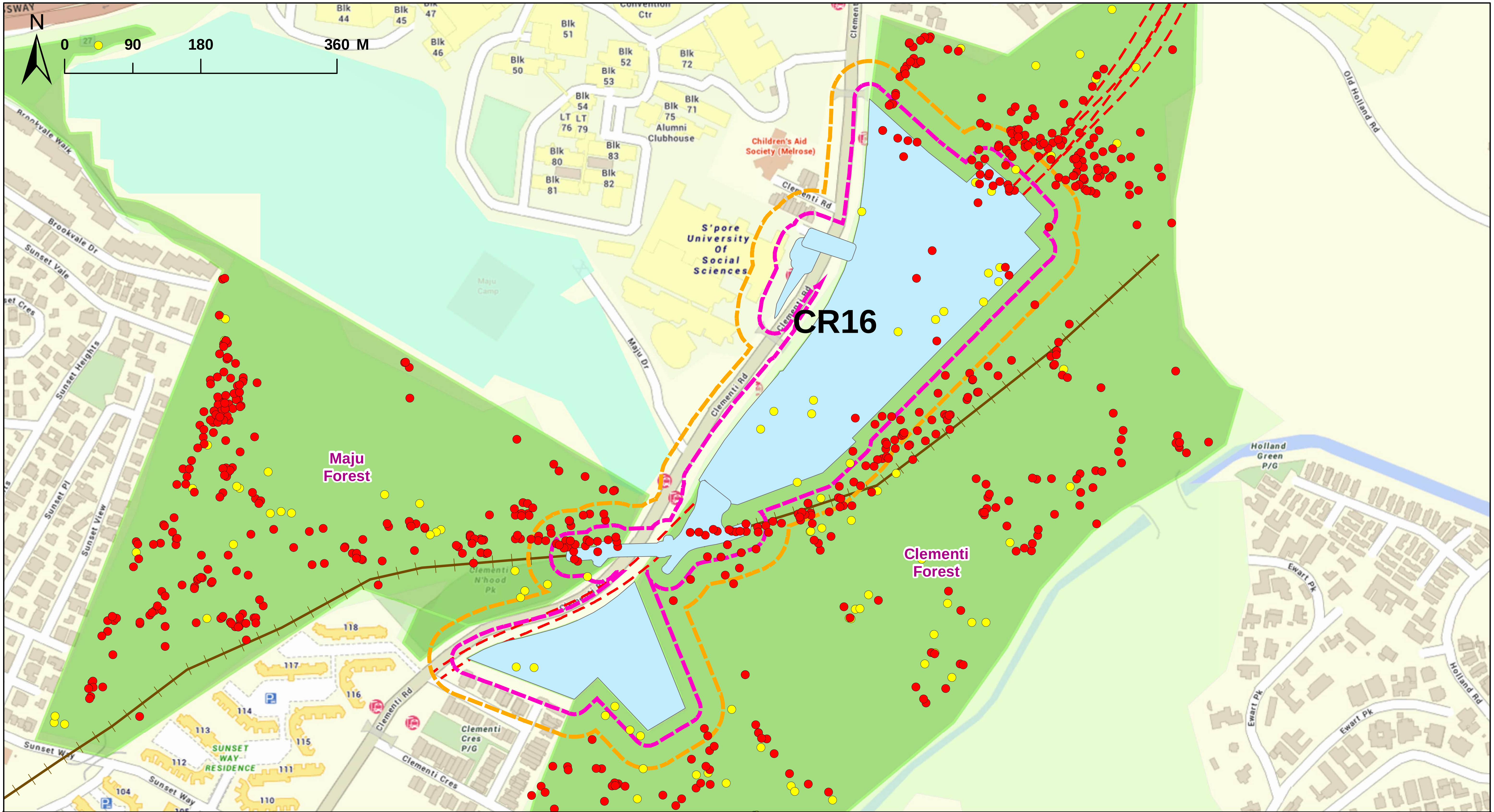
Potential Source of Impacts	Potential Associated Impacts
Dust emissions generated by earthworks processes, including land clearance, soil-stripping, ground levelling, excavation, stockpiling of spoil and landscaping at CR16 worksite.	Dust emissions could potentially result in adverse impacts on air quality and public health and may also generate significant nuisance at receptors, including the biodiversity, located nearby heavy construction worksite areas.
Dust emissions generated by the construction of new structures, such as the station box and ventilation shafts	Dust emissions could potentially result in adverse impacts on air quality and public health and may also generate significant nuisance at receptors, including the biodiversity, located nearby heavy construction worksite areas.
Dust emissions generated from the concrete batching plant within CR16 worksites, including its associated activities such as loading and unloading activities, material handling, transfer conveyors, storage, and stockpiles.	Dust emissions could potentially result in adverse impacts on air quality and public health and may also generate significant nuisance at receptors, including the biodiversity, located nearby heavy construction worksite areas.
Dust emissions from transport of dust and dirt by dumper trucks for transporting spoil within the site and from the site onto public road network, where it may be deposited and resuspended by vehicles using the network.	Dust emissions could potentially result in adverse impacts on air quality and public health and may also generate significant nuisance at receptors nearby haulage routes.

Potential Source of Impacts	Potential Associated Impacts
Gaseous emissions from vehicle exhaust due to movement of construction vehicles and equipment, including spoil disposal	Exhaust emissions (NO_2, SO_2, CO, PM_{10} and $PM_{2.5}$) could potentially impact the air quality in the vicinity of construction worksites.
Gaseous emissions from off-road diesel engines on-site such as generators, if any	Exhaust emissions (NO_2, SO_2, CO, PM_{10} and $PM_{2.5}$) could potentially impact the air quality in the vicinity of construction worksites.

This area has been referred as earthworks footprint (refer to Figure 10-4 for CR16). The earthworks activity includes some extent of soil-cutting, excavation, piling and excavation works, while the construction activity includes the construction of the proposed buildings. As per the information received from LTA, it is assumed that the spoil amount will be greater than 100,000 tonnes for CR16 construction worksite area. At any one time, it is also assumed that 5-10 heavy machineries will be moving within the earthwork footprint.

The worst-case emission source for construction has been assumed to comprise the whole station and entrances footprint planned for development. This area has been referred as construction footprint (refer to Figure 10-5). Due to the high amount of concrete required for station construction, 1 concrete batching plant will be located within CR16 construction worksite area. In line with the IAQM Guidance, the dust emission expected from the concrete batching plant was qualitatively assessed as part of the construction activity. Demolition worksite for the POB has also been considered in the assessment.

The trucks carrying spoil to and from the construction footprint on access roads are also considered as a potential source of emission (referred to as trackout activity) as shown in Figure 10-6. Based on the earthwork footprint for each construction worksite area, the number of outward trucks movement has been conservatively assumed to be >50 HDVs per day for CR16 construction worksite area. The road construction works are expected to be completed and paved before the construction of other development commences. This is to ensure that the potential access roads are not significant dust generation sources. Impact prediction and evaluation were detailed in Section 10.7.1.



Legend

- Species of Conservation Significance
- Large Specimens
- Earthworks Footprint
- 20m from Source
- 50m from Source
- Proposed CRL Alignment (Base)
- Old Jurong Railway Corridor
- Biodiversity Study Area

Rev.	Date	By	Description	Chk'd	App'd
-	MAY 2022	HHL	EIS (Clementi Forest and Maju Forest)	NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

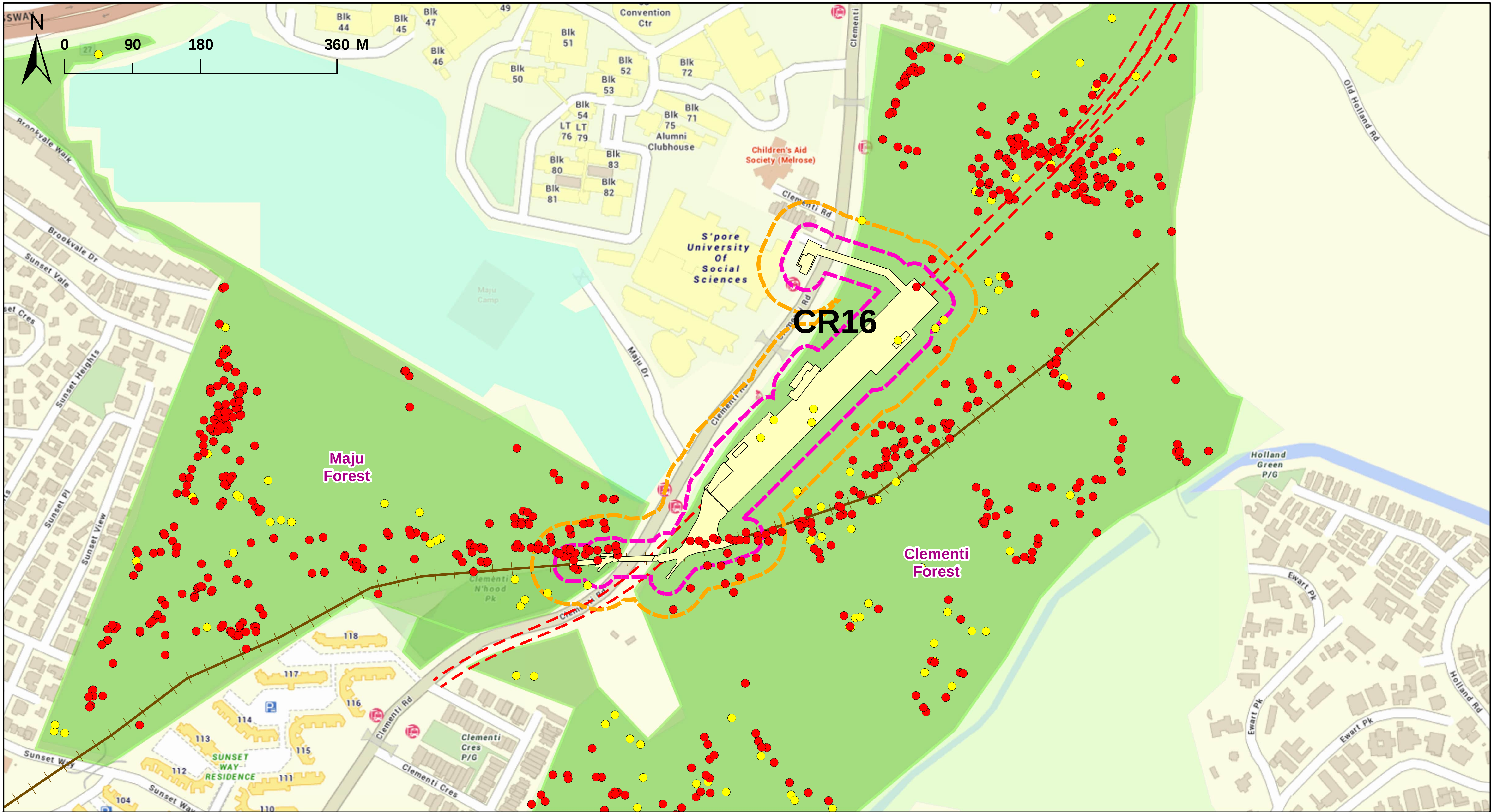
Land Transport Authority
We Keep Your World Moving

Project Title :
CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (CLEMENTI FOREST AND MAJU FOREST)

Figure Title :
CR16 BASE CASE EMISSION SOURCES AND RECEPTORS (EARTHWORKS)

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
ASH	NHT	JAG	10-4	-	1 of 1
	Drawn HHL	Date MAY 2022	CAD File Name :		A3

Note: Source of basemap - OneMap



Legend

- Species of Conservation Significance
- Large Specimens
- Construction Footprint
- 20m from Source
- 50m from Source
- Proposed CRL Alignment (Base)
- Old Jurong Railway Corridor
- Biodiversity Study Area

Rev.	Date	By	Description	Chk'd	App'd
-	MAY 2022	HHL	EIS (Clementi Forest and Maju Forest)	NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

Land Transport Authority – We Keep Your World Moving

Project Title :

CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (CLEMENTI FOREST AND MAJU FOREST)

Figure Title :

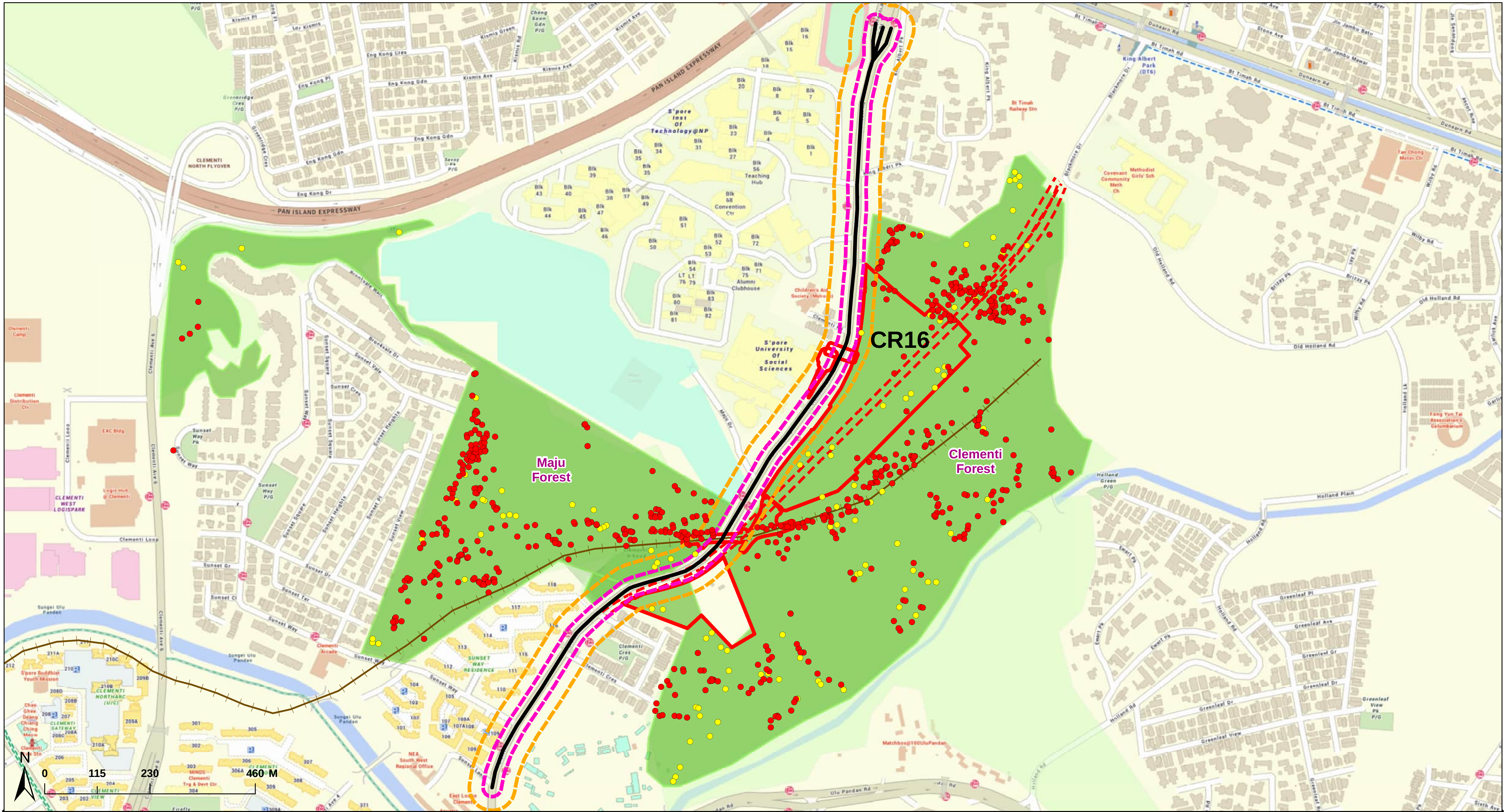
CR16 BASE CASE EMISSION SOURCES AND RECEPTORS (CONSTRUCTION)

Designed	Checked	Approved	Drawn	Date	Figure No.	Rev.	Sheet
ASH	NHT	JAG	HHL	MAY 2022	10-5	-	1 of 1

CAD File Name :

A3

Note: Source of basemap - OneMap



Legend

- Species of Conservation Significance
- Large Specimens
- Potential Access Road
- 20m from Source
- 50m from Source
- Proposed CRL Alignment (Base)
- Base Scenario Construction Worksite Footprint
- Old Jurong Railway Corridor
- Biodiversity Study Area

Rev.	Date	By	Description	Chk'd	App'd
-	MAY 2022	HHL	EIS (Clementi Forest and Maju Forest)	NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title :

CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (CLEMENTI FOREST AND MAJU FOREST)

Figure Title :

CR16 BASE CASE EMISSION SOURCES AND RECEPTORS (TRACKOUT)

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
ASH	NHT	JAG	10-6	-	1 of 1
	Drawn: HHL	Date: MAY 2022	CAD File Name : NA		A3

Note: Source of basemap - OneMap

10.3.2 Operational Phase

During operational phase, since the trains are powered by electricity, they do not emit air emissions as a direct impact to environment through the vent shafts. Hence, as presented in Table 10-9, potential air quality impact during operational phase of the Project would be vehicular emissions due to increased traffic in the vicinity of the Project.

The main air pollutants affecting vegetation and ecosystems are nitrogen oxides (NOx), sulphur dioxide (SO_2) and ammonia (NH_3) [R-48]. In the context of this Project, the air pollutant of concern will be NOx which are produced from road traffic emission. SO_2 is not relevant for this Project as low sulphur content fuel will be used. NH_3 is mainly produced from agricultural activities and therefore, not relevant for the purpose of this Project. There is no published evidence for any direct toxic effect of NOx on animals and therefore effects on animals are not included in ecological impact assessment [R-48].

As per the NEA website, since 1 September 2017, all new petrol vehicles have had to meet the Euro 4 emission standard, and since 1 January 2018, all new diesel vehicles have had to meet the Euro 6 emission standard. The new standards will tighten fine particulate emissions from direct-injection petrol engines in addition to the other pollutants. Since 1 January 2018, the emission standard for all three-wheeled (Cat L5e) and large motorcycles with an engine capacity more than 200cc has been tightened to Euro 4 standard, while smaller motorcycles with an engine capacity of 200cc and below will see the Euro 4 emission standard implemented from 1 January 2020. Compared to the Euro 3 emission standard, the tighter Euro 4 emission standard will help reduce emissions of hydrocarbons and nitrogen oxides (NOx), which are precursors to ozone. The emission standards for various vehicle classes have been summarised in Table 10-10.

Table 10-9 Potential Air Quality Impacts during the Operational Stage

Potential Source of Impacts	Potential Associated Impacts
Gaseous and particulate emissions from vehicle exhaust due to the increased traffic in vicinity of CR16 station due to Project operation.	Exhaust emissions (NO_2, SO_2, CO, PM_{10} and $PM_{2.5}$) could potentially impact the air quality in the vicinity of the vent shafts.

Table 10-10 Emission Standard of Various Vehicle Classes

No	Implementation Date	Vehicle Classes	Emission Standard
1	1 September 2017	New petrol vehicles	Euro 6
2	1 January 2018	New diesel vehicles	Euro 6
3	1 January 2018	Three-wheeled (Cat L5e) and large motorcycles with engine capacity more than 200cc	Euro 4
4	1 January 2020	Smaller motorcycles with engine capacity of 200cc and below	Euro 4

10.4 Identification of Air Sensitive Receptors

10.4.1 Construction Phase

The construction activities at the construction worksite pose a potential risk of dust emissions that may impact upon target habitat areas lying within the zone of influence of the construction site. In line with the IAQM Guidance, a Study Area of 50 m was considered for ecological impacts during construction phase. Table 10-11 below summarises the sensitivity for earthworks, construction, demolition, and trackout at CR16 construction worksite. The CR16 construction worksite is located within the ecologically sensitive receptor.

Based on the distances of emission sources to the identified receptors presented in Figure 10-4 to Figure 10-6, the Sensitivity of the Area was determined to be Priority 1. In line with the IAQM Guidance, Priority 1 refers to construction worksite with emission source located <20m to the nearest ecologically sensitive receptors. No areas classified as Priority 2 or Priority 3 are identified within the Study Area. Flora species of high value identified within the air quality Study Area are presented in Table 10-12.

Table 10-11 Receptor Sensitivity for Air Quality Impact Assessment – Construction Phase

Distance	Identified Receptors	Sensitivity of the Area
CR16 CONSTRUCTION WORKSITE		
For Earthworks:		
Within 20m	Clementi Forest Maju Forest Old Jurong Railway Corridor	Priority 1
Between 20m to 50m	Clementi Forest Maju Forest Old Jurong Railway Corridor	
For Construction:		
Within 20m	Clementi Forest Maju Forest Old Jurong Railway Corridor	Priority 1
Between 20m to 50m	Clementi Forest Maju Forest Old Jurong Railway Corridor	
For Trackout:		
Within 20m	Clementi Forest Maju Forest Old Jurong Railway Corridor	Priority 1
Between 20m to 50m	Clementi Forest Maju Forest Old Jurong Railway Corridor	

Table 10-12 Flora Species of High Value Identified within the Air Quality Study Area

Distance	Identified Species	Status	Number of Species Identified
MAJU FOREST: Dominated by abandoned-land forest, and scrubland and herbaceous vegetation			
Conservation Species			
Within 20m from Worksite	*Alsophila latebrosa* *Amphineuron opulentum* *Callicarpa longifolia*	Vulnerable Endangered Endangered	7 1 1
Between 20m to 50m from Worksite	*Alsophila latebrosa* *Callicarpa longifolia* *Guioa pubescens* *Litsea firma* *Lygodium longifolium* *Uncaria longiflora* var. *pteropoda*	Vulnerable Endangered Vulnerable Vulnerable Vulnerable Critically Endangered	10 2 1 1 1 1
Large Specimens			
Within 20m from Worksite	-	-	-
Between 20m to 50m from Worksite	*Samanea saman*	Casual	1
CLEMENTI FOREST: Dominated by abandoned-land forest, and scrubland and herbaceous vegetation			
Conservation Species			

Distance	Identified Species	Status	Number of Species Identified
Within 20m from Worksite	*Alsophila latebrosa* *Centotheca lappacea* *Chassalia curviflora* *Ficus aurata* var. *aurata* *Macaranga hullettii* *Selaginella argentea* *Streblus elongatus* *Symplocos fasciculata* *Tetracera fagifolia*	Vulnerable Critically Endangered Endangered Vulnerable Critically Endangered Critically Endangered Vulnerable Vulnerable Vulnerable	4 1 1 1 1 1 1 1 1
Between 20m to 50m from Worksite	*Alsophila latebrosa* *Ampelocissus gracilis* *Angiopteris evecta* *Bridelia stipularis* *Centotheca lappacea* *Dienia ophrydis* *Ficus aurata* var. *aurata* *Ficus vasculosa* *Macaranga griffithiana* *Macaranga hullettii* *Oxyceros longiflorus* *Phytocrene bracteate* *Piper pedicellosum*	Vulnerable Endangered Vulnerable Vulnerable Critically Endangered Critically Endangered Vulnerable Endangered Vulnerable Critically Endangered Vulnerable Vulnerable Critically Endangered	21 1 5 1 1 2 6 1 1 1 1 1 1
Large Specimens			
Within 20m from Worksite	*Bambusa heterostachya* *Bambusa vulgaris* *Ficus elastica* *Ficus microcarpa* *Hevea brasiliensis* *Terminalia catappa*	Casual Casual Casual Common Naturalised Common	2 3 3 1 1 1
Between 20m to 50m from Worksite	*Bambusa vulgaris* *Ficus elastica* *Terminalia catappa*	Casual Casual Common	1 1 1

10.4.2 Operational Phase

Potential air quality impact during operational phase of the Project would be vehicular emissions due to increased traffic to the proposed development. Project footprint (i.e. station box and entrances) is located within or in the vicinity of ecologically sensitive receptors. Nearest sensitive receptors which might be impacted by the increased traffic are summarised in Table 10-13 below. As the Project is located within or in the vicinity of ecologically sensitive receptors, the Sensitivity of the Area was determined to be Priority 1.

Table 10-13 Receptor Sensitivity for Air Quality Impact Assessment – Operational Phase

Project Footprint	Identified Receptors	Sensitivity of the Area
CR16	1. Clementi Forest 2. Maju Forest 3. Old Jurong Railway Corridor	Priority 1

10.5 Baseline Air Quality

10.5.1 Baseline Monitoring Results

10.5.1.1 Secondary Data Collection (Review of Background Data)

10.5.1.1.1 *NEA Long Term Ambient Air Quality*

Table 10-14 provides the general NEA ambient air monitoring results for Singapore over the period 2015 – 2019 and compares them with the Singapore Long Term Ambient Air Quality Targets. The Singapore Long Term Air Quality Targets have been adopted in this Report and are generally more stringent than the USEPA National Ambient Air Quality Standards (NAAQS).

It can be observed from Table 10-14 that the NEA monitoring results for background particulate matter less than 10 µm (PM_{10}), particulate matter less than 2.5 µm ($PM_{2.5}$), and ozone (O_3) have consistently exceeded the Singapore Long Term Air Quality Targets over the period 2015 – 2019. Carbon monoxide (CO) and nitrogen dioxide (NO_2) were below the Singapore Ambient Air Quality Long Term Targets between 2015 – 2019. The elevated PM_{10}, $PM_{2.5}$, and O_3 concentrations in Singapore are partly attributable to the intermittent haze periods resulting from forest fires in neighbouring countries, although other significant contributors to the background levels may also be domestic emissions from industries, shipping and motor vehicles.

Table 10-14 NEA Long Term Ambient Air Quality Monitoring [R-47]

Pollutants	Averaging Period	2015 results (µg/m³)	2016 results (µg/m³)	2017 results (µg/m³)	2018 results (µg/m³)	2019 results (µg/m³)	Average results 2015 – 2019 (µg/m³)	Singapore Ambient Air Quality Long Term Targets (µg/m³)
PM_{10}	99th %ile of 24-Hour Averages	**186**	**61**	**57**	**59**	**90**	**90.6**	50
	Annual Mean	**37**	**26**	**25**	**29**	**30**	**29.4**	20
$PM_{2.5}$	99th %ile of 24-Hour Averages	**145**	**40**	**34**	**32**	**62**	**62.6**	25
	Annual Mean	**24**	**15**	**14**	**15**	**16**	**16.8**	10
CO	Maximum 1-Hour Average	3,500	2,700	2,300	2,500	2,300	2,700	30,000
	Maximum 8-Hour Average	3,300	2,200	1,700	2,000	1,700	2,200	10,000
NO_2	Maximum 1-Hour Average	99	123	158	147	156	136.6	200
	Annual Mean	22	26	25	26	23	24.4	40
SO_2	24-Hour Average	**75**	**61**	**59**	**65**	**57**	**63.4**	50
O_3	8-Hour Average	**152**	**115**	**191**	**150**	**125**	**146.6**	100

Pollutants	Averaging Period	2015 results (µg/m³)	2016 results (µg/m³)	2017 results (µg/m³)	2018 results (µg/m³)	2019 results (µg/m³)	Average results 2015 – 2019 (µg/m³)	Singapore Ambient Air Quality Long Term Targets (µg/m³)
Note: Values in **Bold** exceed the Singapore Ambient Air Quality Long Term Targets								

10.5.1.1.2 *Hourly Pollution Standard Index (PSI) and 24-hour PM_{10} and $PM_{2.5}$ Concentrations Readings*

According to NEA's website [W-45], PM_{10} and $PM_{2.5}$ data are subsumed into PSI. Hourly historical PSI, 24-hr PM_{10} and $PM_{2.5}$ readings available on data.gov.sg for Central and West Region of Singapore were collected during primary data collection period for comparison against primary baseline monitoring results.

Figure 10-7 below shows the variation of hourly historical PSI readings in the West Region of Singapore during the primary data collection period, which was from 11 to 18 March 2020. The hourly PSI readings recorded over these days ranged from 29 to 59. The PSI readings during this period are considered Good to Moderate. Moderate PSI readings were observed on the first day of monitoring which in line with the high PM_{10} and $PM_{2.5}$ monitored concentrations on the first day of primary baseline data collection.

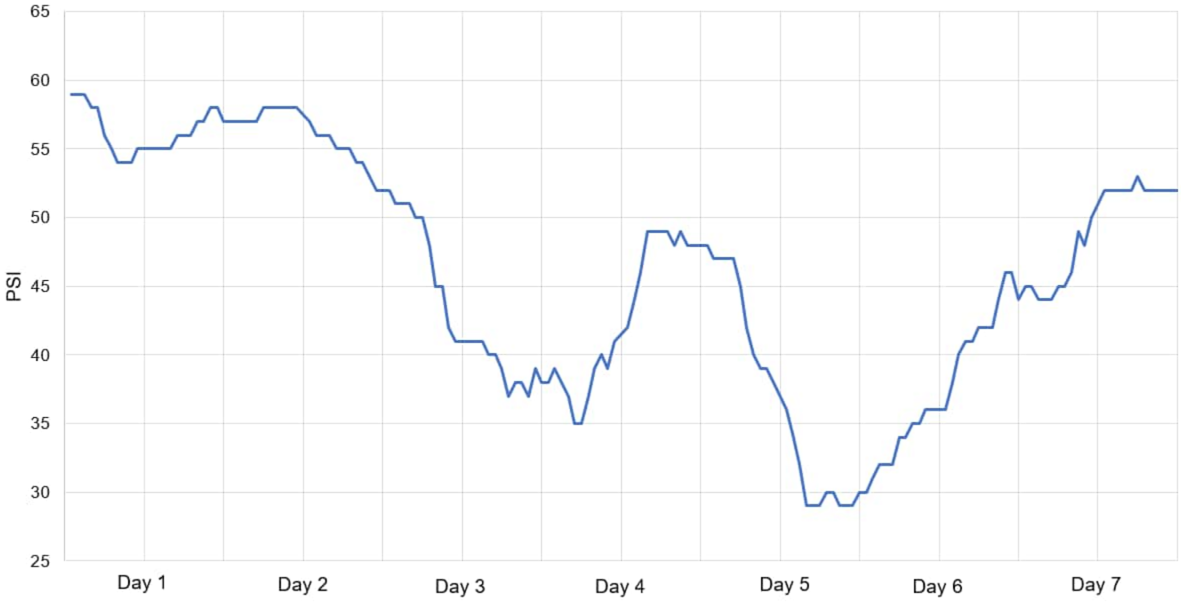


Figure 10-7 Hourly PSI Reading of West Singapore for 11-18 March 2020 [W-46].

Figure 10-8 and Figure 10-9 show the variation of PM_{10} and $PM_{2.5}$ concentrations recorded by the NEA during the primary baseline data collection period for West Singapore. As observed from the figures, both 24-hr PM_{10} and $PM_{2.5}$ concentrations were below the target throughout the monitoring period.

Figure 10-8 24-hr PM$_{10}$ Concentrations of West Singapore for 11-18 March 2020 [W-46].

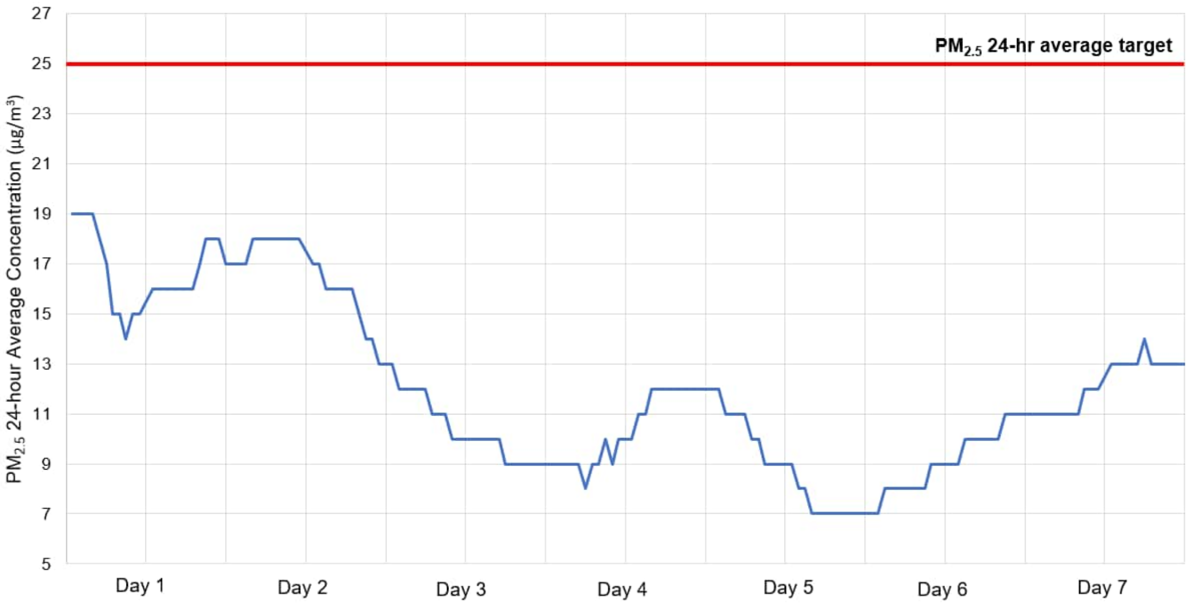


Figure 10-9 24-hr PM$_{2.5}$ Concentrations of West Singapore for 11-18 March 2020 [W-46].

10.5.1.1.3 *Other Parameters (Rainfall, Temperature, Wind Speed)*

Figure 10-10, Figure 10-11, and Figure 10-12 below present the trend of daily total rainfall, mean temperature and mean wind speed observed at Clementi weather monitoring station, from February 2015 to February 2020.

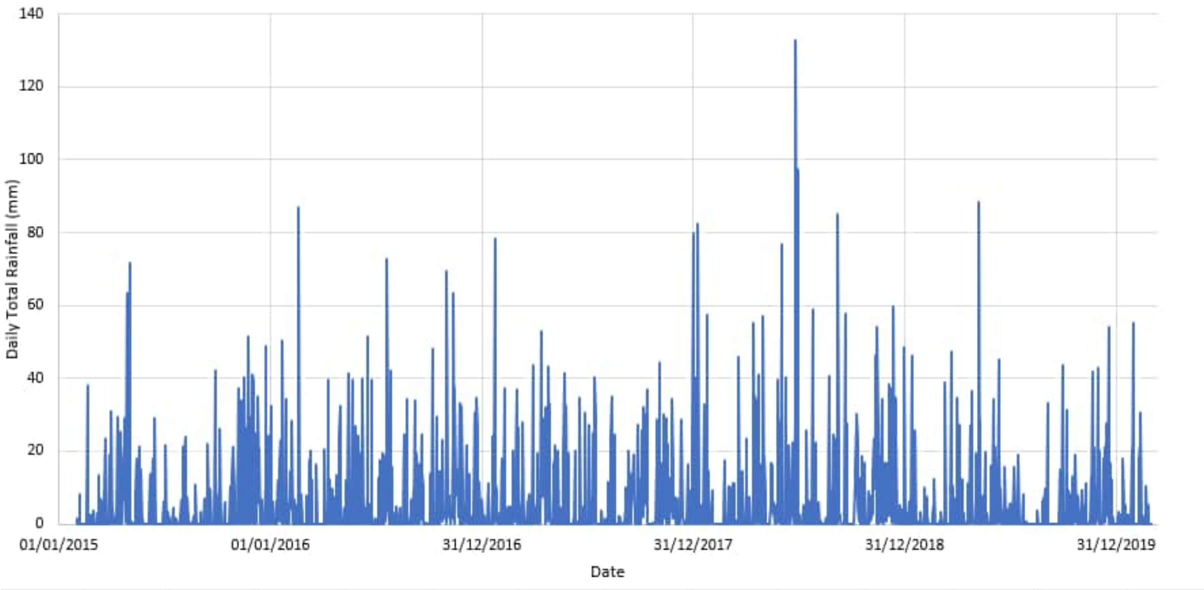


Figure 10-10 Daily Rainfall Monitored at Clementi Monitoring Station [W-44].

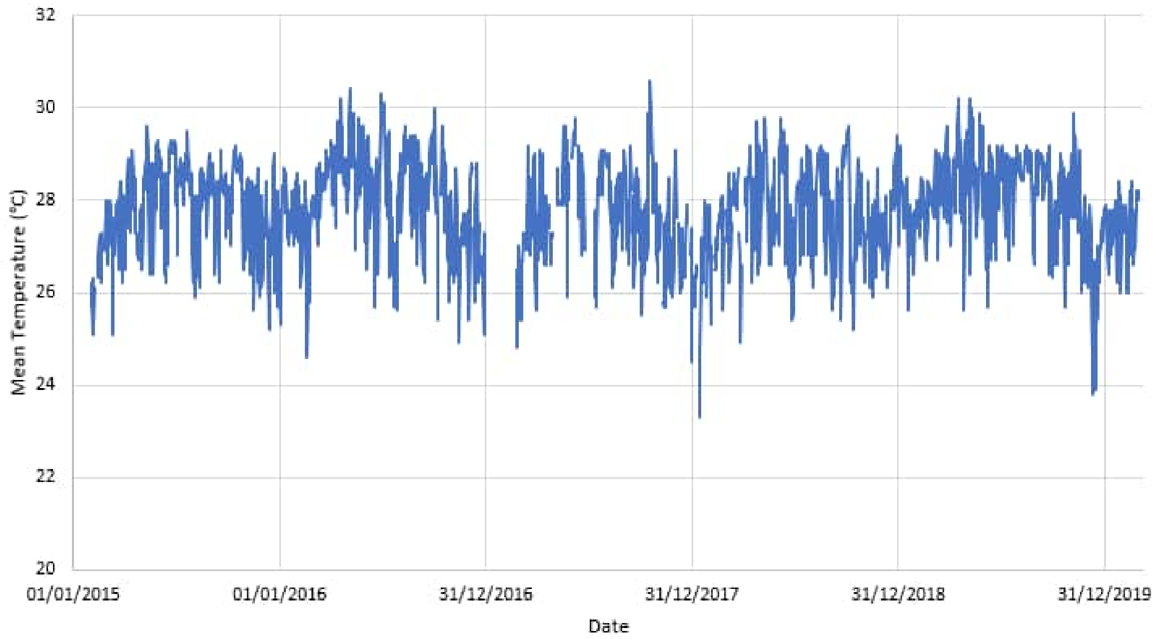


Figure 10-11 Mean Temperature Monitored at Clementi Monitoring Station [W-44].

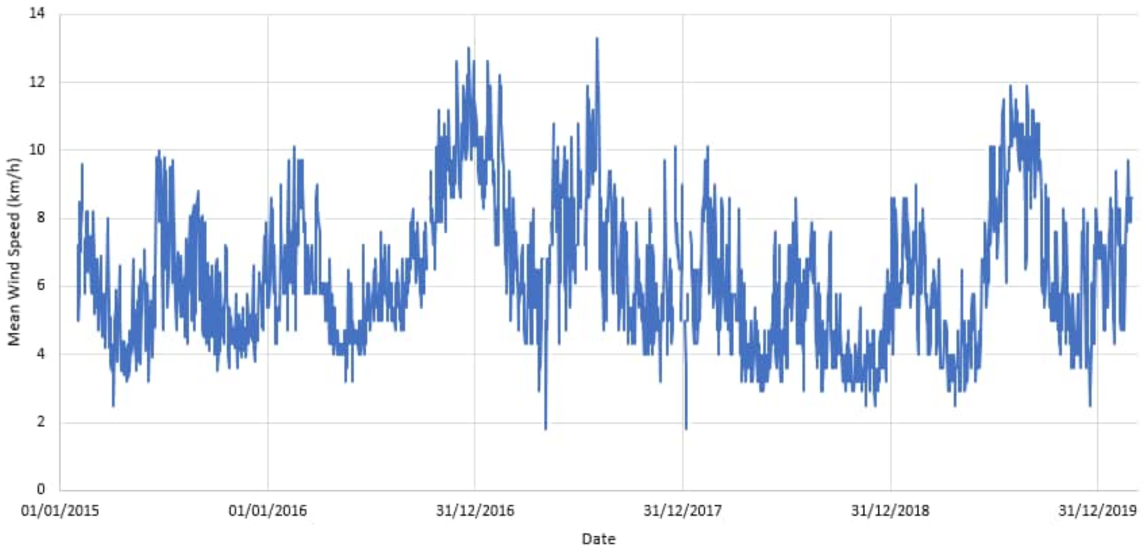


Figure 10-12 Mean Wind Speed Monitored at Clementi Monitoring Station [W-44].

10.5.1.2 Primary Data Collection (Survey & Sampling)

Seven (7) days of continuous ambient air quality monitoring was conducted at the location mentioned above to determine the pollutant concentrations from existing background pollutant sources. The monitoring results for each pollutant at all monitoring locations are summarised in Table 10-15 below and compared with the Singapore Ambient Air Quality Long Term Targets.

Table 10-15 Baseline Air Quality Monitoring Results

Monitoring Location	Monitoring Date	Daily PM_{10} Concentration, µg/m^3			Daily $PM_{2.5}$ Concentration, µg/m^3		
		Average	Max	Min	Average	Max	Min
A01: SUSS	11 – 18 March 2020	17.8	30.1	12.5	14.4	**26.5**	9.4
Singapore Ambient Air Quality Long Term Targets		***50***			***25***		

It can be observed from Table 10-15 that all pollutant concentrations are within the Singapore Ambient Air Quality Long Term Targets at all monitoring locations, except for 1 day at A01 SUSS. The measured value was 26.5µg/m^3, while the target is 25µg/m^3. However, the targets were met for the rest of the week with average daily $PM_{2.5}$ concentration of 14.4µg/m^3 throughout the week.

10.6 Minimum Control for Potential Impacts

10.6.1 Construction Phase

This section proposes minimum controls or standard practices commonly implemented that have been assumed to be implemented for the purposes of impact assessment. The following control measures should be observed during the construction stage to reduce the dust levels:

- The construction footprint will be hoarded on all sides;
- No crushing or screening of demolished construction material will be performed on-site; and
- Road construction will be completed first and paved where possible before the construction of other development commences.

- Implement a wheel washing system (with rumble grids to dislodge accumulated dust and mud prior to leaving the site where reasonably practicable) for local access roads in all construction sites.
- 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.

10.6.2 Operational Phase

No minimum control has been assumed for the purpose of air quality impact assessment during operational phase. Refer to Section 10.7.2 for evaluation of air quality impacts during operational phase.

10.7 Prediction and Evaluation of Air Quality Impacts

10.7.1 Construction Phase

Throughout the study a conservative but credible approach was adopted to assess potential dust impacts. This may lead to an over-estimation of the levels of pollutants that will arise in practice, but this is considered to be appropriate for planning purposes at this stage of the Project and is consistent with precautionary principles.

The assessment is conducted using the site area, hours of operation, timescale of construction, construction material, excavation quantities, surface material and number of vehicles on site as discussed in Section 10.3.1.

Dust from construction sites deposited on vegetation may create ecological stress within the local plant community. During dry periods dust can coat plant foliage adversely affecting photosynthesis and other biological functions. Rainfall removes the deposited dust from foliage and can rapidly leach chemicals into the soil. Large scale construction sites may give rise to dust deposition over an extended period of time and adversely affect vascular plants. Deposition of concrete dust has the potential to increase the surface alkalinity, which in turn can hydrolyse lipid and wax components, penetrate the cuticle, and denature proteins, finally causing the leaf to wilt [P-35]. Dust may affect photosynthesis, respiration, transpiration and allow the penetration of phytotoxic gaseous pollutants [P-28].

In line with the IAQM Guidance, the Impact Intensity was determined by reviewing the scale of construction activities and classifying them as low, medium or high for each activity type (earthworks, construction, and trackout). The amount of dust deposited, and its effects are also dependent upon weather conditions, during wet weather less dust will be generated and that which has been deposited upon foliage is more likely to be washed off. As discussed in Section 10.5.1.1.3, the Project is expected to receive relatively higher rainfall in the long term compared to the other parts of Singapore. Hence, this is expected to help to lessen the intensity of dust generated and deposited upon plant foliage. However, the IAQM methodology does not take into account the rainfall intensity in the Study Area. Therefore, the air quality assessment was expected to be conservative for the purpose of the Project.

The overall Consequence for each activity was classified by considering Impact Intensity with the Receptor Sensitivity. Without any mitigation measures in place, the Likelihood of occurrence of impacts from construction of the Project is classified as Regular as the activity would occur on a regular basis during construction. The Impact Intensity, overall Consequence and Impact Significance are outlined in Table 10-16 to Table 10-18.

Based on the assessment, the unmitigated Impact Significance was predicted to be Moderate to Major for ecological impact. Hence, based on the assessment methodology in Section 10.2.3.1.7, Impact Significance evaluated as Moderate and Major require the adoption of management or mitigation measures.

Table 10-16 Impacts of Dust Risk Assessment – Earthworks (before mitigation)

Construction Worksite	Key Parameter			Impact Assessment				
	Total Site Area (m^2)	No. of Vehicles moving within the site	Total Material Moved (tonnes)	Impact Intensity	Sensitivity of the Area	Overall Consequence/ Dust Risk	Likelihood	Impact Significance
CR16 (Base Scenario)	>10,000	5-10	>100,000	High	Priority 1	High	Regular	Major

Table 10-17 Impacts of Dust Risk Assessment – Construction (before mitigation)

Construction Worksite	Key Parameter			Impact Assessment				
	Total Building Volume (m^3)	Construction Material	No. of concrete batching plant	Impact Intensity	Sensitivity of the Area	Overall Consequence/ Dust Risk	Likelihood	Impact Significance
CR16 (Base Scenario)	25,000-100,000	Concrete	1	Medium	Priority 1	Medium	Regular	Moderate

Table 10-18 Impacts of Dust Risk Assessment – Trackout (before mitigation)

Construction Worksite	Key Parameter			Impact Assessment				
	No. of outward trucks movement per day	Road surface material	Unpaved Road Length (m)	Impact Intensity	Sensitivity of the Area	Overall Consequence/ Dust Risk	Likelihood	Impact Significance
CR16 (Base Scenario)	>50	Non-Dusty	0	High	Priority 1	High	Regular	Major

10.7.2 Operational Phase

During operational phase, since the trains are powered by electricity, they do not emit air emissions as a direct impact to environment through the vent shafts. Thus, as discussed in Section 10.3.2, emissions from vehicle exhaust due to increased traffic to the proposed Project is expected.

NOx can affect plants directly or indirectly. It may directly enter a plant via the stomata, where it has phytotoxic effects. Lower plants such as lichens and bryophytes (including mosses, landworts and hornwarts) are particularly vulnerable to direct exposure to the gases in this way [W-58]. Indirectly, NOx can also deposit onto soil and, following transformation to nitrate, enrich the soil, leading to eutrophication. The effects of elevated NOx concentrations on vegetation can be broadly categorised as [R-49]:

- growth effects: particularly increased biomass, changes in root to shoot ratio and growth of more competitive species, but also including growth suppression of some species;
- physiological effects: e.g. CO_2 assimilation and stomatal conductivity; and
- (bio)chemical effects: e.g. changes in enzyme activity and chlorophyll content (probably through the effects of increased nitrogen).

Indirectly in the long run, accumulation of nitrogen oxides (NOx) via acidic rain causes soil and water to become more acidic and hence, reducing the nutritional value of food sources for fauna [P-72]. There is no published evidence for any direct toxic effect of NOx on animals and therefore effects on animals are not included in ecological impact assessment [R-48].

It is assumed that all new petrol and diesel vehicles will meet Euro VI emission standard, while all motorcycles will meet Euro IV standard going forward and slowly completely convert to these or better standards as they get phased out in 10 years from their onset. Similarly, as observed in Table 10-19, NOx reduction from the last three Euro emission standard tier is 55.56% and 25% for diesel and gasoline passenger cars respectively. Similarly, as observed in Table 10-20, NOx reduction from the last three Euro emission standard tier is approximately 55% and 25% for diesel and gasoline commercial good vehicles respectively across all vehicle categories.

Table 10-19 Euro Emission Standard for Passenger Cars [W-59]

Tier	Approval Date	Emission standard for passenger cars, g/km				
		CO	HC	NOx	HC+NOx	PM
Compression Ignition (Diesel)						
Euro 5a	September 2009	0.50	-	0.18	0.23	0.005
Euro 5b	September 2011	0.50	-	0.18	0.23	0.005
Euro 6	September 2014	0.50	-	0.08	0.17	0.005
Positive Ignition (Gasoline)						
Euro 4	January 2005	1.00	0.10	0.08	-	-
Euro 5	September 2009	1.00	0.10	0.06	-	0.005
Euro 6	September 2014	1.00	0.10	0.06	-	0.005

Table 10-20 Euro Emission Standard for Commercial Good Vehicles [W-59]

Category	Tier	Approval Date	Emission standard for commercial good vehicles, g/km				
			CO	HC	NOx	HC+NOx	PM
Compression Ignition (Diesel)							
N1, Class I ≤ 1305 kg	Euro 5a	September 2009	0.50	-	0.18	0.23	0.005
	Euro 5b	September 2011	0.50	-	0.18	0.23	0.005
	Euro 6	September 2014	0.50	-	0.08	0.17	0.005
	Euro 5a	September 2009	0.63	-	0.235	0.295	0.005

Category	Tier	Approval Date	Emission standard for commercial good vehicles, g/km				
			CO	HC	NOx	HC+NOx	PM
N1, Class II 1305 – 1760 kg	Euro 5b	September 2011	0.63	-	0.235	0.295	0.005
	Euro 6	September 2014	0.63	-	0.105	0.195	0.005
N1, Class III 1760-3500 kg	Euro 5a	September 2009	0.74	-	0.28	0.35	0.005
	Euro 5b	September 2011	0.74	-	0.28	0.35	0.005
	Euro 6	September 2014	0.74	-	0.125	0.215	0.005
N2, 3500 – 12000 kg	Euro 5a	September 2009	0.74	-	0.28	0.35	0.005
	Euro 5b	September 2011	0.74	-	0.28	0.35	0.005
	Euro 6	September 2014	0.74	-	0.125	0.215	0.005
Positive Ignition (Gasoline)							
N1, Class I ≤ 1305 kg	Euro 4	January 2005	1.00	0.10	0.08	-	-
	Euro 5	September 2009	1.00	0.10	0.06	-	0.005
	Euro 6	September 2014	1.00	0.10	0.06	-	0.005
N1, Class II 1305 – 1760 kg	Euro 4	January 2005	1.81	0.13	0.10	-	-
	Euro 5	September 2009	1.81	0.13	0.075	-	0.005
	Euro 6	September 2014	1.81	0.13	0.075	-	0.005
N1, Class III 1760-3500 kg	Euro 4	January 2005	2.27	0.16	0.11	-	-
	Euro 5	September 2009	2.27	0.16	0.082	-	0.005
	Euro 6	September 2014	2.27	0.16	0.082	-	0.005
N2, 3500 – 12000 kg	Euro 5	September 2009	2.27	0.16	0.082	-	0.005
	Euro 6	September 2014	2.27	0.16	0.082	-	0.005

It should also be noted that currently there is a large traffic volume along Clementi Road (CR16 station). Refer to Table 10-21 for 15-min traffic count conducted during peak and off-peak hour on one weekday and one weekend at Clementi Road (both northbound and southbound).

Table 10-21 Vehicular Traffic Volume for Peak and Off Peak Hour

Location	Weekday/ Weekend	Peak Hour			Off Peak Hour		
		Vehicles	Heavy Vehicles	Motor-bikes	Vehicles	Heavy Vehicles	Motor-bikes
Clementi Road	Weekday	1134	100	145	848	137	84
	Weekend	709	51	52	564	64	32

Notes:
- Traffic volume was noted based on 15 minutes duration for each period
- The heavy vehicles included trucks, vans, lorries and buses. Whereas the vehicles included family car, four-wheel car and non-commercial small vehicle
- Vehicular peak hour is defined as 7.30-9.30am and 5-8pm for weekday and 12-2pm for weekday. Off-peak hours are hours other than previously mentioned hours.

The proposed Project has also planned the construction of future roads for maintenance access roads. In principle, an objective of introduction of trains is meant to replace the burden of traffic on roads, and in that sense introduction of CRL Phase 2 is likely to reduce overall traffic on roads at an island wide scale, however locally present traffic near the station is likely to increase. Without any mitigation measures in place, the Likelihood of occurrence of impacts during the operational phase was classified as Regular.

Overall, it seems that given the two factors above (i.e. the implementation of Euro emission standard on new vehicles and current large traffic volume along existing roads), insignificant increase in air quality pollutant levels in the vicinity of proposed Project was expected during the operational phase. The buffer from the neighbouring high ecological sites (i.e. Clementi Forest, Maju Forest) will also help in terms of providing cleaner air from the impact from the vehicles. Some green areas will also not be disturbed as part of the Project. Hence, the Impact Intensity was considered to be Negligible.

As discussed in Section 10.4.2, the Sensitivity of the receptors was classified to be Priority 1. Thus, as per Table 6-6, the Impact Consequence was calculated to be Very Low. Based on the impact significance matrix in Table 10-7, the Impact Significance was predicted to be Minor. No mitigation measures are required during operational phase.

Table 10-22 Impacts of Air Quality Impact Assessment – Operational Phase

Impact Intensity	Sensitivity of the Area	Overall Consequence	Likelihood	Impact Significance
Negligible	Priority 1	Very Low	Regular	Minor

10.8 Recommended Mitigation Measures

10.8.1 Construction Phase

10.8.1.1 Administrative Controls

Based on the assessment in Section 10.7.1, the Impact Significance was determined to be Moderate to Major. In line with the general mitigation measures, the construction worksite areas for CR16 have also been reduced. Refer to Figure 10-13, Figure 10-14 and Figure 10-15 for earthworks, construction and trackout potential emission sources for CR16 Mitigated Scenario worksite area, respectively.

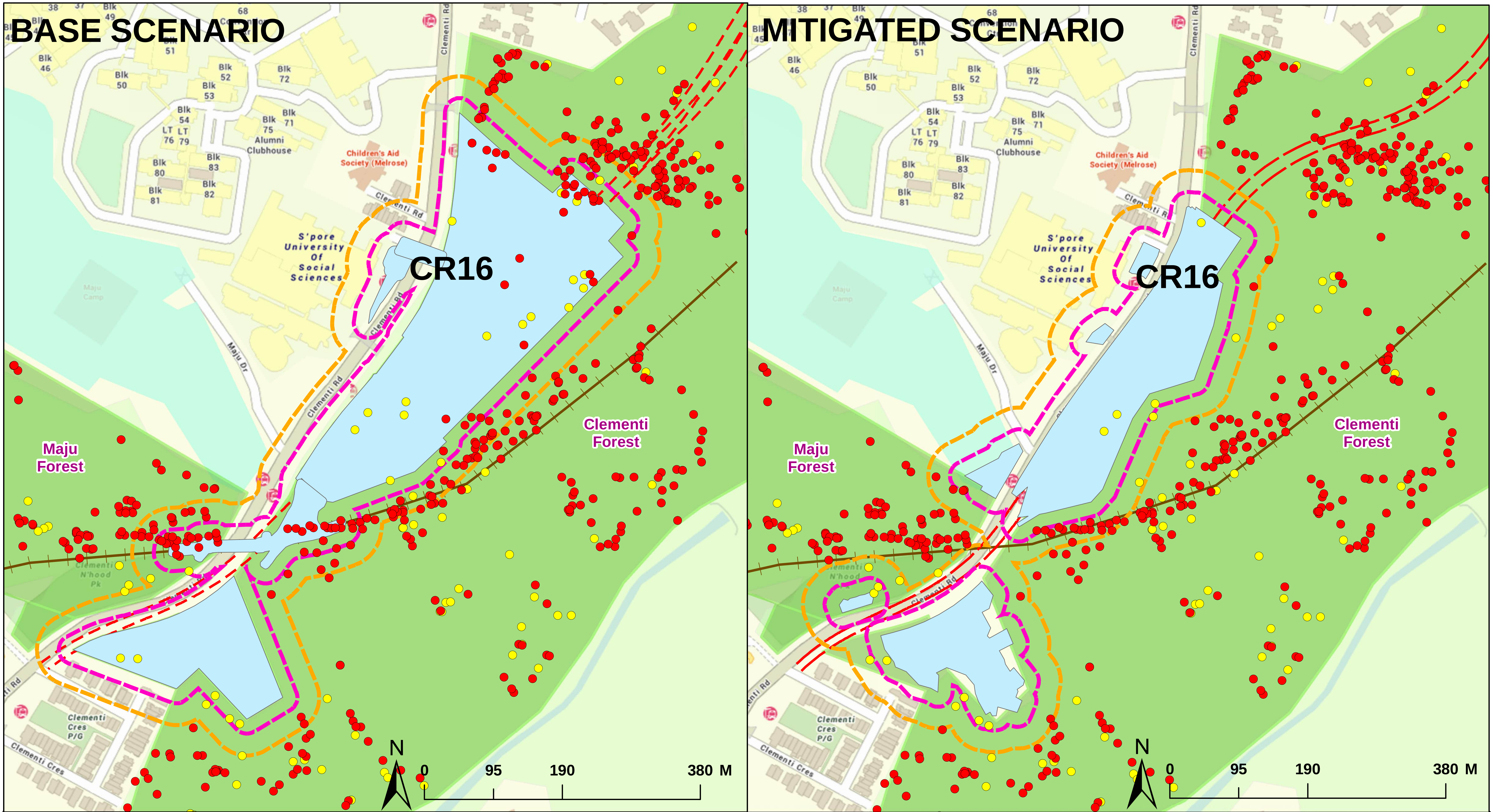
Table 10-23 below summarises the sensitivity of each construction phase for earthworks, construction, and trackout for each construction worksite comparing base and mitigated scenario. All construction worksites are located within or in close proximity to ecologically sensitive receptors. Based on the distances of emission sources to the identified receptors presented in Figure 10-13 to Figure 10-15, the Sensitivity of the Area was determined.

On top of the reduction of construction worksite area, the range of dust mitigation measures to be implemented at the construction sites are outlined in Table 10-24. Upon the implementation of mitigation measures, the Impact Significance was determined to be Minor. This will be detailed in Section 10.9.1.

Table 10-23 Receptor Sensitivity for Air Quality Impact Assessment – Construction Phase (Base and Mitigated Scenarios)

<table>
<tr><th rowspan="2">Distance</th><th colspan="2">Base Scenario</th><th colspan="2">Mitigated Scenario</th></tr>
<tr><th>Identified Receptors</th><th>Sensitivity of the Area</th><th>Identified Receptors</th><th>Sensitivity of the Area</th></tr>
<tr><td colspan="5">CR16 CONSTRUCTION WORKSITE</td></tr>
<tr><td colspan="5"><u>For Earthworks:</u></td></tr>
<tr><td>Within 20m</td><td>1. Clementi Forest
2. Maju Forest
Old Jurong Railway Corridor</td><td rowspan="2">Priority 1</td><td>3. Clementi Forest
4. Maju Forest</td><td rowspan="2">Priority 1</td></tr>
<tr><td>Between 20m to 50m</td><td>1. Clementi Forest
2. Maju Forest
Old Jurong Railway Corridor</td><td>3. Clementi Forest
4. Maju Forest
Old Jurong Railway Corridor</td></tr>
<tr><td colspan="5"><u>For Construction:</u></td></tr>
<tr><td>Within 20m</td><td>5. Clementi Forest
6. Maju Forest
Old Jurong Railway Corridor</td><td>Priority 1</td><td>7. Clementi Forest
8. Maju Forest</td><td>Priority 1</td></tr>
</table>

Distance	Base Scenario		Mitigated Scenario	
	Identified Receptors	Sensitivity of the Area	Identified Receptors	Sensitivity of the Area
Between 20m to 50m	5. Clementi Forest 6. Maju Forest Old Jurong Railway Corridor		7. Clementi Forest 8. Maju Forest	
<u>For Trackout:</u>				
Within 20m	9. Clementi Forest 10. Maju Forest Old Jurong Railway Corridor	Priority 1	11. Clementi Forest 12. Maju Forest Old Jurong Railway Corridor	Priority 1
Between 20m to 50m	9. Clementi Forest 10. Maju Forest Old Jurong Railway Corridor		11. Clementi Forest 12. Maju Forest Old Jurong Railway Corridor	



Legend

- Species of Conservation Significance
- Large Specimens
- Earthworks Footprint
- 20m from Source
- 50m from Source
- Proposed CRL Alignment
- Old Jurong Railway Corridor
- Biodiversity Study Area

Rev.	Date	By	Description	Chk'd	App'd
-	MAY 2022	HHL	EIS (Clementi Forest and Maju Forest)	NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title :

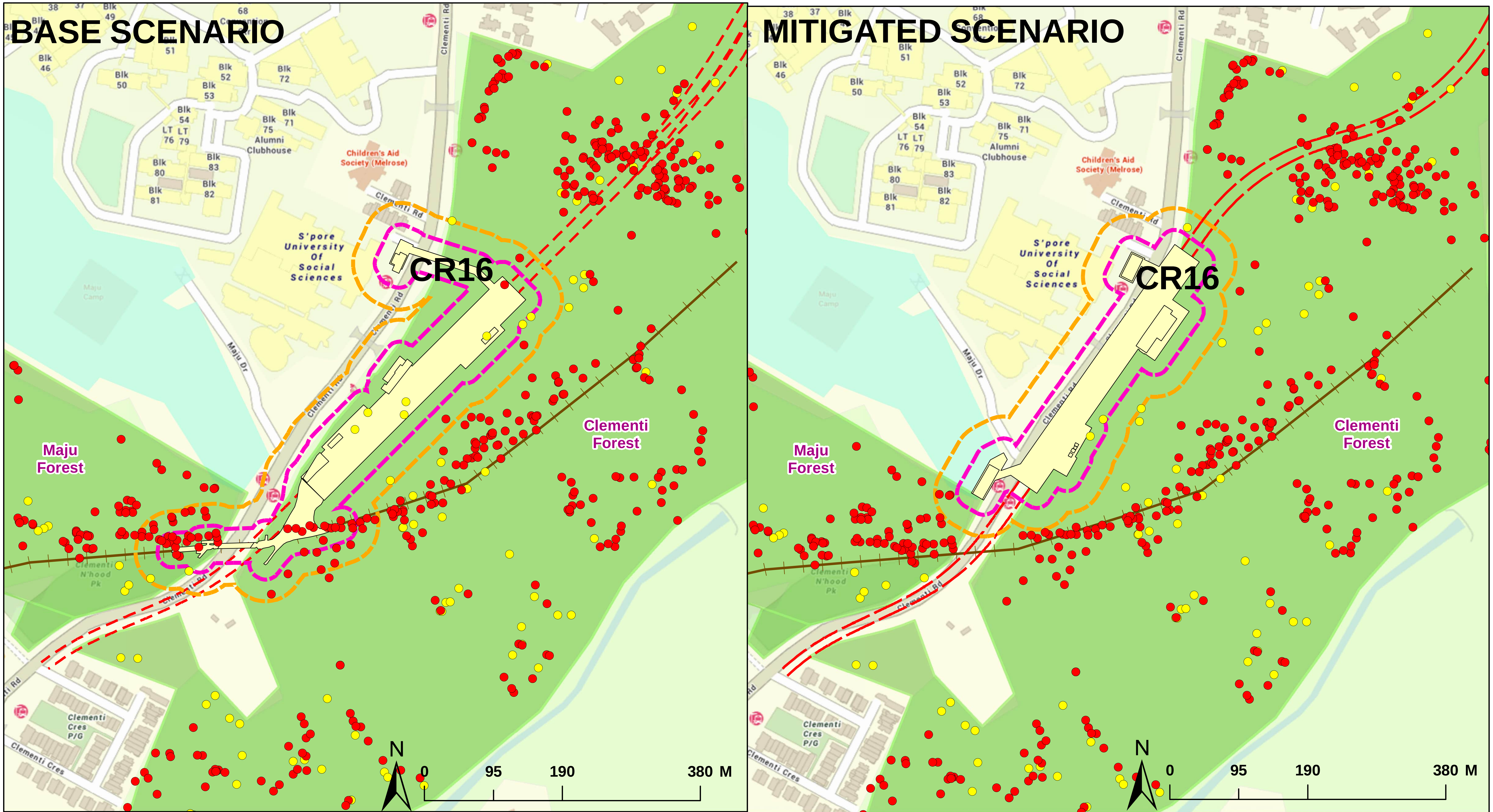
CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (CLEMENTI FOREST AND MAJU FOREST)

Figure Title :

CR16 MITIGATED CASE EMISSION SOURCES AND RECEPTORS (EARTHWORKS)

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
ASH	NHT	JAG	10-13	-	1 of 1
	Drawn HHL	Date MAY 2022	CAD File Name :		A3

Note: Source of basemap - OneMap



Legend

- Species of Conservation Significance
- Large Specimens
- Construction Footprint
- 20m from Source
- 50m from Source
- Proposed CRL Alignment
- Old Jurong Railway Corridor
- Biodiversity Study Area

Rev.	Date	By	Description	Chk'd	App'd
-	MAY 2022	HHL	EIS (Clementi Forest and Maju Forest)	NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

Land Transport Authority
We Keep Your World Moving

Project Title :

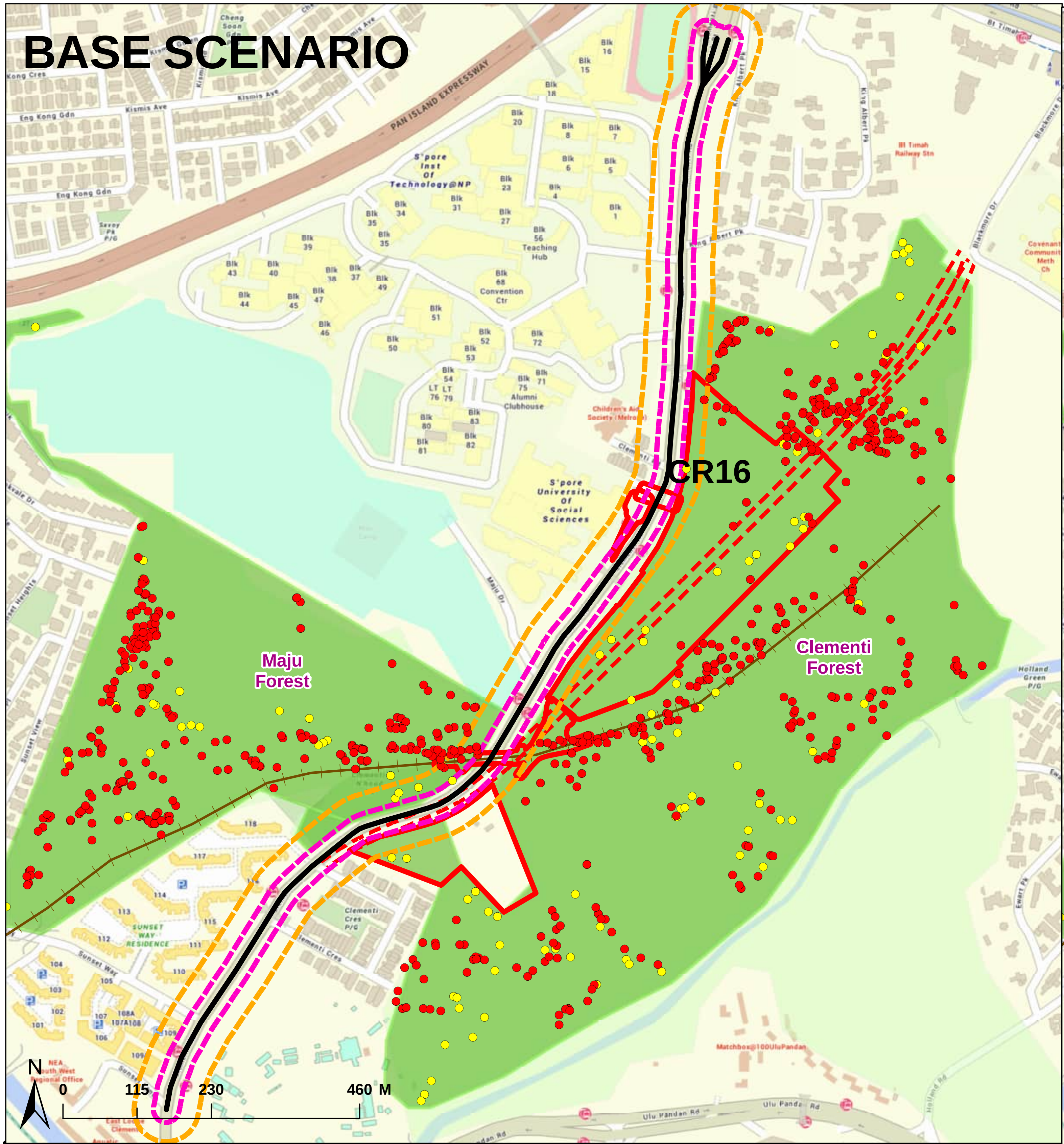
CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (CLEMENTI FOREST AND MAJU FOREST)

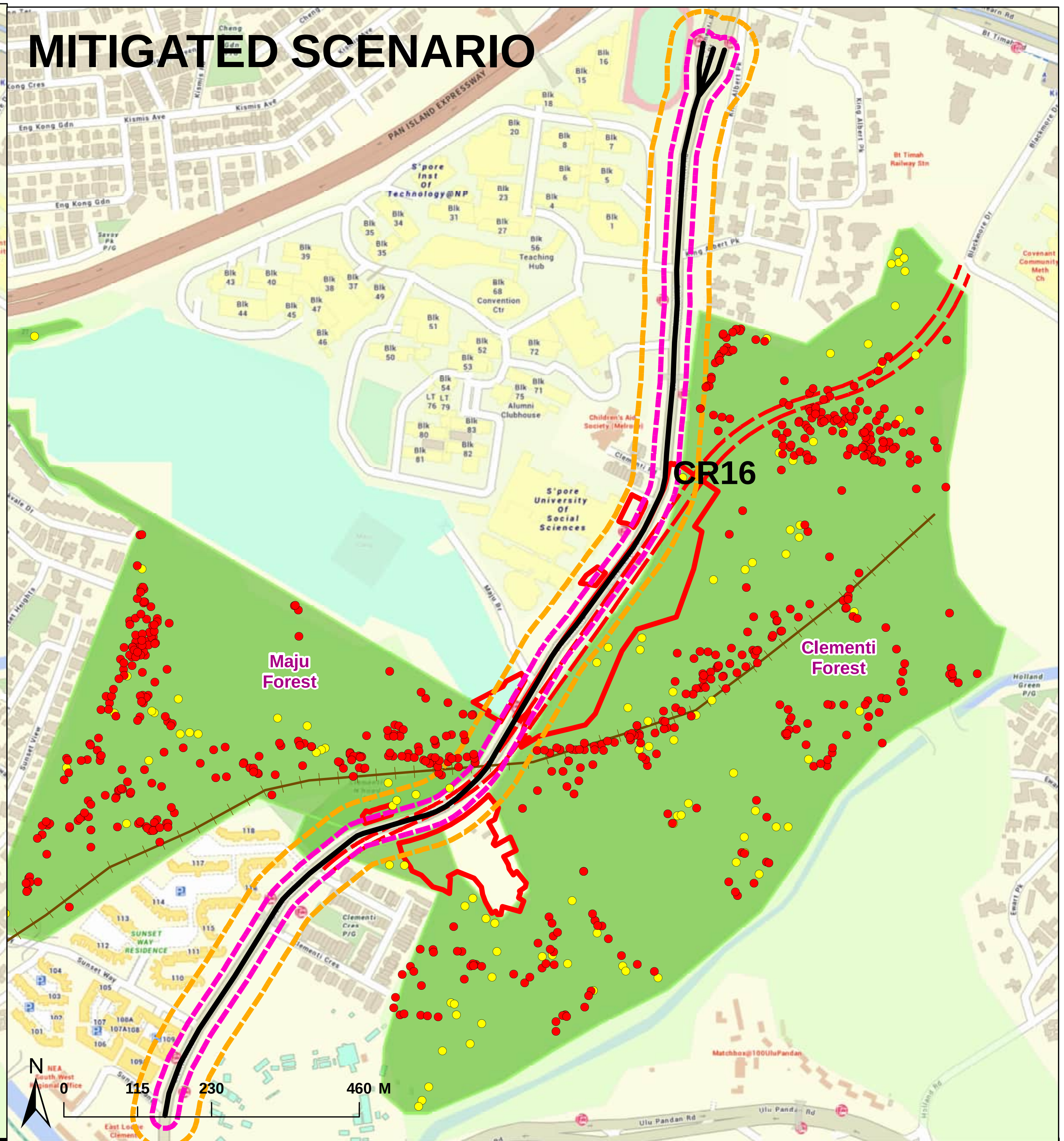
Figure Title :

CR16 MITIGATED CASE EMISSION SOURCES AND RECEPTORS (CONSTRUCTION)

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
ASH	NHT	JAG	10-14	-	1 of 1
Drawn: HHL		Date: MAY 2022	CAD File Name :		A3

Note: Source of basemap - OneMap





Legend

- Species of Conservation Significance
- Large Specimens
- Potential Access Road
- 20m from Source
- 50m from Source
- Proposed CRL Alignment
- Construction Worksite Footprint
- Old Jurong Railway Corridor
- Biodiversity Study Area

Rev.	Date	By	Description	Chk'd	App'd
-	MAY 2022	HHL	EIS (Clementi Forest and Maju Forest)	NHT	JAG

Qualified Person Endorsement :
NA

LTA Endorsement :
NA

Consultant :
AECOM

Land Transport Authority
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Project Title :
CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(CLEMENTI FOREST AND
MAJU FOREST)

Figure Title :
CR16 MITIGATED CASE EMISSION
SOURCES AND RECEPTORS
(TRACKOUT)

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
ASH	NHT	JAG	10-15	-	1 of 1
	Drawn: HHL	Date: MAY 2022	CAD File Name : NA		A3

Note: Source of basemap - OneMap

Table 10-24 Air Quality Mitigation Measures (Construction Phase)

Mitigation Measures	Application
GENERAL MITIGATION MEASURES TO BE IMPLEMENTED THROUGH OUT CONSTRUCTION PERIOD	
Communications	
Develop and implement a stakeholder communications plan that includes community engagement before work commences on site.	Mandatory
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.	Mandatory
Develop and implement an Air Pollution Control Plan (APCP) (see paragraph below for APCP details).	Mandatory
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.	Mandatory
Make the complaints log available to the local authority when asked.	Mandatory
Record any exceptional incidents that cause dust and/or air emissions, either on-site or off-site, and the action taken to resolve the situation in the log book.	Mandatory
Hold liaison meetings with other high-risk construction sites within 500 m of the site boundary, if any, to ensure plans are co-ordinated and dust and particulate matter emissions are minimised.	Mandatory
Monitoring	
Undertake regular (daily frequency recommended) on-site 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 100 m of site boundary. Cleaning should be provided if necessary.	Mandatory
Carry out regular site inspections to monitor and record compliance with the Air Pollution Control Plan.	Mandatory
Increase the frequency of site inspections during prolonged dry or windy conditions.	Mandatory
Conduct monitoring for PM_{10} and $PM_{2.5}$ at suitable locations (refer to Section 13.9.1)	Mandatory
Preparing and maintaining the site	
Plan site layout so that machinery and dust causing activities are located away from receptors, where possible.	Mandatory
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.	Mandatory
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.	Mandatory
Keep site fencing, barriers, and scaffolding clean by cleaning regularly using wet methods (dry methods may give rise to fugitive dust).	Mandatory
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.	Mandatory

Mitigation Measures	Application
Operating vehicle/machinery and sustainable travel	
Ensure all vehicles and engine powered equipment comply with the legislative requirements of Singapore.	Mandatory
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.	Mandatory
Where practicable, avoid the use of diesel- or petrol-powered generators and use mains electricity or battery powered equipment.	Mandatory
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 worksite.	Mandatory
Produce a Construction Logistics Plan to manage the sustainable delivery of goods and materials.	Mandatory
Construction Operations	
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.	Mandatory
Ensure an adequate water supply on the site for effective dust/particulate matter suppression/mitigation, using non-potable water where possible and appropriate.	Mandatory
Use enclosed chutes and conveyors and covered skips wherever possible.	Mandatory
Minimise drop heights from conveyors, loading shovels, hoppers, and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate.	Mandatory
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 any dry spillages, and cleaning should be conducted as soon as reasonably practicable after the event using wet cleaning methods.	Mandatory
Waste Management	
Avoid burning of waste or other materials.	Mandatory
MITIGATION MEASURES FOR EARTHWORKS	
Re-vegetate earthworks and exposed areas/soil stockpiles to stabilise surfaces as soon as practicable. When a particular work is finished in an area, the soil will need to be reinstated upon completion, before moving on to different areas. This will reduce dust emission. In the air assessment it refers to reinstatement as a regrown area, it does not mean replanting same trees. It only refers to vegetation plantation which prevents erosion of soil to form dust.	Mandatory
Use Hessian, mulches or soil tackifiers where it is not possible to re-vegetate or cover with topsoil, as soon as practicable.	Mandatory
Only remove the cover in small areas during work and not all at once.	Mandatory
MITIGATION MEASURES FOR CONSTRUCTION (INCLUDING CONCRETE BATCHING PLANT)	
Avoid scabbling (roughening of concrete surfaces) if possible.	Recommended
Sand and aggregates will be delivered in a dampened stage and will be re-wetted before being dumped into storage bunker.	Recommended
Drop heights at transfer points will be minimised to lessen dust generation	Recommended

Mitigation Measures	Application
Special covered area will be provided for loading and unloading process	Recommended
Water sprays or sprinklers will be employed at conveyor transfer points	Recommended
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.	Mandatory
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.	Recommended
For smaller supplies of fine powder materials ensure bags are sealed after use and stored appropriately to prevent dust.	Recommended
Vent will be provided with efficient fixed filter bags to comply with the dust emissions criteria.	Mandatory
Silos will not be filled up with cement more than 90% of its loading capacity, to avoid overfilling,	Recommended
Silos will be equipped with overfill protection: audible high level sensor alarm and automatic shut-down switch, which could be activated to close when a problem is detected.	Mandatory
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.	Mandatory
Avoid dry sweeping of large areas.	Mandatory
Ensure vehicles entering and leaving sites are covered to prevent escape of materials during transport.	Mandatory
Inspect on-site haul routes for integrity and instigate necessary repairs to the surface as soon as reasonably practicable.	Mandatory
Record all inspections of haul routes and any subsequent action in a site log book.	Mandatory
Install hard surfaced haul routes, which are regularly damped down with fixed or mobile sprinkler systems, or mobile water bowsers and regularly cleaned.	Mandatory
Site access gates to be located at least 10 m from receptors where possible.	Mandatory

The APCP will include the following information as a minimum:

- Summary of all work to be carried out including breakdown of phases and individual activities that may give rise to fugitive dust formation;
- Project title, Project location and area, description of the site layout and locations of areas where dust is most likely to be generated such as haulage routes, excavation areas, etc. This description will also include the location of the water supply or chemical suppressants for applying to the dust generating areas on site;
- List of each dust generating activity, the likely schedule for each activity and the dust control measures to be implemented and frequency for their implementation. The level of detail will depend on the overall Consequence classification identified in this Report and should include as a minimum the mitigation measures listed as mandatory in this document;

- Summary of the air monitoring to be undertaken including monitoring location and schedule. The air monitoring results will be recorded, and trends observed to determine the efficacy of dust control measures over the different construction stages;
- Details and procedures on using the site log book which is used to record information on incidents such as dust episodes, the sources identified, and the action taken and its efficacy. Any complaints will also be recorded within the log book along with the subsequent mitigation implemented and time to close out the complaint. The log book should also be used to keep track of the daily dust control measures implemented such as wheel washing, site watering, site inspections etc.;
- Details of the Superintending Officer (SO) should be included in this plan for managing dust management at the site. The responsibilities of the SO are listed in Section 13.4.3; and
- The air pollution control plan will be reviewed at regular intervals during the construction phase to ensure the effectiveness of the procedures in place and to maintain the goal of minimisation of dust and emissions through the use of best practice and procedures.

10.8.2 Operational Phase

No mitigation measures are required during operational phase as only Minor air quality impact significance was expected during Project operational phase.

10.9 Residual Impacts

10.9.1 Construction Phase

Residual Impact Assessment assumes that the mitigation measures within Section 10.8.1 are implemented in the construction footprint. In the mitigated scenario, the construction footprint is also reduced to avoid encroachment into Stream D/S22. In terms of air quality, specifically for CR16 worksite, the reduction of footprint might result in lower dust emission magnitude for earthworks activity. No change in dust emission magnitude for construction and trackout activities are expected as a result of smaller footprint. Upon assessment of the earthwork activity, the total site area for CR16 Mitigated Scenario remains >10,000 m^2, the number of vehicles moving within the site remains 5-10 vehicles and the estimated spoil moved remains >100,000 tonnes. Hence, the Overall Consequence remains as High even with slightly smaller earthworks footprint.

The Likelihood of occurrence of a significant adverse impact would be classified as Rare, subject to relevant mitigation measures identified being implemented. This Likelihood is combined with Impact Consequence to provide the residual Impact Significance results for the construction footprint. The residual Impact Significance is listed in Table 10-25 to Table 10-27 below.

Based on the assessment, by implementing the proposed mitigation measures, the Likelihood of the impact was expected to reduce from Regular to Rare, resulting in **Minor** Impact Significance.

Based on the assessment, “CR16 Mitigated Scenario” is preferred compared to “CR16 Base Scenario” due to its smaller footprint. Smaller construction footprint would reduce the potential air quality impact to the neighbouring receptors.

Table 10-25 Impacts of Dust Risk Assessment – Earthworks (after mitigation)

Construction Worksite	Key Parameter			Impact Assessment				
	Total Site Area (m^2)	No. of Vehicles moving within the site	Total Material Moved (tonnes)	Impact Intensity	Sensitivity of the Area	Overall Consequence/Dust Risk	Likelihood	Impact Significance
CR16 Mitigated Scenario	>10,000	5-10	>100,000	High	Priority 1	High	Rare	**Minor**

Table 10-26 Impacts of Dust Risk Assessment – Construction (after mitigation)

Construction Worksite	Key Parameter			Impact Assessment				
	Total Building Volume (m^3)	Construction Material	No. of concrete batching plant	Impact Intensity	Sensitivity of the Area	Overall Consequence/Dust Risk	Likelihood	Impact Significance
CR16 Mitigated Scenario	25,000 – 100,000	Concrete	1	Medium	Priority 1	Medium	Rare	**Minor**

Table 10-27 Impacts of Dust Risk Assessment – Trackout (after mitigation)

Construction Worksite	Key Parameter			Impact Assessment				
	No. of outward trucks movement per day	Road surface material	Unpaved Road Length (m)	Impact Intensity	Sensitivity of the Area	Overall Consequence/Dust Risk	Likelihoo d	Impact Significance
CR16 Mitigated Scenario	>50	Non-Dusty	0	High	Priority 1	High	Rare	**Minor**

10.9.2 Operational Phase

As discussed in Section 10.7.2, the potential impact significance due to increased traffic was considered to be **Minor**. No mitigation measures are required during operational phase.

10.10 Cumulative Impacts with Other Major Concurrent Developments

It is known that construction activities are planned to occur in the vicinity of the Project as highlighted in Section 3.4.1. Hence, cumulative impacts from other relevant major concurrent developments in the vicinity of the Project will be assessed and considered.

10.10.1 Construction Phase

There are five (5) nearby concurrent Projects such as PUB Deep Tunnel Sewerage System Phase 2 (DTSS2) Proposed manholes and pipelines construction, proposed Brookvale Drive new road construction, Old Jurong Nature Trail, Clementi Nature Trail and CR15 worksite/station.

The impact significance before mitigation for CR16 ranges from Moderate to Major. Due to the presence of these concurrent construction sites, the construction footprint in this area is expected to be larger. More vehicles moving within the site and more spoil to be moved as part of the excavation stage are also expected. Moreover, construction of residential development is expected to require higher amount of concrete to be transported to the site, increasing potential dust emission within the site and on public roads leading and leaving the site. With all these concurrent construction activities, the cumulative air quality impact during construction phase in the area might significantly increase.

10.10.2 Operational Phase

No cumulative impacts were considered during operational phase.

10.11 Summary of Key Findings

Air quality impacts from the construction and operation of the proposed Project were assessed on air sensitive receptors (ASRs) in the vicinity of the Project site. Potential impacts to the neighbouring sensitive receptors during construction phase mainly include emissions from the heavy vehicular exhaust and dust emitted from the earthworks, construction and trackout activities. During the operational phase, emissions from vehicle exhaust due to increased traffic in the vicinity of the proposed development is identified as the predominant air emission source. In order to assess the current baseline air quality in the Study Area, baseline air quality data was collected at 1 representative monitoring location between 11-18 March 2020. All pollutant concentrations were found to be within the Singapore Ambient Air Quality Long Term Targets, except 1 out of 7 days at SUSS (A01) which recorded 24-hour average $PM_{2.5}$ concentrations of 26.5μg/m^3. However, the targets are met for the rest of the week at A01 with average daily $PM_{2.5}$ concentration of 14.4μg/m^3 throughout the week.

Air quality impact assessment for construction phase was undertaken in accordance with the UK IAQM Guidance on the Assessment of Dust from Demolition and Construction. Pursuant to which, a 50 m Study Area was considered for earthworks, construction and trackout activities due to ecological sensitive receptors in the vicinity of the worksites. Dust generated during construction works can have adverse effects upon vegetation restricting photosynthesis, respiration and transpiration. Furthermore, it can lead to phytotoxic gaseous pollutants penetrating the plants. The overall effect can be a decline in plant productivity. The results of the assessment show that unmitigated impacts were classified as Moderate to Major and have the potential to affect the receptors near the construction footprint unless mitigation measures are put in place (see Section 10.7.1 for assessment details). This is largely because of the large extent of the construction worksite located very close or within the areas with flora, fauna and habitat of high ecological value. This Report pulls together mitigation measures that can be implemented by the Contractor as administrative or management measures, sourcing from best practice measures internationally, which are detailed Section 10.8.1, which when applied successfully, the significance of impacts was anticipated to be reduced to **Minor** (see Section 10.9.1 for details). The key control and mitigation measures include but not limited to development of air pollution control plan, dust control measures on site, site hoarding, planning of dust causing activities-location and timing, reinstating land upon completion of works amongst several others. Based on the assessment, “CR16 Mitigated Scenario” is preferred compared to “CR16 Base Scenario” due to its smaller footprint. Smaller construction footprint would reduce the potential air quality impact to the neighbouring receptors. The construction Contractor is recommended to prepare an air quality management plan incorporating a range of monitoring and mitigation measures in line with Section 10.8.1, Section 13.9.1 and Section 13.13.1.

Air quality impacts were also qualitatively weighed during operational phase. Fugitive emission from vehicle exhaust due to increased traffic in the vicinity of the Project is expected. It is assumed that all new vehicles to meet their Euro emission standard. Furthermore, there is currently a large traffic volume along the Clementi Road. The buffer from some green areas which will not be disturbed as part of the Project, will also help in terms of providing cleaner air from the impact from the vehicles. At a much higher level, trains are meant to replace substantial vehicles from roads, as passengers commute using trains, therefore in that scheme the Project may have a positive effect on road traffic. However, for immediate localised road traffic to and from the station may see some increase. In this aspect with the information assessed at this stage, the air quality impact contributed from the proposed development was anticipated to be **Minor** during the operational phase. No mitigation measures are required during operational phase as no significant air quality impact is expected from Project operation.

Cumulative impacts from other major concurrent development in the vicinity of each construction worksite are presented and detailed in Section 10.10. Due to the presence of these concurrent construction sites, the overall construction footprint was expected to be larger. With all these concurrent construction activities, the cumulative air quality impact during construction phase in the area might significantly increase.

Table 10-28 Summary of Air Quality Impact Assessment

Sensitive Receptor	Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)
Construction Phase		
Clementi Forest	Moderate to Major	**Minor**
Maju Forest	Moderate to Major	**Minor**
Operational Phase		
Clementi Forest	Minor	**Minor** (See Note 1)
Maju Forest	Minor	**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. This does not indicate that impacts are completely eliminated.

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 sensitive ecological 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 phase;
- 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 phase.

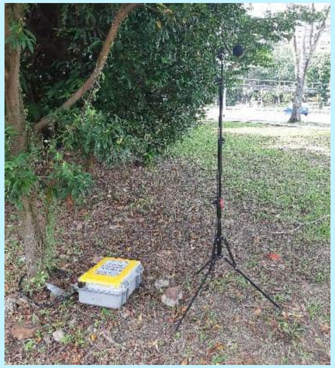
11.2.1 Baseline Airborne Noise Study

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 Four (4) 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 station box and vent shafts;
- 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)
- 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. 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, calibration certificates are shown in Appendix Q 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
N01: Landed housing along Clementi Crescent	CR16 Worksite (Maju Forest and Clementi Forest)	Priority 1, 2, 3 (dependent on species sensitivity)	The Biodiversity Study Areas at Clementi Forest and Maju Forest are situated either site of Clementi. The baseline noise level is found to be dominated by traffic along Clementi Road. Southern end of the CR16 has a separate proposed construction worksite near the terrace houses along Clementi Crescent. Therefore, a representative baseline noise monitoring location south of the CR16 was selected to be a common area near the landed housing along Clementi Crescent	
N02: Within Clementi Forest	CR16 Worksite (Maju Forest and Clementi Forest)	Priority 1, 2, 3 (dependent on species sensitivity)	Clementi Forest is a construction worksite area of the Project within the currently forested Biodiversity Study Area. The selected location represents the internal environment of the Biodiversity Study Area located east of the CR16.	

Monitoring Location	Nearest Construction Worksite Area/Project Footprint	Sensitivity of Receptor at Monitoring Location	Justification	Photo of Monitoring Location
N03: Singapore University of Social Sciences (SUSS)	CR16 Worksite (Maju Forest and Clementi Forest)	Priority 1, 2, 3 (dependent on species sensitivity)	The monitoring location located within the SUSS campus is between Maju Forest and Clementi Forest. The site survey deemed other options around the SUSS receptor not ideal to capture baseline conditions due to external ACMV louvres at the south of the campus and elevated human traffic near the walkways along Clementi Road. Hence, the baseline noise level at this selected location is expected to be dominated by traffic along Clementi Road and is the representative location west of the CR16.	
N04: Children's Aid Society (Melrose Home)	CR16 Worksite (Maju Forest and Clementi Forest)	Priority 1, 2, 3 (dependent on species sensitivity)	The baseline noise level is expected to be dominated by traffic along Clementi Road. Baseline noise monitoring location within the Study Area located west of CR16, representing an area for northern part of the CR16 along Clementi Road and cumulative impact from both construction worksite areas/ Project footprint.	

Legend

- Proposed Noise Monitoring Location
- Proposed CRL Alignment (Base)
- Base Scenario Construction Worksite Footprint
- Station Entrances/ Exits
- TBM Worksite
- Noise Study Area
- Old Jurong Railway Corridor
- Biodiversity Study Area

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAY 2022	PZ	EIS (Clementi Forest and Maju Forest)	JAG/NHT	JAG

Qualified Person Endorsement :
NA

LTA Endorsement :
NA

Consultant :
AECOM

Land Transport Authority
We Keep Your World Moving

Project Title :
CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(CLEMENTI FOREST AND MAJU FOREST)

Figure Title :
BASELINE NOISE MONITORING LOCATIONS

Designed	Checked	Approved
PZ	JAG/NHT	JAG
	Drawn: PZ	Date: MAY 2022

Figure No. :	Rev.	Sheet
11-1	-	1 of 1

CAD File Name : NA | A3

Note: Source of basemap - OneMap

11.2.2 Prediction and Evaluation of Impact Assessment

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

11.2.2.1 Construction Phase

For the assessment on construction phase, the prediction of the noise levels generated from the equipment used during construction detailed in Section 11.3 was predicted using SoundPLAN ver 8.2. Where topography is not available, a flat terrain based on the nearest spot height from the topography survey was taken within the Study Area. A quantitative assessment at 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 6.4.2. Noise contours were provided to the extent that topography is available. Based 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 focuses on three (3) different construction base scenarios and six (6) different mitigated construction scenarios. These scenarios are:

- Base 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;
- Base Scenario 2: Tunnel Boring Machine (TBM) works – Assesses construction noise impacts from the TBM worksites to the sensitive receptors; and
- Base Scenario 3: Construction of station entrances – Assesses construction noise impacts from the respective station entrances to the sensitive receptors.
- Mitigated Scenario 1: Advance work (non TBM/entrance construction work) – Assesses construction noise impacts from advance work worksites to the sensitive receptors;
- Mitigated Scenario 2: Construction of site office – Assesses construction noise impacts from the construction of site office to the sensitive receptors;
- Mitigated Scenario 3: Demolition of POB – Assesses construction noise impacts from the demolition worksite for the POB to the sensitive receptors;
- Mitigated Scenario 4: Main civil work (non TBM/entrance construction work) – Assesses construction noise impacts from the main civil contract work to the sensitive receptors;
- Mitigated Scenario 5: Tunnel Boring Machine (TBM) works – Assesses construction noise impacts from the TBM worksites to the sensitive receptors; and
- Mitigated Scenario 6: 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 were assumed to be carried out at the same time between the different worksites; and
- the predicted noise levels with construction noise impact were assessed more on fauna near the ground level up to 1.5m height since 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 as well.

11.2.2.1.1 *Rock breaking 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 CR16 worksite, the rock level at the western end of the CR16 station box is expected to be above the required formation level based on the available boreholes data from site investigation results. The depth of rock breaking and excavation is proposed to break down at around 27m below ground level.

As a product of rock breaking and excavation, the major side effects on the environment includes air overpressure. When an MIC of any magnitude is discharged, air which acts as a fluid radiates from the rock breaking 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 CR16 is assumed to be 1 time per day and 5 times per week over a span of 8 weeks.

During the writing of this Report, information on rock breaking was not available. Rock breaking and excavation could only be carried out by an appointed Contractor at a later stage. Hence, the approach taken in this section will provide a guideline to the criteria as set out in BS5228-2:2009+A1:2014. Based on assumptions made (rock breaking location, depth, breaking method) and known information (distance to nearest receptors), this assessment will provide an estimate on the maximum amount of maximum instantaneous charge (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 will be used to predict air overpressure based on constants recommended within the guideline with formula (1) below:

$$\boldsymbol{P} = \boldsymbol{K_a}\left(\frac{\boldsymbol{R}}{\boldsymbol{Q^{\frac{1}{3}}}}\right)^{\boldsymbol{a}} \text{ ----------------- (1)}$$

Where

P = pressure in kilopascals

Q = explosives charge mass, in kilograms

R = distance from charge, in metres

Ka = 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 in Singapore, the site constant was assumed based on AS 2187.2-2006. The site constant Ka is commonly ranging from 10 to 100 for confined blasthole charges and hence was conservatively assumed to be 100 for the purpose of the calculation. The site exponent, a, was assumed to be -1.45 for confined blasthole charges. The alternative to confined explosion hole charges would be unconfined surface charges which is usually employed in mine breaking. The distance from charge to the receptor, R, was measured from the centre of the CR16 worksite to the nearest boundary of Clementi Forest which is approximately 47m and to the nearest boundary of Maju Forest is approximately 80m.

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.

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

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 vent buildings was conducted by LTA in a separate study. Based on the predicted results at the boundary due to the operation of the stations, this Study will assess and evaluate the impacts on the ecological receptors identified within Clementi Forest and Maju Forest 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 will be 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-52] and assess 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 sensitive ecological receptors. The ecological impacts from airborne noise are species dependent, hence the assessment will be based on the species identified during site surveys at Maju Forest and Clementi Forest (see Section 11.4 for airborne noise sensitive receptors) in sync with the biodiversity section of this Report. It is to be noted that Maju Forest's and Clementi Forest's ecological receptor noise impact was assessed against the baseline noise level as the noise criterion.

Section 11.2.3.1 and Section 11.2.3.2 below details the construction and operational noise criteria adopted for this study.

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-50]*. 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
- $L_{Aeq(5\ min)}$ 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 the week	Maximum Permissible $L_{Aeq(12\ hour)}$, dB	
		07:00 – 19:00	19:00 – 07:00
(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	-
(c) 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 buildings	Days of the week	Maximum Permissible $L_{Aeq\ (1\ hour)}$ (dB)		
		07:00 – 19:00	19:00 – 22:00	22:00 – 07:00
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 buildings	Days of the week	Maximum Permissible $L_{Aeq\ (5\ mins)}$ (dB)		
		07:00 – 19:00	19:00 – 22:00	22:00 – 07:00
(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 where the noise is being emitted	Monday to Saturday	90	70	55
	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 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 Maju Forest and Clementi Forest).

11.2.3.2 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-51].* Traffic noise with the *NEA Technical Guideline for Land Traffic Noise Impact Assessment, 2016* [R-22] for noise sensitive and residential building receptors.

11.2.3.2.1 *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 will, 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/ receptors	Boundary Noise Limits (reckoned as the equivalent continuous noise level over 15 minutes), dB(A)		
	Day 07:00 – 19:00	Evening 19:00 – 23:00	Night 23:00 – 07:00
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
Maju Forest*	48	49	42
Clementi Forest (Southern)*	48	49	42
Clementi Forest (Northern)*	66	66	60

***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 are measured 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.

11.2.3.2.2 *Land Traffic Noise Impact Assessment Criteria*

NEA's noise requirements are as follows for any new road construction:

1. The noise levels at 1 m from the façade of the new residential/noise sensitive building will not exceed LAeq(1hr) 67 dB; and

2. The indoor noise level of the new residential/noise sensitive building under natural ventilation will 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. Since this Study is only looking at infrastructural development and not the residential development in this area, this criterion is not applicable or used. It will be applicable for future concurrent projects planned in the vicinity, which are residential and noise sensitive buildings.

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 will depend on the inventory adopted during each activity of the construction programme. The main source of noise will be 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 LTA, the station worksites (CR16) will follow a cut and cover construction method. However, it is to be noted that rock breaking and excavation has been proposed at the CR16 worksite and this Study will explore air overpressure impacts from rock breaking and excavation. The construction inventory for the CR16 worksite is shown in Appendix S. Based on the construction inventory for the station worksites, the sound power levels used in the noise model are shown in Table 11-7 below. It is to be noted that rock breaking, excavation and air overpressure was not considered for noise modelling and was assessed semi-qualitatively due to the instantaneous nature of the noise generated from rock breaking and excavation.

Table 11-7 Effective Sound Power Level (Station Worksites)

Construction Activity	Effective Sound Power Level $L_{WA,}$ dB from overall construction inventory			
	$L_{Aeq\ (12\ hours)}$	$L_{Aeq\ (12\ hours)}$	$L_{Aeq\ (5\ min)}$	$L_{Aeq\ (5\ min)}$
	07:00 – 19:00	19:00 – 07:00	07:00 – 19:00	19:00 – 07:00
Base Scenario: CR16 – TBM launching to CR15				
1. Clearance for Construction Area	116	86	119	86
2. Temporary Earth Retaining System (TERS)	118	105	120	108
3. Levelling (Cut and Fill) to Work Platform Level	109	99	114	102
4. Station ERSS- Installation of D Wall/SBP/Sheet Pile	112	112	112	112
5. Installation of Wallers & Struts/Stage excavation	108	108	110	110
6. TBM (Launching to CR15 and CR13) (For Scenario 2)	115	115	115	115
7. Construction of Permanent Structure	110	109	112	112
8. Reinstatement of Work & Exiting Road	115	115	116	116
9. Entrances - Construction of D Wall & Sheet piles (Shaft construction) (For Scenario 3)	119	-	120	-
10. Entrances - Construction of D Wall & Sheet piles (For Scenario 3)	119	-	120	-
11. Construction of Site Office	95	94	97	97
Mitigated Scenario: CR16 – TBM launching to CR15				
Advance Work (For Scenario 1)				
1. Clearance for Construction Area including Tree felling	117	117	120	120

Construction Activity	Effective Sound Power Level L_{WA}, dB from overall construction inventory			
	$L_{Aeq\ (12\ hours)}$	$L_{Aeq\ (12\ hours)}$	$L_{Aeq\ (5\ min)}$	$L_{Aeq\ (5\ min)}$
	07:00 – 19:00	**19:00 – 07:00**	**07:00 – 19:00**	**19:00 – 07:00**
2. 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
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
Main Civil Work (For Scenario 4)				
1. Station ERSS	112	112	112	112
2. Installation of Wallers & Struts/Stage excavation	108	-	110	-
3. Construction of Permanent Structure	110	-	112	-
4. Traffic Diversion	97	97	100	100
5. Construction of Site office (For Scenario 2)	95	94	97	97
6. Demolition of POB (For Scenario 3)	112	-	113	-
7. TBM (Launching to CR15) (For Scenario 5)	115	115	115	115
8 Entrances - Construction of D Wall & Sheet piles (Shaft construction) (For Scenario 6)	119	-	120	-
9 Entrances - Construction of D Wall & Sheet piles (Subway) (For Scenario 6)	119	-	120	-
10. Reinstatement of Work & Exiting Road	115	115	116	116
Note Worst case noise levels are shown in red font .				

As mentioned in Section 11.2.2, these scenarios 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)

Scenario / Worksite	Effective Sound Power Level L_{WA}, dB used in the noise model			
	$L_{Aeq\ (12\ hours)}$ 07:00 – 19:00	$L_{Aeq\ (12\ hours)}$ 19:00 – 07:00	$L_{Aeq\ (5\ min)}$ 07:00 – 19:00	$L_{Aeq\ (5\ min)}$ 19:00 – 07:00
Base Scenario: CR16 – TBM launching to CR15				
Scenario 1: Cut and cover works and associated activities	118	115	120	116
Scenario 2: TBM (Launching)	115	115	115	115

Scenario / Worksite	Effective Sound Power Level L_{WA}, dB used in the noise model			
	L_{Aeq} (12 hours) 07:00 – 19:00	L_{Aeq} (12 hours) 19:00 – 07:00	L_{Aeq} (5 min) 07:00 – 19:00	L_{Aeq} (5 min) 19:00 – 07:00
Scenario 3: Construction of station entrances	119	-	120	-
Mitigated Scenario: CR16 – TBM launching to CR15				
Scenario 1: Advance work	117	117	120	120
Scenario 2: Construction of site office	95	94	97	97
Scenario 3: Demolition of POB	112	-	113	-
Scenario 4: Main civil work	112	112	112	112
Scenario 5: TBM (Launching)	115	115	115	115
Scenario 6: Construction of station entrances	119	-	120	-

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

The likelihood of the assessment is based on the work period and active noise period for machinery. The scenarios as mentioned above are 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 and Duration	Likelihood of exposure
CR16 (Base Scenario)	Rock breaking and excavation	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
	Scenario 2 – TBM Works	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
CR16 (Mitigated Scenario)	Rock breaking and excavation	Likelihood- Certain • Work period = 1 • Active noise period for Machinery = 1 1 x1 =1

Construction Worksite	Construction Activities and Duration	Likelihood of exposure
	Scenario 1: Advance works	Likelihood- Regular • Work period = 0.5 (restricted to daytime) • Active noise period for Machinery = 1 0.5 x1 =0.5
	Scenario 2: Construction of site office	Likelihood- Regular • Work period = 0.5 (restricted to daytime) • Active noise period for Machinery = 1 0.5 x1 =0.5
	Scenario 3: Demolition of POB	Likelihood- Regular • Work period = 0.5 (restricted to daytime) • Active noise period for Machinery = 1 0.5 x1 =0.5
	Scenario 4: Main civil work	Likelihood- Regular • Work period = 0.5 (restricted to daytime) • Active noise period for Machinery = 1 0.5 x1 =0.5
	Scenario 5: TBM (Launching)	Likelihood- Certain • Work period = 1 (24 hours operation) • Active noise period for Machinery = 1 1 x1 =1
	Scenario 6: Construction of station entrances	Likelihood- Regular • Work period = 0.5 (Day time only) • Active noise period for Machinery = 1 0.5 x1 =0.5

Legend

- Watercourses
- Proposed CRL Alignment (Base)
- Base Scenario Construction Worksite Footprint
- Station Entrances/ Exits and Access
- TBM Worksite
- Old Jurong Railway Corridor
- Biodiversity Study Area

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Consultant : AECOM

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Project Title : CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (CLEMENTI FOREST AND MAJU FOREST)

Figure Title : AIRBORNE CONSTUCTION NOISE SOURCE

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Note: Source of basemap - OneMap

11.3.2 Operational Phase

The typical noise sources during operational phase of the Project includes the following:

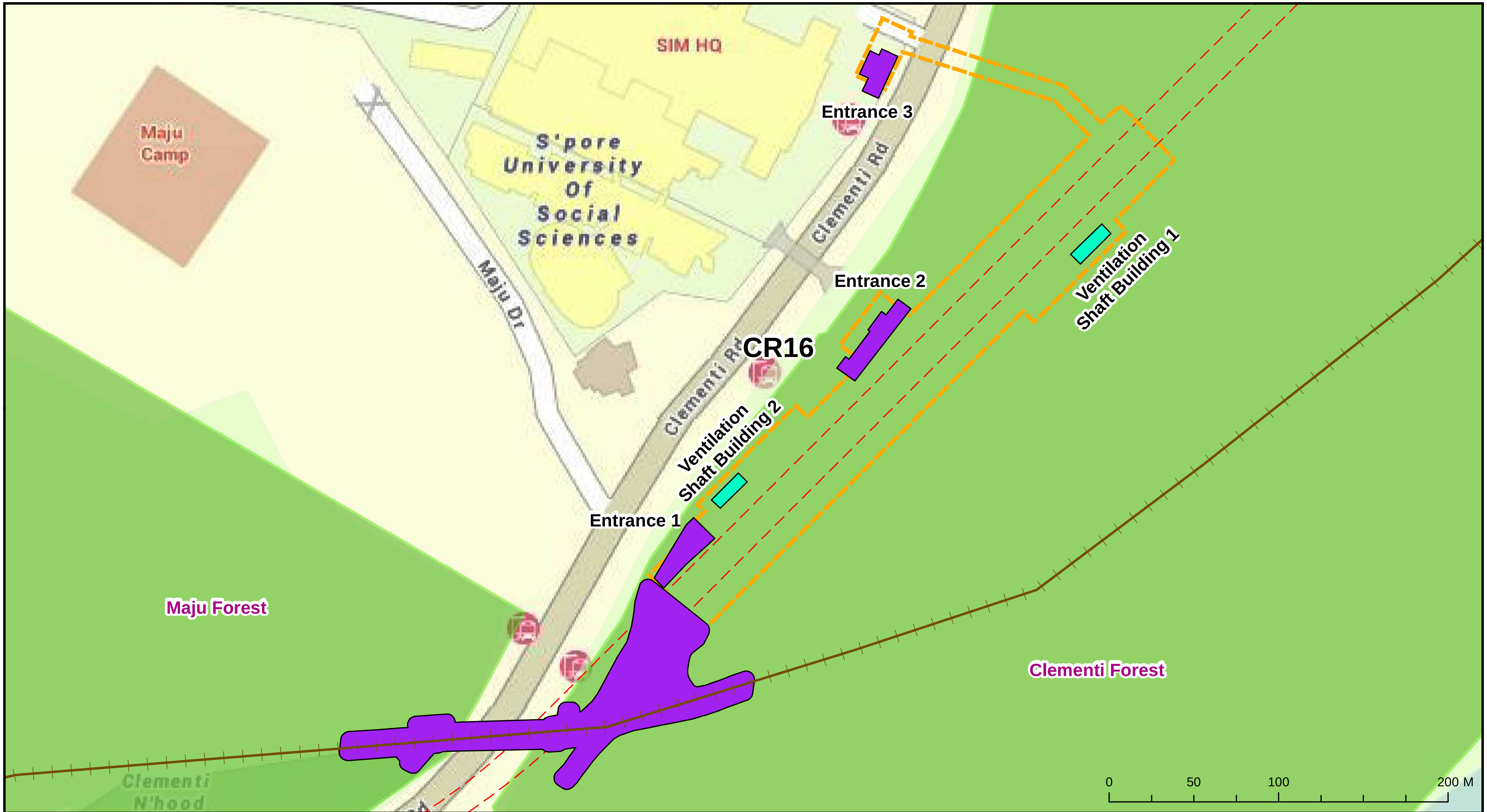
- Traffic noise due to increase in vehicular volume due to the development of the Project; and
- Air-conditioning and mechanical ventilation noise from services at the Project station and vent buildings.

The traffic increase (if any) could potentially cause disturbance to the ecological sensitive receptors within the respective Biodiversity Study Area. The potential noise however could be associated to the slowing down of vehicles at the drop off points for the stations. Traffic noise currently exists with existing roads at the construction worksites. The major road at CR16 is Clementi Road.

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 the station, vent buildings and alignment.

It is to be noted that the railway alignment is not considered as part of this assessment as the rail with operate underground and therefore, not cause any airborne noise impact.

The operational footprint of the station for CR16 is shown in Figure 11-3.



Legend

- Old Jurong Railway Corridor
- Biodiversity Study Area

Above-Ground Structure

- Station Entrances/ Exits (Base)
- Ventilation Shaft Building (Base)

Underground Structures

- Proposed CRL Alignment (Base)
- Station Box Outline (Base)

N

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Figure Title :
CR16 OPERATIONAL FOOTPRINT
NOISE SOURCE

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11-3	-	1 of 1

CAD File Name : A3

Note: Source of basemap - OneMap

11.4 Identification of Airborne Noise Sensitive Receptors

This Study focuses on the noise impacts to the Biodiversity Study Areas 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) shown in Figure 11-4.

Receptor Sensitivity - Habitat

It is to be noted that both the sensitivity of both fauna and habitat are important while identifying sensitivity of noise sensitive receptors. However, during recent nature group (NG) engagement held on 23rd March 2022 for this Project, it was proposed by the NG 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 Sensitivity – Species

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.

Receptor Importance

Species prioritisation of the ecological sensitivity 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

Based on faunistic field assessment within the Biodiversity Study Areas, the receptors of concern in line with the biodiversity section are discussed below. The full list of ecological sensitive receptors is shown in Appendix O.

<u>Literature review findings</u>

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-50]. However, based on faunistic surveys, no Aculeate hymenopterans of conservation significance was observed. Hence, they are classified as Priority 2 sensitive ecological receptor.

It is documented that adult odonates appear to be able to hear however sound does not appear to cause significant behavioural change [P-81]. 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-85]. Adult butterflies are known to make use of existing airborne noise in order to avoid predators [P-30]. Hearing dependent night-flying butterflies and moths are sensitive to sounds in order to avoid predation from bats [P-92}. Based on the above, lepidopterans are considered highly auditory. Hence, classified as Priority 1 sensitive ecological 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-70]. Hence, the aquatic species within waterbodies such as decapods, fishes and tadpoles are considered to be Priority 3 sensitive ecological 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-44]. Hence, amphibians are classified as Priority 1 sensitive ecological 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-59]. Snakes are unable to hear airborne noise and are not considered noise sensitive but are however sensitive to vibrations [P-31]. Turtles and terrapins will follow the classification of aquatic species due to the ability to traverse the lands and water [P-36]. Given the wide range of species classified under reptiles, the classification for Reptiles ranges from Priority 1 to Priority 3 sensitive ecological 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-1]. Hence, birds are classified as Priority 1 sensitive ecological 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-60]. Hence, non-volant mammals are deemed to be highly auditory sensitive and classified as Priority 1 sensitive ecological receptors.

Anthropogenic noise is known to impacts bats negatively by disrupting foraging patterns [P-88] and bats 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 sensitive ecological receptor.

Table 11-10 Ecological Receptor and Airborne Noise Sensitivity Classification

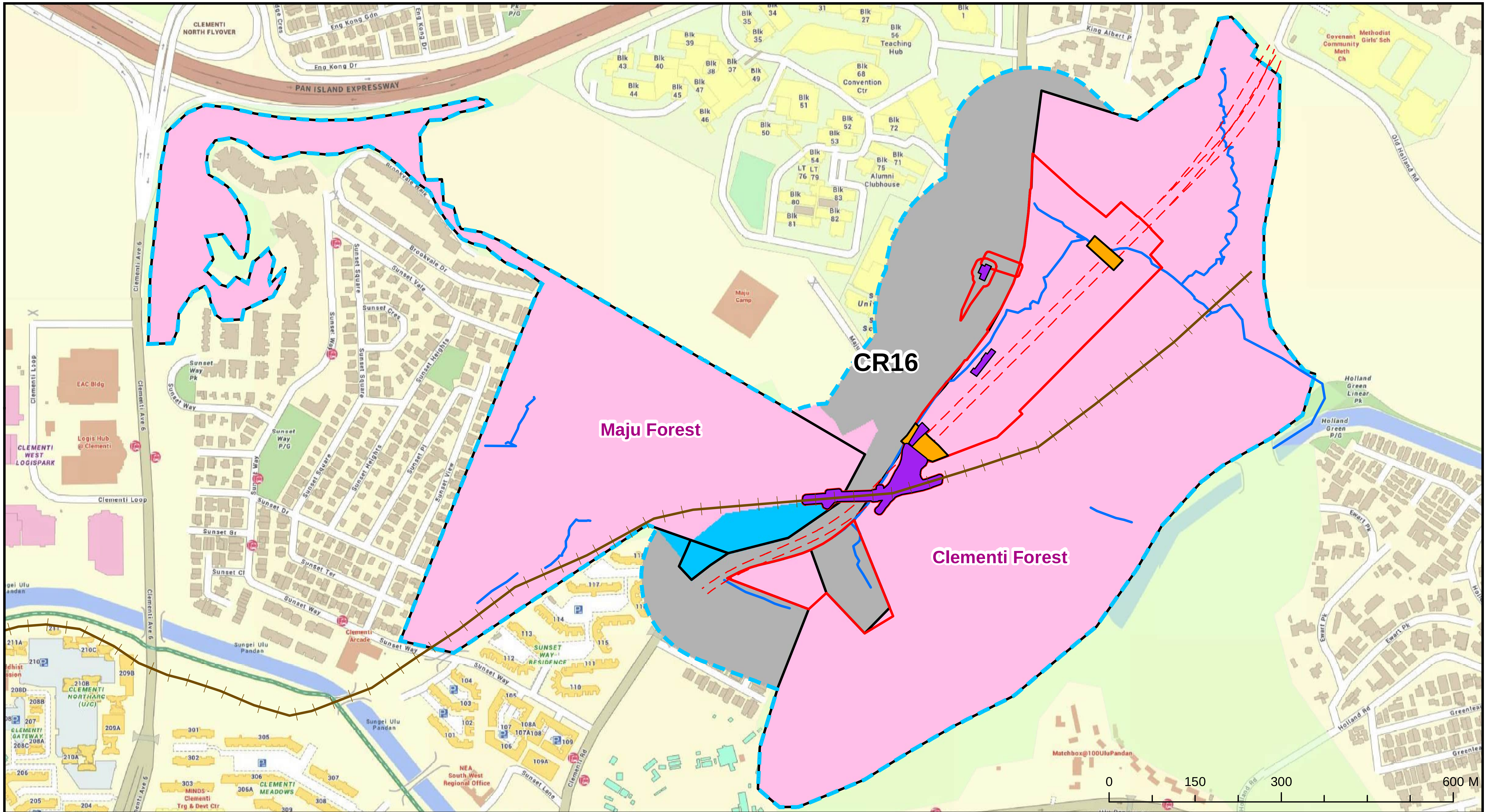
Receptor Number	Receptors	Sensitivity Classification
1	Aculeate hymenopterans • Bee • Wasp	Priority 2
2	Odonates • Damselfly • Dragonfly	Priority 2/Priority 3
3	Lepidoptera • Butterfly • Moth	Priority 1
4	Aquatic Species • Crab • Shrimp • Fishes • Tadpoles	Priority 3
5	Amphibians • Frogs	Priority 1
6	Reptiles • Lizards	Priority 1
7	Reptiles • Snakes	Priority 2
8	Reptiles • Snakes • Turtles and Terrapins	Priority 3
9	Birds	Priority 1
10	Non-volant Mammals	Priority 1
11	Bats	Priority 2

Maju Forest

The faunistic field assessment recorded 131 species with more than half of the recorded assemblage dominated by bird (48 species) and butterfly (33 species) species. Out of the 131 species recorded, 10 of which are of conservation significance (2 non-volant mammal, 7 Birds and 1 Reptile).

Clementi Forest

The faunistic field assessment documented 210 species. The recorded assemblage was dominated by bird (71 species), butterfly (49 species) and moth (33 species) species. Out of the 210 species recorded, 19 of which are of conservation significance (10 birds, 2 butterflies, 2 odonates, 1 aculeate hymenopteran, 1 fish, 1 reptile, 1 non-volant mammal and 1 bat).



Legend

- Watercourses
- Proposed CRL Alignment (Base)
- Base Scenario Construction Worksite Footprint
- Station Entrances/ Exits (Base)
- TBM Worksite (Base)
- Noise Study Area
- Old Jurong Railway Corridor
- Biodiversity Study Area
- Not Assessible
- Priority 1
- Priority 3

N

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Figure Title :
CONSTRUCTION NOISE SENSITIVE RECEPTORS

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11.5 Baseline Airborne Noise

11.5.1 Baseline Monitoring Results

Table 11-11 and Table 11-12 summarises the $L_{Aeq(12\ hour)}$, $L_{Aeq(1\ hour)}$ and $L_{Aeq(5\ min)}$ baseline results for weekdays and Sundays/public holidays respectively. Table 11-13 summarises the $L_{Aeq(15\ min)}$ baseline results. Refer to Appendix N for the baseline noise monitoring report. 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 11-11 Summary of Baseline Noise Monitoring Results – Weekdays (For Construction Noise Impact)

Location	Date of Monitoring	LAeq(12 hour), dB		LAeq(1 hour), dB						LAeq(5 min), dB									
		07:00 – 19:00	19:00 – 07:00	19:00 – 22:00			22:00 – 07:00			07:00 – 19:00			19:00 – 22:00			22:00 – 07:00			
		Overall		Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	
N01: Landed housing along Clementi Crescent	14 Jan - 21 Jan 2020	66	63	64	68	66	57	66	61	61	74	66	63	71	65	53	70	61	
N02: Within Clementi Forest	14 Jan – 21 Jan 2020	52	52	44	70	54	39	65	43	41	71	48	40	75	50	37	71	43	
N03: Singapore University of Social Sciences (SUSS)	24 Jan – 03 Feb 2020	62	58	60	63	61	51	61	56	58	69	62	58	67	61	47	63	56	
N04: Children's Aid Society (Melrose Home)	29 Jan – 05 Feb 2020	66	63	64	70	66	56	69	61	62	71	66	63	72	66	53	70	61	

Table 11-12 Summary of Baseline Noise Monitoring Results – Sunday/Public Holiday (For Construction Noise Impact)

Location	Date of Monitoring	LAeq(12 hour), dB		LAeq(1 hour), dB						LAeq(5 min), dB								
		07:00 – 19:00	19:00 – 07:00	19:00 – 22:00			22:00 – 07:00			07:00 – 19:00			19:00 – 22:00			22:00 – 07:00		
		Overall		Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
N01: Landed housing along Clementi Crescent	14 Jan - 21 Jan 2020	65	63	65	65	65	56	66	61	62	72	65	63	67	65	53	68	60
N02: Within Clementi Forest	14 Jan – 21 Jan 2020	46	51	44	61	51	37	45	40	40	57	45	41	72	46	36	47	40
N03: Singapore University of Social Sciences (SUSS)	24 Jan – 03 Feb 2020	60	57	60	61	60	52	60	55	57	62	60	58	64	60	47	62	55
N04: Children's Aid Society (Melrose Home)	29 Jan – 05 Feb 2020	65	62	64	65	64	55	64	60	60	67	65	64	66	64	53	66	59

Table 11-13 Summary of Baseline Noise Monitoring Results (For Operational Noise Impact)

Location	Date of Monitoring	LAeq(15 min), dB								
		07:00 – 19:00			19:00 – 23:00			23:00 – 07:00		
		Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
N01: Landed housing along Clementi Crescent	14 Jan - 21 Jan 2020	62	73	66	64	70	65	55	67	61
N02: Within Clementi Forest	14 Jan – 21 Jan 2020	41	70	48	40	74	49	36	70	42
N03: Singapore University of Social Sciences (SUSS)	24 Jan – 03 Feb 2020	57	66	62	58	65	61	50	62	55
N04: Children's Aid Society (Melrose Home)	29 Jan – 05 Feb 2020	60	69	66	63	72	66	54	68	60

11.5.2 Corrected Construction Noise Criteria

Based on the baseline noise monitoring results, the overall noise levels for $L_{Aeq(12\ hour)}$ and $L_{Aeq(5\ min)}$ from N01 to N04 were used to calculate the "adjusted maximum permissible noise level" in line with the directions given in Section 11.2.3.2 to determine the construction noise criteria for this Project.

Table 11-14 shows the corrected construction noise criteria and the calculations are shown in Appendix Z.

It is to be noted that ecological receptors noise impact in Maju Forest and Clementi Forest was assessed against the baseline noise level as the noise criterion. Since there is no public holiday for ecological receptors, weekday baseline noise levels were used for noise criteria.

Table 11-14 Corrected Construction Noise Criteria - Weekdays

No.	Types of Affected Receptors	$L_{Aeq(12\ hour)}$, dB		$L_{Aeq(5\ min)}$, dB		
		07:00-19:00	19:00-07:00	07:00-19:00	19:00-22:00	22:00-07:00
N01	(a) Noise Sensitive (Human)	67	63	76	65	62
N02		61	54	75	56	55
N03		64	59	75	62	59
N04		67	63	76	66	62
N01	Ecological Sensitive Receptors*	66	63	66	65	61
N02		52	52	48	50	43
N03		62	58	62	61	56
N04		66	63	66	66	61

***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 $L_{Aeq(15\ Min)}$ from N01 to N04 were used to calculate the "adjusted maximum permissible noise level" in line with the directions given in Section 11.2.3.2 to determine the construction noise criteria for this Project.

Table 11-15 shows the corrected operational noise criteria for human receptors and the calculations are shown in Appendix Z. It is to be noted that ecological receptors noise impact in Maju Forest and Clementi Forest were assessed against the baseline noise level as the noise criterion.

Table 11-15 Corrected Operational Noise Criteria

No.	Types of Affected Buildings/receptors	$L_{Aeq(15\ min)}$, dB		
		07:00-19:00	19:00-23:00	23:00-7:00
N01	(a) Noise Sensitive Premises (Human)	67	65	61
N02		60	56	51

No.	Types of Affected Buildings/receptors	$L_{Aeq(15\ min)}$, dB		
		07:00-19:00	19:00-23:00	23:00-7:00
N03		65	62	56
N04		67	66	60
N02	Maju Forest*	48	49	42
N02	Clementi Forest (Southern)*	48	49	42
N04	Clementi Forest (Northern)*	66	66	60

***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 pre-construction baseline monitoring prior to site clearance, plan for monitoring during the construction phase, and procedure for complaint handling;
- The contractor will 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 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;
- Behavioral 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 NSRs;
- Material stockpiles and other structures will be effectively utilised, wherever practicable, in screening noise from on-site construction activities;
- Tunnel boring 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 ecological sensitive receptors from the base scenarios of the proposed development.

11.7.1 Construction Phase

11.7.1.1 Rock Breaking, Excavation and Air Overpressure

Rock breaking and excavation events are proposed at CR16 worksite with the closest Biodiversity Study Area being Maju Forest and Clementi Forest The approximate distance from CR16 worksite to the boundary of Maju Forest is 80m and to the boundary of Clementi Forest is 47m. Based on the approach mentioned in Section11.2.2.2, the air over pressure for 5.4 kg is 153 dB at 47m distance from Clementi Forest and the air over pressure for 5.4kg is 146 dB at 80m distance from Maju Forest based on formula (2).

Table 11-16 Summary of Prediction and Evaluation of Airborne Noise – Rock Breaking and Excavation Impacts at ⩽ 100m from CR16 Worksite

Horizontal Distance from Worksite, m	Biodiversity Study Area	Receptor Priority	Discharge Mass	SPL	Impact Intensity	Impact Consequence	Likelihood	Impact Significance
47	Clementi Forest (Base)	1	5.4kg	153	Medium	Medium	Certain	Major
80	Maju Forest (Base)	1	5.4kg	146	Low	Low	Certain	Moderate
		3			Low	Very Low	Certain	Minor

Clementi Forest

At Clementi Forest, Priority 1 ecologically sensitive habitats 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**, the resulting impact significance is **Major.**

Maju Forest

At Maju Forest, Priority 1 ecologically sensitive habitats will potentially experience low impact intensity with low impact consequence. Since the likelihood of rock breaking and excavation works occurring during the entire construction is regarded as **Certain**, the resulting impact significance is **Moderate.** Priority 3 ecologically sensitive habitats at Clementi Neighbourhood Park will potentially experience low impact intensity with very low impact consequence and the resulting impact significance is **Minor.**

Since the impact significance is Major in Clementi Forest, the mitigation measures refer to Section 12.9 from vibration section and EMMP requirement from Section 13.11 need to apply**.**

11.7.1.2 Construction Base Scenarios 1 to 3

Based on the modelled noise levels in Table 11-8, the ecological sensitive habitats 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 three 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, and the predicted levels at this height were assessed in more details for Scenario 1 to Scenario 3 and is shown in Table 11-17.

The worst-case noise contours with impact significance (1.5m height) for Base Scenario 1 to Scenario 3 are shown in Figure 11-5 to Figure 11-7.

Table 11-17 Summary of Construction Noise Impacts (Base Scenario)

Scenario	Ecologically sensitive Study Area	Receptor Priority	Maximum Noise Level Observed, dB(A)	Maximum Exceedance Observed*, dB(A)	Impact Intensity	Impact Consequence	Likelihood	Impact Significance	Major Impact Significance Area (Hectares)
1 - Cut and cover works and associated activities	Clementi Forest	1	67	24	High	High	Certain	Major	26.5
	Maju Forest	1	52	9	High	High	Certain	Major	1.4
	Clementi Neighbourhood Park	3	51	8	High	Low	Certain	Moderate	
2 – TBM	Clementi Forest	1	76	33	High	High	Certain	Major	27.6
	Maju Forest	1	61	18	High	High	Certain	Major	3.5
	Clementi Neighbourhood Park	3	52	9	High	Low	Certain	Moderate	
3 - Construction of station entrances	Clementi Forest	1	81	33	High	High	Regular	Major	31.1
	Maju Forest	1	81	33	High	High	Regular	Major	4.5
	Clementi Neighbourhood Park	3	72	24	High	Low	Regular	Moderate	

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

Maju Forest

Maju Forest is in close proximity (150m from worksite) to the CR16 and nursery worksites. Across the three base scenarios, the highest noise level 52dB(A) was predicted for ground level receptors during the cut and cover works and associated activities with 61dB(A) during TBM work and 81dB(A) during construction of station entrances respectively. This is largely dependent on the proximity of the noisy works. As the entrance is closest to the Maju Forest, understandably the noise impact is highest from this phase too. However, this phase is usually short lived for couple of months for construction.

During the cut and cover works and associated activities, Priority 1 ecologically sensitive habitats at Maju Forest will potentially experience the highest exceedance of the noise criterion 9dB(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 Maju Forest will potentially experience the highest exceedance of the noise criterion 18dB(A) (high impact intensity) with high impact consequence. Since the likelihood occurring during the entire construction is regarded as **Certain**, and the resulting impact significance is **Major.** Due to the direct line of sight from southern TBM works, understandably the noise impact is major.

During the Entrance construction, Priority 1 ecologically sensitive habitat at Maju Forest will potentially experience the highest exceedance of the noise criterion 33dB(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.**

Clementi Forest

Clementi Forest is in close proximity (150m from worksite) to the CR16 and nursery worksites. Across the three base scenarios, the highest noise level 67dB(A) was predicted for ground level receptors during the cut and cover works and associated activities, with 76dB(A) during TBM work and 81dB(A) during construction of station entrances respectively. This is largely dependent on the proximity of the noise impact. As the entrance is closed to the Clementi Forest, understandably the noise impact is highest from this phase too. However, this phase is usually short with a few months for construction.

During the cut and cover works and associated activities, Priority 1 ecologically sensitive habitats at Clementi Forest will potentially experience the highest exceedance of the noise criterion 24dB(A) (high impact intensity) with high impact consequence. Since the likelihood is regarded as **Certain**, the resulting impact significance is **Major.**

During the TBM Work, Priority 1 ecologically sensitive habitat at Clementi Forest will potentially experience the highest exceedance of the noise criterion 33dB(A) (high impact intensity) with high impact consequence. Since the likelihood occurring during the entire construction is regarded as **Certain**, the resulting impact significance is **Major.**

During the entrance construction, Priority 1 ecologically sensitive habitat at Clementi Forest will potentially experience the highest exceedance of the noise criterion 33dB(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.**

Clementi Neighbourhood Park

Clementi Neighbourhood Park is in close proximity (150m from worksite) to the CR16 and nursery worksites. Across the three base scenarios, the highest noise level 51dB(A) was predicted for ground level receptors during the cut and cover works and associated activities, with 52dB(A) during TBM work and 72dB(A) during construction of station entrances respectively. This is largely dependent on the proximity of the noise impact. As the entrance is closed to the Clementi Neighbourhood Park, understandably the noise impact is highest from this phase too. However, this phase is usually short with a few months for construction.

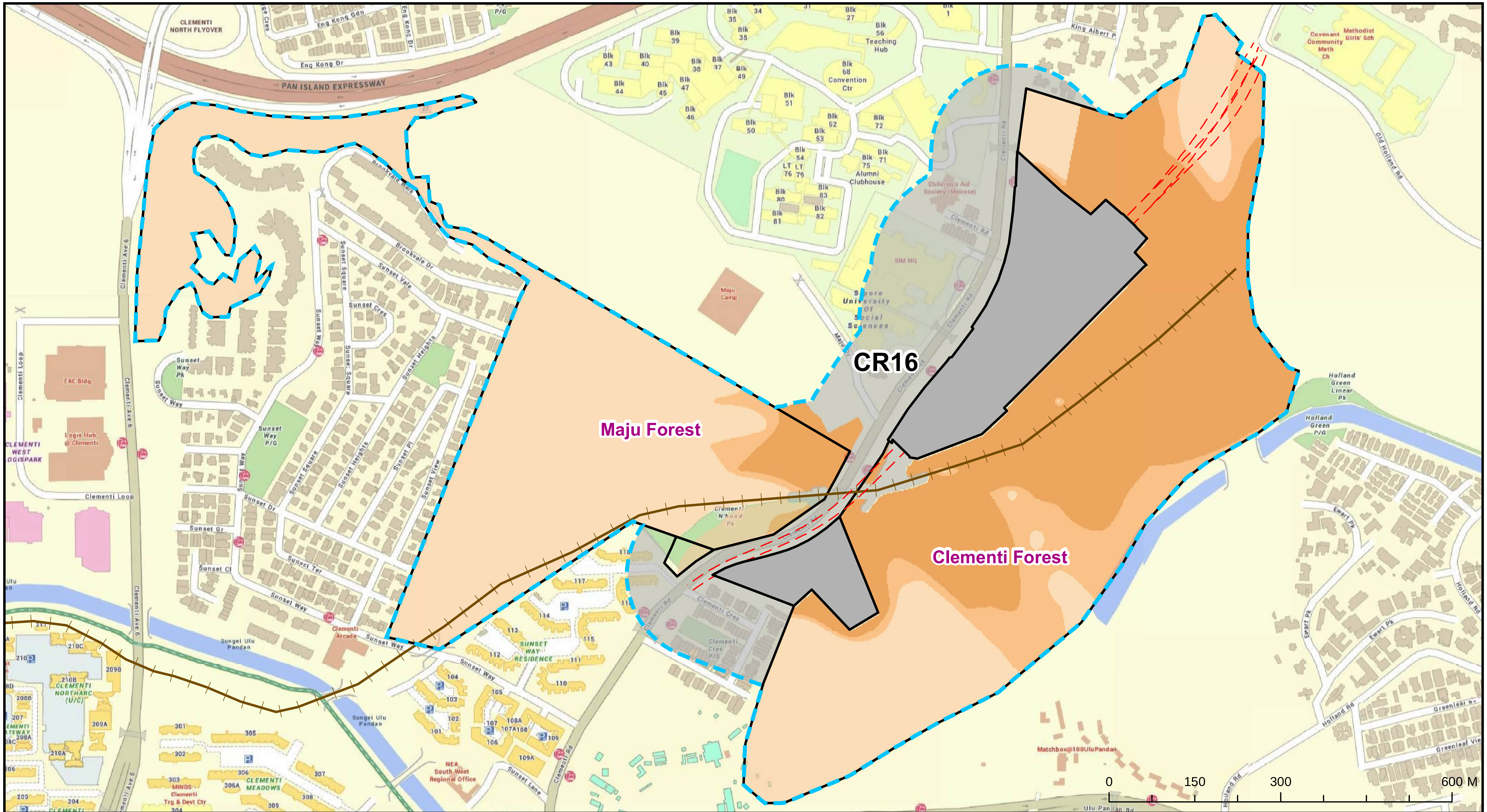
During the cut and cover works and associated activities, Priority 3 ecologically sensitive habitats at Clementi Neighbourhood Park will potentially experience the highest exceedance of the noise criterion 8dB(A) (high impact intensity) with low impact consequence. Since the likelihood occurring during the entire construction is regarded as **Certain**, the resulting impact significance is **Moderate.** Due to the direct line of sight from southern part of construction worksite and nursery worksites, understandably the noise impact is moderate.

During the TBM work, Priority 3 ecologically sensitive habitats at Clementi Neighbourhood Park will potentially experience the highest exceedance of the noise criterion 9dB(A) (high impact intensity) with low impact consequence. Since the likelihood occurring during the entire construction is regarded as **Certain** and the resulting impact significance is **Moderate.** Due to the direct line of sight from southern TBM works, understandably the noise impact is moderate.

During the entrance construction, Priority 3 ecologically sensitive habitats at Clementi Neighbourhood Park will potentially experience the highest exceedance of the noise criterion 24dB(A) (high impact intensity) with low impact consequence. Since the likelihood occurring during the entire construction is regarded as **Regular** 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 were 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 and Maju Forest, 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) and try to avoid vicinity of the construction site for up to 2.5-90 m. It is to be noted that avian species impacted are likely able to find alternative habitats in the surroundings. Impacts of disturbances to these species are unclear, but noise disturbances may affect its communication with other individuals. These are also species that may utilise the ecological connectivity along the Old Jurong Railway. Subsequently, they have adapted to disturbed habitats such as parklands and is increasingly more widespread; and may be able to use alternative habitats around the Biodiversity Study Area

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.



Legend

- Proposed CRL Alignment (Base)
- Base Scenario Construction Worksite Footprint
- Noise Study Area
- Old Jurong Railway Corridor
- Biodiversity Study Area

Impact Significance

- Minor
- Moderate
- Major
- Not Assessible

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAY 2022	PZ	EIS (Clementi Forest and Maju Forest)	JAG/NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

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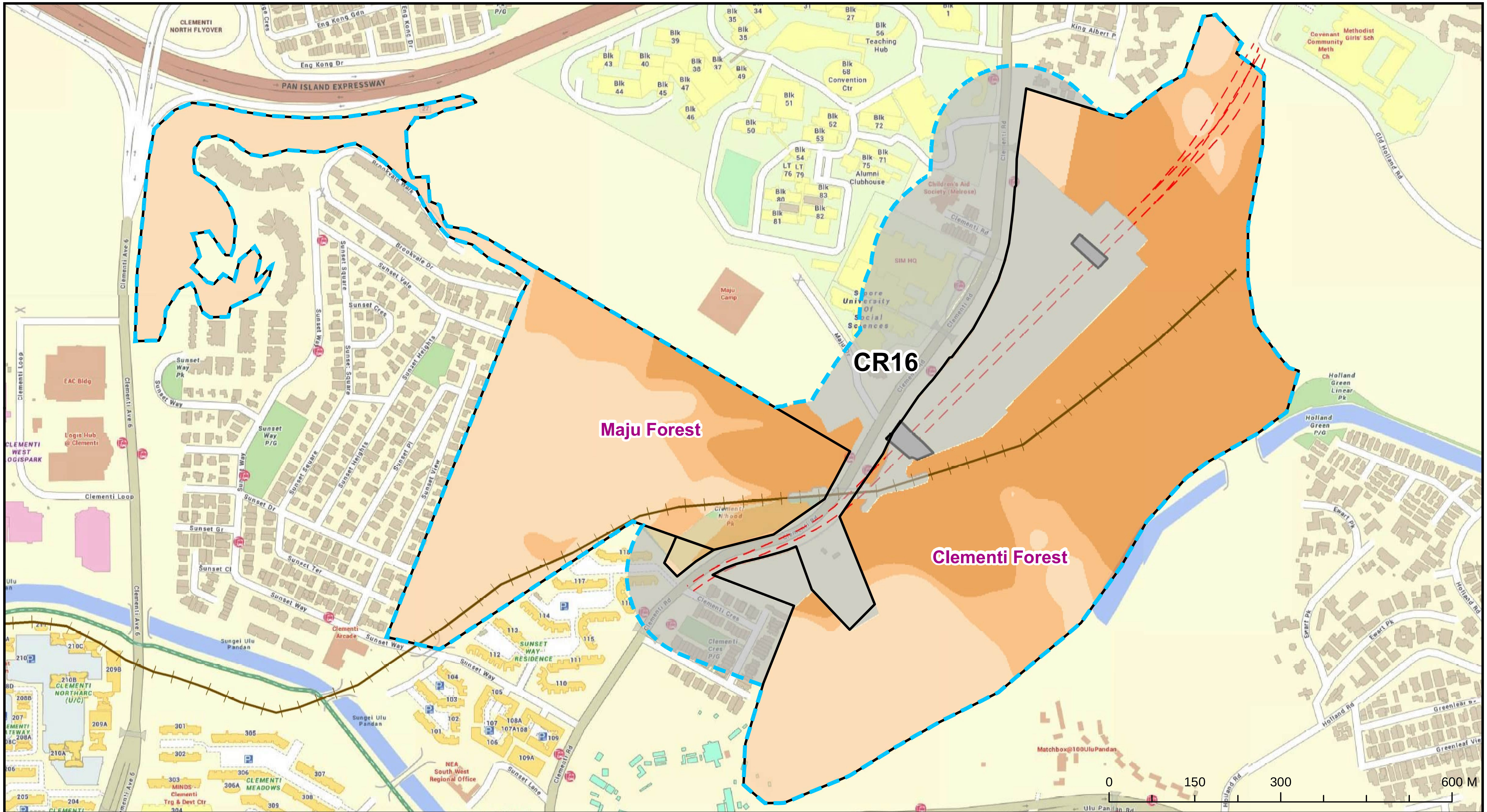
Project Title :
CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(CLEMENTI FOREST AND
MAJU FOREST)

Figure Title :
SCENARIO 1 CUT AND COVER
WORKS AND ASSOCIATED ACTIVITIES
LEQ (5MINS) (7PM – 7AM)
BASE SCENARIO

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
PZ	JAG/NHT	JAG	11-5	-	1 of 1
	Drawn PZ	Date MAY 2022	CAD File Name : NA		A3

Note: Source of basemap - OneMap



Legend

- Proposed CRL Alignment (Base)
- Base Scenario Construction Worksite Footprint
- Noise Study Area
- Old Jurong Railway Corridor
- Biodiversity Study Area

Impact Significance

- Minor
- Moderate
- Major
- Not Assessible

N

Rev.	Date	By	Description	Chk'd	App'd
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Qualified Person Endorsement : NA

LTA Endorsement : NA

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Project Title :
CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (CLEMENTI FOREST AND MAJU FOREST)

Figure Title :
SCENARIO 2 TBM LEQ (5MINS) (7PM – 7AM) BASE SCENARIO

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
PZ	JAG/NHT	JAG	11-6	-	1 of 1

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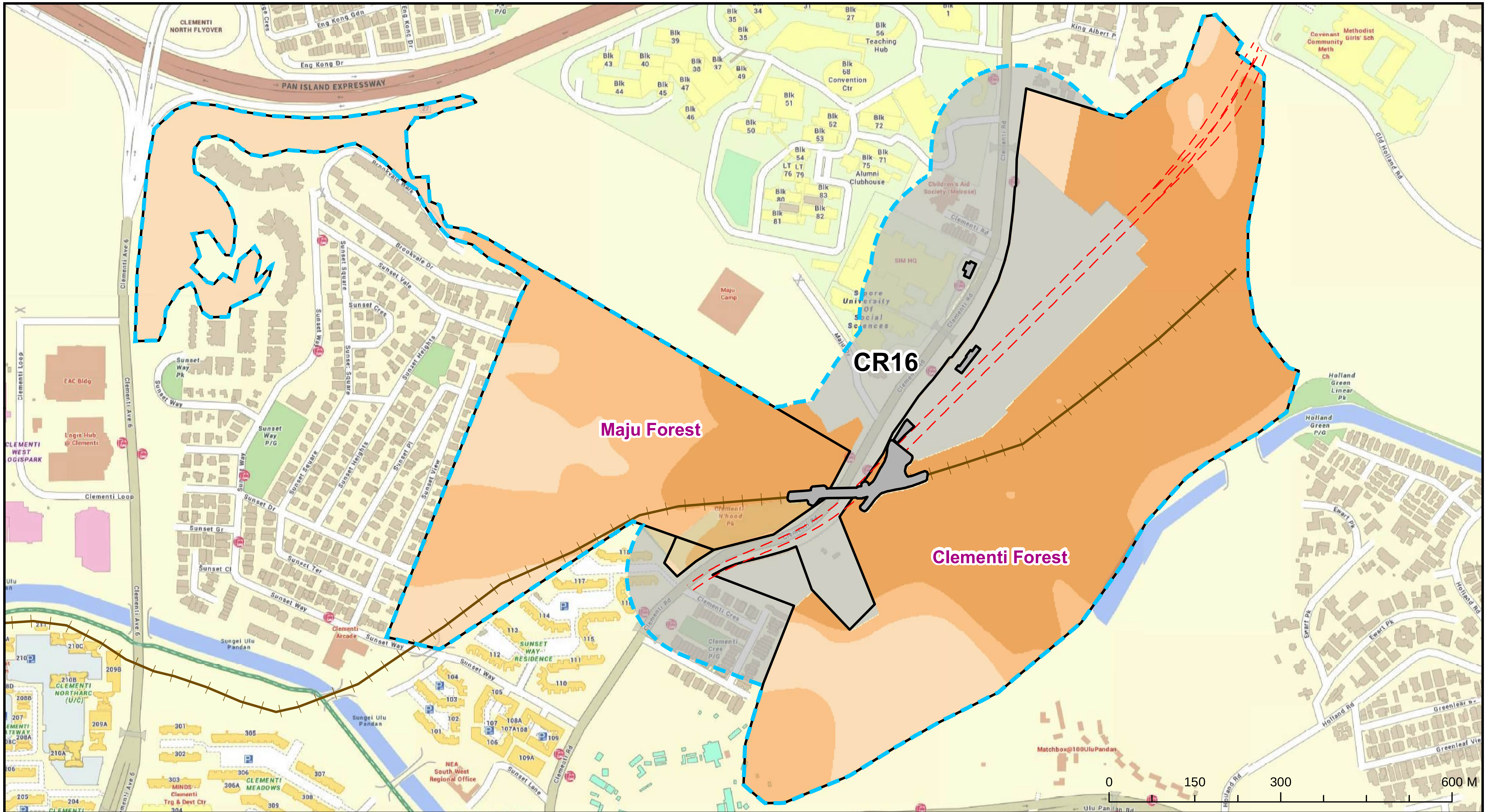
Note: Source of basemap - OneMap



Legend

- Proposed CRL Alignment (Base)
- Base Scenario Construction Worksite Footprint
- Noise Study Area
- Old Jurong Railway Corridor
- Biodiversity Study Area

Impact Significance

- Minor
- Moderate
- Major
- Not Assessible

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAY 2022	PZ	EIS (Clementi Forest and Maju Forest)	JAG/NHT	JAG

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Consultant : AECOM

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Project Title :
CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(CLEMENTI FOREST AND
MAJU FOREST)

Figure Title :
SCENARIO 3 ENTRANCE
CONSTRUCTION LEQ (5MINS)
(7AM – 7PM) BASE SCENARIO

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
PZ	JAG/NHT	JAG	11-7	-	1 of 1
	Drawn PZ	Date MAY 2022	CAD File Name : NA		A3

Note: Source of basemap - OneMap

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 vent buildings will be conducted by LTA in a separate study. The criteria for noise at each location has been provided 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 11-18. Given that the design of this building will be such as to meet the boundary noise requirements as stated in this Report, and the design of the building will be such as it camouflages in the surroundings; the expected noise impact during operational phase will be **negligible**.

Table 11-18 Project Criteria for Operational Noise Impact Assessment- Ecology

No.	Types of Affected Receptors	$L_{Aeq(15\ min)}$, dB		
		07:00 to 19:00	19:00 – 23:00	23:00 – 07:00
Maju Forest (N02)*	Ecologically sensitive receptors	48	49	42
Clementi Forest (Southern) (N02)*		48	49	42
Clementi Forest (Northern) (N04)*		66	66	60

***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

Traffic noise around the vent shafts is expected to be low as very rare visit to this building is expected for maintenance purposes only. Since there is no addition of new access roads for these vent shafts, and they will be accessible via current existing roads, the noise from the routine traffic will dominate the noise levels. The station CR16 will be situated along existing roads and is not expected to add on any new roads as well. CR16 is located near busy roads, and it is possible that addition of traffic due to railway station may not double the traffic in the area; however, it is possible that since these both locations are near schools/ university, the commuters may be those attending these educational institutes and currently coming by road, will change to commute by trains; in which case, the traffic on the road may reduce. Therefore, it seems that though noise levels from traffic may reduce in and around CR16. At the time of writing of this Report, there was no study done on the predicted traffic conditions at this stage near these establishments and the discussion above is based on basic understanding of the area and land use in the vicinity. In absence of specialist traffic study, there is no evaluation 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 levels and the impacts as detailed in the sections above

11.8.1.1 Elimination/Substitution

- It is recommended to reduce the works planned at CR16 worksite in terms of footprint in Clementi Forest, Maju Forest, the underground connection, TBM launch/ retrieval options etc. Based on discussion and further design development, it was made possible pursuant to the base scenario to have an option where cross over is cancelled, TBM launch at south end was removed and to bring the TBM north side location inwards away from the stream intended for conservation.

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.
- For noisy machinery such as the Secant Pile Auger - that typically operates for long period, the soundproof baffles can be mounted directly on the machine around the engine cowling.

The implementation of noise mitigation comes about in two steps:

Step 1: 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 will 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 will 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 will be placed as close as possible to either the source or the receiver position, for maximum effectiveness;
- Materials having noise absorptive properties will 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 will be at least ten times the height of the barrier.
- Noise Barrier of minimum STC 20 is proposed to be erected at all the locations (both for advance works and main construction works) presented in Figure 11-8 in order to mitigate the construction noise to the noise sensitive receptors. These locations are:
    - For advance works:
        - 6 m high noise barrier at the west and south-east construction boundary of CR16 advance worksite fronting noise sensitive receptors,
        - 12m high noise barrier at north-east construction boundary of CR16 advance worksite fronting noise sensitive receptors after completion of advance worksite construction,
    - For main construction works:
        - 12 m high noise barrier at the west construction boundary of CR16 main construction worksite fronting noise sensitive receptors,
        - Use the existing 6 m high noise barrier from the south-east construction boundary of CR16 advance worksite and 12m high noise barrier from the north-east construction boundary of CR16 advance worksite
        - LTA's standard TBM enclosure (one facade opening at northern side) 15m high at boundary of CR16 launch shaft.
- 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.
- At Clementi Forest during the TBM work, there is an exceedance of up to 33 dB is found without noise barrier. AECOM proposes a LTA's standard TBM enclosure (one facade opening at northern side) 15m high at boundary of CR16 launch shaft presented in Figure 11-8 in order to mitigate the construction noise to the noise sensitive receptors. Based on the couple of noise barrier TBM enclosure 15m high with side opening analysis, it was determined that TBM enclosure (one facade opening at northern side) 15m high at boundary of CR16 launch shaft gives the maximum benefit of noise reduction especially eastern side of CR16 worksite which is the closed proximity to the Biodiversity Study Area. The exceedance dB in the Base Scenario, Mitigated Scenario and the benefit of noise barrier with one facade opening at northern side and two facades

opening at northern and southern side respectively are shown in Table 11-19. noise barrier with one facade opening at northern side and two facades opening at northern and southern side were presented in Figure 11-9.

Table 11-19 Comparison of Noise Level Exceedance from TBM worksite

Name	Receptor Sensitivity	Type	Exceedance in $L_{Aeq(5\ min)}$ Criteria (19:00 – 07:00)			
			Base Scenario	Mitigated Scenario	Mitigated Scenario with Enclosed Noise Barrier (15m)	
					Open Facade Opening (Northern Side)	Two Facade Opening (Northern and Southern Side
Clementi Forest						
North-east site of TBM worksites	1	Ecological	22	2	-	-
Eastern side of TBM worksite			33	21	6	12
Northern side of TBM worksites			5	5	12	9

Step 3: As a last resort in order to manage complaints, or mitigate further if there are intermittent noisy works, Table 11-20 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 11-20 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.

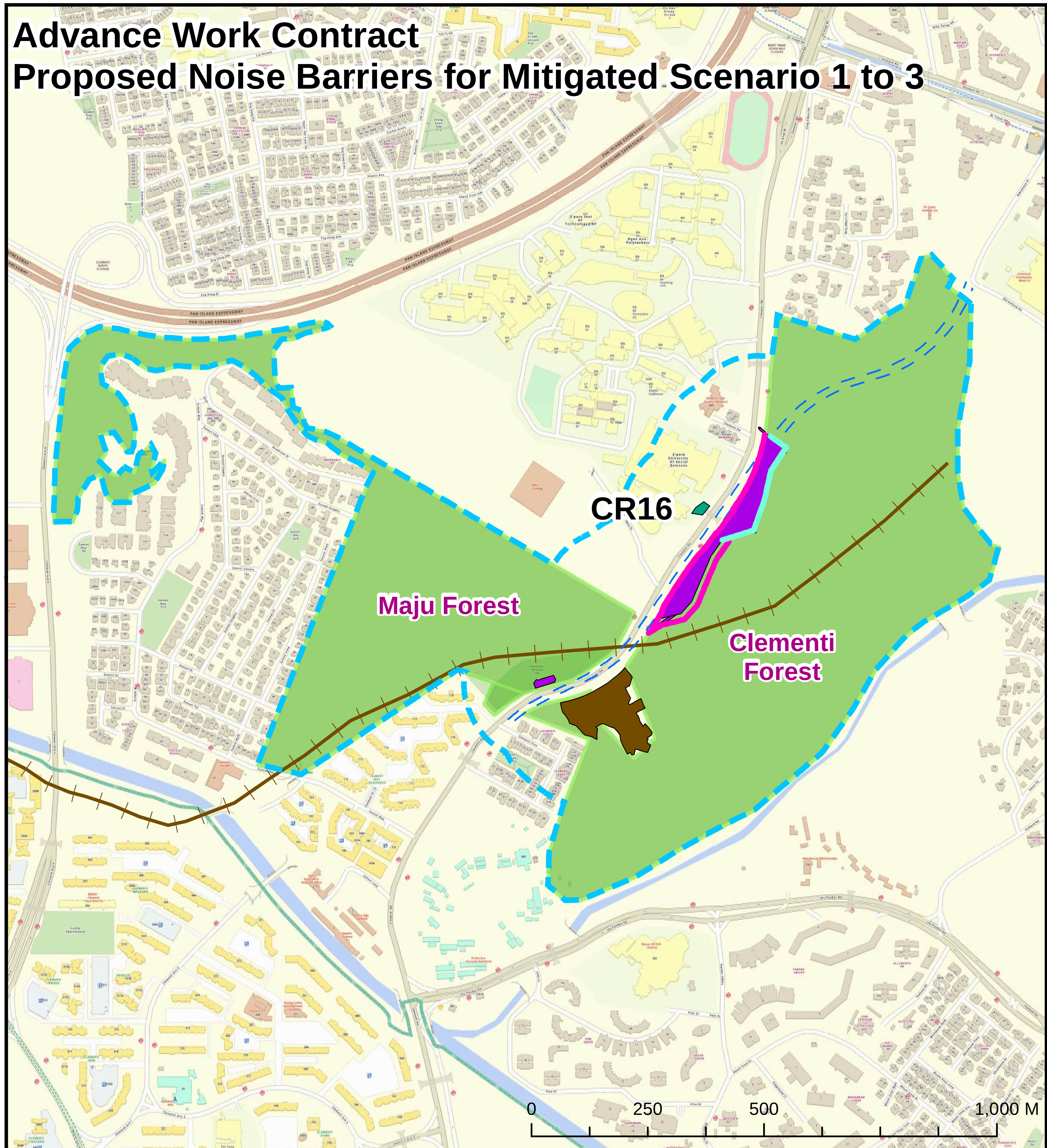
Table 11-20 Control of Noise Source from Construction Site

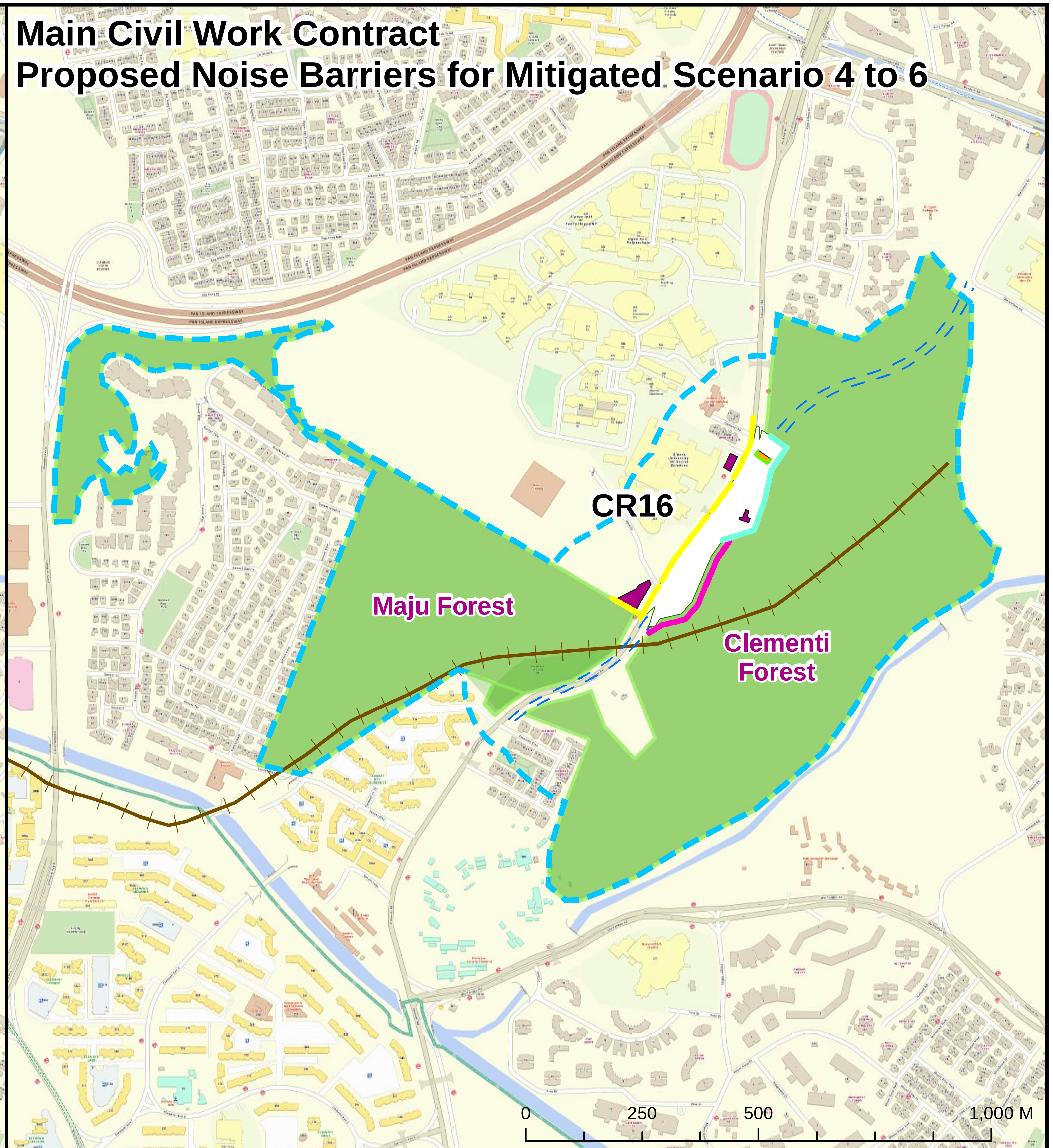
Type of Equipment	Equipment	Reduction Level, dB(A) [1]	Description of Source Control
Compressors & Generators	Generators	-20	Acoustic dampening of metal casing of body shell; acoustic enclosure or screen between the generator and receptor. The acoustic casing for the generator will be proprietary product supplied by the generator manufacturer. The screen, if used, will be as close as possible to the generator and it will be of a solid construction (minimum STC 20 or surface density > 20kg/m^2) 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.
Earth-moving Plant	Crane	-10	Manufacturers' enclosure panels to be kept closed. The engines of these vehicles will not be exposed and clad with the manufacturers' enclosure to reduce noise
	Roller	-10	

Type of Equipment	Equipment	Reduction Level, dB(A) [1]	Description of Source Control
	Gantry Crane	-10	break-out. Manufacturer-supplied silencers for the engine exhausts will be installed and maintained.
	Dump Truck	-10	
	Excavator with Rock Breaker	-10	
	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 will be as close as possible to the pile-driving and extracting activities and will be of a solid construction (minimum STC 20 or surface density > $20kg/m^2$) 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





Legend

- Proposed CRL Alignment (Mitigated)
- Noise Study Area
- Old Jurong Railway Corridor
- Biodiversity Study Area
- Proposed Noise Barrier-6m
- Proposed Noise Barrier-12m
- Proposed Noise Barrier - Enclosed Noise Barrier (15m)
- Proposed Noise Barrier-12m (Construct After Completion of Advance Work Construction)
- Advance Work Construction (Scenario 1)
- Construction of Site Office (Scenario 2)
- Demolition of POB (Scenario 3)
- Main Civil Work (Scenario 4)
- TBM (Scenario 5)
- Entrance Construction (Scenario 6)

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAY 2022	PZ	EIS (Clementi Forest and Maju Forest)	JAG/NHT	JAG

Qualified Person Endorsement :
NA

LTA Endorsement :
NA

Consultant :
AECOM

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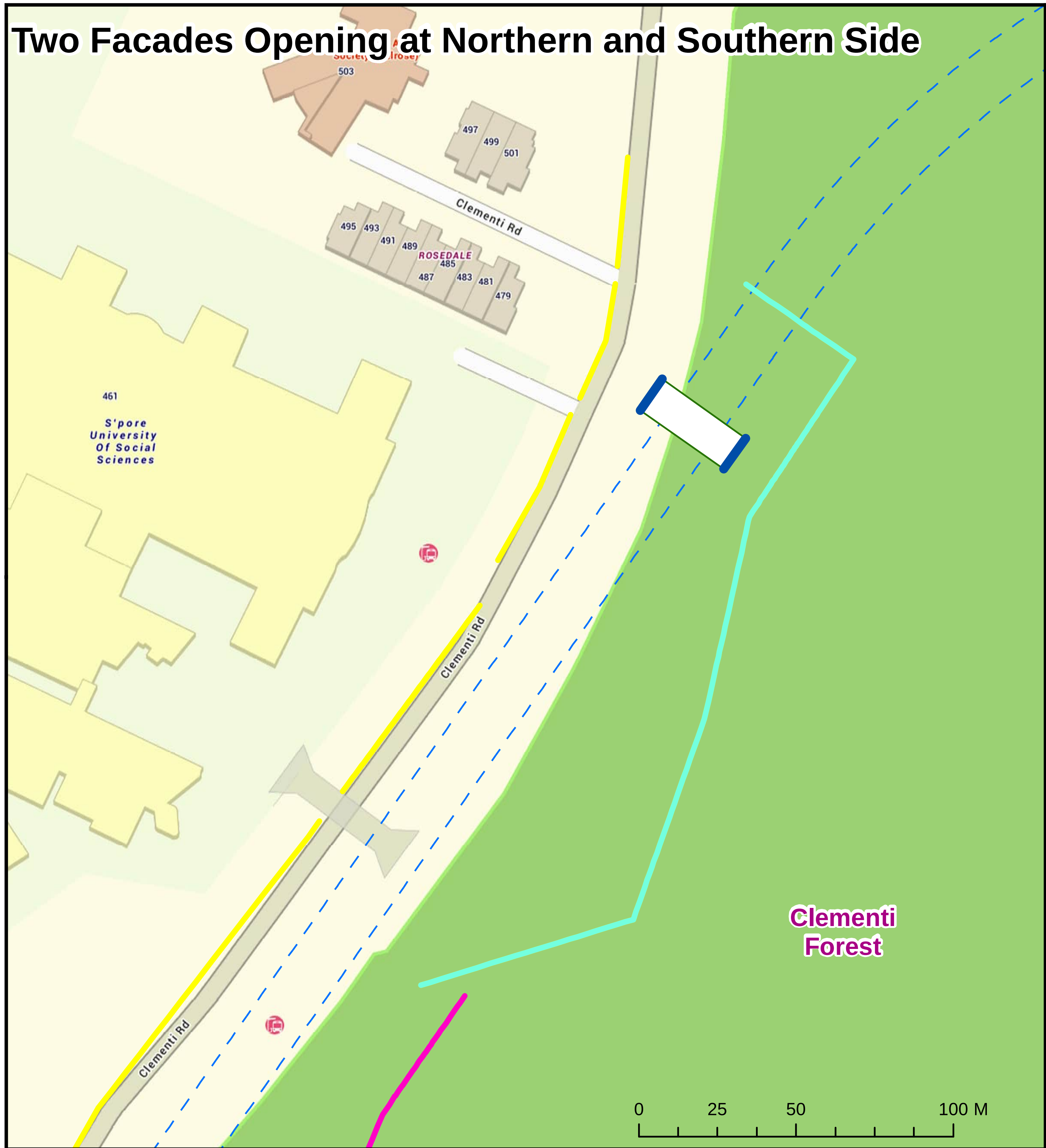
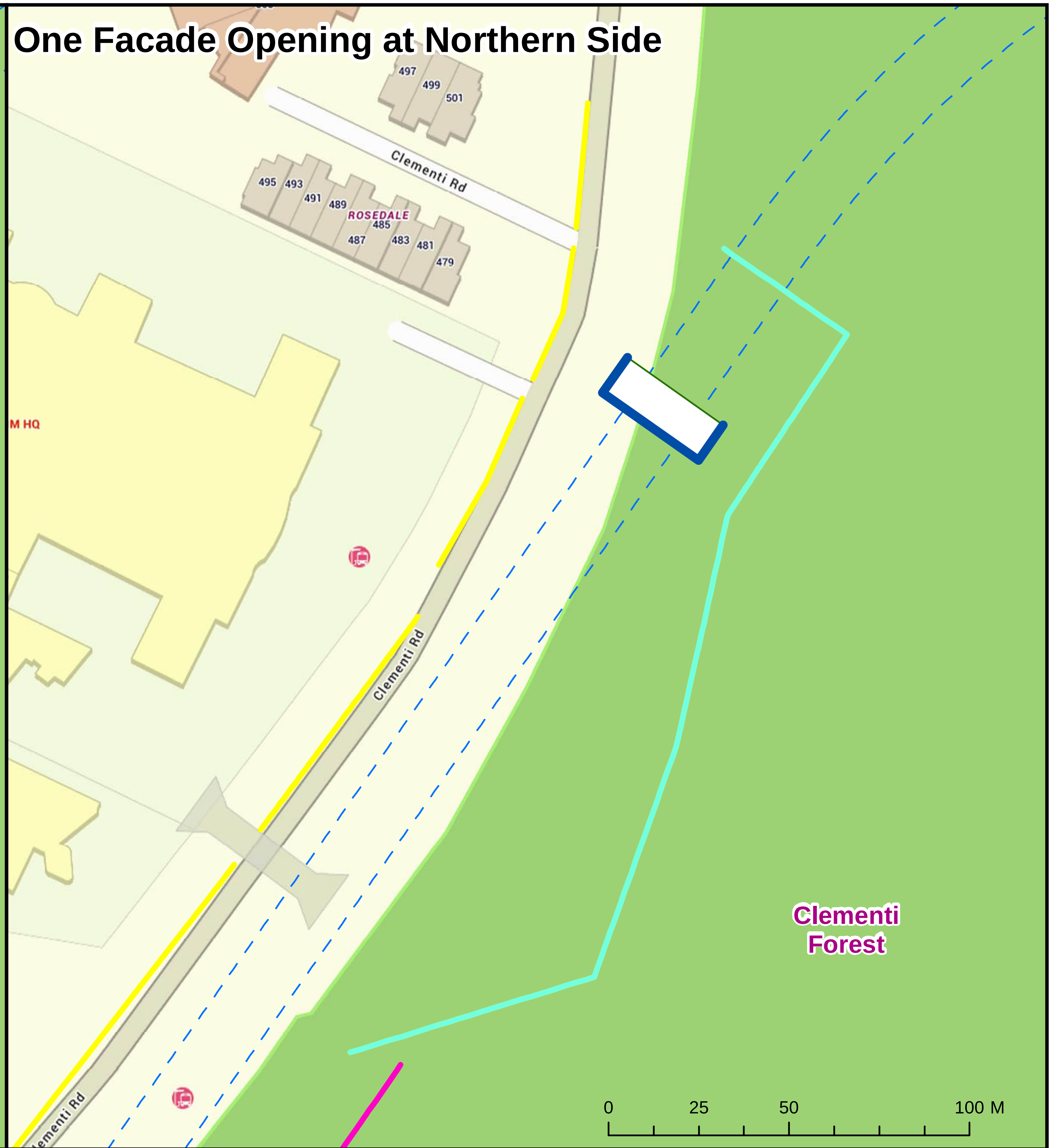
Project Title :
CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(CLEMENTI FOREST AND
MAJU FOREST)

Figure Title :
NOISE BARRIER LOCATION

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
PZ	JAG/NHT	JAG	11-8	-	1 of 1
	Drawn PZ	Date MAY 2022	CAD File Name : NA		A3

Note: Source of basemap - OneMap





Legend

- Proposed Noise Barrier-12m (Construct After Completion of Advance Work Construction)
- Proposed Noise Barrier - Enclosed Noise Barrier (15m)
- Proposed Noise Barrier-6m
- Proposed Noise Barrier-12m
- Proposed CRL Alignment (Mitigated)
- Mitigated Scenario TBM Worksite Footprint
- Noise Study Area
- Biodiversity Study Area
- Old Jurong Railway Corridor

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAY 2022	PZ	EIS (Clementi Forest and Maju Forest)	JAG/NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

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Project Title : CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (CLEMENTI FOREST AND MAJU FOREST)

Figure Title : TBM ENCLOSED NOISE BARRIERS

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
PZ	JAG/NHT	JAG	11-9	-	1 of 1
	Drawn PZ	Date MAY 2022	CAD File Name : NA		A3

Note: Source of basemap - OneMap

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 are 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.

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 Operation 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 if any to be designed and implemented;
- 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 detailed design stage and in accordance with *Technical Guideline for Land Traffic Noise Impact Assessment [R-52].*

11.9 Residual Impacts

11.9.1 Rock Breaking and Excavation Air Overpressure

Rock breaking and excavation events are proposed at the CR16 worksite with the closest Biodiversity Study Area being Clementi Forest and Maju Forest. The approximate distance from CR16 worksite to the boundary of Clementi Forest is 35m and to the boundary of Maju Forest is 80m.

Based on the approach mentioned in Section 11.2.2.1, the air over pressure for 5.4 kg is 156 dB at 47m distance from Clementi Forest and the air over pressure for 5.4kg is 146 dB at 80m distance from Maju Forest based on formula (2).

Table 11-21 Summary of Prediction and Evaluation of Airborne Noise – Rock Breaking and Excavation Impacts (Mitigated Scenario) at ≤ 100m from CR16 Worksite

Horizontal Distance from Worksite, m	Biodiversity Study Area	Receptor Priority	Discharge Mass (Up to)	SPL	Impact Intensity	Impact Consequence	Likelihood	Impact Significance
35	Clementi Forest (Mitigated)	1	5.4kg	156	Medium	Medium	Certain	Major
80	Maju Forest (Mitigated)	1	5.4kg	146	Low	Low	Certain	Moderate
		3			Low	Very Low	Certain	Minor

For the Mitigated Scenario at Clementi Forest, Priority 1 ecologically sensitive habitats 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, the resulting impact significance is **Major.**

For the Mitigated Scenario at Maju Forest, Priority 1 ecologically sensitive habitats will potentially experience low impact intensity with low impact consequence. Since the likelihood of rock breaking and excavation works occurring during the entire construction is regarded as **Certain**, the resulting impact significance is **Moderate.** Priority 3 ecologically sensitive habitats at Clementi Neighbourhood Park will potentially experience low impact intensity with very low impact consequence and the resulting impact significance is **Minor.**

Since the impact significance is Major in Clementi Forest, the mitigation measures refer to Section 12.9 from vibration section and EMMP requirement from Section 13.11 need to apply to reduce the residual impact**.**

11.9.2 Construction Mitigated Scenarios 1 to 6

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 due to noise reduction at the source and erection of noise barrier etc.

Since the likelihood of the assessment was based on the work period and active noise period for machinery. The likelihood evaluation of Scenario 1 to Scenario (refer to Table 11-9) except TBM work became Regular as the work period reduces from 24 hr (Base Scenario) to 12 hr (7am-7pm) in the Mitigated Scenario of CR16 worksites.The residual construction noise impact for post mitigated scenarios is shown in Table 11-22.

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Table 11-22 Summary of Construction Noise Impacts (Residual)

Scenario	Ecologically sensitive Study Area	Receptor Priority	Maximum Noise Level Observed, dB(A)	Maximum Exceedance Observed*, dB(A)	Impact Intensity	Impact Consequence	Likelihood	Impact Significance	Impact Significance Area (Hectares)
1 – Advance Work	Clementi Forest	1	81	33	High	High	Regular	Major	28.5
	Maju Forest	1	69	21	High	High	Regular	Major	2.1
	Clementi Neighbourhood Park	3	66	18	High	Low	Regular	Moderate	
2 – Construction of site office	Clementi Forest	1	49	6	Medium	Medium	Regular	Moderate	0.5
	Maju Forest	1	40	-	Negligible	Very Low	Regular	Minor	13.2
	Clementi Neighbourhood Park	3	44	1	Low	Very Low	Regular	Minor	
3 – Demolition of POB	Clementi Forest	1	58	10	High	High	Regular	Major	1.3
	Maju Forest	1	42	-	Negligible	Very Low	Regular	Minor	6.7
	Clementi Neighbourhood Park	3	42	-	Negligible	Imperceptible	Regular	Negligible	
4 – Main civil work	Clementi Forest	1	51	3	Low	Low	Regular	Moderate	2.9
	Maju Forest	1	46	-	Negligible	Very Low	Regular	Minor	11.4
	Clementi Neighbourhood Park	3	47	-	Negligible	Imperceptible	Regular	Negligible	
5 – TBM	Clementi Forest	1	70	12	High	High	Certain	Major	14.6
	Maju Forest	1	34	-	Negligible	Very Low	Certain	Minor	7.1
	Clementi Neighbourhood Park	3	34	-	Negligible	Imperceptible	Certain	Negligible	
6 – Construction of station entrances	Clementi Forest	1	63	15	High	High	Regular	Major	8.4
	Maju Forest	1	69	21	High	High	Regular	Major	1.7
	Clementi Neighbourhood Park	3	54	6	Medium	Very Low	Regular	Minor	

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

- Scenario 1: Advance works based on the residual airborne construction noise prediction above, Priority 1 ecologically sensitive habitat at Clementi Forest and Maju Forest will potentially experience 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 Priority 3 ecologically sensitive receptors at Clementi Neighbourhood Park will potentially experience high impact intensity and the resulting impact significance is **Moderate**.
- Scenario 2: Construction of site office, Priority 1 ecologically sensitive habitat at Clementi Forest will potentially experience medium impact intensity and the resulting impact significance is **Moderate**. But for Priority 1 ecologically sensitive receptors at Maju Forest will potentially experience negligible impact intensity and the resulting impact significance is **Minor**. Priority 3 ecologically sensitive receptors at Clementi Neighbourhood Park will potentially experience low impact intensity and the resulting impact significance is **Minor**.
- Scenario 3: Demolition of POB, Priority 1 ecologically sensitive habitat at Clementi Forest will potentially experience high impact intensity and the resulting impact significance is **Major**. But for Priority 1 ecologically sensitive receptors at Maju Forest and Priority 3 ecologically sensitive receptors at Clementi Neighbourhood Park will potentially experience negligible impact intensity and the resulting impact significance is **Minor** and **Negligible** respectively**.**
- Scenario 4: Main construction works, Priority 1 ecologically sensitive habitat at Clementi Forest will potentially experience low impact intensity and the resulting impact significance is **Moderate**. But for Priority 1 ecologically sensitive receptors at Maju Forest and Priority 3 ecologically sensitive receptors at Clementi Neighbourhood Park will potentially experience negligible impact intensity and the resulting impact significance is **Minor** and **Negligible** respectively**.**
- Scenario 5: TBM work Priority 1 ecologically sensitive habitat at Clementi Forest will potentially experience high impact intensity and the resulting impact significance is **Major**. But for Priority 1 ecologically sensitive receptors at Maju Forest and Priority 3 ecologically sensitive receptors at Clementi Neighbourhood Park will potentially experience negligible impact intensity and the resulting impact significance is **Minor** and **Negligible** respectively**.**
- Scenario 6: Construction of station entrances, Priority 1 ecologically sensitive habitat at Clementi Forest and Maju Forest will potentially experience high impact intensity and the resulting impact significance is **Major**. But for Priority 3 ecologically sensitive receptors at Clementi Neighbourhood Park will potentially experience low impact intensity and the resulting impact significance is **Minor**.

The residual airborne noise contours with impact significance (1.5m high) are shown in Figure 11-10 to Figure 11-15. 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)

Base Scenario Evaluation

Scenario	Ecologically sensitive Study Area	Receptor Priority	Maximum Exceedance Observed*, dB(A)	Impact Intensity	Impact Consequence	Likelihood	Impact Significance	Impact Significance Area percentage (Hectares)
1 - Cut and cover works and associated activities	Clementi Forest	1	24	High	High	Certain	Major	55% (26.5 ha)
	Maju Forest	1	9	High	High	Certain	Major	4% (1.4 ha)
	Clementi Neighbourhood Park	3	8	High	Low	Certain	Moderate	
2 – TBM	Clementi Forest	1	33	High	High	Certain	Major	58% (27.6 ha)
	Maju Forest	1	18	High	High	Certain	Major	11% (3.5 ha)
	Clementi Neighbourhood Park	3	9	High	Low	Certain	Moderate	
3 - Construction of station entrances	Clementi Forest	1	33	High	High	Certain	Major	65% (31.1 ha)
	Maju Forest	1	33	High	High	Certain	Major	14% (4.5 ha)
	Clementi Neighbourhood Park	3	24	High	Low	Certain	Moderate	

Post Mitigated Evaluation

Scenario	Ecologically sensitive Study Area	Receptor Priority	Maximum Exceedance Observed*, dB(A)	Impact Intensity	Impact Consequence	Likelihood	Impact Significance	Impact Significance Area percentage (Hectares)	Duration
1 – Advance Work	Clementi Forest	1	33	High	High	Regular	Major	52% (28.5 ha)	About 14 months
	Maju Forest	1	21	High	High	Regular	Major	6% (2.1)	
	Clementi Neighbourhood Park	3	18	High	Low	Regular	Moderate		
2 – Construction of site office	Clementi Forest	1	6	Medium	Medium	Regular	Moderate	1% (0.5 ha)	About 4 months
	Maju Forest	1	-	Negligible	Very Low	Regular	Minor	40% (13.2 ha)	
	Clementi Neighbourhood Park	3	1	Low	Very Low	Regular	Minor		
3 – Demolition of POB	Clementi Forest	1	10	High	High	Regular	Major	2% (1.3)	About 4 months
	Maju Forest	1	-	Negligible	Very Low	Regular	Minor	20% (6.7 ha)	
	Clementi Neighbourhood Park	3	-	Negligible	Imperceptible	Regular	Negligible		
4 – Main civil work	Clementi Forest	1	3	Low	Low	Regular	Moderate	5% (2.9 ha)	About 41 months
	Maju Forest	1	-	Negligible	Very Low	Regular	Minor	35% (11.4 ha)	
	Clementi Neighbourhood Park	3	-	Negligible	Imperceptible	Regular	Negligible		
5 – TBM	Clementi Forest	1	12	High	High	Certain	Major	27% (14.6 ha)	About 15 months
	Maju Forest	1	-	Negligible	Very Low	Certain	Minor	22% (7.1 ha)	
	Clementi Neighbourhood Park	3	-	Negligible	Imperceptible	Certain	Negligible		
6 – Construction of station entrances	Clementi Forest	1	15	High	High	Regular	Major	15% (8.4 ha)	About 6 months
	Maju Forest	1	21	High	High	Regular	Major	5% (1.7 ha)	
	Clementi Neighbourhood Park	3	6	Medium	Very Low	Regular	Minor		

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

Based on the residual airborne noise impact assessment above, the proposed 6m noise barriers and 12m noise barriers during CR16 main construction works will be beneficial by reducing impact significance:

- from Major (Base Scenario 1; Cut and cover works and associated activities) to **Moderate** (Post Mitigated Scenario 4: main construction works) at Clementi Forest;
- from Major (Base Scenario 1; Cut and cover works and associated activities) to **Minor** (Post Mitigated Scenario 4: main construction works) at Maju Forest;
- from Moderate (Base Scenario 1; Cut and cover works and associated activities) to **Negligible** (Post Mitigated Scenario 4: main construction works) at Clementi Neighbourhood Park;
- area of Major impact significance significantly reduced from 26.5 hectares (Base Scenario 1; Cut and cover works and associated activities) to 1.3 hectares (Post Mitigated Scenario 2: Construction of site office) at Clementi Forest.

During CR16 TBM work, the proposed 6m noise barriers, 12m noise barriers and LTA's standard TBM enclosure (one facade opening at northern side) 15m high at boundary of CR16 launch shaft will be beneficial by reducing impact significance;

- from Major (Base Scenario 2: TBM) to **Minor** (Post Mitigated Scenario 5: TBM) at Maju Forest;
- from Moderate (Base Scenario 2: TBM) to **Negligible** (Post Mitigated Scenario 5: TBM) at Clementi Neighbourhood Park;
- area of Major impact significance significantly reduced from 27.6 hectares (Base Scenario 2:TBM) to 14.6 hectares (Post Mitigated Scenario 5: TBM) at Clementi Forest.

During Construction of station entrances, the proposed 6m noise barriers and 12m noise barriers will be beneficial by reducing the noise level:

- from 33 dB(A) exceedance (Base Scenario 3: Construction of station entrances) to 15 dB(A) exceedance (Post Mitigated Scenario 6: Construction of station entrances) at Clementi Forest;
- from 33 dB(A) exceedance (Base Scenario 3: Construction of station entrances) to 21 dB(A) exceedance (Post Mitigated Scenario 6: Construction of station entrances) at Maju Forest;
- from 24 dB(A) exceedance -high impact intensity (Base Scenario 3: Construction of station entrances) to 6 dB(A) exceedance - low impact intensity (Post Mitigated Scenario 6: Construction of station entrances) at Clementi Neighbourhood Park;
- area of Major impact significance significantly reduced from 31.1 hectares (Base Scenario 3: Construction of station entrances) to 8.4 hectares (Post Mitigated Scenario 6: Construction of station entrances) at Clementi Forest; and,
- area of Major impact significance significantly reduced from 4.5 hectares (Base Scenario 3: Construction of station entrances) to 1.7 hectares (Post Mitigated Scenario 6: Construction of station entrances) at Maju Forest.

During advance works, the proposed 6m noise barriers at the west and south-east construction boundary of CR16 advance worksite will be beneficial by reducing the noise level at the southern part of the Clementi Forest only since there is no noise barrier alone the northern part of the construction site and the resulting impact significance will be Major at Clementi Forest and Maju Forest. Note that the north-eastern part currently is a very low-lying area. This area will need to be backfilled during advance works. Therefore, erecting a noise barrier will practically not be possible at this stage before backfilling works. Once station platform is reached the advance work Contractor will need to erect 12 m barrier in the northeast which will remain on site for the main construction work phase as well. Due to this aspect, further mitigation of noise in the northeast in advance work phase due to site conditions, was not practicable, as per discussions with LTA.

There is little no benefit to the receptors at height from noise barriers also due to the terrain in Clementi Forest and Maju Forest, where the terrain is likely to be high behind the construction site, which has cut slope and is sited at a lower ground than the Clementi Forest and Maju Forest behind. 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

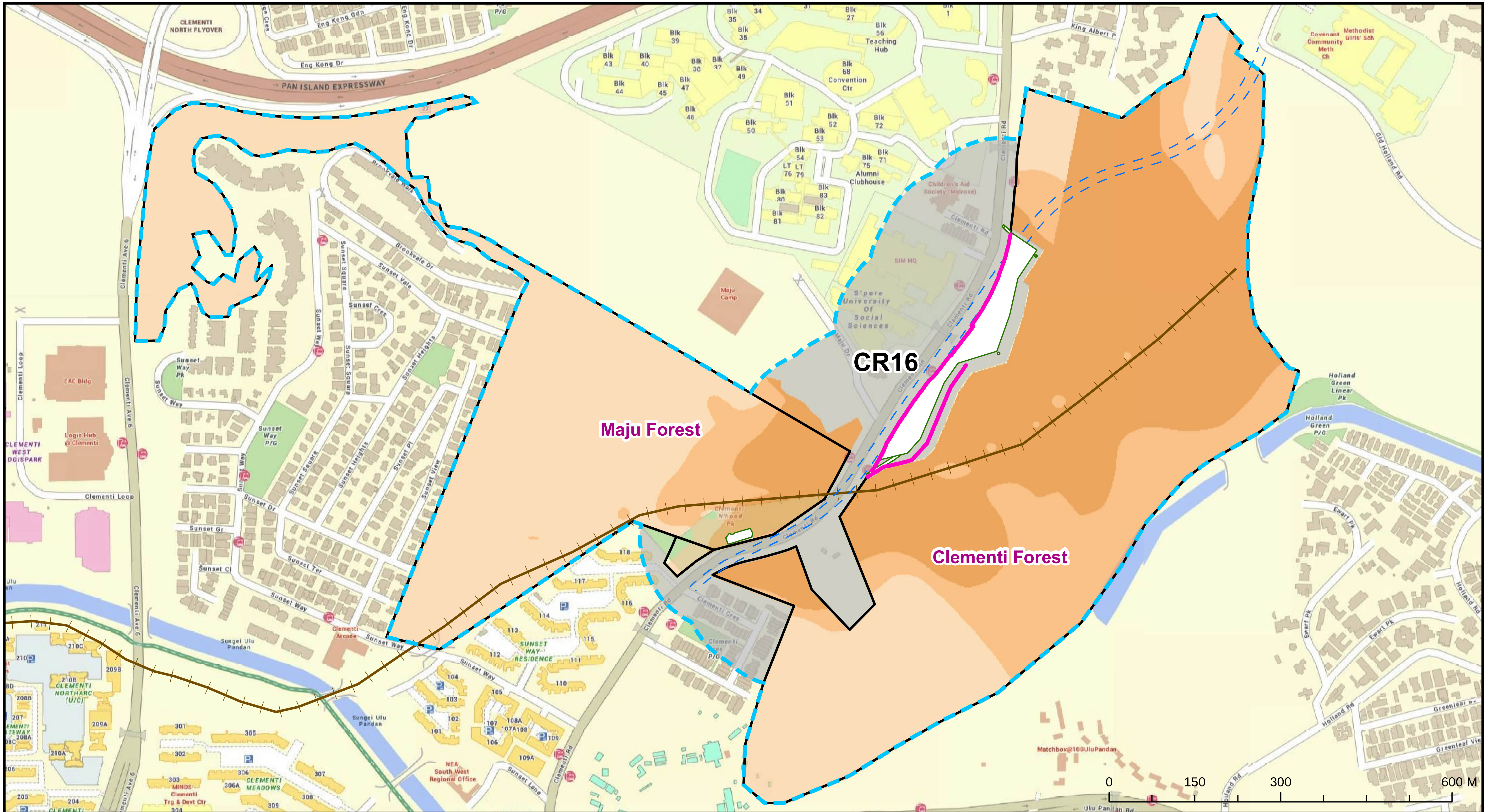
- Clementi Forest: Major
- Maju Forest: Major
- Clementi Neighbourhood Park: Moderate

Post Mitigated Scenario

- Clementi Forest: Moderate to **Major**
- Maju Forest: Minor to **Major**
- Clementi Neighbourhood Park: Negligible to **Moderate**

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 are presented in Figure 11-16 to Figure 11-21.The area of “Major” impact significance are expected to be reduced significantly and can be seen obviously in the figures.



Legend

- Noise protection wall
- Proposed CRL Alignment (Mitigated)
- Mitigated Scenario Construction Worksite Footprint
- Noise Study Area
- Old Jurong Railway Corridor
- Biodiversity Study Area

Impact Significance

- Minor
- Moderate
- Major
- Not Assessible

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAY 2022	PZ	EIS (Clementi Forest and Maju Forest)	JAG/NHT	JAG

Qualified Person Endorsement :
NA

LTA Endorsement :
NA

Consultant :
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Project Title :
CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(CLEMENTI FOREST AND
MAJU FOREST)

Figure Title :
SCENARIO 1: ADVANCE WORK
CONSTRUCTION LEQ (5MINS)
(7AM – 7PM) MITIGATED SCENARIO

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
PZ	JAG/NHT	JAG	11-10	-	1 of 1
	Drawn PZ	Date MAY 2022	CAD File Name :		A3

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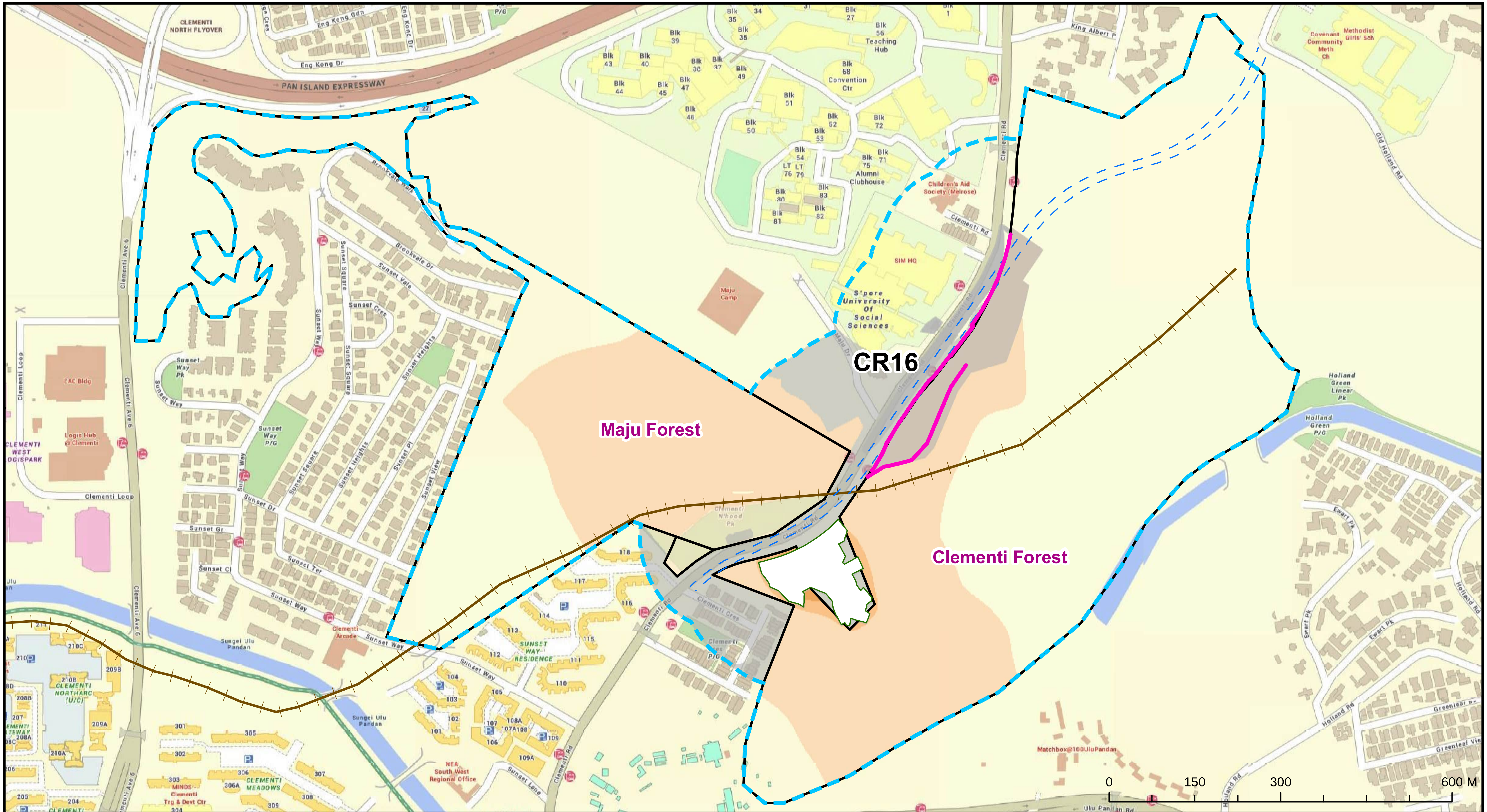

Legend

- Noise protection wall
- Proposed CRL Alignment (Mitigated)
- Mitigated Scenario Construction Worksite Footprint
- Noise Study Area
- Old Jurong Railway Corridor
- Biodiversity Study Area

Impact Significance

- Negligible
- Minor
- Moderate
- Major
- Not Assessible

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAY 2022	PZ	EIS (Clementi Forest and Maju Forest)	JAG/NHT	JAG

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Figure Title :

SCENARIO 2: CONSTRUCTION OF SITE OFFICE LEQ (5MINS) (7AM – 7PM) MITIGATED SCENARIO

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
PZ	JAG/NHT	JAG	11-11	-	1 of 1
	Drawn: PZ	Date: MAY 2022	CAD File Name :		A3

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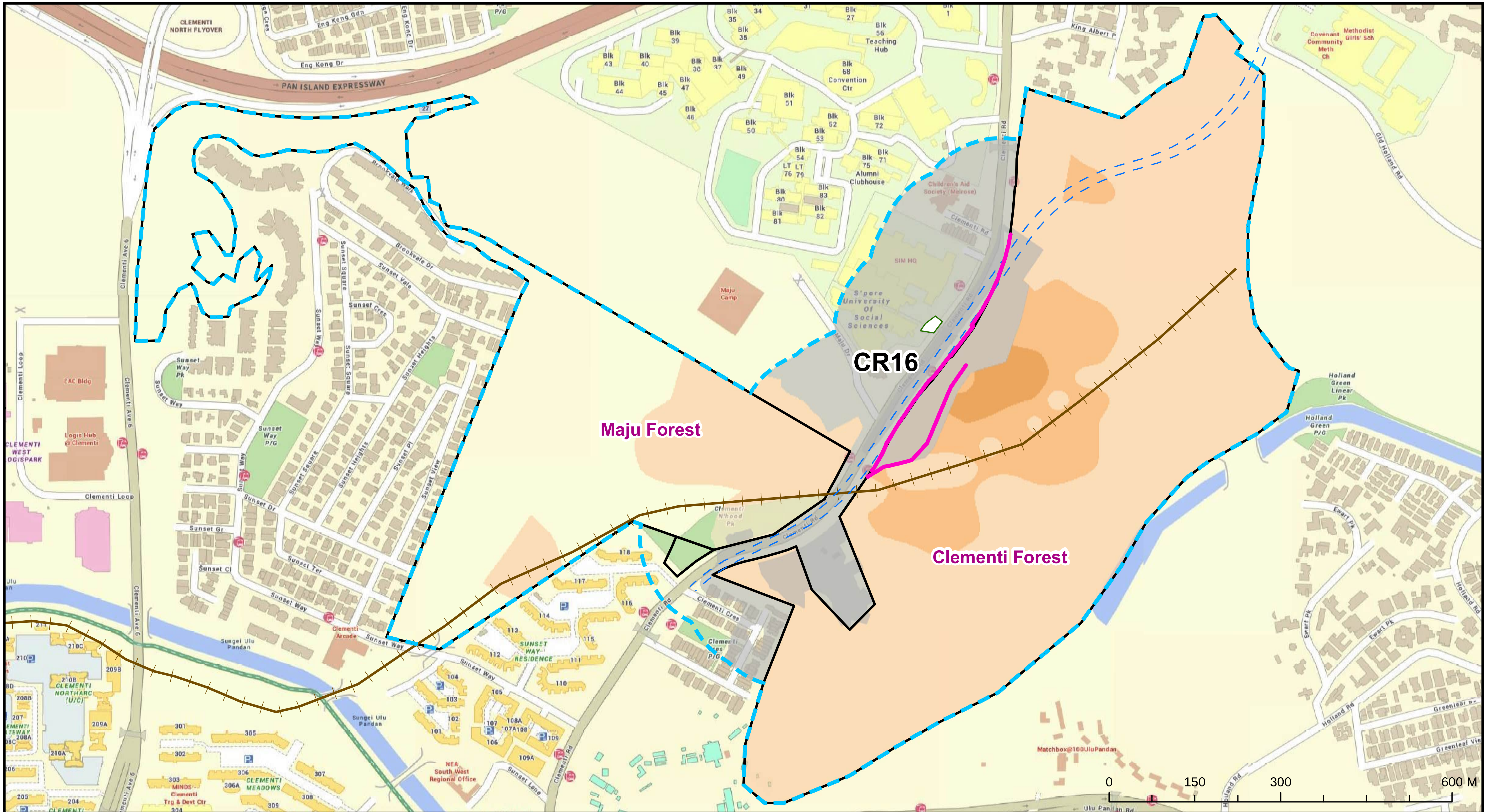

Legend

- Noise protection wall
- Proposed CRL Alignment (Mitigated)
- Mitigated Scenario Construction Worksite Footprint
- Noise Study Area
- Old Jurong Railway Corridor
- Biodiversity Study Area

Impact Significance

- Negligible
- Minor
- Moderate
- Major
- Not Assessible

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAY 2022	PZ	EIS (Clementi Forest and Maju Forest)	JAG/NHT	JAG

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CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (CLEMENTI FOREST AND MAJU FOREST)

Figure Title :

SCENARIO 3: DEMOLITION OF POB LEQ (5MINS) (7AM – 7PM) MITIGATED SCENARIO

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
PZ	JAG/NHT	JAG	11-12	-	1 of 1

Drawn: PZ

Date: MAY 2022

CAD File Name :

A3

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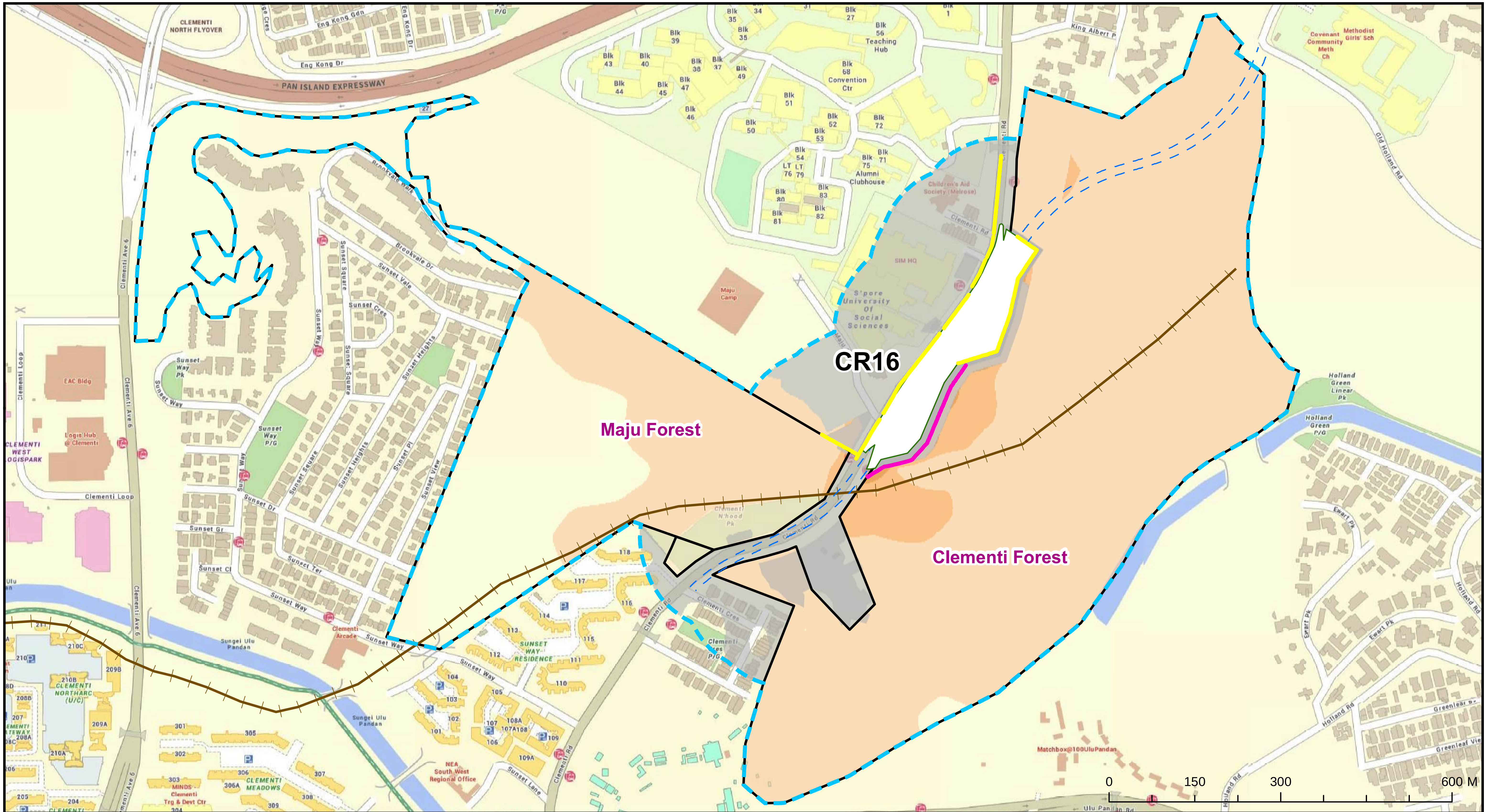

Legend

- Proposed Noise Barrier-6m
- Proposed Noise Barrier-12m
- Proposed CRL Alignment (Mitigated)
- Mitigated Scenario Construction Worksite Footprint
- Vibration Study Area
- Old Jurong Railway Corridor
- Biodiversity Study Area

Impact Significance

- Negligible
- Minor
- Moderate
- Major
- Not Assessible

N

Rev.	Date	By	Description	Chk'd	App'd
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LTA Endorsement : NA

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(CLEMENTI FOREST AND
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Figure Title :
SCENARIO 4: MAIN CIVIL WORK
LEQ (5MINS) (7AM – 7PM)
MITIGATED SCENARIO

Designed	Checked	Approved
PZ	JAG/NHT	JAG

Drawn	Date
PZ	MAY 2022

Figure No. :	Rev.	Sheet
11-13	-	1 of 1

CAD File Name : A3

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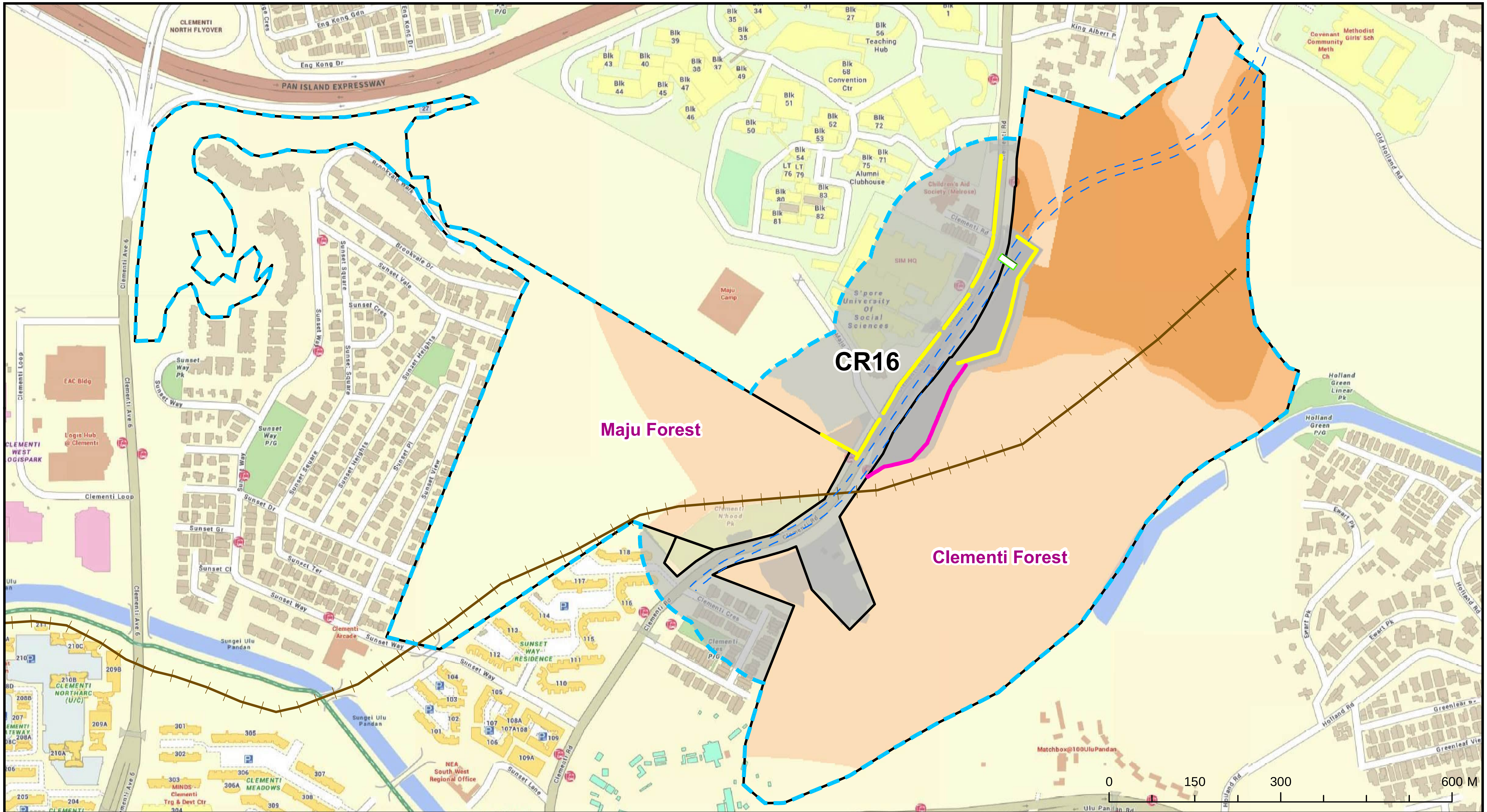

Legend

- Proposed Noise Barrier - Enclosed Noise Barrier (15m)
- Proposed Noise Barrier-6m
- Proposed Noise Barrier-12m
- Proposed CRL Alignment (Mitigated)
- Mitigated Scenario Construction Worksite Footprint
- Vibration Study Area
- Old Jurong Railway Corridor
- Biodiversity Study Area

Impact Significance

- Negligible
- Minor
- Moderate
- Major
- Not Assessible

N

Rev.	Date	By	Description	Chk'd	App'd
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LTA Endorsement : NA

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Figure Title :

SCENARIO 5: TBM (5MINS) (7PM – 7AM) MITIGATED SCENARIO

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
PZ	JAG/NHT	JAG	11-14	-	1 of 1
	Drawn PZ	Date MAY 2022	CAD File Name :		A3

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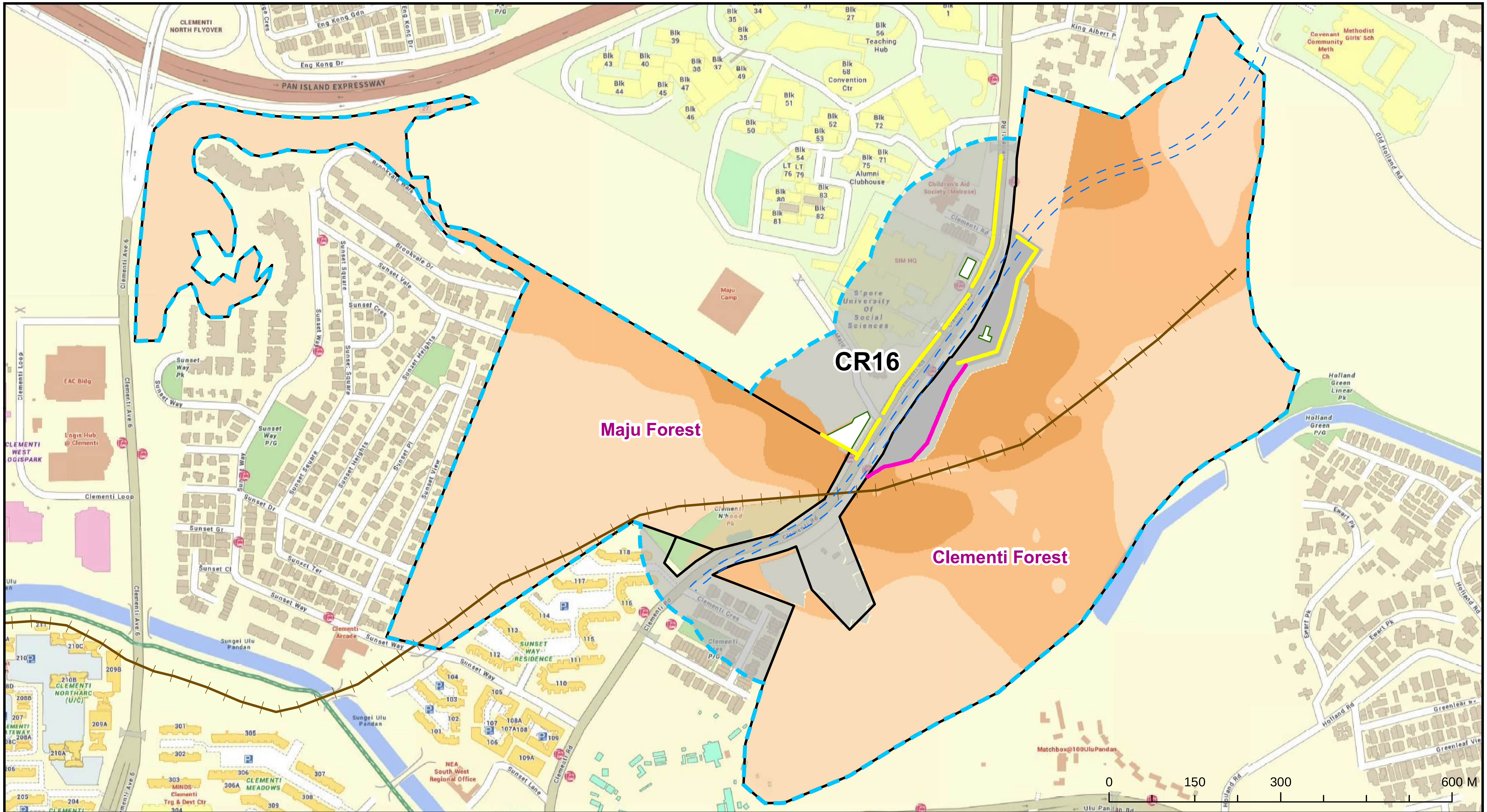

Legend

- Proposed Noise Barrier-6m
- Proposed Noise Barrier-12m
- Proposed CRL Alignment (Mitigated)
- Mitigated Scenario Construction Worksite Footprint
- Vibration Study Area
- Old Jurong Railway Corridor
- Biodiversity Study Area

Impact Significance

- Minor
- Moderate
- Major
- Not Assessible

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAY 2022	PZ	EIS (Clementi Forest and Maju Forest)	JAG/NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

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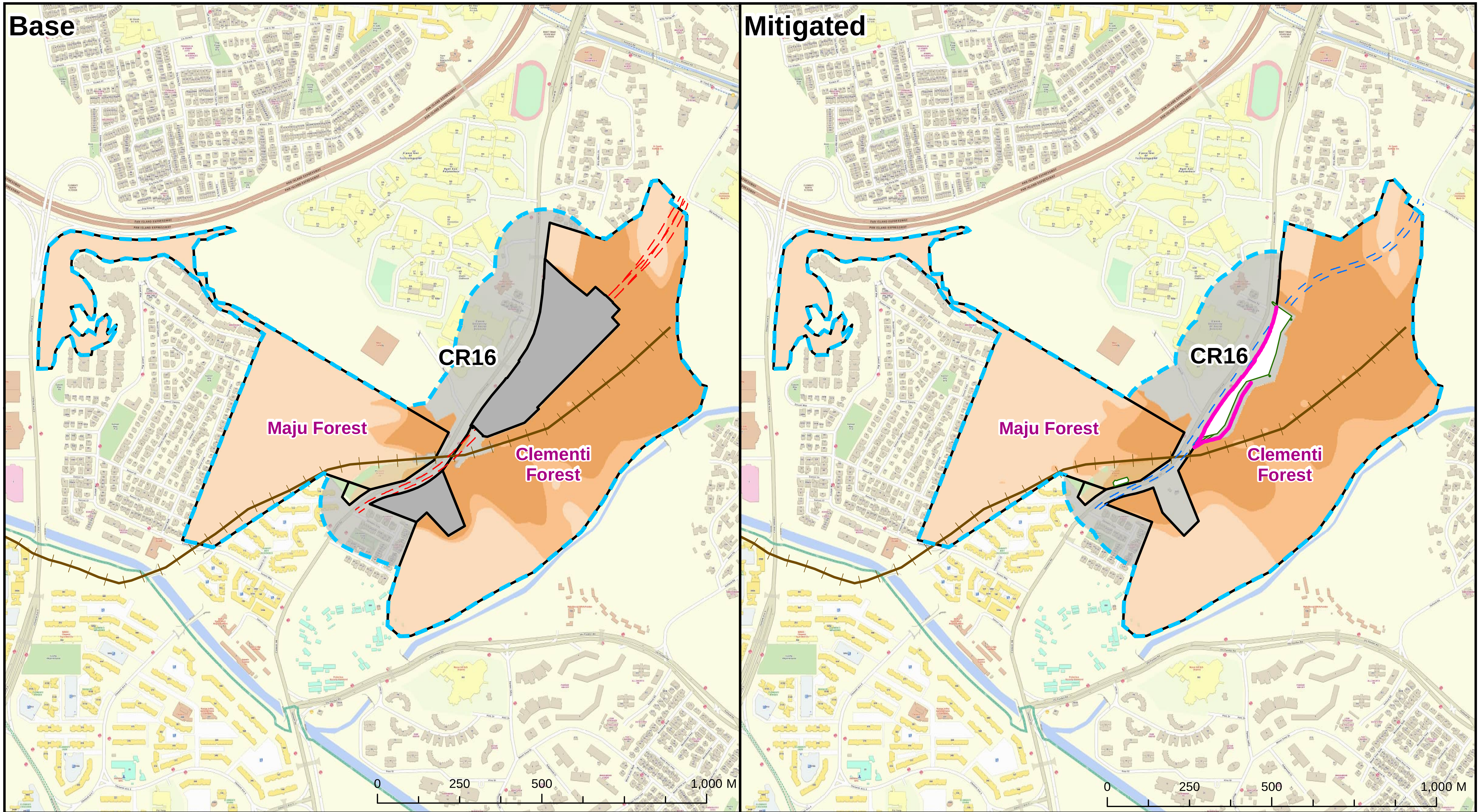
(CLEMENTI FOREST AND
MAJU FOREST)

Figure Title :
SCENARIO 6: ENTRANCE
CONSTRUCTION LEQ (5MINS)
(7AM – 7PM) MITIGATED SCENARIO

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
PZ	JAG/NHT	JAG	11-15	-	1 of 1
	Drawn PZ	Date MAY 2022	CAD File Name :		A3

Note: Source of basemap - OneMap



Legend

- Proposed Noise Barrier-6m
- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint
- Noise Study Area
- Old Jurong Railway Corridor
- Biodiversity Study Area

Impact Significance

- Minor
- Moderate
- Major
- Not Assessible

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAY 2022	PZ	EIS (Clementi Forest and Maju Forest)	JAG/NHT	JAG

Qualified Person Endorsement :
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LTA Endorsement :
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ENVIRONMENTAL IMPACT STUDY
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Figure Title :
COMPARISON OF BASE SCENARIO 1 CUT AND COVER WORKS AND ASSOCIATED ACTIVITIES AND MITIGATED SCENARIO 1 ADVANCE WORK CONSTRUCTION

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
PZ	JAG/NHT	JAG	11-16	-	1 of 1
	Drawn PZ	Date MAY 2022	CAD File Name : NA		A3

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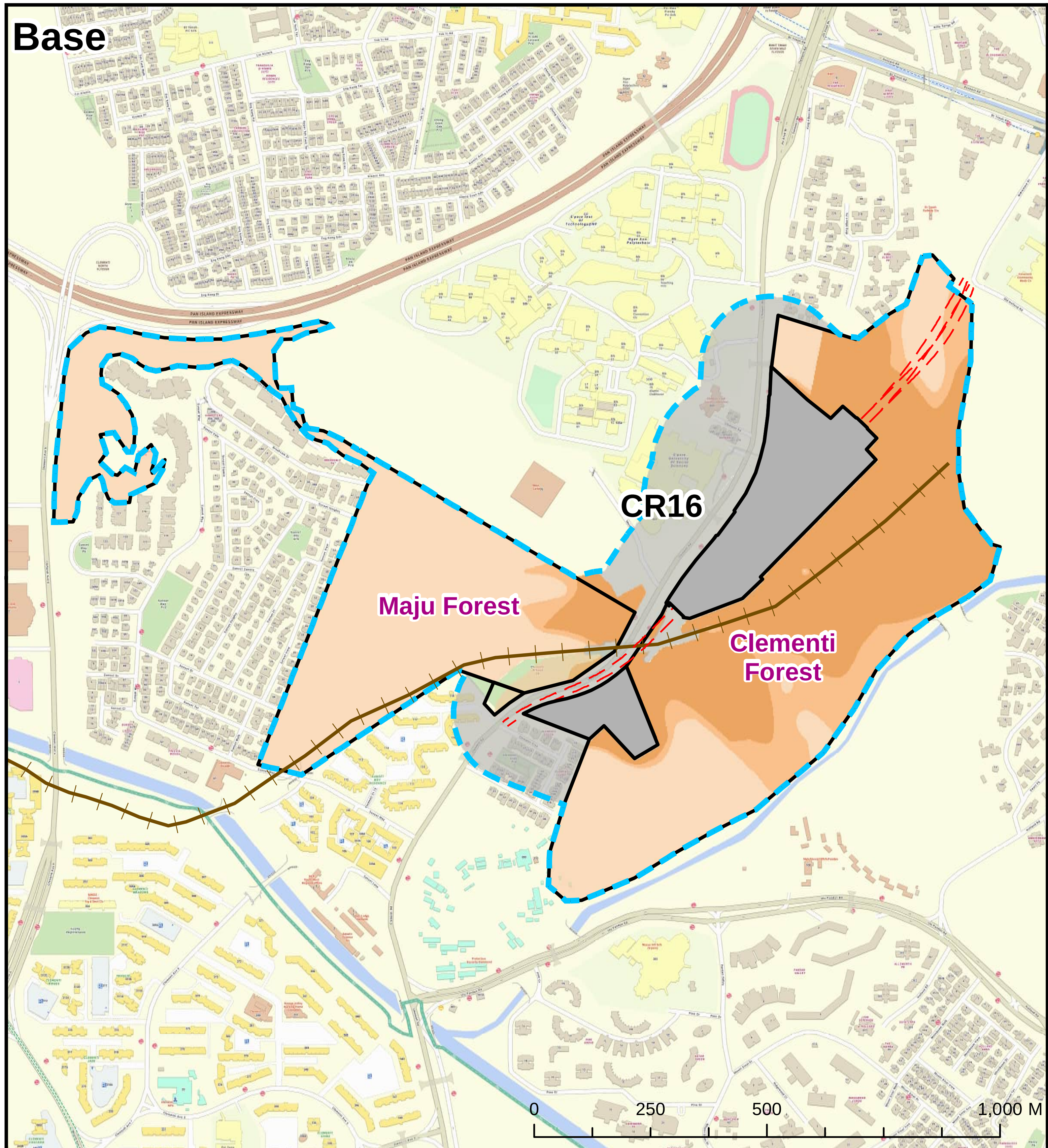

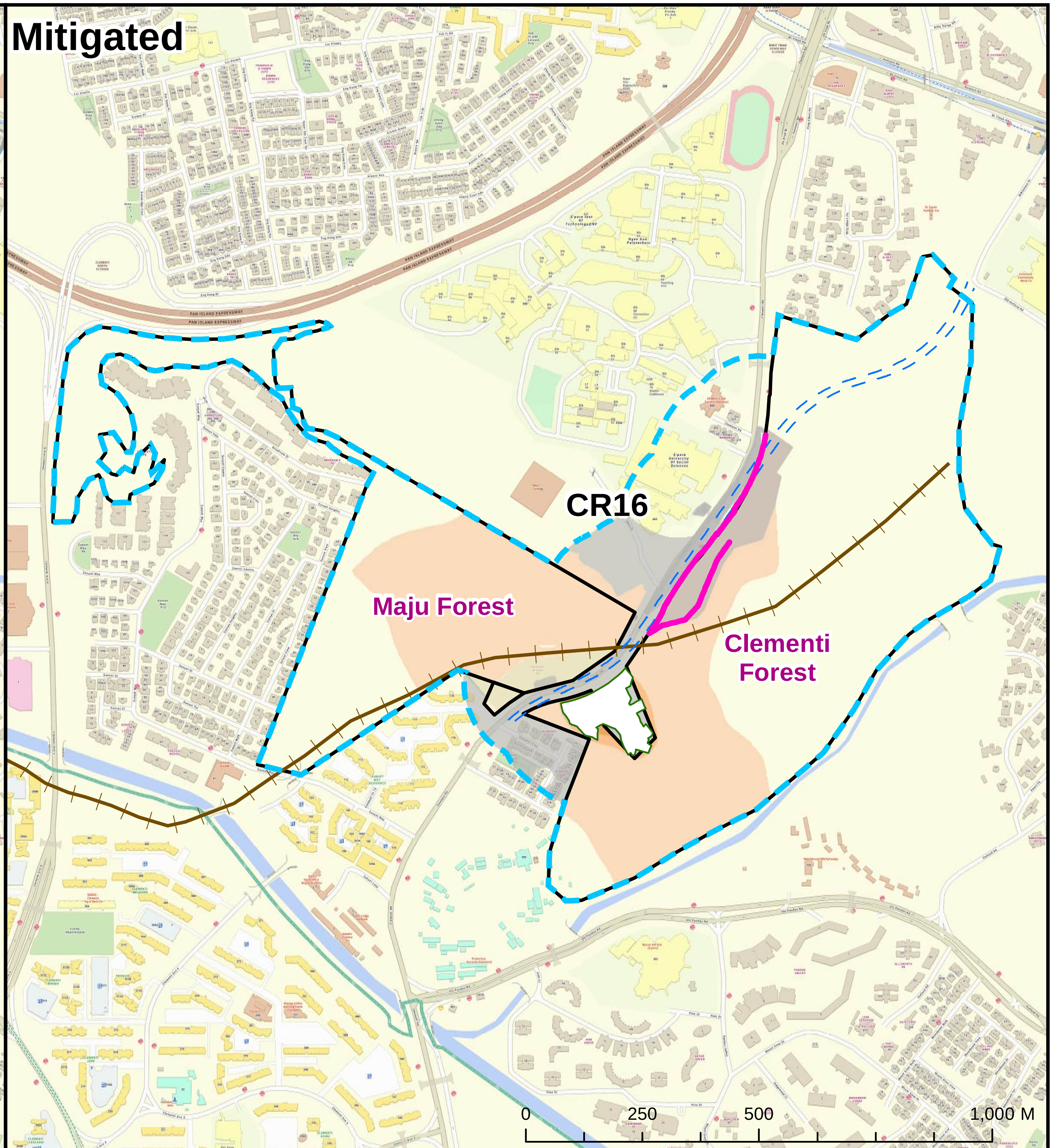

Legend

- Proposed Noise Barrier-6m
- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint
- Noise Study Area
- Old Jurong Railway Corridor
- Biodiversity Study Area

Impact Significance

- Negligible
- Minor
- Moderate
- Major
- Not Assessible

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAY 2022	PZ	EIS (Clementi Forest and Maju Forest)	JAG/NHT	JAG

Qualified Person Endorsement :
NA

LTA Endorsement :
NA

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(CLEMENTI FOREST AND
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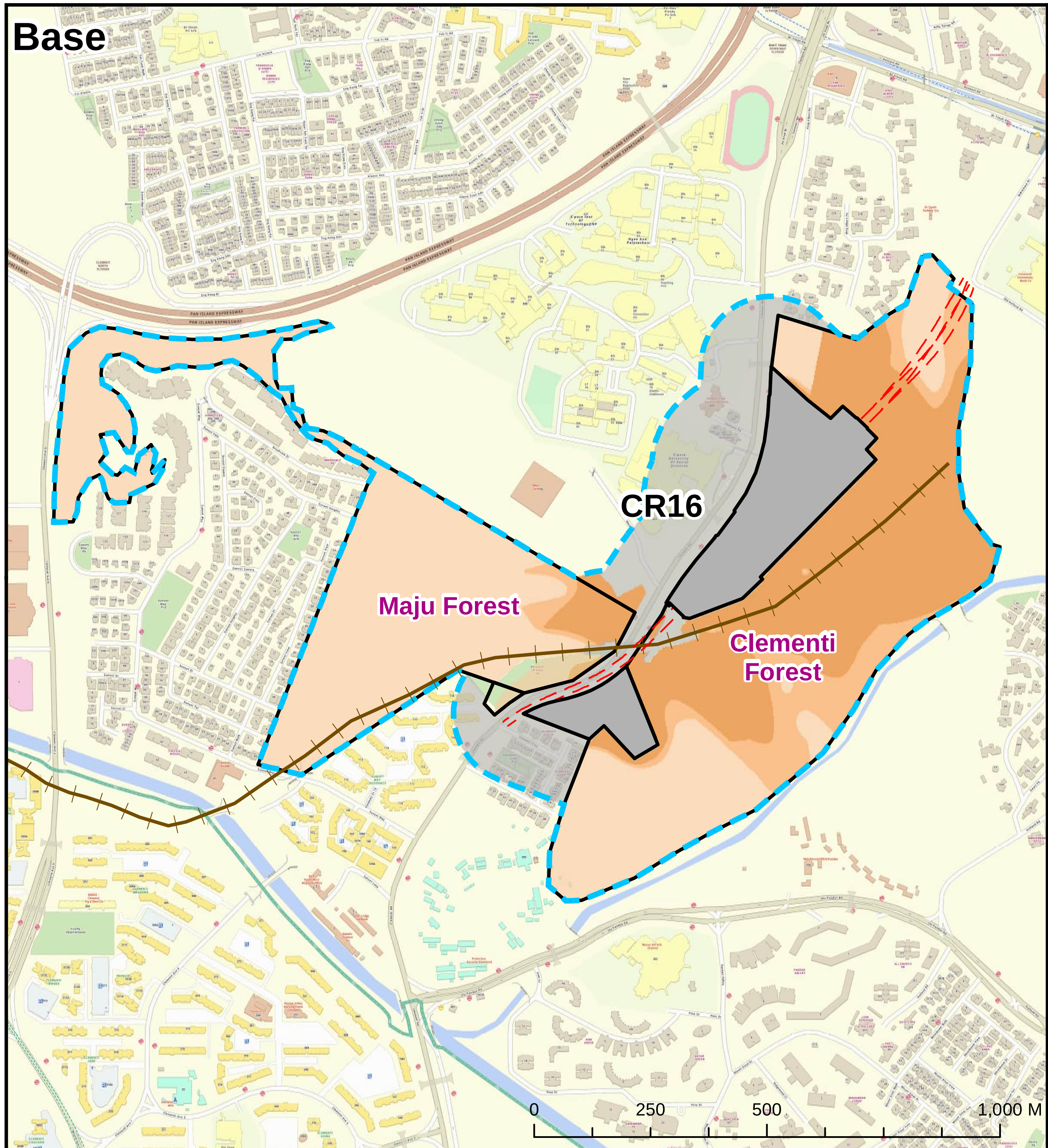
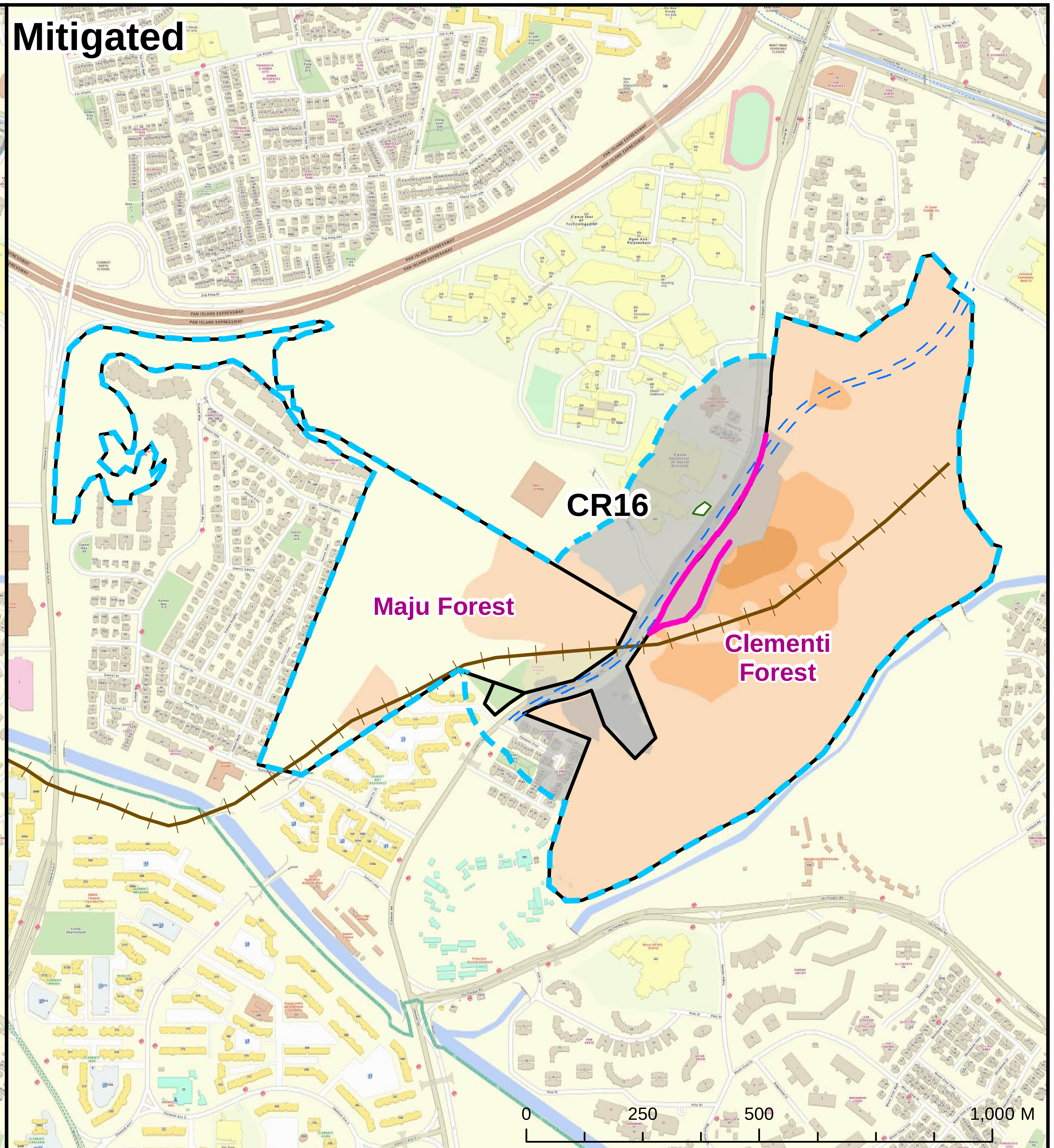
Figure Title :
COMPARISON OF BASE SCENARIO 1
CUT AND COVER WORKS AND
ASSOCIATED ACTIVITIES AND
MITIGATED SCENARIO 2:
CONSTRUCTION OF SITE OFFICE

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
PZ	JAG/NHT	JAG	11-17	-	1 of 1
	Drawn PZ	Date MAY 2022	CAD File Name : NA		A3

Note: Source of basemap - OneMap





Legend

- Proposed Noise Barrier-6m
- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint
- Noise Study Area
- Old Jurong Railway Corridor
- Biodiversity Study Area

Impact Significance

- Negligible
- Minor
- Moderate
- Major
- Not Assessible

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAY 2022	PZ	EIS (Clementi Forest and Maju Forest)	JAG/NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

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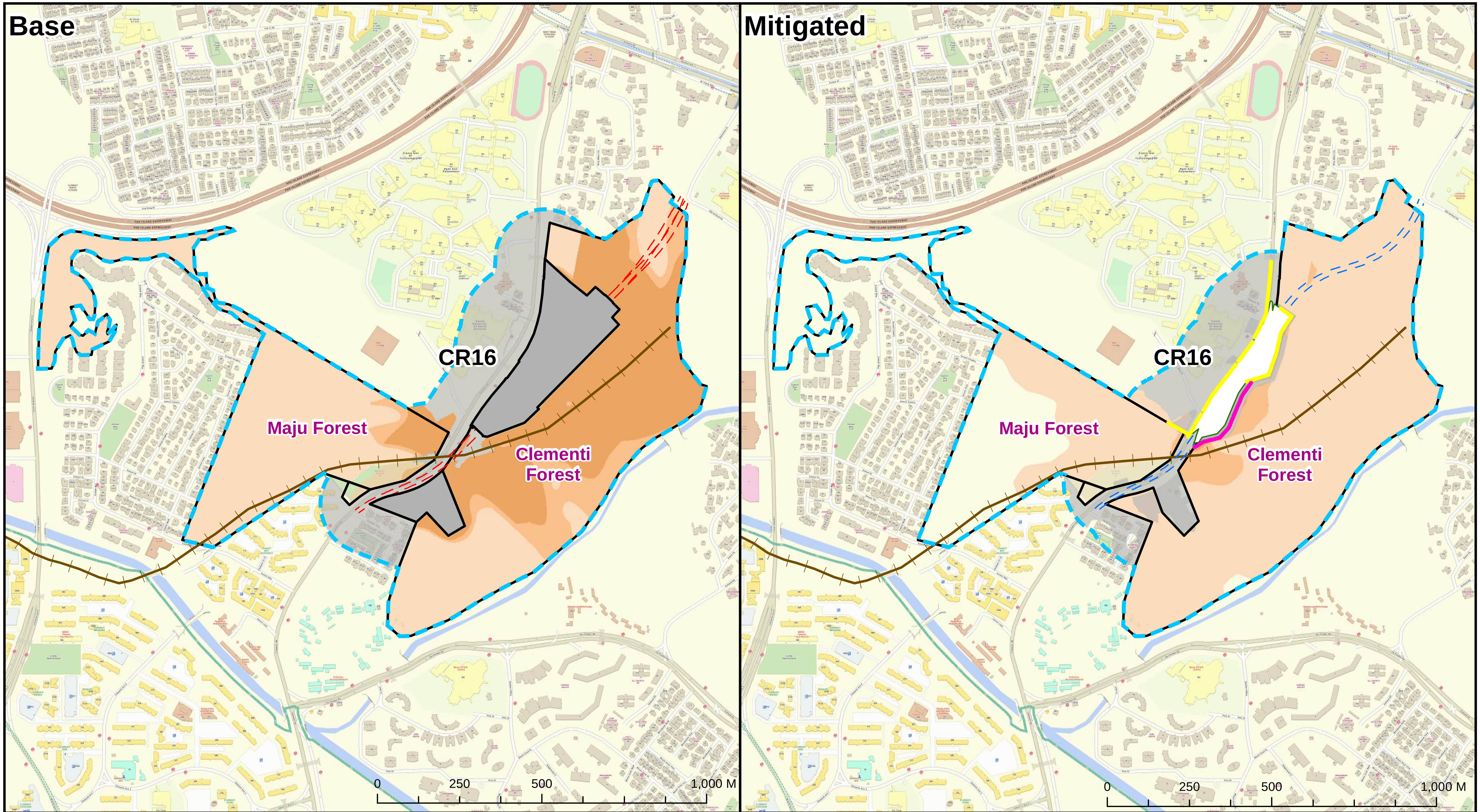
Land Transport Authority — We Keep Your World Moving

Project Title :
CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(CLEMENTI FOREST AND
MAJU FOREST)

Figure Title :
COMPARISON OF BASE SCENARIO 1
CUT AND COVER WORKS AND
ASSOCIATED ACTIVITIES AND
MITIGATED SCENARIO 3:
DEMOLITION OF POB

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
PZ	JAG/NHT	JAG	11-18	-	1 of 1
	Drawn PZ	Date MAY 2022	CAD File Name : NA		A3

Note: Source of basemap - OneMap



Legend

- Proposed Noise Barrier-6m
- Proposed Noise Barrier-12m
- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint
- Noise Study Area
- Old Jurong Railway Corridor
- Biodiversity Study Area

Impact Significance

- Negligible
- Minor
- Moderate
- Major
- Not Assessible

Rev.	Date	By	Description	Chk'd	App'd
-	MAY 2022	PZ	EIS (Clementi Forest and Maju Forest)	JAG/NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

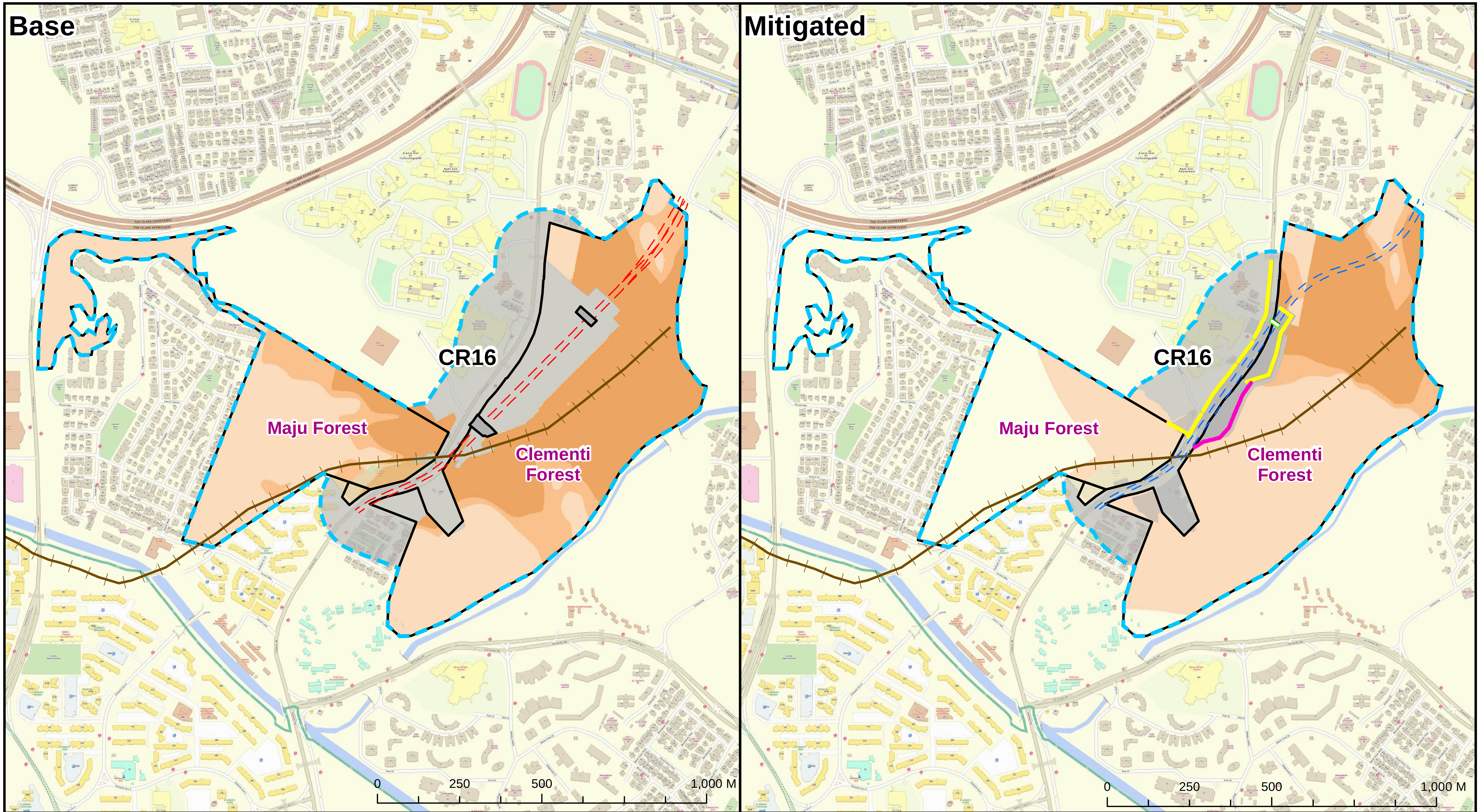
Land Transport Authority — We Keep Your World Moving

Project Title : CONTRACT CR2005 ENVIRONMENTAL IMPACT STUDY (CLEMENTI FOREST AND MAJU FOREST)

Figure Title : COMPARISON OF BASE SCENARIO 1 CUT AND COVER WORKS AND ASSOCIATED ACTIVITIES AND MITIGATED SCENARIO 4: MAIN CONSTRUCTION WORK

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
PZ	JAG/NHT	JAG	11-19	-	1 of 1
	Drawn PZ	Date MAY 2022	CAD File Name : NA		A3

Note: Source of basemap - OneMap



Legend

- Proposed Noise Barrier - Enclosed Noise Barrier (15m)
- Proposed Noise Barrier-6m
- Proposed Noise Barrier-12m
- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint
- Noise Study Area
- Old Jurong Railway Corridor
- Biodiversity Study Area

Impact Significance

- Negligible
- Minor
- Moderate
- Major
- Not Assessible

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAY 2022	PZ	EIS (Clementi Forest and Maju Forest)	JAG/NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title :

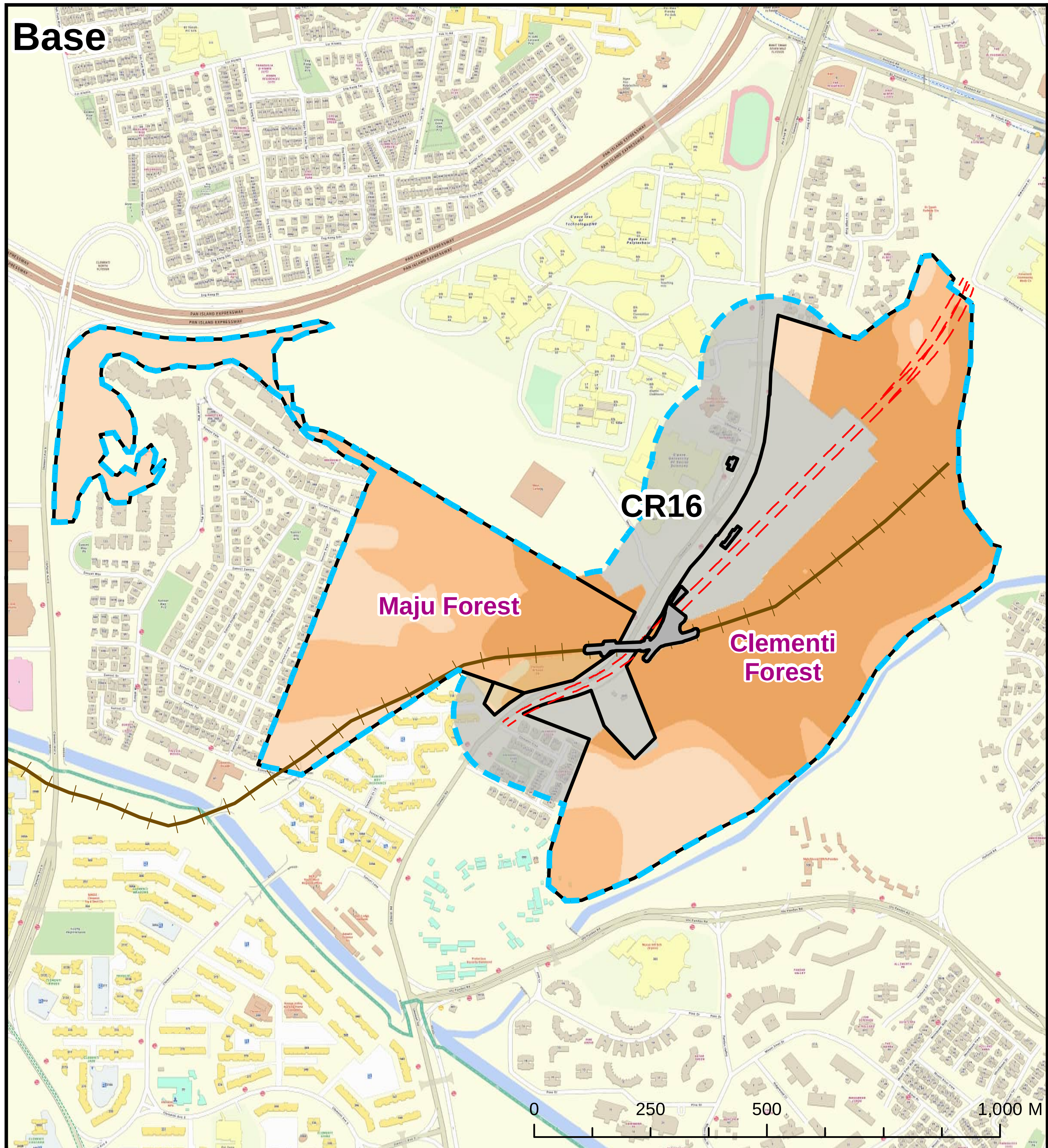
CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(CLEMENTI FOREST AND
MAJU FOREST)

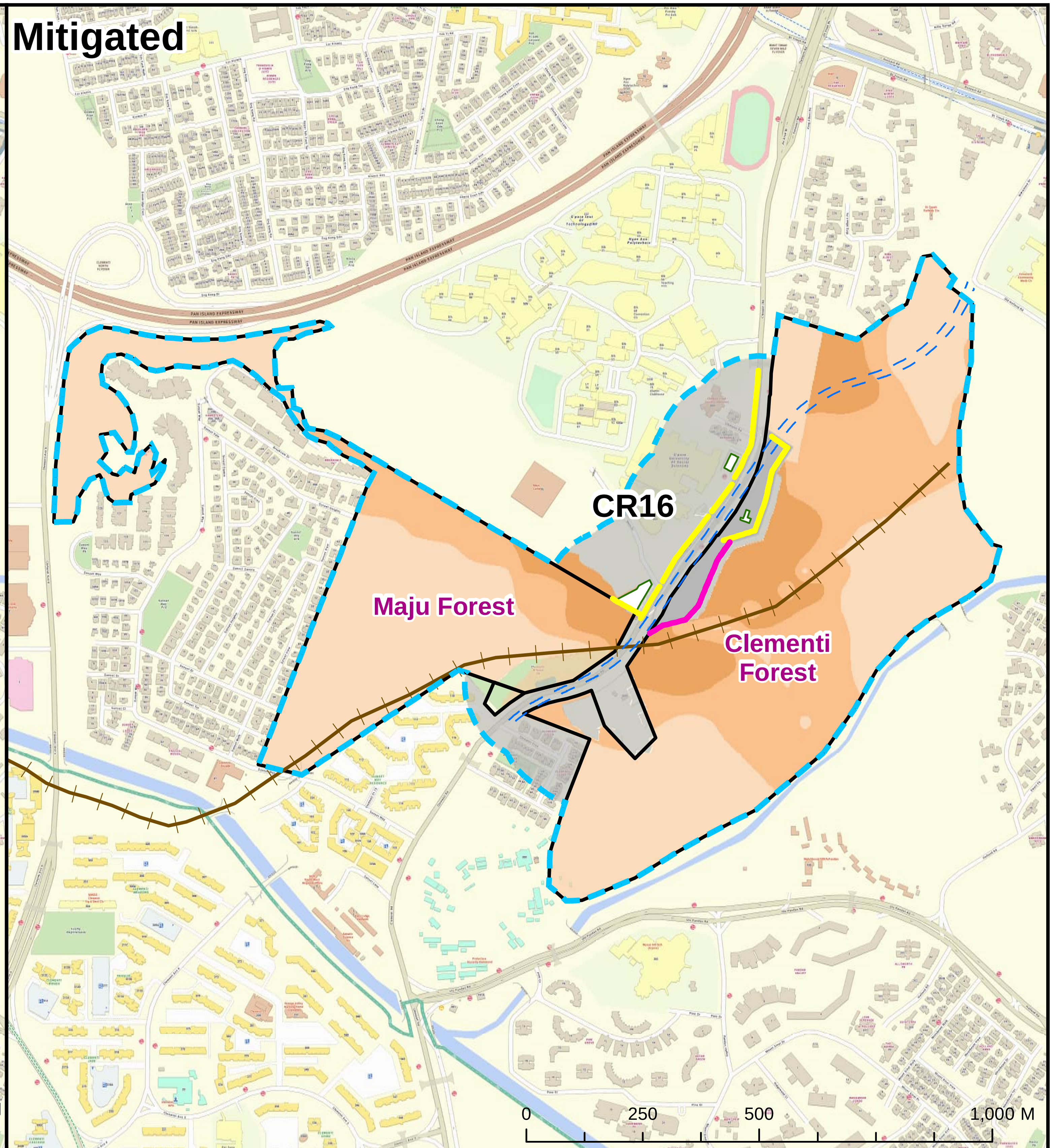
Figure Title :

COMPARISON OF BASE SCENARIO 2: TBM AND MITIGATED SCENARIO 5: TBM WORK

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
PZ	JAG/NHT	JAG	11-20	-	1 of 1
	Drawn: PZ	Date: MAY 2022	CAD File Name : NA		A3

Note: Source of basemap - OneMap





Legend

- Proposed Noise Barrier-6m
- Proposed Noise Barrier-12m
- Proposed CRL Alignment (Base)
- Proposed CRL Alignment (Mitigated)
- Base Scenario Construction Worksite Footprint
- Mitigated Scenario Construction Worksite Footprint
- Noise Study Area
- Old Jurong Railway Corridor
- Biodiversity Study Area

Impact Significance

- Minor
- Moderate
- Major
- Not Assessible

N

Rev.	Date	By	Description	Chk'd	App'd
-	MAY 2022	PZ	EIS (Clementi Forest and Maju Forest)	JAG/NHT	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

Land Transport Authority
We Keep Your World Moving

Project Title :

CONTRACT CR2005
ENVIRONMENTAL IMPACT STUDY
(CLEMENTI FOREST AND
MAJU FOREST)

Figure Title :

COMPARISON OF BASE SCENARIO 3:
ENTRANCE CONSTRUCTION AND
MITIGATED SCENARIO 6:
ENTRANCE CONSTRUCTION

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
PZ	JAG/NHT	JAG	11-21	-	1 of 1

	Drawn	Date	CAD File Name :	
	PZ	MAY 2022	NA	A3

Note: Source of basemap - OneMap

11.10 Cumulative Impacts with Other Major Concurrent Developments

It is known that construction activities are planned to occur in the vicinity of the Project as highlighted in Section 3.4.1. Hence, cumulative impacts from other relevant major concurrent developments in the vicinity of the Project will be assessed and considered.

11.10.1 Construction Phase

Manholes MH-4A and MH-4B near Old Jurong Railway as part of PUB DTSS2 link sewer project and construction of CR15 worksite near the Clementi Forest are planned in the vicinity of CR16 worksite. The impact significance before mitigation for CR16 ranges from Moderate to Major. Due to the presence of these concurrent construction sites, the construction footprint in this area is expected to be larger. Much more extensive PME are required, and area excavated or impacted to Clementi Forest are more than that required by CR16 worksite only. It is expected that the cumulative impact from these construction sites will, therefore, be much significant impact than the CR16 worksite alone in this area with an impact significance potentially increasing to Major.

Impact from the DTSS construction which is restricted typically in road reserves may add little to concurrent noise owing to its location, provided no additional space is occupied in the woods or impacted by DTSS footprint on either side.

11.10.2 Operational Phase

Concurrent project such as DTSS construction is restricted typically only in road reserve and may add little to cumulative noise owing to its location and smaller footprint than CR15/ CR16 construction footprint. However, once CR16 is operational and largely noisy works would be underground, thus meaning that no significant noise impact will occur due to CR16 in operation.

11.11 Summary of Key Findings

Noise impact assessment was carried for the construction phase of the proposed worksite for CR2005. The construction noise Study Area was defined as combination of Maju Forest, Clementi Forest and 150m from the CR16 worksite. The noise impact assessment for the operational phase of the proposed CR16 worksite for CR2005 included providing boundary noise criteria for ACMV at the station and qualitatively assesses traffic noise to the noise sensitive receptors within Maju Forest and Clementi Forest. However, it is to be noted that LTA may not be designing in detail for the compliance to noise criteria at this stage, in which case the imposed criteria at boundary will form a mandatory requirement when the worksite is designed during detailed design stage. Baseline noise monitoring (recorded average $L_{Aeq(12\ hour)}$, $L_{Aeq(1\ hour)}$ and $L_{Aeq(5\ min)}$) was carried out at four locations. Uncorrected baseline noise was used as a more stringent criterion for assessment of ecological receptors in this Study.

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 played an important role in noise propagation and was included in this assessment. A quantitative assessment at the noise sensitive receptors (within Biodiversity 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 6.4.2. Noise contours were provided. Based on the impact evaluation, mitigation to reduce airborne noise impacts was 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 base scenarios and six (6) different mitigated scenarios respectively. The three Base Scenarios are: Scenario 1: Cut and cover works and associated activities; Scenario 2: Tunnel Boring Machine (TBM) works; and Scenario 3: Construction of station entrances. Six (6) different Mitigated Scenarios are: Scenario 1: Advance work; Scenario 2: Construction of site office; Scenario 4: Demolition of POB; Scenario 4; Main civil work, Scenario 5; Tunnel Boring Machine (TBM) works; and Scenario 6: 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.

The modelling undertaken as part of the impact assessments for construction base scenario 1 to base scenario 3, results indicated that an impact significance of Major is likely to occur, with a maximum exceedance of 33 dB(A) at Maju Forest and 33 dB(A) at Clementi Forest. 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 CR16 worksite within Clementi Forest 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 6m, 12m respectively, are used for specific mitigated scenario i.e. use of LTA standard 15m full enclosed noise barrier for TBM with one façade opening (as shown in Figure 11-8).

Based on the residual airborne noise impact assessment above, the proposed 6m and 12m noise barriers at CR16 main construction worksite will be beneficial by reducing the impact significance and area of major impact significance from Major (Base Scenario) to Moderate-Major (Post Mitigated scenario) at Clementi Forest and by reducing the impact significance from Major (Base Scenario) to Minor-Major (Post Mitigated Scenario) at Maju Forest.

During Advance work construction, the proposed 6m noise barriers at the west and south-east construction boundary of CR16 Advance worksite will only reduce the noise level at the southern part of the Clementi Forest since there is no noise barrier along the northern part of the construction site; the resulting impact significance will therefore be Major at Clementi Forest and Maju Forest. Whilst the noise barrier will reduce the impact to ground level and low height noise sensitive receptors, said mitigation will not reduce the impact to arboreal receptors which utilise tree canopies. However, the total areas of "Major" impact significance are expected to be reduced significantly from base to mitigated worksite and can be seen obviously in the noise figures (refer to Figure 11-16 to Figure 11-21).

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 CR16 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 CR16 worksite (Base Scenario) rock breaking and excavation works, Priority 1 ecologically sensitive receptors from Clementi Forest 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. The Priority 1 ecologically sensitive receptors at Maju Forest will potentially experience low impact intensity, with a resulting impact significance of Moderate. The resulting impact significance for Priority 3 ecologically sensitive receptors at Maju Forest is Minor. After applying the mitigation measures within Section 11.8 are implemented, from CR16 Worksite (Mitigated Scenario) rock breaking and excavation works, Priority 1 ecologically sensitive receptors from Clementi Forest 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. The Priority 1 ecologically sensitive receptors at Maju Forest will potentially experience low impact intensity, with a resulting impact significance of Moderate. The resulting impact significance for Priority 3 ecologically sensitive receptors at Maju Forest is Minor. Since the impact significance is Major in Clementi Forest, the further mitigation measures refer to Section 12.9 from vibration section and EMMP requirement from Section 13.11 need to apply to reduce the residual impact.

For the cumulative impact assessment with the concurrent projects, Manholes MH-4A and MH-4B near Old Jurong Railway as part of PUB DTSS2 project and construction of CR15 worksite near the Clementi Forest are planned in the vicinity of CR16 worksite. The impact significance before mitigation for CR16 ranges from Moderate to Major. Due to the presence of these concurrent construction sites, the construction footprint in this area is expected to be larger. Much more extensive PME are required, and area excavated or impacted to Clementi Forest are more than that required by CR16 worksite only. It is expected that the cumulative impact from the construction will, therefore, be much more significant impact than the CR16 worksite alone in this area with an impact significance potentially increasing to Major. The detailed information associated with the CR15 construction, such as noise contour figures, equipment inventory and PMEs, were not included in this Report, however, were provided in a separated EIS report for CR15.

Impact from the DTSS construction which is restricted typically in road reserves may add little to concurrent noise owing to its location, provided no additional space is occupied in the woods or impacted by DTSS footprint on either side.

Concurrent project such as DTSS construction is restricted typically only in road reserve and may add little to cumulative noise owing to its location and smaller footprint than CR15/ CR16 construction footprint. However, once CR16 is operational and largely noisy works would be underground, thus meaning that no significant noise impact will occur due to CR16 in operation.

Table 11-24 Summary of Airborne Noise Impact Assessment

Sensitive Receptor	Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)
Construction Phase		
Clementi Forest	Major	**Moderate to Major**[1]
Maju Forest	Major	Minor to Major[1]
Operational Phase		
Clementi Forest	Negligible	**Negligible**[2]
Maju Forest	Negligible	**Negligible**[2]

Note:
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.