Cross Island Line (CRL) Phase 2 Environmental Impact Study (EIS) – Clementi Forest and Maju Forest

Non Technical Summary (NTS)

Land Transport Authority's Objectives

With the vision to strengthen the connectivity and resilience of the land transport network in Singapore to support a car-lite nation, LTA has set off with an ambitious journey with one of the key targets being the expansion of the rail network to about 360km by 2030. This means connecting eight in 10 households to within 10 minutes of a train station. With a 360km long rail network, Singapore will have a total rail length that is longer than major cities such as Tokyo or Hong Kong, and be on par with London and New York City.

As part of the vision, LTA's eighth MRT line, the Cross Island Line (CRL) will be Singapore's longest fully underground line at more than 50 kilometres long. It will serve existing and future developments in the eastern, western, and north-eastern corridors, connecting major hubs such as Jurong Lake District, Punggol Digital District and Changi region.

When operational, it will have the highest number of interchange stations, with almost half the stations on the line being linked to existing rail stations. This means more alternative travel routes to get to desired destinations. More than 100,000 households will benefit from CRL, and common recreational spaces such as Changi Beach Park and Bishan-Ang Mo Kio Park will also become accessible by public transport.

(Sources: LTA. Cross Island Line. 8 March 2021 & LTA. Upcoming Projects. Updated on 5 January 2022)

Overview

The proposed Cross Island Line (CRL) will be constructed in three phases. The first phase of the CRL is currently in the early stages of the construction stage. This Environmental Impact Study covers the second phase of the CRL where a section of the alignment passes through the following vegetated areas:

- Forested area east of Clementi Road ("Clementi Forest"); and,
- Forest area west of Clementi Road and north of Sunset Way ("Maju Forest").

This Document

This Document presents a Non-Technical Summary (NTS) of the findings from the Environmental Impact Study (EIS) conducted as a part of the CRL Phase 2 (CRL2) alignment for both construction and operational phase.

Scope and Objective of EIS

The **Scope of the EIS** covers the construction and operational impacts on the environment from above and below ground (i.e., biodiversity, hydrology and surface water quality, soil and groundwater, air quality, airborne noise, and ground-borne vibration). Where the impacts were deemed to be "Significant" or "Moderate/Major", appropriate mitigation measures were also recommended, along with the proposed Environmental Monitoring and Management Plan (EMMP) to manage these impacts.

The **Objective of EIS** is to present an assessment of the potential environmental impacts arising from and associated with the construction and operation of CRL Phase 2 (CRL2) at CR16 Station on the forested areas identified in the vicinity of the Project for its biodiversity value (i.e., Clementi Forest and Maju Forest). These identified forested areas along the alignment have formed the Biodiversity Study Area for this report. The study of pre-construction environmental baseline conditions along this route was conducted and included as part of the EIS.

The Project

Project Location and Components

In this Project, **Clementi Forest and Maju Forest** were identified as Biodiversity Study Areas as shown in Figure 1, which were assessed against the worksites along the CR16 CRL2 alignment (base scenario) as listed below:

- CR16 main construction worksite within Clementi Forest, intended for the Tunnel Boring Machine (TBM) launching activities and construction of a station with its associated facilities;
- CR16 Worksite at Nursery, intended for site office, stockpile, etc.; and
- CR16 Worksite at Old Jurong Railway (OJR) intended for pedestrian walkway underneath Clementi Road.

Upon completion of the construction works, the site will become the CR16 station.

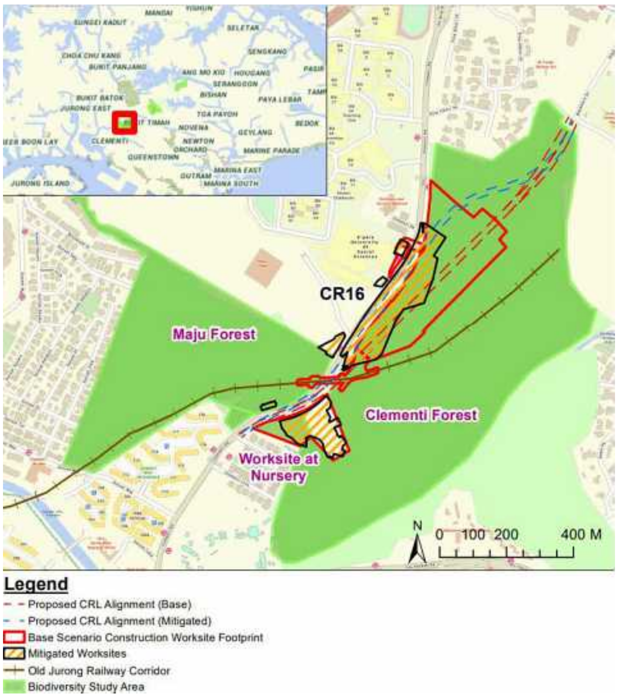


Figure 1: Project Location, Base & Mitigated Worksites

To prepare the worksites for construction works, the Project will start with activities such as site clearance, the construction of site access, road and utility diversion works, and the installation of instrumentation. Ground improvement works may be required at the TBM launch worksite in order to improve soil stability in the area, while rock breaking and excavation may be required at the main construction worksite area. For tunnel construction, a TBM will be launched from CR16 towards the north, while a second TBM will be launched from a shaft further south in order to connect the tunnels to the CR16 station.

The construction of MRT structures would be carried out before reinstatement and/or landscaping works during the final stage of the construction phase.

Under the base scenario, initial plans were drawn to have part of the Old Jurong Railway Corridor under Clementi Road, enhanced as a pedestrian walkway (utilising a 'light touch' or a natural theme) with ancillary facilities. This was subsequently reconsidered after an assessment of the impact on biodiversity and is explained in later parts of this NTS.

Environmental Consultation Process and Stakeholders Engagement

Prior to the commissioning of the EIS, an Environmental Consultation Process was undertaken by LTA with the relevant technical Agencies (i.e., MPA, SFA, NEA, NParks), as well as MND/URA, to confirm the scope of the EIS of the Project which was then documented in the form of an Inception Report for approval from the relevant Agencies.

Nature Groups were also engaged throughout the process to share the EIS findings, as well as to discuss design optimisation/mitigation measures and any other key biodiversity issues related to this Project. LTA will continue to engage Nature Groups throughout the Project on further measures to mitigate any potential environmental impact even during the construction phase.

Environmental Impact Mitigation Through Design Optimisation

Extensive engagements were made with stakeholders (including Nature Groups) to discuss measures to reduce environmental impacts during the EIS process, including the design optimisation of worksites as a method of Impact Avoidance/Elimination. The optimised worksites are referred to as mitigated scenarios in the EIS.

For context, the base scenario worksite area covers approximately 124,058 sqm, whereas the mitigated worksite area was reduced to 65,429 sqm.

Given development will partially take place beneath an active road (**Figure 1**), construction will be undertaken in stages, namely the advance worksites, stage 1 worksites and stage 2 worksites.

This optimisation has greatly helped in reducing encroachment into the Biodiversity Study Area or its further fragmentation, hence minimizing environmental impacts on the ecologically sensitive receptors in Clementi Forest. These optimisations include but are not limited to:

- Reducing the construction footprint to avoid and minimise direct encroachment into Clementi Forest, and Biodiversity Study Area, to minimise environmental impacts to the ecologically sensitive receptors.
- Splitting of CR16 worksites into several sites, including the cleared site in Clementi Forest and the worksite within the centre of Clementi Road for station construction, demolition worksite for the existing pedestrian overhead bridge, and Worksite at Nursery for non-construction related activities (e.g.,

site offices). This minimises land to be taken from Clementi Forest and to still allow Clementi Road to be operational during construction.

- Removal of the pedestrian walkway proposed to occur through Old Jurong Railway Corridor.

The worksite for CR16 was optimised during the study (see **Figure 3**).

Overview of Assessment Methodology

The assessment was undertaken by identifying the Study Area, categorising the sensitive receptors within Study Area, followed by the prediction and evaluation of impacts, and then the recommendation of mitigation measures and EMMP where relevant. The environmental impacts studied were direct impacts on biodiversity, or indirectly via other environmental aspects such as air quality, noise quality, vibration, hydrology and water quality and soil and groundwater.

Definition of Study Area and Identification of Sensitive Receptors

The Study Area, defined as a representative area covering the construction / operational footprint of the Project, was used for the assessment of environmental impacts. The Study Area identified for each environmental parameter varies based on the relevant legislation or international guidelines as shown in **Figure 2** and **Figure 3** below.

Figure 2: Study Area of CR16 (Base Scenario)

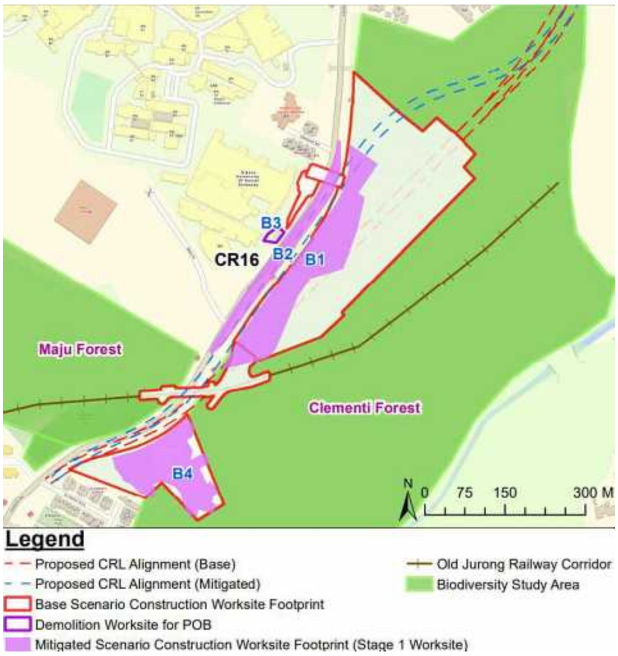


*Figure **3**: Study Area of CR16 (Mitigated Scenario)*

The assessment criteria for each parameter were also established based on similar sources of local and international guidelines or precedent reports and are detailed in the EIS.

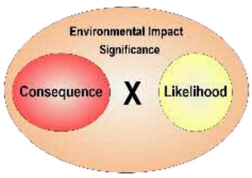
The sensitive receptors identified for this EIS were predominantly comprised flora and fauna, or their habitats within the Biodiversity Study Areas situated nearby the construction worksites, i.e., Clementi Forest, Maju Forest and Old Jurong Railway Corridor. The ecologically sensitive receptors were classified into Priority 1, 2 and 3, which were defined differently within each environmental discipline (viz., air, noise, vibration, hydrology and surface water quality, and soil and groundwater) and detailed in the EIS Baseline Data Collection.

Baseline Data Collection

To establish the baseline conditions of the Study Area, pre-construction environmental baseline data were collected from both primary sources (e.g., on-site water sampling, air, noise and vibration monitoring, site reconnaissance survey) and secondary sources (e.g., review of available environmental surveys, soil and groundwater baseline reports, publicly available data such as maps and weather data from an online database, existing literature, books, etc.).

Prediction and Evaluation of Impact

Impacts were evaluated based on their Significance, which is a measure of the weight that should be given to each impact in decision making and if it warrants impact management. It was assessed with consideration of two main factors: Impact Consequence and Likelihood of Occurrence.



Impact Consequence is a function of a range of considerations including impact spread, impact duration, impact intensity and nature, legal and guideline compliance. Likelihood of Occurrence refers to how likely an event would occur during the project construction and operational phases, which considers the frequency of exposure to the receptor.

In general, a risk-based matrix was used for the summation of Impact Consequence and Likelihood of Occurrence as shown in **Figure 4**.

Consequence / Likelihood	Imperceptible	Very Low	Low	Medium	High
Unlikely/ Remote	Negligible	Negligible	Negligible	Negligible	Negligible
Less Likely/ Rare	Negligible	Negligible	Minor	Minor	Minor
Possible/ Occasional	Negligible	Minor	Minor	Moderate	Moderate
Likely/ Regular	Negligible	Minor	Moderate	Moderate	Major
Certain/ Continuous	Negligible	Minor	Moderate	Major	Major

Figure 4 Impact Significance Matrix (General)

The application of these matrices may differ slightly for ground-borne vibration and air quality impact assessments. The full definitions of impact assessment terms and methodology were detailed in the EIS.

Impact Mitigation, Monitoring and Management

The mitigation, monitoring and management approach was defined in line with the NParks Biodiversity Impact Assessment (BIA) 2020, and the international risk assessment guidelines adopted in Singapore, as shown in **Figure 5.**

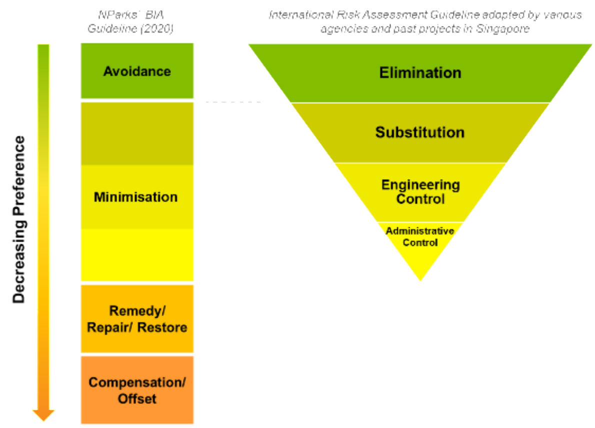


Figure 5: Mitigation Hierarchy

Baseline Environment

Both primary and secondary sources of information were used to establish the baseline conditions at the surrounding areas of this Project.

Other than secondary sources, on-site field surveys and monitoring works were conducted to establish the baseline conditions of:

- Biodiversity
- Hydrology and Surface Water Quality
- Air Quality
- Airborne Noise
- Ground-borne Vibration

The baseline data review for Soil and Groundwater was carried out via secondary source only, i.e., from the findings of Historical Land Use Survey (HLUS) as well as site investigations recorded in separate studies.

Biodiversity

The size of the Biodiversity Study Areas in the EIS are as follows:

- Clementi Forest: 58.3ha
- Maju Forest: 33.2 ha.

As Maju Forest and Clementi Forest are located adjacent to each other, their historical land uses likely show some similarities. A topographic map of the sites from 1914 shows that the sites were characterised by hilly terrain, particularly at Maju Forest, and streams and swamp at Clementi Forest. However, an aerial photograph from 1950 indicates that Maju Forest was cleared and comprised grassland.

The Keretapi Tanah Melayu (KTM) railway, which commenced operations in the early 1930s and ran from Malaysia to Tanjong Pagar, cuts through Clementi Forest. Construction of the railway likely introduced large disturbance to both Clementi Forest and Maju Forest.

Between 1975 and 2005, Maju Forest and Clementi Forest appear to have matured into abandoned-land forest, a forest typified by plantation trees and exotic plant species. Clementi Forest, on the other hand, was used as a rubber plantation between the 1920s and 1940s, that is believed to have been abandoned during World War II.

Field surveys were conducted from November 2019 – March 2020 covering all known vegetation and habitat types to understand the biodiversity at Clementi and Maju Forests.

Clementi Forest

Clementi Forest is characterised by four vegetation types, with half the site dominated by abandoned-land forest. The remaining area comprised scrubland and herbaceous vegetation, waste woodland and managed vegetation.

A total of 303 plant species were recorded, with the floristic assemblage being largely native (52.1% native species). 51 species of plants of conservation significance were recorded and mostly distributed within the abandoned-land forest. While these patches constitute some threatened species, the forest canopy layers were dominated by rubber trees (*Hevea brasiliensis*) persisting from past cultivation practices. Vegetation along the Old Jurong Railway Corridor is relatively distinct, vegetated with several plants of the stream-associated species, *Alsophila latebrosa* and *Blechnum finnlaysonianum*, in the understorey. The native *Campnosperma auriculatum* trees and saplings were also found growing along the track. A specimen of the nationally Presumed Extinct *Asplenium nitidum* fern was found growing on the trunk of an *Elaeis guineensis* palm, near the entrance to Clementi Forest via the Old Jurong Railway Corridor and adjacent to Clementi Road. Notably, two individuals of the rare terrestrial orchid species, *Dienia ophrydis*, which was thought to be extinct in Singapore, were seen growing in the relatively shaded forest understorey along the Old Jurong Railway Corridor.

The faunistic field assessment recorded 210 species with more than half of the recorded assemblage dominated by bird and butterfly species. A total of 19 species of conservation significance were recorded and distributed across the Study Area with no distinct hotspot. Some notable records include the nationally Critically Endangered Malayan softshell turtle (*Dogania subplana*), nationally Vulnerable small duskhawker (*Gynacantha bayadera*), nationally Vulnerable variable featherlegs (*Copera vittata*) and straw-headed bulbul (*Pycnonotus zeylanicus*). The Study Area, therefore, supports local populations of fauna conservation significance, and other forest-dependent fauna and/or species of restricted distribution that are increasingly threatened by habitat loss.

Along DS/1 (considered the site's main stream), the presence of native species, such as common walking catfish, illustrates the stream's value in supporting local populations of these aquatic species, especially when streams are increasingly becoming uncommon habitats in Singapore. A pond present in the southern portion of Clementi Forest also provides breeding habitats for uncommon duskhawker species such as dingy duskhawker (*Gynacantha subinterrupta*).

Ecological surveys suggest the importance of the Study Area as a biodiversity refugia that can support populations of floral and faunal species of conservation significance, with the native-dominated secondary forest, natural streams and contiguous forest connecting these habitats as areas of high ecological value (see **Figure 6**). Figure 6 covers the base scenario worksites only, due to the biodiversity baseline study being undertaken before the optimised design was finalised.

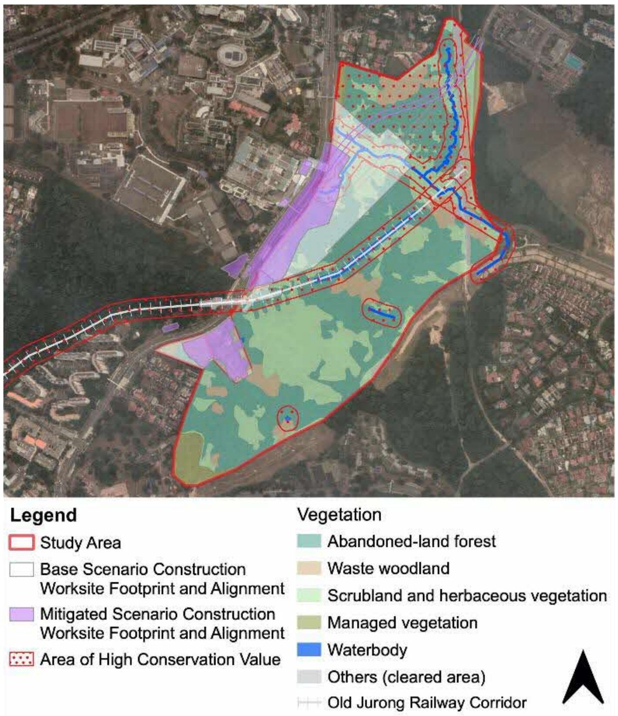


Figure 6: Areas of High Conservation Value at Clementi Forest

Figure 7: Examples of Biodiversity Species in Clementi Forest

Maju Forest

Maju Forest is characterised by five vegetation types. Abandoned-land forest and native-dominated secondary forest occupy more than half of the site, and the rest of the site comprises scrubland and herbaceous vegetation, waste woodland and managed vegetation.

A total of 305 plants were recorded, with the assemblage largely native (52.8%). 47 plant species of conservation significance were recorded and mostly distributed within the native-dominated secondary forest and abandoned-land forest. Several individuals of stream-associated species were encountered near the waterbodies in Maju Forest, particularly along the Old Jurong Railway Corridor; they are the nationally Vulnerable tree fern *Alsophila latebrosa* specimens, one nationally Vulnerable fern *Pteris semipinnata* specimens, and one nationally Endangered shrub *Callicarpa longifolia* specimen.

The faunistic field assessment recorded 130 species with more than half of the recorded assemblage dominated by bird and butterfly species. A total of 10 species of conservation significance were recorded and distributed across the Study Area with no distinct hotspot; they are likely able to be using the entire Study Area. Some notable records include the nationally Vulnerable chocolate sailor (*Neptis harita harita*), the straw-headed bulbul (*Pycnonotus zeylanicus*) and Sunda pangolin (*Manis javanica*), in which Singapore is a stronghold. The records of forest-dependent species and/or species of restricted distribution, such as the glossy horsehoe bat (*Rhinolophus lepidus*) and copper-cheeked frog (*Chalcorana labialis*) show the value of the Study Area in supporting local populations of these species. Furthermore, native-dominated secondary forest, such as that present within the Study Area, provides resources and habitats for native fauna.

The waterbodies within the Study Area were often dry with disconnected shallow pools of water. Though records of aquatic fauna were low along the waterbodies, natural waterbodies are increasingly uncommon, and they provide habitat to some uncommon or forest-dependent species such as the copper-cheeked frog (*Chalcorana labialis*). Therefore, the secondary forest and waterbodies present within Maju Forest are of high ecological value which supports populations of Species of Conservation Value.

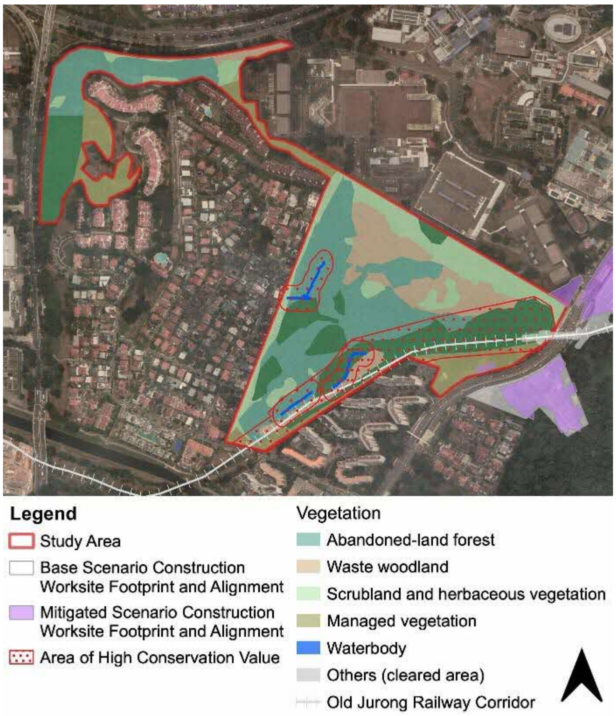


Figure 8: Areas of High Conservation Value at Maju Forest

Figure 9: Examples of Biodiversity Species in Maju Forest

Hydrology and Surface Water Quality

The hydrological baseline study aims to identify waterbodies present in the Study Area including their location, water flow conditions and bank characteristics. Based on topographic survey data, site surveys as well as PUB water catchment maps, water catchment areas within the vicinity of the Biodiversity Study Area (BSA) mainly contribute to the identified eight (8) major watercourses. Water from the identified drains/streams will eventually flow to Sungei Pandan. The water from Sungei Pandan is pumped into Pandan Reservoir for drinking water purposes. In addition, some of the natural streams 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 conservation values, supporting surrounding ecological systems.

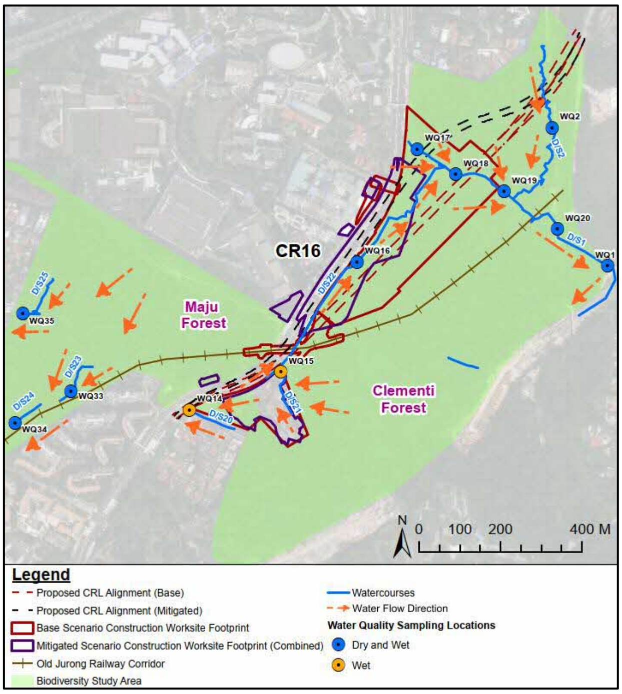


Figure 10: Water Sampling Location in the vicinity of Clementi Forest and Maju Forest

To study water quality within the identified drains/streams, two (2) dry and one (1) wet weather samples were taken from each of the 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 for 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), orthophosphates (PO_4-P), total nitrogen (TN), and nitrate (NO_3-N). Results were compared with both NEA discharge guidelines in Singapore and criteria for aquatic life from other countries. Generally, the water quality conditions in the tested drains/streams were perennially fed from rainwater, but with low flow. Their water quality was good for aquatic life in terms of temperature, pH, TDS, turbidity, TSS, BOD_5, COD, TN, and NO_3-N in the watercourses of Clementi Forest. DO is above the criteria at most of the stations, except for WQ2, WQ18 and WQ19 in Clementi Forest and WQ34 and WQ35 in Maju Forest (lower than 4 mg/L) during dry and/or wet weather, due to their stagnant conditions. However, previous similar studies in Singapore also show freshwater aquatic life thriving in DO below 4 mg/L in Singapore, the freshwater aquatic life may have adapted and therefore found to thrive in these conditions in Singapore. 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.

Soil and Groundwater

Soil and groundwater impact assessment was carried out qualitatively based on the HLUS study findings, previously carried out soil and/ or groundwater studies within Study Area and predicted groundwater drawdown by LTA.

Soil profile underneath the Study Area generally consists of sandy silt. Besides silt, layers of silty sand, clay and sandy clay were also observed.

Metals (i.e., arsenic, antimony, barium, cadmium, chromium, copper, lead, molybdenum, nickel and zinc) and Total Petroleum Hydrocarbons (TPH) were detected in the majority of soil samples, all below their respective Dutch Intervention Values (DIVs). Reported concentrations of detected vanadium were below the indicative levels for severe soil contamination as per Dutch Standards. The Dutch Intervention Values (DIV) as defined in the Dutch Environmental Guidelines Soil Remediation Circular, indicate when the functional parameters for the soil and groundwater for humans, plants and animals are seriously impaired or in danger of being so. As such, and in the lack of national guidelines/ criteria regarding soil and/ or groundwater quality, the DIVs are referenced in the latest Code of Practice for Pollution Control by the NEA, Guideline on Environmental Baseline Study published by JTC as well as Environmental Site Assessment Guidelines published by SLA. Furthermore, faecal coliforms were also detected in the soil samples.

The average groundwater level ranged from +9.21 mRL to 21.75 mRL. 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 the northeast, and it follows surrounding topography.

A review of the groundwater analytical results showed that only lead in groundwater samples collected in RC/30204 and RC/30205 (i.e., 75.2 µg/kg and 95.4 µg/kg, respectively) exceeded their DIV (i.e. 75 µg/kg). However, the risk-based assessment showed that the reported concentrations of lead are well-below screening levels and do not present an unacceptable risk to the health of future construction workers via dermal contact and incidental ingestion. The rest of the parameters tested in groundwater do not exceed their respective DIVs.

Air Quality

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 on neighbouring sensitive receptors during the construction phase mainly include emissions from the heavy vehicular exhaust and dust emitted from the earthworks, construction and track out activities. During the operational phase, emissions from vehicle exhausts due to increased traffic in the vicinity of the proposed development were identified as the predominant air emission source. In order to assess the current baseline air quality in the Study Area, baseline air quality data were 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 A01 SUSS which recorded 24-hour average $PM_{2.5}$ concentrations of 26.5 µg/m^3. However, the targets were met for the rest of the week at A01 with an average daily $PM_{2.5}$ concentration of 14.4 µg/m^3 throughout the week.

It should also be noted that there are no feasible equipment access points to the Clementi Forest or Maju Forest for the air quality monitoring to be conducted within the Clementi Forest and Maju Forest. Hence, SUSS has been identified as a representative monitoring location for the purpose of the Project.

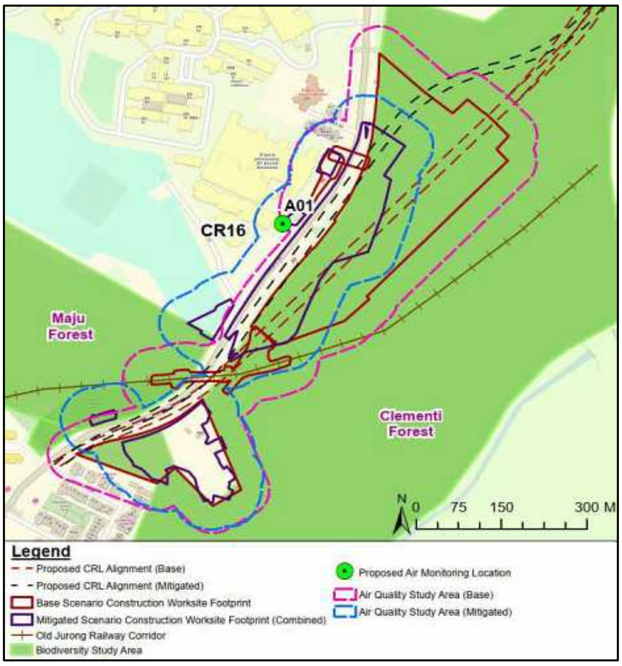


Figure 11: Air Baseline Monitoring in the vicinity of Clementi Forest and Maju Forest

Airborne Noise

Baseline noise monitoring was carried out at four locations: Landed housing along Clementi Crescent, Within Clementi Forest, Singapore University of Social Sciences (SUSS), Children's Aid Society (Melrose Home) within the period of January 2020 to February 2020. The Norsonic 131 Sound Level Meter was used to record the baseline noise levels over time periods of average 12 hours (long term), 1 hour and 5 minutes (short term) at each location.

As advised by NParks, the pre-construction baseline served as the criteria for ecologically sensitive receptors and the predicted noise levels were assessed by "no-worse-off than baseline" approach. This is generally much more stringent than NEA's noise criteria for human receptors.

Four (4) noise monitoring locations were set. For the Project-specific noise criteria, the baseline noise level from N02 within the Clementi Forest and N04 Children's Aid Society (Melrose Home) which is near the northern part of the construction worksite were used (see **Figure 12*)*** to study the baseline noise level. The average baseline noise levels for weekdays were recorded at $L_{eq(12hours)}$ 52-66 dB(A) and $L_{eq(5mins)}$ 43-66 dB.

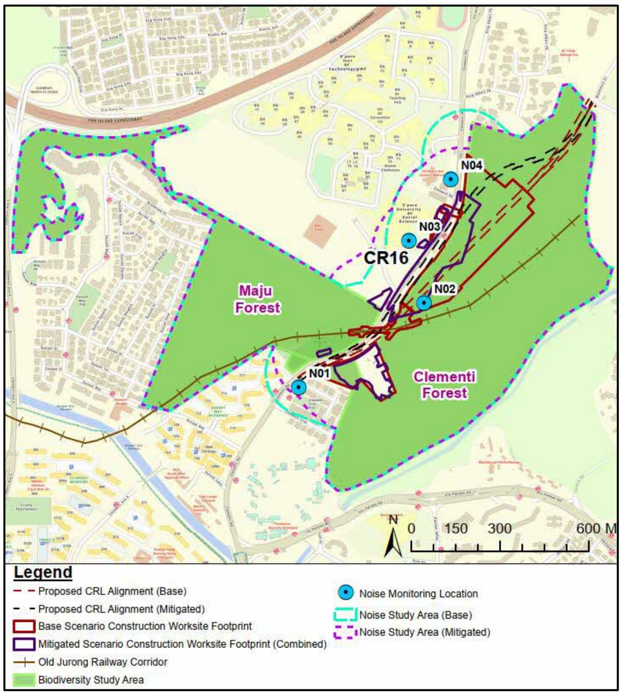


Figure 12: Noise Baseline Monitoring in the vicinity of Clementi Forest and Maju Forest

Ground-borne Vibration Baseline

Ground-borne vibration impact assessments have been carried out for piling and tunnel boring works. The impact assessment identifies ecologically sensitive receptors within 100 m from the CR16 worksite and 100 m from the centre of the alignment. Based on the literature review, the ecological species were first evaluated for their sensitivity towards ground-borne vibration and further classified into Priority 1, Priority 2 and Priority 3 sensitive ecological receptors based on their Conservation Significance in Clementi Forest and Maju Forest.

Baseline vibration monitoring was conducted at representative locations of the vibration Biodiversity Study Areas (Clementi Forest and Maju Forest) to gather information on the existing ground-borne vibration levels experienced by sensitive ecological receptors and to determine the assessment criteria for ground-borne vibration impact assessment for construction and operational phase.

The baseline vibration monitoring results show that the 99th percentile baseline vibration level [peak particle velocity (PPV)] at Maju and Clementi Forests is 0.08 mm/s for both locations. Since there are no standardised vibration criteria for fauna, the Project uses step increment in human response[1], and the baseline vibration results to develop an assessment approach.

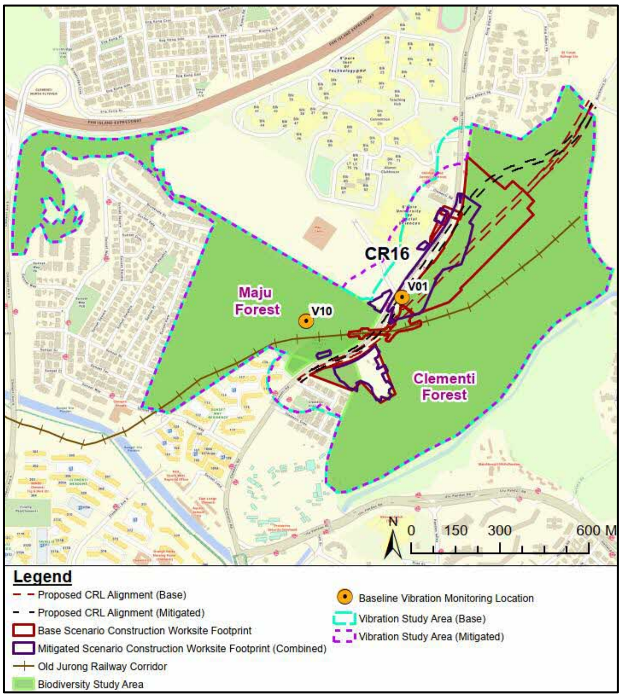


Figure 13: Vibration Baseline Monitoring in the vicinity of Clementi Forest and Maju Forest

Minimum Controls

Minimum controls are non-site-specific measures which comprise of common best site practices mandatory for implementation at all construction worksites, as well as basic practices required under local regulations and guidelines. As per the impact assessment methodology, minimum control measures were considered as the basis of impact prediction and evaluation. In other words, minimum controls were sometimes known as upstream mitigation measures integrated as part of the initial impact assessment before the additional mitigation measures being proposed during the residual impact assessment later in the EIS process.

Key Minimum Controls in Construction Phase

A list of minimum control measures was summarized for each assessed environmental parameter in the EIS, in which some key examples for the construction phase are:

- Prepare Safety Operational Procedures (SOPs) and Emergency Response Plans on site, which includes Noise Management Plan (NMP), Erosion Control Measures (ECM) plan, Air Pollution Control Plan (APCP) and other plans (e.g. for chemical storage and handling, waste storage and handling, etc.) to avoid and minimise environmental impacts. A review of Noise Impact Assessment (NIA) was suggested if there are changes to Project activities or worksite design which differ from that in the EIS;
- Engage arborists, flora and fauna specialists to clearly mark out the Tree Protection Zones, plants with conservation value, wildlife or nesting structures that are being active before the start of works;
- Engage a qualified erosion control professional (QECP) to formulate and implement ECM plan (e.g., install silt fences along site hoarding) in accordance with PUB requirements to eliminate the risk of discharging construction wastewater into natural streams, where the robust ECM plan will include but not limited to:
  - Practice due diligence in proper handling and storage of all construction wastes including hazardous wastewater (e.g., oily wastewater, thinners, solvents, paints from surface run-off and machinery), as well as ensure proper disposal by authorized dealers or licensed waste collectors;
  - Install CCTV monitoring including Silty Imagery Detection System (SIDS) at the public drains to monitor surface run-off discharge to these drains;
  - Include ECM tanks/ponds prior to discharge of treated effluent (only stormwater runoff) in worksites. Treated water should be tested prior to discharge;
  - Adequate drainage, cut off drains, sump pit, road kerb, piping and toe wall will be designed for channelling of construction process wastewater and storm runoff separately.
- Design and implement proper Earth Retaining Stabilizing Structures to limit the impact from unstable slopes and groundwater settlement;
- Implement Reduce, Reuse and Recycle hierarchy for solid waste and wastewater generated onsite;
- Avoid placing food waste in bins situated outside of worksites to avoid human-wildlife conflict. Where site staff take breaks outside, all waste must be disposed of in the bins provided. This potential issue will be included within the biodiversity toolbox talk; and,
- Adopt construction method and use construction equipment that generates less noise, dust and

[1] According to BS5228-2: 2009+A1:2014, the Code of Practice for Noise and Vibration Control on Construction and Open Sites, human response refers to the vibration levels that produce an effect or consequence of human perception and disturbance.

vibration, which includes but is not limited to the following, where applicable:

- Construct paved access roads where possible before starting work on site;
- Implement dust control measures such as dust screens, hessian mulch and water suppression systems;
- Reduce the number of operating powered mechanical equipment (PME) used. The operating schedule will also be optimised to minimise intermittent noises from machines;
- Equipment emitting directional noise, to be directed away from ecologically sensitive receptors;
- Conduct dilapidation studies, careful selection of low noise and vibratory equipment/ trucks;
- Apply noise abatement measures, including covering PMEs with acoustic shed/enclosure, applying silencers or mufflers on equipment, etc.

Key Minimum Controls in Operational Phase

Similarly, some key examples of minimum controls for the operational phase include but are not limited to:

- Permanent drainage systems should be designed in accordance with the requirements in PUB's Code of Practice on Surface Water Drainage;
- 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., as well as eventual discharge of treated water;
- 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;
- Proper handling, storage and disposal of hazardous and non-hazardous new or used chemicals during the operational process. Provide spill kit where necessary;
- Heavy maintenance works and noisy equipment delivery should be kept within the daytime (9am to 5pm). This will only be allowable beyond these hours, only in the instance of an emergency/safety critical operations; and
- Acoustic treatment for equipment to meet noise level limit at site boundary where necessary.

Impact Assessment Findings

Overview of Impact Assessment

In short, the impact of all assessed environmental parameters in the EIS was first evaluated based on the base scenario worksite, along with the consideration of minimum controls as the basis. Thereafter, additional mitigation measures (including mitigated scenarios of worksites) were provided for Moderate and Major impacts and incorporated as part of the residual impact assessment, where relevant.

Biodiversity

Table 1: Summary of Biodiversity Impact Assessment

Sensitive Receptor	Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)
Construction Phase		
Clementi Forest	Major – Negligible	**Moderate (Note1) – Negligible**
Maju Forest	Major – Negligible	**Minor – Negligible**
Operational Phase		
Clementi Forest	Moderate – Negligible	**Minor – Negligible**
Maju Forest	Major – Negligible	**Minor – Negligible**

Note:

1. Though vegetation and habitat loss has been reduced by moving the station footprint away from Clementi Forest and main stream (DS/1 and DS/2), the loss of vegetation due to site clearance from the new worksite would still result in moderate impact for scrubland and herbaceous vegetation. Such vegetation and habitat loss are permanent and irreversible.

Areas of high conservation value were identified at both Clementi and Maju Forests during baseline studies. Following the mitigation hierarchy, design optimisation was applied to avoid or minimise the impact on ecologically sensitive receivers. Where such impact could not be avoided, minimization and compensatory measures were applied.

The most severe impact from the construction phase at Clementi Forest is of major significance from habitats, and floral and faunal species for the base scenario. This was mainly due to loss of habitat and/or vegetation during site clearance, mortality to floral species and the loss of terrestrial and aquatic ecological connectivity for faunal species. The Major impact was reduced to **moderate** after optimisation of the worksite—however, disturbance to tributary stream (D/S22) and habitat/vegetation loss is permanent and irreversible and thus moderate impacts cannot be reduced further. Other impacts such as habitat degradation and changes in species composition were reduced to **minor/negligible**.

While the most severe impact from the construction phase at Maju Forest is of major significance. This was due to works resulting in loss of habitat and/or vegetation during site clearance to habitats, mortality to floral species and the loss of ecological connectivity for faunal species. After the application of the mitigation measures, all impacts were reduced to **minor/negligible** impact significance. This is chiefly due to the shifting of the worksite out of Maju Forest.

The most severe impact from the operational phase at Clementi Forest is of major significance. This was mainly due to the loss of ecological connectivity from the proposed pedestrian walkway along Old Jurong Railway Corridor for faunal species. After the application of the mitigation measures, the Old Jurong Railway Corridor under Clementi Road was left untouched, resulting in a reduced **minor/negligible** impact significance.

Like Clementi Forest, due to the removal of the pedestrian walkway along Old Jurong Railway Corridor, major impacts were reduced. Coupled with optimisation of the worksite, impacts were reduced to **minor/negligible**.

The detailed list of other recommended mitigation measures (e.g., implementing road calming measures for animal crossing, transplanting or harvest trees/ saplings of conservation significance, executing fauna response and rescue protocol, limited night works and optimise night lighting strategies etc.) are included in the EIS to further minimize the biodiversity impacts of the Study Area.

Hydrology and Surface Water Quality

Table 2: 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**
	Natural Steam D/S2	Negligible	**Negligible**
	Concrete Drain D/S20	Minor	**Minor**
	Earth Drain D/S21	Major	**Minor**
	Natural Steam 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**
	Natural Steam D/S2	Negligible	**Negligible**
	Concrete Drain D/S20	Negligible	**Negligible**
	Earth Drain D/S21	N.A. (Note 1)	**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. *After application of mitigation measures, major/moderate impact significance was mostly reduced to minor/negligible impact significance. This is largely due to the shifting worksite away from main stream (D/S1 and D/S2 streams) and the optimisation of worksite within Clementi Forest. Yet, there are still residual* ***moderate*** *impact significance due to worksite still resulting in disturbance to tributary stream (D/S22) and habitat/vegetation loss are permanent and irreversible*

During the construction phase, the potential sources of hydrology and surface water quality impacts are mainly from construction activities such as surface runoff during site clearance, wastewater from concrete batching plant and tunnelling activities, spoil generation, improper handling during storage and disposal of solid wastes and liquid wastes, accidental spill and leaks during the use and storage of chemical substances, etc.

During the operational phase, the potential sources of hydrology and surface water quality impacts are mainly from stormwater runoff which contains pollutants built-up in the new developed area during heavy rain events, increase of runoff peak flow draining to the stream or drain during storm events, as well as reduced baseflow (sub-surface water discharge) due to the permanent change in land use of the new development.

The impact on hydrology and water quality was assessed to cause Major impacts on watercourses (i.e., D/S1, D/S21 and D/S22) in the vicinity of CR16 worksites during the construction phase, and Moderate impacts on the hydrology and water quality of watercourses (i.e., D/S1 and D/S22) in Clementi Forest during the operational phase, even with implemented minimum controls. Hence, mitigation measures are proposed to temporarily divert the affected section of natural stream (D/S22) in the CR16 worksite during both construction and operational phases, while conserving the main stream (D/S1) outside of the CR16 worksite due to its high ecological importance during the construction phase.

To reduce the impact on the drain/streams, LTA has relocated the CR16 worksite away from D/S1 and D/S21 in the CR16 mitigated scenario. This minimises hydrological, water quality and ecological impacts during both construction and operational phases. All the diverted drains will seek PUB's approval and drain design will follow PUB's Code of Practice on Surface Water Drainage to have an adequate flow capacity to cater for changes in land use from the existing condition, and avoid any negative impact on slope foundations of existing road structures. Slope stability analysis will also be included in the detailed design for the drain diversion at a later stage. Any storm discharge from worksites to diverted drain requires to meet the NEA guidelines if applicable. In addition, the diverted natural stream (D/S22) in Clementi Forest is expected to provide continuous flow, as in the existing condition, (especially during dry days) to maintain any ecological water habitats at its downstream. The impact significance is therefore reduced to Minor.

For other watercourses in the forested areas in which the construction or operational footprints are not located within the watercourses' catchment, the impact on hydrology and water quality was assessed to cause only Minor impacts during both construction and operational phases. Thus, no additional management or mitigation measures other than the minimum controls identified and those incorporated in the construction and operational plans are required.

Therefore, given that the minimum controls and mitigation measures for the CRL2 construction and operational activities will be implemented, the significance of residual impacts from the potential sources of contamination at the sensitive water receptors was assessed to be **Negligible to Minor** as shown in Table 2.

Soil and Groundwater

Table 3: 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** (Note 1)
Maju Forest	Negligible - Minor	**Negligible – Minor** (Note 1)
Operational Phase		
Clementi Forest	Minor	**Minor** (Note 1)
Maju Forest	Minor	**Minor** (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 eliminated.		

The potential impacts on soil and groundwater of historical and current land use as well as activities associated with the construction and operational phases of the Project were discussed by using the information from historical land use surveys, construction waste information and other best available data. The soil and groundwater impact study was carried out qualitatively based on the findings from the HLUS study and the previous soil and/ or groundwater investigation studies.

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 toxic chemical waste used or generated on site, improper management of excavated soil and extracted groundwater, as well as potential leakage from improper handling of hazardous chemical/substances on site.

The potential sources of soil and groundwater impact during the operational phase are expected to be mainly from maintenance of the alignment, vent shaft 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.

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 of potential sources of soil and groundwater impacts during construction and operational phases such as decreased groundwater baseflow feeding into the streams, toxic chemical waste generation and improper handling of hazardous chemicals/substances and soil and groundwater was assessed to be **Negligible - Minor** to the sensitive receptors and no further mitigation measures were required for CRL2 Project.

Air Quality

Table 4: 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** (Note 1)
Maju Forest	Minor	**Minor** (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.

Air quality impact assessment for the construction phase was undertaken in accordance with the UK IAQM Guidance on the Assessment of Dust from Demolition and Construction. Pursuant to this, 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 on 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. This is largely because of the large extent of the construction worksite located very close to or within the areas with flora, fauna and habitat with high ecological value.

The key control and mitigation measures include but are not limited to the development of an air pollution control plan, dust control measures on site, site hoarding, planning of dust causing activities-location and timing, and reinstating land upon completion of works amongst several others. Based on the assessment, the “CR16 Mitigated Scenario” is preferred compared to the “CR16 Base Scenario” due to its smaller footprint. A smaller construction footprint would reduce the potential air quality impact on the neighbouring receptors.

Air quality impacts were also qualitatively weighed during the operational phase. Fugitive emission from vehicle exhaust due to increased traffic in the vicinity of the project was expected. It is assumed that all new vehicles meet their Euro emission standard. Furthermore, there is currently a large traffic volume along 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 derived from vehicles. At a much higher level, trains are meant to replace substantial vehicles on 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 stations may see some increase. In this aspect with the information assessed at this stage, the air quality impact contributed by the proposed development is anticipated to be **Minor** during the operational phase.

The construction contractor is recommended to prepare an air quality management plan incorporating a range of monitoring and mitigation measures. Details are provided in the EIS Report.

Airborne Noise

Table 5: 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** (Note 1)
Maju Forest	Major	**Minor to Major** (Note 1)
Operational Phase		
Clementi Forest	Negligible	**Negligible** (Note 2)
Maju Forest	Negligible	**Negligible** (Note 2)

Note:

1. Due to the surrounding ambient noise levels which are naturally very low, the fact that sensitive receptors are in close proximity, and that noise barriers are unlikely to impede noise that will reach habitat on elevated/undulant terrain, meaning receptors in these locations will still be impacted. Collectively, these therefore mean, that impact significance cannot be reduced further.
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.

The noise impact assessment was carried out for the construction and operational phases of the proposed worksites for the Project.

For the classification of receptor sensitivity to airborne noise, auditory sensitivity of the respective species was used to assign receptor priority. Species that use sound for communication, foraging and breeding or are known to have their behaviours disrupted by sound were assigned Priority 1 status for auditory sensitivity. Species that are less affected by airborne noise but are of Conservation Significance were assigned Priority 2. Species that are less affected by airborne noise and are not of Conservation Significance were assigned Priority 3. A habitat sensitivity map was used as a basis from which to decide the probability of finding a species in the area. The noise Study Areas are Maju Forest, Clementi Forest and the area within 150m of the construction worksites.

The noise levels generated from the equipment used during the construction phase were predicted using Sound PLAN ver 8.2. Topography played an important role in noise propagation and was included in this assessment.

A quantitative assessment of the noise sensitive receptors (within the Study Area) was carried out and compared with the stipulated Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008. Based on the impact evaluation, mitigation to reduce airborne noise impacts was recommended for the affected ecological noise sensitive receptors. The approach selected for noise impact assessment was a very stringent “no worse off than average baseline” approach in this Project owing to its proximity to a nature reserve.

The study of construction noise impact on noise sensitive receptors focused on three (3) different construction base scenarios and six (6) different mitigated scenarios. Base scenarios were, Scenario 1: Cut and cover works and associated activities; Scenario 2: TBM works; and Scenario 3: Construction of station entrances where construction noise impacts to the sensitive receptors were assessed. Mitigated scenarios were, Scenario 1: Advance works; Scenario 2: Construction of site office; Scenario 3: Demolition of POB; Scenario 4: Main civil works; Scenario 5: TBM works; and Scenario 6: Construction of station entrances where construction noise impacts to the sensitive receptors were assessed. 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 are 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 the Scenario 1: Cut and cover works and associated activities to Scenario 3: Construction of station entrances for the construction phase, base scenario results showed impact significance of Major at Maju Forest and Clementi Forest.

During the operational phase, the potential impacts would arise from the ACMV noise at the ventilation shaft buildings and traffic noise from the neighbouring public roads to the Biodiversity Study Areas (i.e., Maju Forest and Clementi Forest).

For the purpose of ACMV noise, a “no worse off than average baseline” approach was imposed at the boundary of ventilation shaft buildings and will form a mandatory requirement when this is designed and built at a later stage as design engineering develops in the next phase. Note that a separate study for the facility or ventilation buildings was conducted by LTA under a separate study. It was understood from the separate study that the ACMV 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 the stringent approach as proposed in this EIS.

Whilst for the qualitative assessment of traffic noise, there is no addition of new access roads for these ventilation shafts, and they will be accessible via current existing roads, therefore the noise from the routine traffic will dominate the noise levels. The station is located near busy roads, and it is possible that the addition of traffic due to the railway station may not double the traffic in the area; however, it is possible that since the station is near schools/university, the commuters may be those attending these educational institutes and currently coming by road, who will change to commute by trains; in which case, the traffic on the road may reduce. With current knowledge at this stage, the variations can only be speculated on, as described. Overall, the airborne noise impact during the operational phase was evaluated to be Negligible.

Mitigation measures were proposed and considered during the residual noise impact assessment, which includes but are not limited to:

- Design optimisation to reduce the footprint of the worksite (see **Figure 1**);
- 6 m high noise barrier at the west and south-east construction boundary of CR16 Advance worksite which is fronting noise sensitive receptors;
- 12m high noise barrier at north-east construction boundary of Advance worksite which is fronting noise sensitive receptors after completion of Advance worksite construction;
- 12 m high noise barrier at the west construction boundary of main construction worksite fronting noise sensitive receptors;
- Use the existing 6 m high noise barrier from the south-east construction boundary of the Advance worksite and 12m high noise barrier from the north-east construction boundary of the Advance worksite during main construction works; and
- LTA’s standard 15m high full enclosure with an open façade opening at the northern side for TBM work around the launch shaft location when tunnel boring works commence. The proposed noise barriers are presented in **Figure 14**.
- Administrative measures including

– To avoid early morning day-time noisy activities between 7 to 9 am as far as possible on site to reduce impact to avifauna
– 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; and
– To avoid above-ground night works after 7pm for all non-safety critical activities.

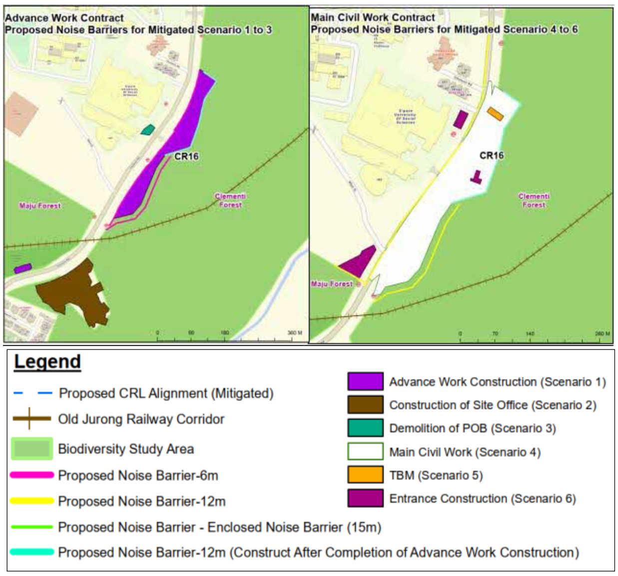


Figure 14: Noise Barrier Location

Overall, the ground level and low-height noise sensitive receptors benefit significantly from the noise barrier, however, receptors at height may not benefit from noise barriers since noise travels with the line-of-sight principle. The worst-case assumptions on construction equipment usage, period of usage, and a more conservative approach for barrier heights were used in this stage to inform the worst impacts predicted in these locations of a highly sensitive nature. Notwithstanding the above, when the design is more firmed up in the detailed design phase, an optimisation of noise models with a more realistic use of equipment and area of worksite will be used to redefine the noise impacts at a later stage by the Contractor as well.

Following the residual impact assessment with all the recommended mitigation measures, the worst-case residual impact significance became **Minor to Major** at Maju Forest and Moderate to Major at Clementi Forest. It is to be noted that there is little 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 the height immediately next to the construction site are likely to have a straight line of sight despite a noise barrier, therefore due to surrounding extremely low ambient noise levels, sensitive receptors in close proximity, and undulant terrain with a high elevated area which cannot be blocked by the proposed noise barrier, residual impact significance became Major. It is to be noted that the area of "Major" impact significance is expected to be reduced significantly for the mitigated scenario due to noise reduction at the source and erection of noise barriers. Since the residual impact significance was **Major**, portable noise barriers were recommended to be situated nearby noisy equipment/ activities. Furthermore, it was recommended that no night works take place after 7pm for all non-safety critical activities since the site is adjacent to sensitive receptors.

Ground-borne Vibration

Table 6: Summary of Ground-borne Vibration Impact Assessment

Sensitive Receptor	Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)	Resultant Impact Significance with Further Mitigation Measures (if required)
Construction Phase			
Clementi Forest	Negligible - Major	Negligible - Major	**Negligible – Moderate (Note 2)**
Maju Forest	Negligible - Major	Negligible - Major	**Negligible – Moderate (Note 2)**
Operational Phase			
Clementi Forest	Minor	Minor (Note 1)	**Minor (Note 1)**
Maju Forest	Minor	Minor (Note 1)	**Minor (Note 1)**

Note:
1. The initial impact assessment with minimum controls was considered insignificant (Negligible to Minor), no residual impact assessment was undertaken, hence the impact significance remained the same. Note that this does not indicate that impacts are completely eliminated.
2. Construction activities such as pipe jacking, rock breaking and excavation and tunnel boring produce high PPV levels at the biodiversity sensitive receptors. It is essential to implement EMMP measures to reduce the impact significance to **Moderate**.
3. Residual impact significance considers impact after worksite design optimisation has been implemented, whereas resultant impact significance considers design optimisation in addition to a commitment to no night works and the installation of temporary water barriers to prevent fauna from exiting onto roads.

Based on the review of the proposed construction activities for this Project, an assessment was carried out for the ground-borne vibration impact for rock breaking and excavation, vibratory piling, tunnel boring, pipe jacking, bulldozing, and vibratory compaction works on the identified Biodiversity Study Area. Table 6 discusses the impact assessment results.

High amplitude vibratory compactors, rock breaking and excavation activities produced vibration levels exceeding 5 mm/s. Hence the activities were screened for partial burrow collapse. Pipe jacking (spot) produces the highest PPV of 9 mm/s at Clementi Forest, followed by vibratory piling for entrances with a PPV of 8.75 mm/s at Maju Forest. During these activities, there is a risk that the vibration causes impacts on the structural integrity of the animals' habitat, such as burrows. The study recommends mitigation measures to limit the construction activities such that impact intensity remains below the levels for structural impacts.

In addition, the potential impact on fauna is a change in behaviour during their day-to-day activities, such as communication, breeding and foraging habits within their home range. The potential impact intensity experienced by the fauna was evaluated based on the predicted vibration levels and the impacted area within the Biodiversity Study Area or species-specific home range information from literature, such as mouse deer and pangolin. At Maju and Clementi Forests, the construction works impact. Priority 1 ecological receptors breeding season. Typically, birds and animals move away from instantaneous and short duration works like pipe jacking, rock breaking and excavation, and the passing of the tunnel boring machine and are likely to return to their original activity soon after the works are complete. During these critical construction phases, the study recommends continuous vibration and fauna behaviour monitoring (using camera traps and specialists' observation). For construction activities that may last for a more extended period (i.e., a few months), it is advisable to control the vibration levels to practical levels to minimise the size of the impacted duration.

LTA predicted ground-borne vibration levels due to train operation in a separate study. The study assesses the vibration impacts on sensitive ecological receptors. The assessment results show that minimum control measures are sufficient to mitigate the ground-borne vibration impacts on the sensitive receptors at Clementi Forest and Maju Forest. The overall impact significance is **Minor**.

Environmental Monitoring & Management Plan (EMMP)

Overview

An EMMP was proposed to monitor and manage the environmental impacts of the construction and operational phases associated with the Project. The EMMP also aimed to provide an overall picture of the potential roles and responsibilities required during each phase of the Project. The coverage of the proposed EMMP involved environmental parameters that were assessed in this EIS study, namely biodiversity, hydrology and surface water quality, soil and groundwater, air quality, airborne noise and ground-borne vibration. The EMMP detailed how recommended mitigation measures prepared for the impact assessment are to be implemented and specified recommended monitoring measures to assess the effectiveness of the mitigation measures.

EMMP during Construction Phase

The proposed EMMP during the construction phase include following General LTA's SHE Specifications guidance document throughout the construction phase. Additional project specific EMMP includes the following, but is not limited to:

- Flora and fauna monitoring and management programme, e.g., conduct pre-site clearance inspection (including pre-felling tree inspections) to minimize fauna injury and mortality during site clearance, monitoring of vegetation along the hoarding line for unauthorized vegetation clearance and forest edge effects, enact wildlife response plan when trapped/dead/dangerous animals are encountered around or within the worksite, etc.

Figure 15: Example of Flora Monitoring Along Hoarding

- Inspect hoarding and perimeter drains daily to ensure no discharge of untreated surface runoff and no clogging;
- Perform site inspection during heavy storm events to ensure no flooding;
- Install necessary instrumentations to monitor changes in groundwater level during construction;
- Perform online real-time monitoring for TSS, as well as conduct in-situ water quality monitoring (suggested monthly) for the remaining in-situ parameters (i.e., temperature, pH, conductivity, TDS and DO) at discharge points of construction sites and at the sensitive natural streams (i.e., D/S1 and D/S22) of high ecological importance throughout construction period;
- Perform ex-situ water quality monitoring (suggested monthly) for all the ex-situ parameters (i.e., BOD_5, COD, TN, NO_3-N, TP, PO_4-P, oil & grease - total, oil and grease - hydrocarbon, lead, zinc, mercury and *Enterococcus*, total alkalinity, TOC, NH_4-N), at discharge points of construction sites if discharging into public drains and at the sensitive natural streams (i.e., D/S1 and D/S22) of high ecological importance;
- Perform monitoring of PM_{10} and $PM_{2.5}$ at Clementi Forest and Maju Forest, 1 week prior to site clearance averaged over 1-day period; and continuous monitoring of dust deposition in

mg/m^2/day during construction phase averaged over 4-week period;

- Perform pre-construction airborne noise monitoring of $L_{eq(12\ hours)}$, $L_{eq(1\ hour)}$, and $L_{eq(5\ min)}$ prior to site clearance and continuous monitoring at the boundaries of Clementi Forest and Maju Forest throughout the construction period;
- The Contractor will control construction vibration levels using best available techniques (BAT) for pipe jacking (Advanced Works), high vibratory compactors (Stage 1), vibratory pile drivers for entrances (Stage 2), and tunnel boring (Stage 2) and rock breaking and excavation (Stage 2);
- The Contractor will ensure that the vibration levels for any construction activities at Maju Forest and Clementi Forest (excluding the worksite area) do not exceed PPV, 8 mm/s;
- Identifying burrows before the start of construction and monitoring burrow collapse during construction activities;
- Monitor for any fauna behaviour (e.g., dashing onto the road) resulting in road-kill incidents, for at least thirty (30) minutes after rock breaking event; and,
- Erect temporary barriers (i.e., water barriers) along Clementi Road, Brookvale Drive (if there are no hoardings for existing construction works present) and Maju Forest during pipe jacking, rock breaking and tunnel boring activities. In addition, hoardings must be included at the worksites, and canvas sheets must be added onto existing railings along Brookvale Drive and Clementi Road.

EMMP for Commissioning/ Operational Phase

The proposed EMMP during commissioning/ operational phase include but not limited to:

- In general, Contractor/Operator will perform a regular site inspection and environmental audit during the commissioning phase, especially on:
  - Drainage system within and in the vicinity of the station, especially during heavy storm events
  - Log of waste generation and condition of storage of hazardous chemicals
- Regular site inspections for both flora and fauna in the initial commissioning phase to be conducted to evaluate any impact of the development;
- Prepare Compliance Report after the scheduled audit; and
- Schedule and perform monitoring for biodiversity, water quality, ground-borne vibration, and airborne noise against the criteria specified in the EIS.

The detailed lists of EMMP for construction and commissioning / operational phases are provided in the EIS.

Figure 16: Examples of photographs showing monthly monitoring and inspection on-site

Conclusion

The EIS was carried out based on the relevant local and international guidelines. Minimum controls were formed by referring to these guidelines and the common best practices in the industry, incorporated as the basis of impact assessment. Where the implementation of minimum controls was insufficient to alleviate any significant environmental construction or operational impacts (with "Moderate" to "Major" impacts), additional general and Project-specific mitigation measures were further proposed in consultation with LTA and Nature Groups to mitigate the potential environmental impacts to as low as reasonably practicable. The summary of impact significance with minimum controls and potential residual impact significance with mitigation measures of the assessed environmental aspects for both construction and operational phases are presented in the following table.

Table 7: Summary of Impact Assessment

Sensitive Receptor		Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)
Construction Phase			
Clementi Forest	Biodiversity	Major – Negligible	Moderate (Note1) – Negligible
	Hydrology & Surface	Major - Negligible-	Minor - Negligible

Sensitive Receptor		Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)
	Water Quality		
	Soil & Groundwater	Moderate to Major	Minor (Note 3)
	Air Quality	Moderate to Major	Minor
	Airborne Noise	Major	Moderate to Major (Note 2)
	Ground-borne Vibration	Negligible - Major	Negligible – Major (Note 4)
Maju Forest	Biodiversity	Major – Negligible	Minor – Negligible
Maju Forest	Hydrology & Surface Water Quality	Negligible	Negligible
Maju Forest	Soil & Groundwater	Moderate to Major	Minor (Note 3)
Maju Forest	Air Quality	Moderate to Major	Minor
Maju Forest	Airborne Noise	Major	Minor to Major (Note 2)
Maju Forest	Ground-borne Vibration	Negligible - Major	Negligible – Major (Note 4)
Operational Phase			
Clementi Forest	Biodiversity	Moderate – Negligible	Minor – Negligible
Clementi Forest	Hydrology & Surface Water Quality	Moderate - Negligible	Minor - Negligible
Clementi Forest	Soil & Groundwater	Minor	Minor (Note 3)
Clementi Forest	Air Quality	Minor	Minor (Note 3)
Clementi Forest	Airborne Noise	Negligible	Negligible (Note 3)
Clementi Forest	Ground-borne Vibration	Minor	Minor (Note 3)
Maju Forest	Biodiversity	Negligible - Major	Negligible – Minor
Maju Forest	Hydrology & Surface Water Quality	Negligible	Negligible
Maju Forest	Soil & Groundwater	Minor	Minor (Note 3)
Maju Forest	Air Quality	Minor	Minor (Note 3)

Sensitive Receptor		Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)
	Airborne Noise	Negligible	Negligible (Note 3)
	Ground-borne Vibration	Minor	Minor (Note 3)

Note:

1. Though vegetation and habitat loss has been reduced by moving the station footprint away from Clementi Forest and main stream (DS/1 and DS/2), the loss of vegetation due to site clearance from the new worksite would still result in moderate impact on scrubland and herbaceous vegetation. Such vegetation and habitat loss are permanent and irreversible
2. Due to the surrounding ambient noise levels which are naturally very low, the fact that sensitive receptors are in close proximity, and that noise barriers are unlikely to impede noise that will reach habitat on elevated/undulant terrain, meaning receptors in these locations will still be impacted. Collectively, these therefore mean, that impact significance cannot be reduced further.
3. 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 eliminated.
4. Construction activities such as pipe jacking, rock breaking and excavation and tunnel boring produce high PPV levels at the biodiversity sensitive receptors. It is essential to implement EMMP measures to reduce the impact significance to Moderate.

A few of the key proposed monitoring, management or mitigation measures worth highlighting, include but are not limited to:

Impact mitigation through design optimisation (Avoidance of Impact)

- To ensure development can be undertaken partially beneath Clementi Road, the mitigated scenario has been divided into three stages, which include the Advance Worksite, Stage 1 and Stage 2 Worksites. The aim of these is to minimise environmental impacts on ecologically sensitive receptors of Clementi and Maju Forests.
- Remove the Access to CR16 worksite from Old Jurong Railway Corridor to avoid impacting areas of high conservation value and ecological connectivity.

Additional mitigation for residual impact during the construction phase after design optimisation (Minimisation of Impact)

- Avoid peak breeding seasons (May to July) for tree-felling activities, as much as possible;
- Implement bird friendly building design to reduce bird strikes;
- Above-ground works not critical for safety reasons within worksite will only be allowed from 7am to 7pm. However, noisy activities sha will only be allowed from 9am to 5pm, as much as possible. If night works are essential, suggest to:
  - Prevent areas from being artificially lit, only install lighting where necessary
  - Limit duration of lighting, avoid peak nocturnal fauna activity
  - Reduce trespass of lighting and change the spectrum of lighting
  - Setting dark buffers, illuminance limits and zonation
  - Species-specific strategy
  - Reduce operating power mechanical equipment to a minimum
- Heavy maintenance works and noisy equipment delivery should be kept within the daytime (9am to 5pm) during the operational phase, as much as possible.
- Hydrology of Clementi Forest should remain to ensure no downstream impacts. Box culverts or stream diversion of D/S22 watercourse can be applied to ensure hydrology remains intact;
- Enhancement of ecological connectivity:
  - Plant keystone flora e.g., fig trees;
  - Increase vertical vegetation structures;
  - Plant native species and avoid planting of exotic non-native species and include species which support butterflies and birds;
  - Prioritise intensive greening along streets or with areas of low disturbances.

Overall, the assessment findings demonstrated that the optimised design of CR16 Worksites is beneficial to minimise the direct impacts on the identified ESS, i.e., Maju Forest and Clementi Forest.

A robust EMMP was then provided in EIS, detailing the environmental monitoring and management plans to review the effectiveness of the proposed mitigation measures during the construction, commissioning and operational phases.