Cross Island Line (CRL) Phase 2 Environmental Impact Study (EIS) – Windsor & Eng Neo Avenue Forest

Non-Technical Summary

Land Transport Authority's Objectives

With the vision to strengthen the connectivity and resilience of 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 rail network to about 360km by 2030. This means connecting eight in 10 households to within 10 minutes of a train station. With 360km of rail network, Singapore will have a total rail length that is longer than major cities such as Tokyo or Hong Kong today, 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 reach the desired destination. 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

This Environmental Impact Study covers the second phase of the CRL (CRL2) where sections of the alignment pass through the following vegetated areas:

- Forested area between PIE and Fairways Drive (Eng Neo Avenue Forest)
- Forested areas Adjacent to Fairways Quarters (Site I and Site II)
- Forested areas in the northern tip of Windsor Nature Park and the northern forest fragment located north of Island Club Road (Windsor, the latter of which is referred as the "Windsor northern 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 phases.

This NTS and the EIS of this Project excludes the alignment portions within the Central Catchment Nature Reserve (CCNR) which was covered under the *Environmental Impact Assessment on Central Catchment Nature Reserve for the Proposed Cross Island Line* (hereinafter referred to as "CCNR EIA") gazetted by LTA on 2 September 2019.

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). Additionally, 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) from Turf City to Bright Hill, on the forested areas identified in the vicinity of the Project for its biodiversity value (i.e. Eng Neo Avenue Forest, Sites I and II, Windsor), excluding the CCNR area. 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, **Eng Neo Avenue Forest, Sites I and II, and Windsor** were identified as Biodiversity Study Areas as shown in **Figure 1**, which were assessed against the worksites along the CRL2 alignment (base scenario) as listed below:

- A1-W2 worksite near Eng Neo Avenue Forest, Sites I and II, intended for the Tunnel Boring Machine (TBM) launching activities;
- A1-W1 worksite at Windsor intended for the CRL Facility Building (FB);
- Worksite for underpinning works near Peirce Secondary School; and
- Worksite for TBM retrieval works near CR13 Bright Hill MRT Station.

  (Note: CR13 excavation, shaft, and station construction works are under separate contract of CRL1)

Upon completion of the construction works, the A1-W1 site will include a facility building (also named as "FB4" in this NTS) to support the rail operations.

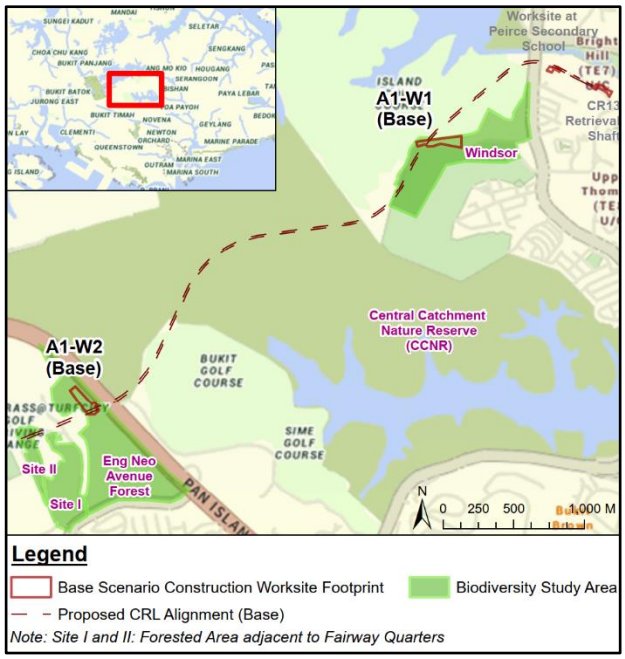

Figure 1: Project Location (Base Scenario)

To prepare the worksites for construction works, the Project will start with activities such as site clearance for site setting up, construction of site access, road and utility diversion works, and installation of instrumentation. Ground improvement works may be required at the TBM launch worksite in order to improve the soil stability in the area. The TBM will be launched from A1-W2 worksite towards Bright Hill Station worksite, passing through A1-W1 worksite.

FB4 at A1-W1 worksite will be built for purposes of supporting the CRL line during operations. Given its close proximity to Windsor, it has been designed to be compact and its façade will include greening and other design considerations to blend in with the forested surroundings.

It is noted that there are no stations located within the section of the alignment under this EIS.

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, PUB) 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.

The key optimisations were the relocation of A1-W2 to occupy fewer forested areas and the significant reduction in worksite area for A1-W1.

The A1-W2 worksite (base scenario) was originally located within Eng Neo Avenue Forest and was initially intended as a facility building to support the long tunnel stretch underneath the CCNR. Further optimisation studies on the facility building design made it possible for the relocation of A1-W2 worksite (mitigated scenario) outside of Eng Neo Avenue Forest (see **Figure 2**) to existing less vegetated areas near Turf Club Road and Fairways Drive.

The A1-W1 worksite has been downsized from 15,000 m^2 to 7,000 m^2 and partially shifted into the adjacent Singapore Island Country Club (see **Figure 3**), which significantly reduces impact to flora and fauna in the area. In addition, the final footprint of the at grade structure for the FB4 at A1-W1 was also optimised. This optimisation is achieved by relocating the plantrooms underground to reduce the footprint at-grade.

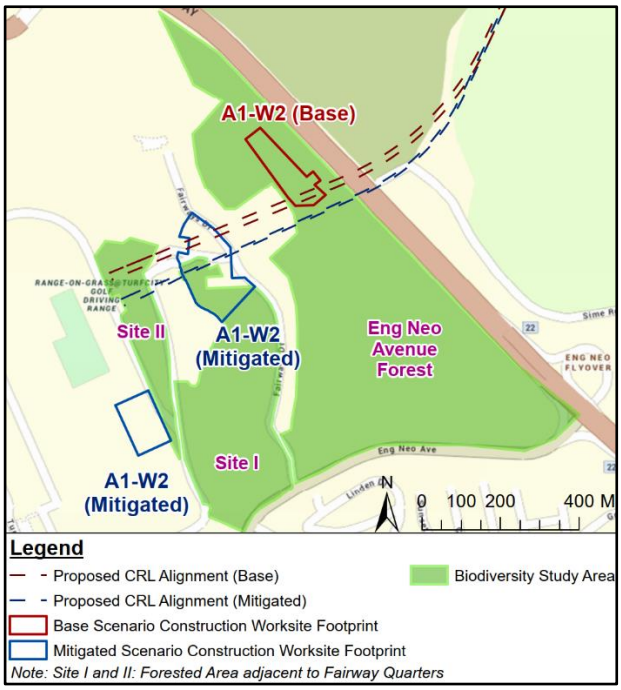

Figure 2: Design Optimisation of A1-W2

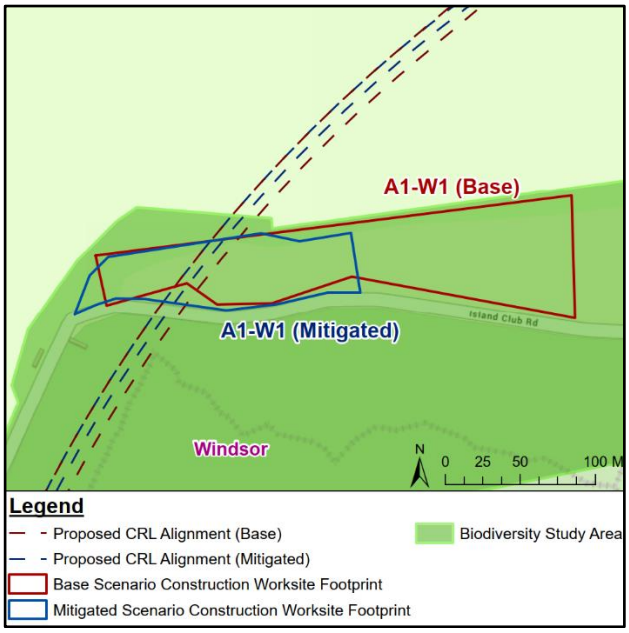

Figure 3: Design Optimisation of A1-W1

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 recommendation of mitigation measures and EMMP where relevant. The environmental impacts studied were direct impacts to biodiversity, or indirectly via other environmental aspects such as air quality, noise quality, vibration, hydrology and water quality and soil and groundwater.

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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 4** to **Figure 7** below.

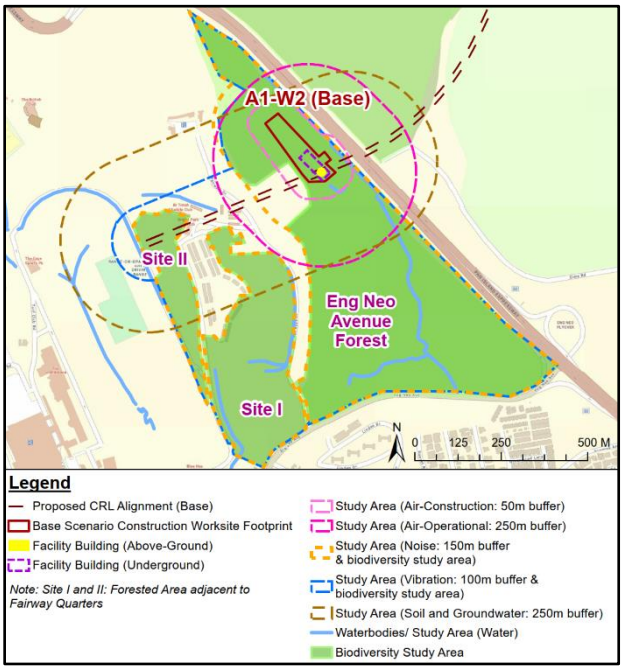


Figure 4: Study Area of A1-W2 (Base Scenario)

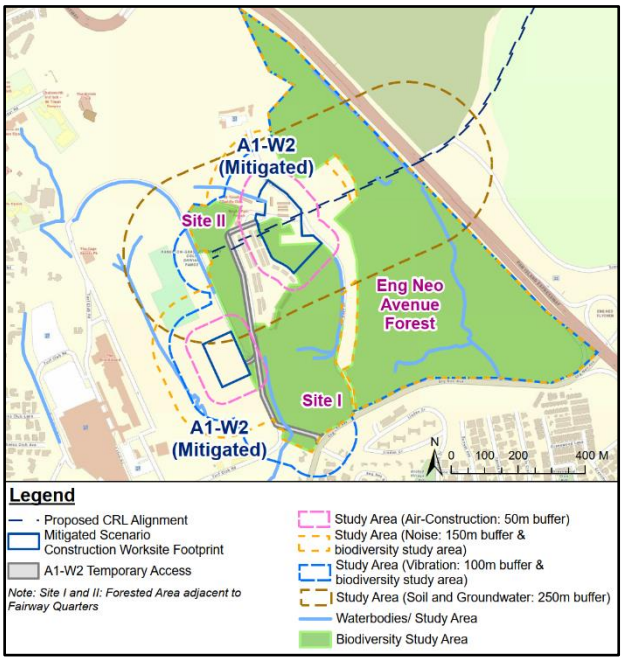


Figure 5: Study Area of A1-W2 (Mitigated Scenario)

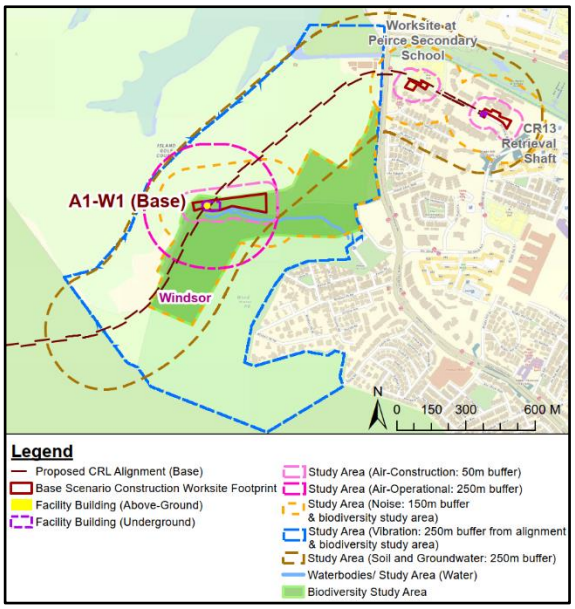


Figure 6: Study Area of A1-W1 (Base Scenario)

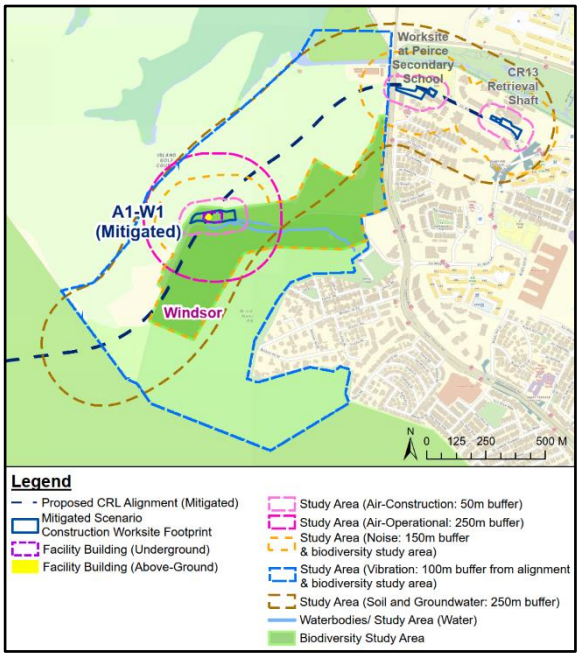


Figure 7: Study Area of A1-W1 (Mitigated Scenario)

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

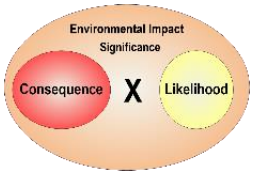
The sensitive receptors identified for this EIS were mainly flora and fauna or their habitats within the Biodiversity Study Area nearby the construction worksites, i.e. Eng Neo Avenue Forest, Sites I and II, and Windsor. The ecologically sensitive receptors were classified into Priority 1, 2 and 3, which 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

To establish the baseline conditions of the Study Area, pre-construction environmental baseline data was 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's construction and operational phases, which considers the frequency of exposure to the receptor.

In general, a risk-based matrix was used for summation of Impact Consequence and Likelihood of Occurrence as shown in **Figure 8**. The full definitions of impact assessment terms and methodology were detailed in the EIS.

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 8: Impact Significance Matrix (General)

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 9**.

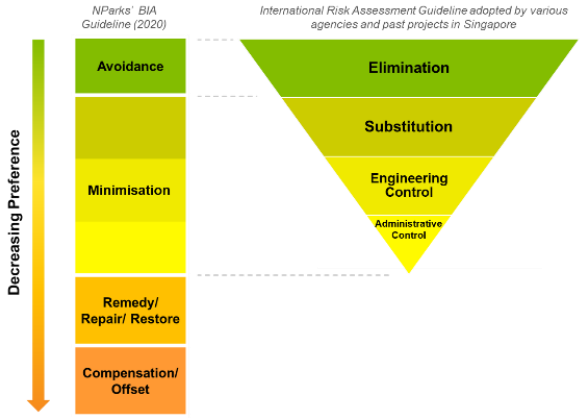


Figure 9: Mitigation Hierarchy

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 a separated study.

Biodiversity

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

- Eng Neo Avenue Forest: 39.2 ha
- Sites I and II: 16.8 ha, and
- Windsor: 29.7 ha.

Once a rubber plantation, Eng Neo Avenue Forest was also part of Bukit Timah Nature Reserve (BTNR) and CCNR, before the construction of the Pan Island Expressway in the 1970s. Therefore, there remains a chance of expecting biodiversity of conservation significance within Eng Neo Avenue Forest. Furthermore, volant species may still be able to cross the expressway and move between the two areas.

Similarly, Windsor was once a rubber plantation that was subsequently abandoned. In 2017, Windsor Nature Park was designated as a green buffer for the Central Catchment. As it is contiguous with the CCNR to its west, the assemblage of biodiversity within the Study Area is expected to overlap with that of the CCNR.

Upon the shift of A1-W2 worksite completely out from Eng Neo Avenue Forest, the Sites I and II (16.8 ha) were also surveyed and assessed for biodiversity impacts as a small portion of the worksite occupies part of the forested area. Given its proximity to Eng Neo Avenue Forest, biodiversity of conservation significance was expected within the floral and faunal assemblage.

Field surveys were conducted from November 2019 – April 2020 and March 2020 – September 2020 covering all known vegetation and habitat types to understand the biodiversity at Eng Neo Avenue Forest and Windsor, and from July 2021 – December 2021 covering all known vegetation and habitat types at Sites I and II.

Eng Neo Avenue Forest

Eng Neo Avenue Forest is characterized by five main vegetation types: native-dominated secondary forest, abandoned-land forest, scrubland and herbaceous vegetation, waste woodland and managed vegetation. Waste woodland occupied the largest area (33.4%) within the Study Area, followed by scrubland and herbaceous vegetation (31.1%) and abandon-land forest (27.6%).

A total of 284 plant species from 89 families were recorded. The floristic assemblage is largely native (60.2% native species), with 80 species considered as conservation significant. These species of conservation significance are widely distributed across the Study Area, and such high overall species richness for species of conservation significance is normally only associated with late-successional forests in Singapore. This includes the recently rediscovered *Dioscorea orbiculata var. tenuifolia*, a climber species, and *Piper pedicellosum*, a nationally Critically Endangered species, that were found throughout the Study Area. Additionally, large parent trees with girth size > 3m have also been recorded.

Faunal field surveys recorded 233 species, with over half of these records species comprising bird and butterfly species. A total of 15 species of conservation significance were recorded - some notable records utilising the site include the nationally Endangered changeable hawk-eagle (*Nisaetus cirrhatus*) and globally and nationally Critically Endangered Sunda pangolin (*Manis javanica*). The nationally Near Threatened Sunda colugo (*Galeopterus variegatus*) was also recorded and noted as a species of interest. Furthermore, the nationally Near Threatened Wagler's pit viper which was thought to be restricted to CCNR was detected here. The Study Area is also home to a thriving population of painted bronzebacks (*Dendrelaphis pictus*), with significant numbers found.

Two waterbodies were observed, one anaerobic pond in the west of Study Area and a natural forested stream flowing from north to south cuts through the Study Area. Along the stream, although not of conservation significance, records of the uncommon fiery coraltail damselfly (*Ceriagrion chaoi*) and native common walking catfish (*Clarias* cf. *batrachus*) were observed. The

common walking catfish once a widespread species, has seen a marked decline in its populations outside of the Central Nature Reserve due to competition and displacement. In addition, the anaerobic pond provides habitat to marsh-associated species such as the uncommon slaty-breasted rail (*Lewinia striata*), sapphire flutter (*Rhyothemis triangularis*) and emperor dragonfly (*Anax guttatus*).

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 waterbodies and contiguous forest connecting these habitats as areas of high conservation value (see **Figure 10**).

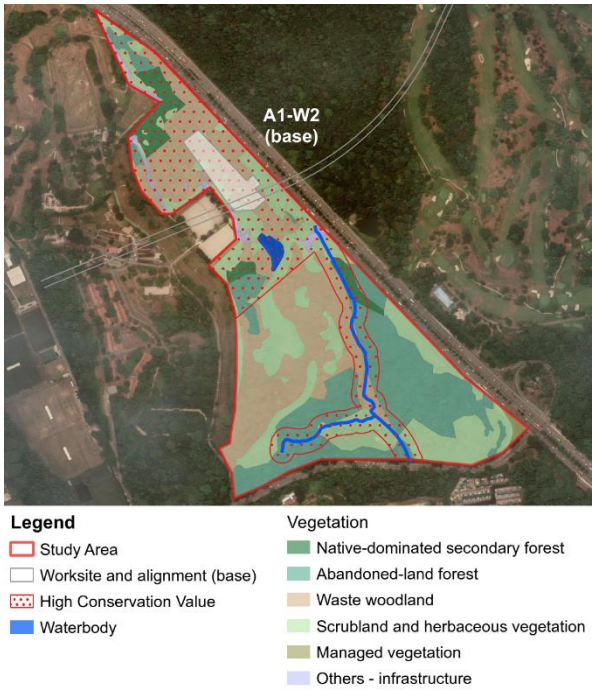


Figure 10: Areas of High Conservation Value at Eng Neo Avenue Forest

Figure 11: Examples of Biodiversity Species in Eng Neo Avenue Forest

Sites I and II

Sites I and II are characterised by five vegetation types. Mixed forest (5.1 ha, 30.4%) dominates the site, followed by abandoned-land forest (3.0 ha, 18.0%). Three patches of native-dominated secondary forest present occupy 17.1% (2.9 ha) of the Study Area. Managed vegetation (1.4 ha, 8.3%) and scrubland and herbaceous vegetation (2.7 ha, 16.2%) are also present.

A total of 270 plant and species groups from 89 families were recorded. More than half of the floristic assemblage is native (51.5%, 139 native species). Many species found in the native-dominated secondary forest in Sites I and II can also be found in the CCNR and are less commonly encountered in other secondary forests in Singapore. There is high overall native species richness at the site, a feature characteristic of late-successional forests in Singapore. Nationally threatened specimens widespread, and large parent trees also occur in the Study Area. Fifty-four species of plants of conservation significance were recorded and mostly distributed within the native-dominated secondary forest and the mixed forest.

The faunistic field assessment recorded 165 species with more than half of the recorded assemblage dominated by bird and butterfly species. A total of 13 species of conservation significance were recorded, scattering across the Study Area. Some notable records include the nationally Critically Endangered spotted wood owl (*Strix seloputo*), the nationally Vulnerable bamboo bat (*Tylonycteris* sp.), and the globally and nationally Critically Endangered Sunda pangolin (*Manis javanica*), which were found throughout the Study Area.

Two waterbodies were observed - one naturalised stream flowing from north to south in the west of Study Area

(D/S16) and a naturalised stream flowing from north to south in the east of the Study Area (D/S15). Along the waterbody D/S16, notable records of the common walking catfish (*Clarias* cf. *batrachus*) were made, showing value of this forest stream. The other waterbody D/S15, while it did not show any records of fauna species of conservation significance, is also regarded as of high ecological value due to the increasing loss of stream habitats within Singapore and its location within the native-dominated secondary forest.

The entire Study Area provides important forest connectivity between the larger forest patches to the north and to the east (Eng Neo Avenue Forest), allowing the dispersal of floral and faunal species. The native-dominated secondary forest and mixed forest in particular, were found to be rich in floral species of conservation significance, while the Sunda pangolin (*Manis javanica*) was found to be utilising the entire Study Area. Hence, the majority of the Study Area including the native-dominated secondary forest, mixed forest, abandoned-land forest, both waterbodies, some managed vegetation and scrubland and herbaceous vegetation patches have been designated as areas of high ecological value (**see Figure 12).**

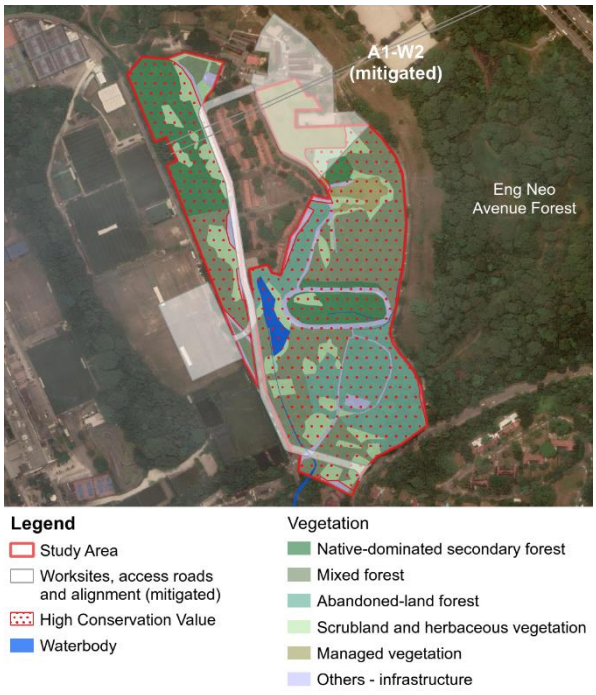


Figure 12: Areas of High Conservation Value at Sites I and II

Figure 13: Examples of Biodiversity Species in Sites I and II

Windsor

Windsor Nature Park occupies more than half the Study Area in Windsor, while the remaining area consist largely of abandoned-land forest and managed vegetation. The abandoned-land forest consists of a mix of fruit tree species that were possibly remnants of past settlement, while the native-dominated secondary forest in the Windsor northern forest occupies 3% of the Study Area.

A total of 329 plant species from 103 families were recorded. The floristic assemblage is largely native (59.9% native species), with conservation significant species largely restricted to the native-dominated secondary forest patches; flora species include *Rourea asplenifolia*, *Gironniera subaequalis*, *Rourea fulgens*, and *Baccaurea sumatrana*. With some only having records of only one specimen - *Enkleia malaccensis* and *Elaeocarpus rugosus* tree within Study Area.

229 faunal species were recorded scattering across the Study Area with more than half of the records being bird and butterfly species. A total of 26 species of conservation significance were recorded - some records include the nationally Vulnerable tiny Sheartail Dragonfly (*Microgomphus chelifer*), nationally Endangered Horsfield's Flying Squirrel (*Lomys horsfieldii*) and Lesser Mousedeer (*Tragulus kanchil*).

Three waterbodies were observed. Within the northern fragment, two streams were observed and may be connected via underground waterflow, with both having forest stream character. A single stream system runs from west to east within Windsor Nature Park, encompassing both forest streams characters and open-country streams

character with lower canopy cover, higher temperatures and smaller leaf litter accumulation. Other notable records of aquatic fauna include the native freshwater prawn (*Macrobrachium malayanum*) and nationally Vulnerable Gold-ringed Cat Snake (*Boiga melanota*) recorded along the stream within Windsor Nature Park.

Windsor is also expected to be used by arboreal fauna which are usually restricted to the nature reserves. These arboreal species include the Sunda Slow Loris (*Nycticebus coucang*) and Raffles Banded Langur (*Presbytis femoralis femoralis*) nationally Endangered and Critically Endangered respectively. The slow loris has been recorded in both the northern forest and Windsor Nature Park. Subsequently, the forest-dependent Sunda Colugo (*Galeopterus variegatus*) and nationally Endangered Horsfield's Flying Squirrel (*Iomys horsfieldii*), also considered as arboreal species, have been recorded across the Study Area. Sightings of these arboreal species across both forest patch indicate the usage of the canopy connections across Island Club Road. Though the Raffles Banded Langur was not recorded in our period of study, this connectivity remains to be an important crossing for these Critically Endangered species due to their restricted home range (CCNR).

Additionally, sightings of terrestrial fauna such as globally and nationally Critically Endangered Sunda Pangolin (*Manis javanica*) and nationally Endangered Lesser Mousedeer (*Tragulus kanchil*) across the Study Area also indicate the ability of these species to cross between both forest patches. To conclude, the Study Area supports local populations of conservation significance flora and fauna, with Windsor Nature Park, the native-dominated secondary forest area and all natural waterbodies regarded as areas of high ecological value (see **Figure 14**).

Figure 14: Areas of High Conservation Value at Windsor

Figure 15: Examples of Biodiversity Species in Windsor

Hydrology and Surface Water Quality

The hydrological baseline survey aimed to identify watercourses present in the Study Area including their location, water flow conditions and bank characteristics. Based on topographic survey data, site survey as well as PUB water catchment map, water catchment areas within the vicinity of the A1-W1 and A1-W2 worksites mainly contribute to the identified nine (9) major watercourses (see **Figure 16** and **Figure 17**). Water from the identified drains/streams will partly flow to MacRitchie Reservoir and most of the water will eventually flow to Marina Reservoir, which stores water for drinking water purpose. Besides, one of the natural streams in Eng Neo Avenue Forest and Windsor Nature Park [i.e. D/S14 in **Figure 16** and D/S13 in **Figure 17**] is located within the areas of high ecological conservation values, supporting surrounding ecological systems.

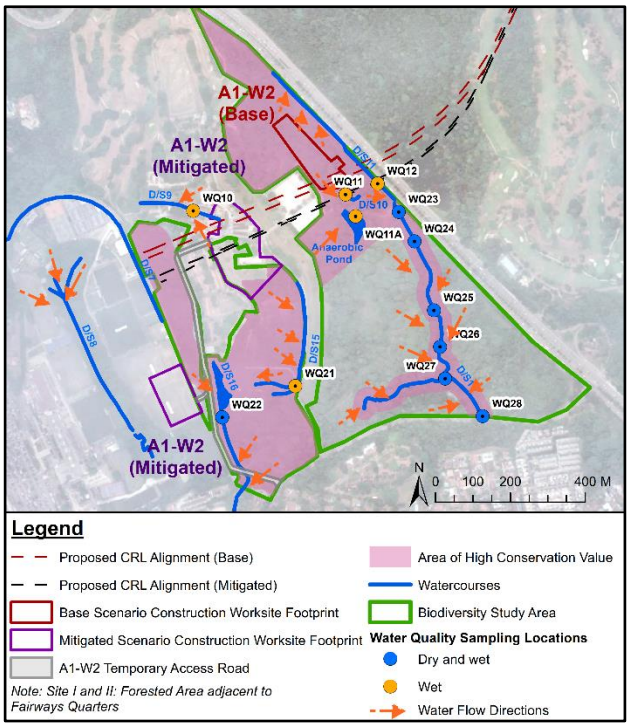


Figure 16: Water Sampling Location at Eng Neo Avenue Forest

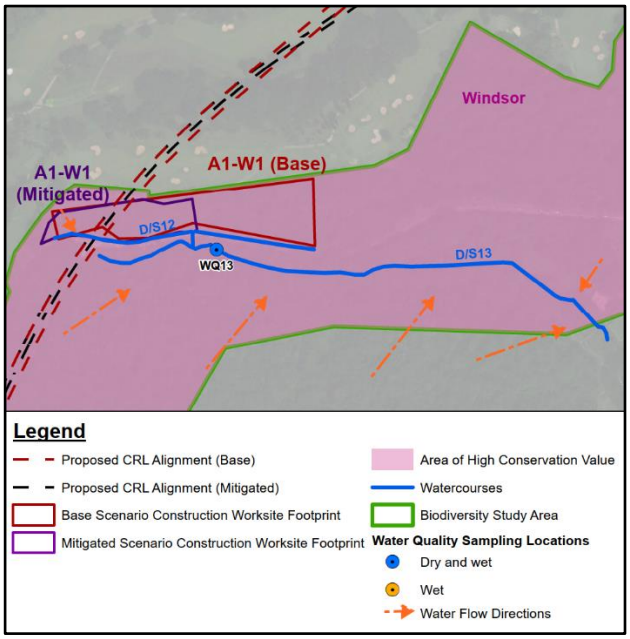


Figure 17: Water Sampling Location at Windsor

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 from Eng Neo Avenue Forest, Sites I and II and Windsor Nature Park. Water samples were tested for both physical and chemical parameters relevant for sustenance of aquatic life including temperature, pH, TDS (total dissolved solids), DO (dissolved oxygen), turbidity, TSS (total suspended solids), BOD_5 (biological oxygen demand), COD (chemical oxygen demand), TP (total phosphorus), PO_4-P (orthophosphate), TN (total nitrogen), NH_4-N (ammoniacal nitrogen), NO_3-N (nitrate), TOC (total organic carbon), *Enterococcus* and Pb (lead). Results were compared with both NEA discharge guidelines in Singapore and identified international criteria for aquatic life. The international criteria include guidelines/ criteria from United Nations Economic Commission for Europe, United States Environmental Protection Agency, Australian & New Zealand, Canada, Philippines and Malaysia.

Eng Neo Avenue Forest

Within Eng Neo Avenue Forest, D/S10 and D/S11 were almost dried during dry weather and D/S14 had perennial flow, while the Anaerobic Pond had stagnant water inside. Generally, the water quality was within relevant criteria in terms of temperature, pH, TDS, turbidity, TSS, BOD_5, COD, TN, and NO_3-N. DO is above the criteria at most of the stations, except for Anaerobic Pond (i.e. WQ11A) and upstream of D/S14 (i.e. WQ23, WQ24 and WQ25) with DO of lower than 4 mg/L. 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.

It should be noted that the Anaerobic Pond within Eng Neo Avenue Forest had relatively degraded water quality condition for any aquatic life. This was consistent with biodiversity baseline findings, which suggested no aquatic life with high ecological value was found inside the Pond at the time of biodiversity survey. However, the Pond has certain ecological value as it still supports surrounding bird species. The natural stream of D/S14 was found to support freshwater aquatic life of conservation values and considered to be of high ecological value in the Eng Neo Avenue Forest.

Sites I and II

At Site I, ephemeral concrete drains (i.e. D/S9 and D/S15) and perennial naturalised stream (i.e. D/S16) were identified and sampled accordingly. The water quality at drains D/S9 and D/S15 and stream D/S16 (i.e. WQ22) were within or close to most of the parameter criteria except for relatively high BOD_5, turbidity and/or TSS during wet weather. This might be due to flushing of solids from urban areas and vegetation. COD level at stream D/S16 during wet weather was also exceeded the international criteria of aquatic life.

Despite the relatively poor water quality during wet weather in this perennial stream D/S16, biodiversity survey findings have shown that there is aquatic life within this watercourse. Furthermore, there were sightings of freshwater fishes during the time of dry weather water quality survey as well.

Windsor

One (1) main concrete drain and one (1) main natural stream were found within Windsor. The concrete drain runs along the boundary of A1-W1 with ephemeral flow

(see **Figure 17**). It collects surface runoff from the Singapore Island Country Club (SICC) and subsequently discharges to the natural stream through an underground culvert structure. The main natural stream with perennial flow is located within the Windsor Nature Park with envisioned high ecological conservation values. It will eventually reach Marina Reservoir.

All water quality parameters at the natural stream met international guidelines except for phosphorus, indicating potential eutrophication in the stream, which is consistent with the site observation of greenish waterbodies with algae.

Soil and Groundwater

The soil and groundwater baseline study for this EIS included review and analysis of data available from previously soil and/ or groundwater investigation studies carried out within Study Area. The potential of encountering historically contaminated soil was assessed based on the existing data available from the HLUS study.

Generally, the soil profile encountered at Eng Neo Avenue Forest, Site I and Site II consists of sandy silt, while the soil profile at Windsor mostly consists of slightly gravelly sandy silt. Intrusions of clay and sand (with different particle share) were found on all sites. Backfill layer was also found on most of the investigated locations.

The review of available soil analytical results (i.e. samples collected in the proximity of Site II) showed that none of the tested samples exceeded their respective Dutch Intervention Values (DIV). Photoionization detector (PID) readings recorded were between 0.2 and 12.1 parts per million (ppm), indicating negligible concentration of VOCs. No visual or olfactory evidence of contamination of soil was noted during field activities.

Based on groundwater elevation data collected as part of soil and/ or groundwater investigations carried out in the vicinity of Eng Neo Avenue Forest, Sites I and II, the average groundwater level ranged from 17.45 mRL (i.e. west of Site II) to the to 31.05 mRL (i.e. northeast of Eng Neo Avenue Forest). The groundwater elevation in the vicinity of Windsor was found to be slightly lower, with average groundwater elevation ranging from 9.99 mRL to 21.31 mRL.

The groundwater elevation contour maps developed based on the available groundwater level data suggest that the groundwater flow direction generally follows the topography, and it flows towards major natural nearby watercourses. Based on the available data, in the vicinity of Sites I and II, groundwater was inferred to be flowing towards west. In the vicinity of A1-W2 groundwater flows towards south-east, towards watercourses while generally following the site's topography. The groundwater flow direction in the vicinity of Windsor is inferred to be towards south (i.e. towards D/S13). The groundwater elevation data collected north of the Windsor suggest that the flow direction of groundwater which is further away from the major watercourse (i.e. D/S13) follows the topography of the site and flows towards north – northeast. The calculated flow velocity of groundwater in area underlying Eng Neo Avenue Forest, Sites I and II is 0.36 m per year, while the velocity of groundwater underlying Windsor is calculated to be 0.73 m per year. The groundwater seepage velocity typically varies depending on different clay, silt and sand contents at a specific location and should be used as a general guide only.

Based on physicochemical parameters assessed, the groundwater beneath Sites I and II can be described as generally acidic (except for groundwater sample RC/40169 which is slightly basic). Furthermore, presence of non-aqueous phase liquid (NAPL) was not observed during well development and sampling event.

Metals, including arsenic, antimony, barium, chromium, mercury, molybdenum and zinc were detected in most groundwater samples at concentrations above their respective level of reporting (LOR). Cobalt was detected only in one collected groundwater sample and copper and lead in another groundwater sample. The concentrations of these metals were all below their respective DIVs.

TPH (only C15-C28 fraction) was detected in majority of groundwater samples. However, all detected TPH concentrations were below DIV. TOC was detected in majority of collected groundwater samples, at concentrations 3.5 to 39.8 mg/L. Fluoride was only detected in one groundwater sample at a concentration of 0.90 mg/L.

Chloride, phosphate, sulphate and total ammoniacal, total nitrogen (TN), TP and faecal coliform nitrogen were detected in all groundwater samples. The remaining parameters analysed for the groundwater samples were below their respective LORs.

Air Quality

In order to assess the current baseline air quality in the Study Area, baseline air quality data were collected from the monitoring locations at Eng Neo Avenue Forest (see **Figure 18**) from 26 March to 2 April 2020, as well as at Windsor from 19 June to 26 June 2020. Particulate matters (PM_{10} and $PM_{2.5}$) were measured for 1 week unattended to collect the ambient air quality data within the Study Area.

At Eng Neo Avenue Forest, the average daily PM_{10} and $PM_{2.5}$ concentration ranged from 14.6-25.5 $\mu g/m^3$ and 10.0-16.9 $\mu g/m^3$ respectively. Secondary air monitoring data from other concurrent study carried out by AECOM in close proximity to Sites I and II, and Eng Neo Avenue Forest have also been analysed. Ambient air quality was conducted at 2 locations for 1 week, ranging from 14.0-24.2 $\mu g/m^3$ and 7.9-16.4 $\mu g/m^3$ for PM_{10} and $PM_{2.5}$ concentration respectively.

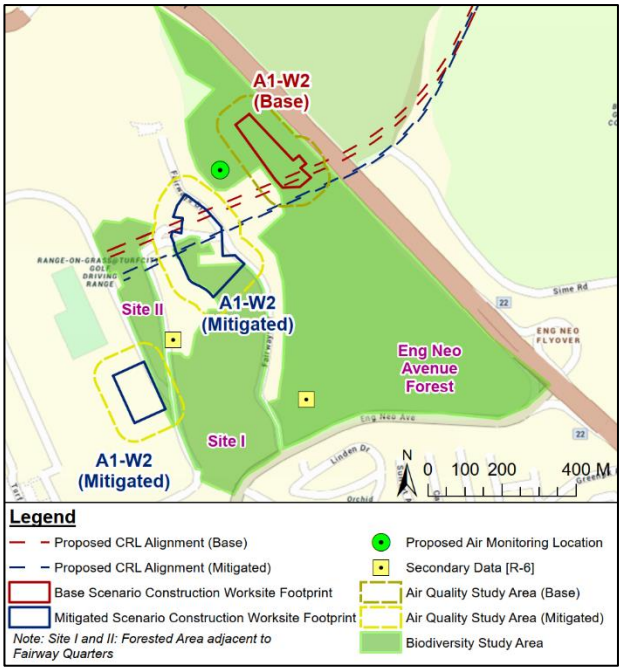


Figure 18: Air Baseline Monitoring at Eng Neo Avenue Forest

For air monitoring at Windsor (see **Figure 19**), the average daily PM_{10} and $PM_{2.5}$ concentration ranged between 6.3-13.6 µg/m3 and 3.6-9.6 µg/m3 respectively.

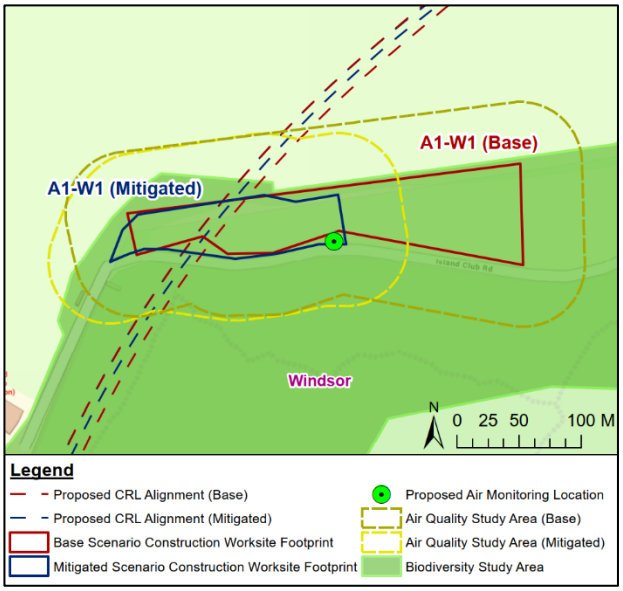


Figure 19: Air Baseline Monitoring at Windsor

All pollutant concentrations were found to be within the Singapore Ambient Air Quality Long Term Targets (i.e. 50 µg/m^3 and 25 µg/m^3, respectively for PM_{10} and $PM_{2.5}$).

Airborne Noise

Baseline noise monitoring was carried out at six (6) locations: Swiss School in Singapore, Eng Neo Avenue Forest, Peirce Secondary School and Windsor within the period of January 2020 to April 2020; Sites I and II within the period of September 2021. Additional five (5) monitoring locations are secondary sources extracted from other concurrent studies carried out by AECOM in the vicinity as baseline references. The Norsonic 131 Sound Level Meter was used to record the baseline noise levels over time periods of 12 hours (long term), 1 hour, 15 minutes and 5 minutes (short term) at each location. As advised by NParks, these pre-construction baseline served as the criteria for ecologically sensitive receptors and the predicted noise levels were assessed by no-worse-off than baseline. This is generally much more stringent than NEA's noise criteria for human receptors.

Three (3) noise monitoring locations were set within/ near Eng Neo Avenue Forest, Sites I and II respectively (see **Figure 20**) to study the baseline noise level. The average baseline noise levels for weekday were recorded at $L_{eq(12hours)}$ 48-57 dB(A) and $L_{eq(5mins)}$ 46-56 dB.

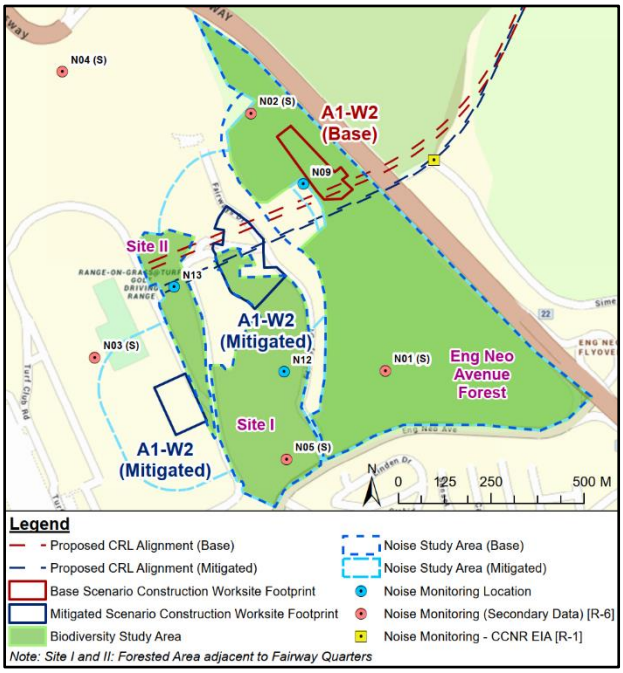


Figure 20: Noise Baseline Monitoring at Eng Neo Avenue Forest[1]

The average noise level measured at Windsor (see **Figure 21**) for weekday were $L_{eq(12hours)}$ 59 dB(A) and $L_{eq(5mins)}$ 55 dB.

[1] LTA. Contract C1001 Environmental Impact Assessment on CCNR for the Proposed Cross Island Line. 2 September 2019.

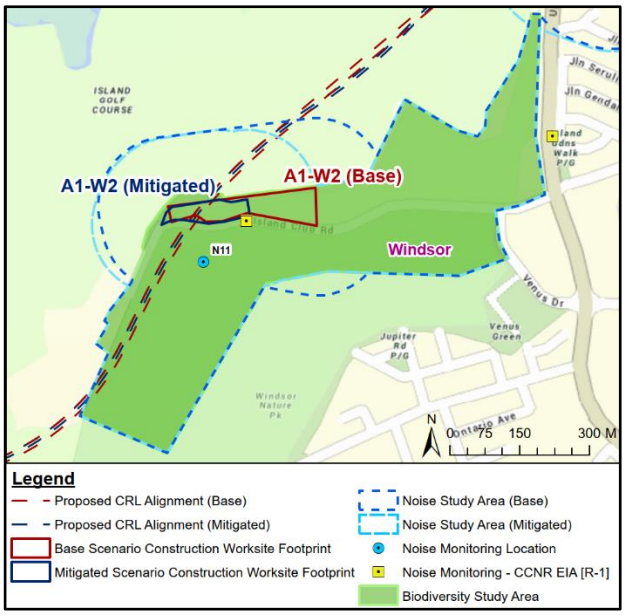


Figure 21: Noise Baseline Monitoring at Windsor

Ground-borne Vibration Baseline

Baseline vibration monitoring was conducted at three (3) representative locations within Eng Neo Avenue Forest (i.e. V07 (2020), V07 (2022) and V07A (2022) in **Figure 22**) and Windsor (i.e. V08 in **Figure 23**).

Baseline monitoring was carried out in the vicinity of the proposed worksite area as part of this study at both A1-W1 and A1-W2 sites. Besides, secondary data was gathered from vibration monitoring results from other projects in the vicinity of the A1-W1 worksite (i.e. the PUB's BKSR Project and the LTA's CCNR EIA) to provide a comprehensive analysis.

The baseline vibration monitoring results show that the 99th percentile baseline vibration level [peak particle velocity (PPV)] at Windsor and Eng Neo Avenue Forest is 0.07 mm/s and 0.02 mm/s, respectively. Since there are no standardised vibration criteria for fauna, the step increment in human response [2] was referenced. The baseline vibration results were subsequently used to develop an assessment criterion that meets the Project's requirements.

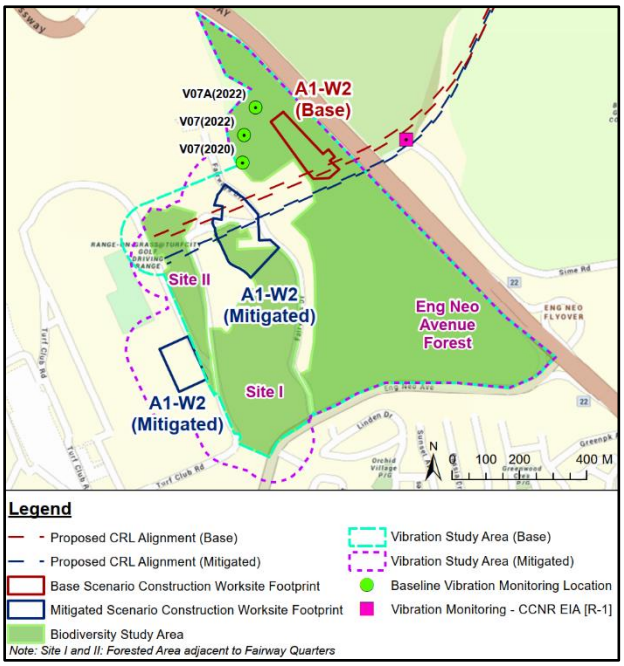


Figure 22: Vibration Baseline Monitoring at Eng Neo Avenue Forest[2]

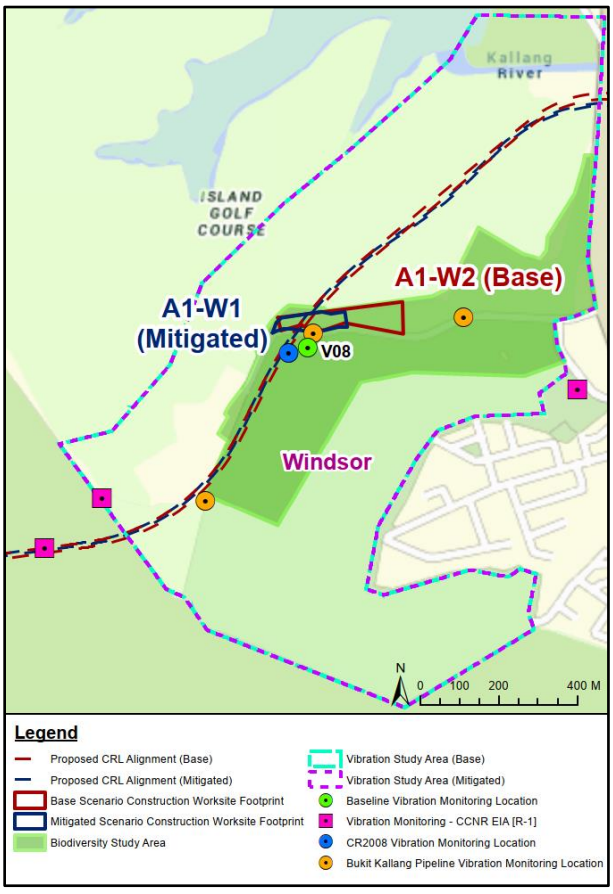


Figure 23: Vibration Baseline Monitoring at Windsor[2]

[2] According to BS5228-2: 2009+A1:2014, human response refers to the vibration levels that produce an effect or consequence of human perception and disturbance.

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 construction phase are:

- Prepare Safety Operational Procedures (SOPs) and Emergency Response Plans on site, which include 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 differs 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 risk of discharging construction wastewater into natural stream, where the robust ECM plan shall 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 runoff 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 runoff discharge to these drains;
  - Include ECM tanks/ponds prior to discharge of treated effluent (only stormwater runoff) at Island Club Road; treated water to be tested prior to discharge;
  - Adequate drainage, cut off drains, sump pit, road kerb, piping and toe wall shall be designed for channelling of construction process wastewater and stormwater runoff separately.
- Design and implement proper Earth Retaining Stabilizing Structures to limit 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 worksite to avoid human-wildlife conflict. Where site staff take breaks outside, all waste must be disposed 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 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, include 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 not limited to:

- Permanent drainage systems should be design 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 shall be discharged into any watercourse or land;

- Proper handling, storage and disposal of hazardous and non-hazardous new or used chemicals during 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; 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		
Eng Neo Avenue Forest	Minor to Major	Negligible
Site I and Site II	Negligible to Major	Minor to Major[1]
Windsor	Major	Moderate to Major[1]
Operational Phase		
Eng Neo Avenue Forest	Negligible to Moderate	Negligible
Site I and Site II	Negligible to Minor	Minor
Windsor	Moderate	Minor

Note:

1. Major impact still exists due to due to the irreversible loss of vegetation and habitats during site clearance in construction phase (Sites I and II: mortality and impediment to seedling recruitment for two flora species - *Alstonia angustiloba* and *Thyrsostachys siamensis*; Windsor: mortality for six flora species - *Bambusa multiplex, Cyrtophyllum fragrans, Ficus benjamina, Glochidion zeylanicum var. zeylanicum, Guioa pubescens, Palaquium obovatum*).

Areas of high conservation value were identified at Eng Neo Avenue Forest, Sites I and II and Windsor during baseline studies. Following the mitigation hierarchy, design optimisation was applied to further avoid or minimise impact to ecologically sensitive receivers. Where such impact could not be avoided, minimisation and compensatory measures were applied.

Based on the base scenario, during construction phase, site clearance will result in removal of 1.5 ha of mixed vegetation, constituting to 3.83% of the Study Area at Eng Neo Avenue Forest. Though small in comparison to the overall Study Area, removing vegetation for the worksite might result in habitat fragmentation within the Study Area, bringing about Major impacts to flora and fauna within Eng Neo Avenue Forest, mainly due to mortality. During operational phase, the most substantive impact to habitats, floral and faunal species is of Moderate significance at Eng Neo Avenue Forest. These impacts arise for flora from competition from exotic species.

Based on base scenario for A1-W1, during construction phase, Major impacts are expected at Windsor due to the removal of high ecological value habitats such as the native-dominated secondary forest and potentially important canopy connection. Major impacts are also expected for flora and fauna, due to mortality, and loss of habitats, food sources, and connectivity respectively. During operational phase, the most substantive impact to habitats, floral and faunal species is of Moderate significance at Windsor. The impacts mainly arise from competition from exotic species for flora and for fauna, collisions with buildings for birds, loss of ecological connectivity and injury or mortality.

By implementing recommended mitigation measures (detailed in the EIS report), especially the shifting and optimisation of A1-W2 worksite out of Eng Neo Avenue Forest, direct impacts to vegetation and habitat loss would be reduced to Negligible at Eng Neo Avenue Forest during construction phase. Other impacts on flora and fauna such as loss of ecological connectivity would also be reduced to Negligible. During operational phase, impacts on habitats, flora and fauna are hence also expected to be Negligible.

However, since the A1-W2 worksite will be shifted out of Eng Neo Avenue Forest into Sites I and II, Moderate impacts are expected due to land clearance at the construction phase in the Sites I and II, major impacts for some flora species as a result of mortality and impediment to seedling recruitment, while minor/negligible impacts on fauna. During the operational phase, minor/negligible impacts on habitats, flora and fauna are also expected. This assessment is due to the absence of any above-ground operational facility at Sites I and II.

Similarly, for Windsor, adopting the optimised A1-W1 worksite would reduce the major impacts of vegetation loss and habitat loss to Moderate; and reduce loss of ecological connectivity to faunal species to Moderate.

However, impact on some floral species remain/become Major due to mortality that comes with land clearance.

During the operational phase, the most substantive impact to habitats, floral and faunal species is of Minor significance at Windsor. Beyond design optimisation, application of the recommended mitigation measures such as planting up areas with a (native) planting palette similar to adjacent forest composition post-construction, and enhancing ecological connectivity for fauna can help reduce the impacts 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.) were included in the EIS to further minimise 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			
Eng Neo Avenue Forest	Earth Drain D/S10	Moderate	Negligible
	Concrete Drain D/S11	Moderate	Negligible
	Steam D/S14	Major	Negligible
Site I and Site II	Concrete Drain D/S9	Negligible	Minor
	Concrete Drain D/S15	Negligible	Negligible
	Stream D/S16	Negligible	Moderate[2]
Windsor Nature Park	Natural Stream D/S13	Minor	Minor
-	Roadside drains in the vicinity of Worksites at Peirce Secondary School and CR13)	Minor	Minor
Operational Phase			
Eng Neo Avenue Forest	Earth Drain D/S10	Moderate	Negligible
	Concrete Drain D/S11	Moderate	Negligible
	Steam D/S14	Moderate	Negligible
Site I and Site II	Concrete Drain D/S9	Negligible	Negligible
	Concrete Drain D/S15	Negligible	Negligible
	Stream D/S16	Negligible	Negligible
Windsor Nature Park	Natural Stream D/S13	Minor	Minor
-	Roadside drains in the vicinity of Worksites at Peirce Secondary School and CR13)	N.A.[1]	N.A. [1]

Note:
1. N.A. – Not applicable as the worksites at CR13 and Peirce Secondary School will have only permanent underground structures without housing any facilities.
2. Water Quality: Moderate at Site I, as the proposed road will cross existing major drain in Site I, even with diverted drain or culvert, the impact cannot be reduced further mainly due to the immediate presence of drain segment adjacent to the construction site.

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, 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, increased runoff peak flow draining to the stream or drain during storm events, as well as reduced baseflow (sub-surface water discharge) due to the change in land use of the new development.

The hydrology change was assessed to cause Moderate impacts on watercourses (i.e. D/S10, D/S11 and D/S14 in **Figure 16**) in the vicinity of A1-W2 during both construction and operational phases, even with implemented minimum controls. Hence, mitigation measures were proposed to shift A1-W2 outside of Eng Neo Avenue Forest as the “Mitigated Scenario”, which reduced the impact significance on watercourses in Eng

Neo Avenue Forest to Negligible during both construction and operational phases. On the other hand, during construction phase, the proposed "Mitigated Scenario" was assessed to cause Major impact on D/S16 at Site I. With the proposed additional mitigation measures of flow diversion before construction, flow diversion will seek for PUB's approval and the design of diversion will follow PUB's Code of Practice on Surface Water Drainage. Any storm discharge from the worksite to the diverted drain requires to comply with NEA Trade Effluent Discharge Limits if applicable. Therefore, the impact significance on D/S16 would reduce to Moderate.

For the rest of the watercourses, the impact on hydrology and surface water quality was assessed to cause only Negligible to Minor impacts during both construction and operational phases with consideration of the minimum control measures (e.g. effective ECM and monitoring implemented as recommended in the Code of Practice on Surface Water Drainage, appropriate disposal of any waste listed in the Environmental Public Health (General Waste Collection) Regulations by licensed waste operator/collector, etc.). Hence, no additional management or mitigation measures were required. However, it was noted that LTA also did further minimise the worksite A1-W1 area from the base scenario to mitigated scenario to significantly reduce adverse impact on surrounding biodiversity. This has also helped to further reduce its hydrology and surface water quality impact on the surrounding watercourses due to its smaller worksite.

Therefore, given that the minimum controls (e.g., audits on environmental management procedures etc.) shall be carried out on site and mitigation measures of other relevant environmental parameters for the proposed construction and operational activities will be implemented, the significance of residual impacts from the potential sources of contamination at the sensitive watercourse receptors was assessed to be **Negligible to Moderate**.

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		
Eng Neo Avenue Forest	Minor	Minor
Site I and Site II	Minor	Minor
Windsor	Minor	Minor
Operational Phase		
Eng Neo Avenue Forest	Minor	Minor
Site I and Site II	Minor	Minor
Windsor	Minor	Minor

The potential impacts on soil and groundwater of historical and current land uses 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. Soil and groundwater impact study was carried out qualitatively based on the findings from the HLUS study and the SECS (2021) EBS.

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 where groundwater is partially supported with biodiversity conservation significance were identified as Priority 2 sensitive receptors but could only be assessed with the results of previously carried out soil and groundwater investigation based on which groundwater flow was deduced.

During construction phase, the potential sources of soil and groundwater impact were expected to be mainly from pre-construction activities (e.g. site clearance, levelling and 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, as well as potential leakage from improper handling of hazardous chemical/substances on site.

During operational phase, the potential sources of soil and groundwater impact were expected to be mainly from maintenance of the alignment, vent buildings etc. 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 were included in the EIS, for example, 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 and disposal of excavated soil and groundwater, toxic chemical waste generation and improper handling of hazardous chemicals/substances was assessed to be Minor to the sensitive receptors with the implementation of minimum controls, therefore no further mitigation measures were required.

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		
Eng Neo Avenue Forest	Moderate to Major	Minor
Site I and Site II	Negligible[1]	Minor
Windsor	Moderate to Major	Minor
Operational Phase		
Eng Neo Avenue Forest	Minor	Minor
Site I and Site II	Minor	Minor
Windsor	Minor	Minor

Note:
1. Base scenario worksite is located >50m from Site I and Site II. Thus, based on IAQM Guidance, air quality impact is deemed insignificant at Site I and Site II.

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 are identified as the predominant air emission source.

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 showed that unmitigated impacts were assessed as Moderate to Major across all construction worksites analysed and have the potential to affect the receptors near the construction worksite area unless mitigation measures are put in place. This is mainly because of the large extent of the construction worksite located very close or within the areas with flora, fauna and habitat with high ecological value. By implementing the recommended mitigation measures, the impact significance was anticipated to be reduced to Minor.

The key air quality 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. The mitigation measures are also applicable for the utility diversion works at A1-W1 worksite and access road construction at A1-W2 worksite. The worksite option with smaller footprint (i.e., Mitigated Scenario) was preferred. Smaller construction footprint would reduce the potential air quality impact to the neighbouring receptors.

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 was expected. It was assumed that all new vehicles to meet their Euro emission standard. Furthermore, there is currently a large traffic volume along the PIE. 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. Immediate localized road traffic to and from the FB4 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 would be required during operational phase as no significant air quality impact was expected from the Project's operation.

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		
Eng Neo Avenue Forest	Major	Minor
Site I and Site II	Negligible to Major	Negligible to Major[1]
Windsor	Moderate to Major	Minor to Moderate[1]
Operational Phase		
Eng Neo Avenue Forest	Negligible	Negligible
Site I and Site II	Negligible	Negligible
Windsor	Negligible	Negligible

Note:
1. Due to surrounding extremely low ambient noise levels, sensitive receptor in the close proximity, and undulant

Sensitive Receptor	Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)
terrain with high elevated area which cannot be blocked by the proposed noise barrier.		

Noise impact assessment was carried 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. Habitat sensitivity map was used for this project as basis to decide the probability of a finding of species in the area, and for this assessment. The noise Study Area are Eng Neo Avenue Forest, Sites I and II, Windsor and the area within the 150m from construction worksites.

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

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

The study on construction noise impact to the noise sensitive receptors focused on two (2) different construction scenarios which were, Scenario 1: Cut and cover works and associated activities- assess construction noise impacts from the cut and cover worksites to the sensitive receptors; and Scenario 2: TBM works - assess construction noise impacts from the TBM worksites to the sensitive receptors. It is to be noted that impacts on higher elevation receptors such as bird species are likely able to find alternative habitats in the surroundings for reasons more than just noise, including increased human presence, light, noise and other activities also. Therefore, the predicted noise levels with construction noise impact more on fauna near the ground level up to 1.5m height, hence, the predicted levels at this height were assessed in more details.

For the Scenario 1 (Cut and cover works and associated activities) to Scenario 2 (TBM works) for construction phase, base scenario results showed impact significance of Moderate to Major at Windsor, impact significance of Major at Eng Neo Avenue Forest, and impact significance of Negligible to Major at Site I and Site II.

During operational phase, the potential impacts would arise from the ACMV noise at the FB4 and traffic noise from the neighbouring public roads to the Biodiversity Study Areas (i.e., Sites I and II, Eng Neo Avenue Forest, Windsor).

For the purpose of ACMV noise, a "no worse off than average baseline" criteria was imposed at the boundary of FB4 and shall 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 contract. 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 criteria as proposed in this EIS.

Whilst for the qualitative assessment on traffic noise, it was expected for that around the FB4 to be low due to infrequent visits or only during scheduled maintenance only. In addition, there was no addition of new access roads around the FB4, in other words, the traffic noise will be dominated by the routine traffic. Overall, the airborne noise impact during operational phase was evaluated to be Negligible.

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

- Design optimisation to reduce footprint of A1-W1 and A1-W2 worksites (see **Figure 2** and **Figure 3**);
- 12m high noise barrier around the boundary of A1-W1 worksite;
- 12m high noise barrier around the boundary of A1-W2 worksite to be set up as part of the site preparation before any construction works commence; and
- 15m high full enclosure for A1-W2 (TBM works) around the launch shaft location when tunnel boring works commence.
- Administrative measures including
  - To avoid demolition works where possible;
  - To explore alternative piling methods that can allow construction works to be discontinued at evenings (for A1-W1 worksite only);

- To avoid above-ground construction works on Sunday and Public Holiday; and
- To avoid above-ground night works after 7pm for all non-safety critical activities.

Overall, the ground level and low-height noise sensitive receptors benefit significantly from the noise barrier, however receptors at top of the trees may not benefit from noise barriers since noise travels with the line of sight principle. Once the height of the barriers increases, the foundation and the area of site clearance required to support the barriers also increases. Therefore a couple of height sensitivity analyses were included in the assessment to propose optimised heights of noise barriers, where the listed heights above were deemed sufficient to provide maximum benefit to the arboreal receptors around the site, while any further increase to noise barrier height could not yield any further benefit to the receptors at both worksites.

Besides, it is worth noting that worst case assumptions on construction equipment usage, period of usage, and more conservative approach for barrier heights were used in this stage to inform the worst impacts predicted in these locations of highly sensitive nature. Notwithstanding the above, when the design is more firmed up in detailed design phase, an optimisation of noise models with more realistic use of equipment and area of worksite shall 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 for the Scenario 1 (Cut and cover works and associated) became Minor in Eng Neo Avenue Forest, Minor to Moderate in Windsor and Moderate to Major in Site I and Site II. The worst-case residual impact significance for Scenario 2 (TBM works) became Minor in Eng Neo Avenue Forest, and Negligible to Moderate in Site I and Site II.

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)
Construction Phase		
Eng Neo Avenue Forest	Minor to Major	Minor to Moderate[1]
Site I and Site II	Negligible to Moderate	Negligible to Moderate[1]
Windsor	Minor to Major	Minor to Moderate[1]
Operational Phase		
Eng Neo Avenue Forest	Minor	Minor
Site I and Site II	Minor	Minor
Windsor	Minor	Minor

Note:
1. The Moderate residual impact on all the Biodiversity Study Areas, although with mitigation measures, is due to construction activities such as pipe jacking, rock breaking and excavation and tunnel boring produce high PPV levels at the studied forested areas. Thus, EMMP measures should be implemented.

This EIS had taken a range of approaches based on minimal data available in literature at the time of writing the EIS for the study's comprehensiveness.

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, piling and tunnel boring, bulldozing and vibratory compaction works on the identified Biodiversity Study Area.

During rock breaking and excavation, there is a risk that the vibration causes impacts to the structural integrity of the animals' habitat, such as burrows. Therefore, for this assessment, mitigation measures were recommended to limit the rock breaking and excavation activity such that impact intensity remains below the levels for structural impacts.

Another 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 Windsor, some Priority 1 and 2 ecological receptors (e.g., the Red-legged crake, Red junglefowl and Long-tailed parakeet) may also be impacted during the breeding season. Typically, birds and animals may move away from instantaneous and short duration works like rock breaking and excavation and the passing of the tunnel boring machine but are likely to return to their original activity soon after the works are completed. However, during these critical construction phases, continuous vibration monitoring and fauna behaviour monitoring (using camera traps and specialists' observation) were recommended to study the actual impact. For piling 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 area. For example, a bored pile technique should be used when required during the daytime.

The critical mitigation measures recommended are the cancellation of TBM launch/ retrieval at A1-W1 (significant reduction of truck activity and heavy equipment on-site) and optimisation of the sites (in terms of size and location for A1-W1 and A1-W2, respectively). Other mitigation measures recommended are tri-axle trucks, rotary bored piling (or low vibration secant bored piling, completing the scheduled work on time, none or minimal night works, regulation of rock breaking and excavation based on feedback from vibration monitoring equipment and wildlife specialists on-site. Given that the mitigation measures are implemented, the mitigated scenarios' impact significance was assessed as Negligible to Moderate.

During the operational phase, assessing the impacts of train induced ground-borne vibration also adopted the same criteria.

Operational vibration impact assessment results indicate that a standard trackform and deep tunnel depth are sufficient to mitigate vibration impacts on sensitive fauna species. Hence, the impact was assessed as Minor. Therefore, no further mitigation measures were recommended in this case.

Environmental Monitoring & Management Plan (EMMP)

Overview

An EMMP was proposed to monitor and manage 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 details how recommended mitigation measures prepared for the impact assessment are to be implemented and specifies recommended monitoring measures to assess the effectiveness of the mitigation measures.

EMMP for Construction Phase

The proposed EMMP before and during the construction phase follows the *General LTA's SHE Specifications* guidance document. Additional contract-specific EMMP includes the following, but not limited to:

- Flora and fauna monitoring and management programme, e.g., conduct pre-site clearance inspection (including pre-felling tree inspections) to minimise 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 24: 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 event 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 for the remaining in-situ parameters (i.e. Temperature, pH, Conductivity, TDS and DO) at discharge points of construction sites (suggested monthly) and at the sensitive stream/drain (suggested bi-weekly at D/S13 and D/S16) throughout construction period;
- Perform ex-situ water quality monitoring for all the ex-situ parameters (i.e., BOD_5, COD, Total Nitrogen, Nitrate, Total Phosphorus, Orthophosphate, Oil and Grease Total, Oil and Grease (HC), Lead, Zinc, Mercury, Total Alkalinity, TOC, NH_4-N, *Enterococcus*), at discharge points of construction sites (suggested monthly) and at the sensitive stream/drain (suggested bi-weekly at D/S13 and D/S16) if discharging into public drains;
- Perform monitoring of PM_{10} and $PM_{2.5}$ at Sites I and II, and Windsor, 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 Sites I and II, Eng Neo Avenue Forest (at the boundary closest to A1-W2 worksite) and Windsor (at the boundary closest to A1-W1 worksite) throughout the construction period;
- Perform pre-construction ground-borne vibration monitoring (Triaxial with 3G remote communication) of peak particle velocity (PPV) prior to site clearance, as well as continuous vibration monitoring throughout construction phase which is in conjunction with one proposed noise monitoring location at Windsor; and
- Perform airborne noise and ground-borne vibration monitoring in tandem with biodiversity camera traps where it is relevant as part of the additional faunistic

survey programme during specific construction stages (i.e., site clearance stage, tunnel boring stage, piling stage, as well as rock breaking and excavation stage) at Windsor to study the impact of vibration on fauna's behaviour; and

- Monitoring of burrow collapse and installation of water-filled barrier at both sides of Island Club Road during rock breaking and excavation stage.

EMMP for Commissioning/ Operational Phase

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

- In general, Contractor/ Operator shall perform regular site inspection and environmental audit during the commissioning phase, especially on:
  - Drainage system within and in the vicinity of the FB4, especially during heavy storm event
  - 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 from 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 operational phases are provided in the EIS.

Figure 25: 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			
Eng Neo Avenue Forest	Biodiversity	Negligible to Major	Negligible
	Hydrology and Water Quality	Moderate to Major	Negligible
	Soil and Groundwater	Minor	Minor
	Air Quality	Moderate to Major	Minor
	Airborne Noise	Major	Minor
	Ground-borne Vibration	Minor to Major	Minor to Moderate[4]
Site I and Site II	Biodiversity	Negligible to Major	Negligible to Major[1]
	Hydrology and Water Quality	Negligible	Negligible to Moderate[2]
	Soil and Groundwater	Minor	Minor
	Air Quality	Negligible[1]	Minor
	Airborne Noise	Negligible to Major	Negligible to Major[3]
	Ground-borne Vibration	Negligible to Moderate	Negligible to Moderate[4]
Windsor	Biodiversity	Negligible to Major	Negligible to Major[1]
	Hydrology and Water Quality	Minor	Minor
	Soil and Groundwater	Minor	Minor

Sensitive Receptor		Impact Significance with Minimum Controls	Residual Impact Significance with Mitigation Measures (if required)
	Air Quality	Moderate to Major	Minor
	Airborne Noise	Moderate to Major	Minor to Moderate[3]
	Ground-borne Vibration	Negligible to Major	Negligible to Moderate[4]
Operational Phase			
Eng Neo Avenue Forest	Biodiversity	Negligible to Moderate	Negligible
	Hydrology and Water Quality	Moderate	Negligible
	Soil and Groundwater	Minor	Minor
	Air Quality	Minor	Minor
	Airborne Noise	Negligible	Negligible
	Ground-borne Vibration	Minor	Minor
Site I and Site II	Biodiversity	Negligible to Minor	Minor
	Hydrology and Water Quality	Negligible	Negligible
	Soil and Groundwater	Minor	Minor
	Air Quality	Minor	Minor
	Airborne Noise	Negligible	Negligible
	Ground-borne Vibration	Minor	Minor
Windsor	Biodiversity	Negligible to Moderate	Negligible to Minor
	Hydrology and Water Quality	Minor	Minor
	Soil and Groundwater	Minor	Minor
	Air Quality	Minor	Minor
	Airborne Noise	Negligible	Negligible
	Ground-borne Vibration	Minor	Minor

Note:

1. Biodiversity: Major impact still exists due to the irreversible loss of vegetation and habitats during site clearance in construction phase (Sites I and II: mortality and impediment to seedling recruitment for two flora species - *Alstonia angustiloba* and *Thyrsostachys siamensis*; Windsor: mortality for six flora species - *Bambusa multiplex, Cyrtophyllum fragrans, Ficus benjamina, Glochidion zeylanicum var. zeylanicum, Guioa pubescens, Palaquium obovatum*).
2. Water Quality: Moderate at Site I, as the proposed road will cross existing major drain in Site I, even with diverted drain or culvert, the impact cannot be reduced further mainly due to the immediate presence of drain segment adjacent to the construction site.
3. Noise: 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.
4. Vibration: the Moderate residual impact on all the Biodiversity Study Areas, although with mitigation measures, is due to construction activities such as pipe jacking, rock breaking and excavation and tunnel boring produce high PPV levels at the studied forested areas. Thus, EMMP measures should be implemented.

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

Impact mitigation through design optimisation (Avoidance of Impact)

- A1-W1 worksite
  - Omission of tunnel launching and associated tunnel operations at this location. A TBM inspection/maintenance point, integrated into the FB4 construction shaft is considered at this location to ensure the safe completion of the 5km of tunnel between Turf City and Bright Hill
  - Vertical (underground) arrangement of FB4 layout and rooms to minimise pop-up structure at surface
  - With an optimised FB4 layout, the worksite footprint required for construction activities is also reduced to as minimum as reasonably practicable, minimising impact to surroundings
- A1-W2 worksite
  - Full relocation of construction worksite out of Eng Neo Avenue Forest
  - Omission of above-ground facility building and replaced by underground tunnel ventilation to support the rail operations

The above are achieved through extensive design coordination to optimise the tunnel ventilation requirements.

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

- Implementation of site-specific biodiversity mitigation measures at Windsor:

  - Road calming measures (e.g., road signages, speed limitation, etc.)
  - Construct rope bridges across Island Club Road for ecological connectivity for arboreal and non-gliding mammals
  - Enhance existing culvert along Island Club Road for non-volant wildlife crossing

Figure 26: Example of Rope Bridge [photo: Desmond Lee/Facebook]

- Implementation of site-specific biodiversity mitigation measures at Sites I and II:
  - Construct new culvert with a continuous barrier along Fairways Drive Road for wildlife crossing
- Implementation of proposed noise barriers on site to reduce construction noise impact;
- Avoid peak breeding seasons (May to July) for tree-felling activities as much as possible;
- Above-ground works not critical for safety reasons shall only be allowed from Mondays to Saturdays (i.e., avoiding works on Sunday and public holidays) from 7am to 7pm. However, noisy activities (e.g., piling, excavation) shall 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 spectrum of lighting
  - Setting dark buffers, illuminance limits and zonation
  - Species-specific strategy
  - Reduce operating power mechanical equipment to minimum
- During rock breaking and excavation events at A1-W1 worksite:
  - Water-filled barrier should be installed on both sides of Island Club Road to prevent fauna from fleeing to the road resulting in road kills during rock breaking and excavation activities
  - Ecologists shall be present to observe fauna movements and to assess effectiveness of the water-filled barrier/fence
  - Appointed Contractor shall take note to restrict the entry of visitors into the trails of Windsor
- Heavy maintenance works and noisy equipment delivery should be kept within the daytime (9am to 5pm) during operational phase as much as possible.

Overall, the assessment findings demonstrated that the optimised designs of A1-W1 and A1-W2 worksites were beneficial to minimise the direct impacts on the identified Biodiversity Study Areas, i.e., Sites I and II, Eng Neo Avenue Forest and Windsor.

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 and operational phases.