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# N112 VIADUCT PROJECT AT SEMBAWANG ROAD

# FINAL ENVIRONMENTAL IMPACT STUDY REPORT

**Submitted by:**

TEMBUSU
Asia

Description **Final Environmental Impact Study Report for N112 Viaduct Road Development Project at Sembawang Road**

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# ABBREVIATIONS

| Abbreviation | Definition |
|---|---|
| µg/m$^3$ | microgram per cubic meter |
| CEMMP | Construction Environmental Management and Monitoring Plan |
| CF | constant frequency |
| CO | carbon monoxide |
| COP | Code of Practice |
| Cult. | cultivated |
| dBA | A-weighted decibel |
| ECM | Earth Control Measure |
| ECMO | Earth Control Measure Officer |
| ECO | Environmental Control Officer |
| EIA/S | Environmental Impact Assessment/Study |
| EMMP | Environmental Management and Monitoring Plan |
| EPH | Environmental Public Health |
| EPHA | Environmental Public Health Act |
| EPM | Environmental Protection and Management |
| EPMA | Environmental Protection and Management Act |
| ES | Environmental Score |
| FM | Frequency Modulated |
| GPS | Global Positioning System |
| HDB | Housing Development Board |
| kVA | Kilovolt-amps |
| hp | Horsepower |
| hr | hour |
| IUCN | International Union for the Conservation of Nature |
| kHz | kilohertz |
| km | kilometer |
| $LA_{eq}$ | equivalent continuous A-weighted sound power level |
| Leq | equivalent continuous noise level |
| LTA | Land Transport Authority |
| m | meter |
| m$^2$ | meter square |
| mg/L | milligram per liter |
| mg/m$^3$ | milligram per cubic meter |
| mins | minutes |
| ms | milliseconds |
| MND | Ministry of National Development |
| MPA | Maritime and Port Authority of Singapore |
| NEA | National Environment Agency |

| Abbreviation | Definition |
|---|---|
| n.d. | no date |
| $NO_2$ | nitrogen dioxide |
| NParks | National Parks Board |
| NSFD | Near Sulphur-Free Diesel |
| PCN | Park Connector Network |
| $PM_{10}$ | particulate matter with diameter ≤ 10 micrometers |
| $PM_{2.5}$ | particulate matter with diameter ≤ 2.5 micrometers |
| ppb | parts per billion |
| PPE | Personal Protective Equipment |
| ppm | parts per million |
| PSI | Pollutant Standards Index |
| PUB | Public Utilities Board |
| QECP | Qualified Erosion Control Professional |
| RIAM | Rapid Impact Assessment Matrix |
| RC | Reinformed Concrete |
| s | seconds |
| SFA | Singapore Food Agency |
| SS | Singapore Standards |
| SSO | Singapore Statutes Online |
| t | Tonnes |
| TAC | TEMBUSU Asia Consulting Pte Ltd |
| TIW | Toxic Industrial Waste |
| TOR | Terms of Reference |
| TPZ | Tree Protection Zones |
| TSS | Total Suspended Solids |
| URA | Urban Redevelopment Authority |
| US EPA | United States Environmental Protection Agency |
| .wav | Waveform Audio File format |
| WHO | World Health Organisation |

# GLOSSARY

**Abundance:** The number of a single species recorded at any given time period or location.

**Biodiversity:** The variety of plant and animal life in the world, habitat or location, a high level of which is usually considered to be important and desirable. Biodiversity can be assessed at more focused taxonomic groups such as “bird biodiversity”, in which case it is interchangeably with “diversity”.

**Conservation Status:** A status given to a species that is threatened with becoming extinct either locally or globally. These species may be restricted to only a small area, show noticeable decline in abundance over time, or have a historically low global population size. Assessments can be made either at global level under the IUCN’s Red List of Threatened Species or at national level (e.g. Singapore’s Red Data Book of Threatened Plants and Animals).

**Constant Frequency (CF)**: The portion of an ultrasonic bat call that has a constant (or near constant) frequency; in a sonogram display, this will appear as horizontal line.

**Ecology:** The pattern of relations between organisms and their environment.

**Edge Effect:** The effect of an abrupt transition between two quite different adjoining ecological communities on the numbers and kinds of organisms in the marginal habitat

**Fauna:** Referring to all animal life present in an area. Animals are defined as any species from the Kingdom Animalia.

**Flora:** Referring to all plant life present in an area. Plants are defined as any species from the Kingdom Plantae.

**Frequency Modulated (FM)**: Portion of an ultrasonic bat call that has a constantly changing frequency; this will typically appear in a sonogram as a steeply dipping line which, depending on the species, may be straight, slightly curved, or may have varying steepness.

**Genus:** A taxonomic group above species. A genus consists of closely related species. For example, Grey Heron and Purple Heron are closely related species in the same genus *Ardea*, hence their scientific names are *Ardea cinerea* and *Ardea purpurea* respectively.

**Habitat:** The natural home or environment of an animal, plant, or other organisms.

**Herpetofauna:** A taxonomic sub-group that includes amphibians and reptiles.

**Impact:** Any positive or negative alteration of existing conditions caused directly or indirectly by the project.

**kHz (kilohertz)**: A measure of frequency equivalent to 1,000 cycles per second. Human hearing may extend up to 20 kHz. Most bat calls are beyond 20 kHz, extending locally up to 245 kHz in the case of *Kerivoula hardwickii*.

**Leachate:** Any liquid that, in the course of passing through matter, extracts soluble or suspended solids, or any other component of the material through which it has passed.

**Microclimate:** Local atmospheric zone where the climate differs from the surrounding area.

**Mitigation Measure:** Means to prevent, reduce or control negative environmental effects of a project, and repair any damage to the environment caused by those effects through replacement, restoration, compensation or any other means.

**ms (milliseconds)**: 1/1000 of a second. Duration of individual bat pulses typically range from 2 ms, in some species of Myotis, to more than 50 ms, in some local emballonurids such as *Saccolaimus saccolaimus*.

**Odonate:** A taxonomic sub-group of Insects that includes dragonflies and damselflies.

**Population:** The term population can be in reference to the total number of a species found in a given area (e.g. global population, or Singapore population). It is also used as a term to define distinct sub-sets of a species based on the level of inter-mixing. For example, an island may hold two populations of a species if there are two groups of the same species present and those groups are sufficiently prevented (geographically or behaviourally) from mixing, forming separate breeding populations.

**Regenerated Forest**: a forest that has its trees and plants regrown through various means, e.g. seed dispersion by wind and animals or through human assistance.

**Species:** The standard classification of living organisms. It is defined as a group of living organisms consisting of similar individuals capable of exchanging genes or interbreeding. It is represented by the second word of the scientific name of an organism. For example, the scientific name of a Long-tailed Macaque is *Macaca fascicularis*, where *fascicularis* is its species name.

**Taxa:** In reference to a specific taxonomic group. In order of specificity, the taxonomic groups are: Kingdom, Phylum, Class, Order, Family, Genus, Species.

**Transect:** A predefined line or belt along which observations and/or measurements are taken.

.**wav**: Denotes a WAV (Waveform Audio) file format, which is used for raw and typically uncompressed audio recordings, which in this EIS is used for bat acoustic recordings.

# EXECUTIVE SUMMARY

The Land Transport Authority (LTA) is implementing the North South Corridor (NSC) project that connects the Northern and Central parts of Singapore. A section of the NSC viaduct will be passing through the Sembawang Woods. TEMBUSU Asia Consulting Pte Ltd is commissioned by China Civil Engineering, China Railway 11, and Wai Fong (CCW) Consortium to provide consultancy services to conduct an EIS for this proposed project (viaduct) stretch passing through this forested area. The EIS report has been prepared in accordance with scope of work provided by Client and outcome of technical agency consultation process.

The EIS was undertaken at the detailed design and construction stages of the Project, and therefore assesses the proposed development and activities based on an alignment that was determined from safety and land use considerations, including the necessity to minimise impacts on biodiversity.

This EIS report aims to provide a baseline assessment of the project site, identify the sensitive receptors, assess the potential impacts, recommend appropriate mitigation measures to reduce the residual impacts to acceptable levels. The potential impacts on the following environmental aspects have been considered in this assessment:

- Biodiversity
- Noise
- Hydrology & Water Quality
- Ambient Air Quality
- Light
- Waste Management
- Vector Control

A stakeholder consultation session was conducted with various Nature Groups to review & agree on the mitigation measures to address the anticipated environmental impacts and to implement the project in environmental sound manner.

Overall, it is concluded that the impacts from this project are expected to be of acceptable levels (i.e. consequential environmental changes would be minor) and contained locally, provided the identified and prescribed environmental mitigation measures are diligently implemented, especially during construction and operation phases.

The main findings of each environmental aspect studied has been summarised as follows.

**Biodiversity**

The project site is located ~1.5 km from the Central Catchment Nature Reserve and other forested areas, making it suitable for biodiversity, particularly the volant animals. A ten-week long baseline survey was conducted within project study area comprising various field survey methodologies such as visual flora and fauna transects, camera trapping, small mammal trapping and acoustic bat recording. The site consists of various habitat types, of which the most significant is the native-dominated regenerated forest west of Sembawang Road.

Impacts from project activities, including vegetation clearance, increased noise, and increased artificial light, may have undesirable impacts to biodiversity, especially to species of conservation value found at the project site. For plant species that are likely to be affected,

LTA will assess and carry out transplanting, where feasible. The impact on freshwater habitat caused by the backfilling of a natural stream near Sembawang Road for the construction of access road and viaduct will be mitigated by a natural bank design, which can act as an alternative habitat for stream-dependent animals. Other significant mitigation measures that will be implemented include erecting temporary hoarding at project boundary, retaining corridor between forested areas, and reinstating habitats where possible upon completion of works.

Care should be taken to avoid human-wildlife conflict during the construction phase due to presence of feral dogs and Long-tailed Macaques. Connectivity between habitats is to be preserved to reduce the possibility of roadkill due to collision between vehicles and animals. With the implementation of recommended mitigation measures—e.g. training the construction staff on wildlife encounters, erecting physical barriers to prevent fauna from crossing the road, and designating areas for food and waste disposal—it is expected that any such impacts will be reduced to an acceptable level.

Given that the project footprint is largely within mixed regenerated forest, the native-dominated forest west of Sembawang Road will remain relatively untouched. Negative impacts on species of conservation value will largely be avoided after the implementation of mitigation measures.

**Noise**

As the project site is vegetated, it is inhabited by various fauna species which may be sensitive to noise. There are sensitive human receptors situated within the project study area along Springside Avenue and Springside View. A seven-day continuous (24x7) noise monitoring was carried out at three locations to establish baseline noise levels. The baseline noise levels generally complied with Singapore's noise regulations. It is anticipated that the main noise sources during the construction phase will be associated with high-impact stationary and mobile equipment. The overall impact of noise on the sensitive receptors has been assessed as minor and can be further controlled if recommended noise mitigation measures—such as avoiding night works as far as possible, using construction equipment and vehicles with low noise levels, and erecting noise barriers at strategic locations—are suitably designed and implemented.

**Hydrology & Water Quality**

The project site is a part of the Lower Seletar Reservoir catchment area. There is no regular stormwater drainage network within project study area. There are two minor natural streams within project study area. Likely impacts from the construction phase of proposed project includes sediment runoff and siltation which may affect water quality. Also, one of natural stream near Sembawang Road is likely to be affected due to backfilling required for construction of access road as part of the project which may impact local drainage pattern. Mitigation measures—such as properly implementing Earth Control Measures (ECMs) and diverting the drainage flow to existing culvert near Sembawang Road to cater for hydrological patterns on the site—will be carried out to reduce the impact on water quality of project area.

**Ambient Air Quality**

Currently there are not any stationary source of air pollution within project study area as well as its surrounding area. Based on available secondary baseline data, it is observed that the

project study area enjoys good air quality. There are sensitive human receptors within project study area along Springside Avenue and Springside View. The air quality will potentially be affected by activities associated with viaduct construction, especially from an increase in airborne particulates and heavy-vehicle exhaust emissions. These may create a moderate and direct impact on local air quality and affect sensitive receptors located in the proximity of dust generating construction activities, including biodiversity of project area. These impacts can be brought down to an acceptable level with the implementation of various mitigation measures—e.g. implementing dust suppression plan, covering stockpiles of dusty materials with impervious sheeting, and regular watering of construction site.

**Light**

Impacts of light pollution during the construction period is possible but expected to be minor considering night work will be avoided as far as practicable. Nonetheless, mitigation measures such as adjustment of working hours and appropriate positioning of artificial lights during the construction phase and appropriate design of lights for operational phase are recommended to reduce the impact.

**Waste Management**

It is anticipated that the main sources of waste during construction phase will be from cut vegetation, excavated material, general construction waste, personal waste and/or hazardous waste. With the implementation of the mitigation measures proposed—such as implementing a waste management plan, reusing timber wastes for wood industry, and properly disposing the waste through licensed collectors—any negative impact is expected to be reduced to an acceptable level.

**Vector Control**

The primary impact of the construction phase of the project is potential increase in the immediate vector population. Secondary to this, an increase in the number of vectors has the potential to increase the likelihood of vector-borne diseases affecting humans. Key mitigation measures include source reduction and effective drainage through implementation of vector control plan. With its implementation, it is expected that these impacts can be reduced to an insignificant level. Considering the sensitive nature of Sembawang forested area, fogging is not recommended to be carried out as part of vector control measures.

An Environmental Management and Monitoring Plan (EMMP) has been proposed to manage the identified environmental impacts during construction phase. It also includes environmental monitoring requirements containing on-site visual compliance monitoring and physical monitoring (i.e. Noise, Water & Air) which will help to verify the effective implementation of mitigation measures during construction stage.

# 1 INTRODUCTION

## 1.1 Project Background

The Land Transport Authority (LTA) is implementing the North South Corridor (NSC), a road project that connects the Northern and Central parts of Singapore. The NSC comprises of a viaduct, for which the alignment was announced in 2011, amongst active mobility features. The China Civil Engineering, China Railway 11, and Wai Fong (CCW) Consortium is responsible for the design and construction of a section of the NSC viaduct located between Sungei Seletar and Yishun Avenue 5. The total length of main viaduct is approximately 3.3 km while having three slip ramps. A stretch of this viaduct section of approximately 800 m long and width varies between 40–60 m will be passing through the Sembawang Woods, a substantial part of which is covered with natural vegetation. An Environmental Impact Study (EIS) is required to study the impacts of the viaduct project to the forested area's environment and biodiversity and to recommend appropriate mitigation measures to minimise the impacts.

TEMBUSU Asia Consulting Pte Ltd is commissioned by the CCW Consortium to provide consultancy services and conduct an EIS within the forested area prior to the project development.

This EIS will establish the environmental baseline of the project site within the forested area, study the impacts of road project activities on the environment, and recommend appropriate mitigation measures.

## 1.2 Environmental Impact Study Objectives

The EIS was undertaken at the detailed design and construction stages of the Project, and therefore assesses the proposed development and activities based on the pre-determined viaduct corridor alignment. The recommendations made in this report focus on the measures that are required to be implemented at the construction and operation stages of the project to minimise the impact on the biodiversity at the forested area.

The principal objective of the EIS is to provide clear and concise technical information for decision-making on the potential environmental impacts associated with the construction of the proposed road project.

The key objectives of this EIS are to:

- Understand the environmental baseline through the collection of both primary and secondary data.
- Assess the impacts of the development during the construction and operational phases of the project on the environment.
- Present appropriate mitigation measures to reduce the level of impact for each activity assessed that has a moderate to major impact.
- Recommend an environmental management framework to monitor the mitigation measures implementation.

It is understood that the information presented in the EIS will contribute to decisions on:

- The overall acceptability of any adverse environmental consequences that are likely to arise as a result of the road construction works
- The conditions and requirements for the construction of the road project to mitigate adverse environmental consequences whenever practicable; and
- The acceptability of residual impacts after the proposed mitigation measures are implemented.
- The proposed mitigation measures, in consultation with agencies and the nature groups.

The undertaking of the EIS will therefore promote environmentally sound and sustainable development.

## 1.3 Report Structure

The EIS report is structured as follows:

- Chapter 1 introduces the project background and the general information of the EIS, covering its objectives, report structure, and limitations.
- Chapter 2 provides the description of the proposed project, land use history of the project study area and its surroundings, and activities associated with the proposed project.
- Chapter 3 outlines the EIS approach, including its scope and impact assessment methodology that is applied in the preparation of this report.
- Chapter 4 presents assessment of environmental impacts on biodiversity and its proposed mitigation measures.
- Chapter 5 discusses the noise impacts and proposes the mitigation measures.
- Chapter 6 describes the hydrology and water quality of the project study area and provides the impacts and mitigation measures.
- Chapter 7 provides a description of the ambient air quality impacts of the project and proposes the mitigation measures.
- Chapter 8 discusses the impacts from light pollution and proposes the mitigation measures.
- Chapter 9 discusses the waste impacts and proposes the mitigation measures.
- Chapter 10 details the vector control assessment and mitigation requirements.
- Chapter 11 summarises the impact assessment and mitigation measures of each environmental aspect.
- Chapter 12 outlines the proposed Environmental Management and Monitoring Plan (EMMP).
- Chapter 13 lists the references used in the report.

## 1.4 Limitations of the EIS Report

The EIS is conducted as per the TOR set forth in scope of work provided by Client and outcome of technical agency consultation process. The extent of collection of baseline data is guided by the respective TOR.

In preparing this report, we relied, in whole or in part, on data and information provided by the client and third parties, which information has not been independently verified and

which has assumed to be accurate, complete, and reliable. Therefore, while TAC has utilized its best efforts in preparing this Report, it does not warrant or guarantee the conclusions set forth in this report, which are dependent or based upon data, information or statements supplied by third parties or the client.

# 2 PROJECT OVERVIEW

## 2.1 Project Location

The project site is located between Sembawang Road and Lentor Avenue on its west and east respectively, south of Yishun Avenue 1, and roughly north of Springside Road (Figure 2.1). The project site is within the Ministry of Defense (MINDEF) land and access is restricted. The viaduct alignment was pre-determined based on safety and land use considerations. Specifically, it cannot be located further north as (1) the entry ramp would then be too close to the junction and lead to unsafe weaving of traffic; and (2) it would impact MINDEF's training ground. It also cannot be located further south given the need for adequate set-back distance to the residential areas in Springleaf.

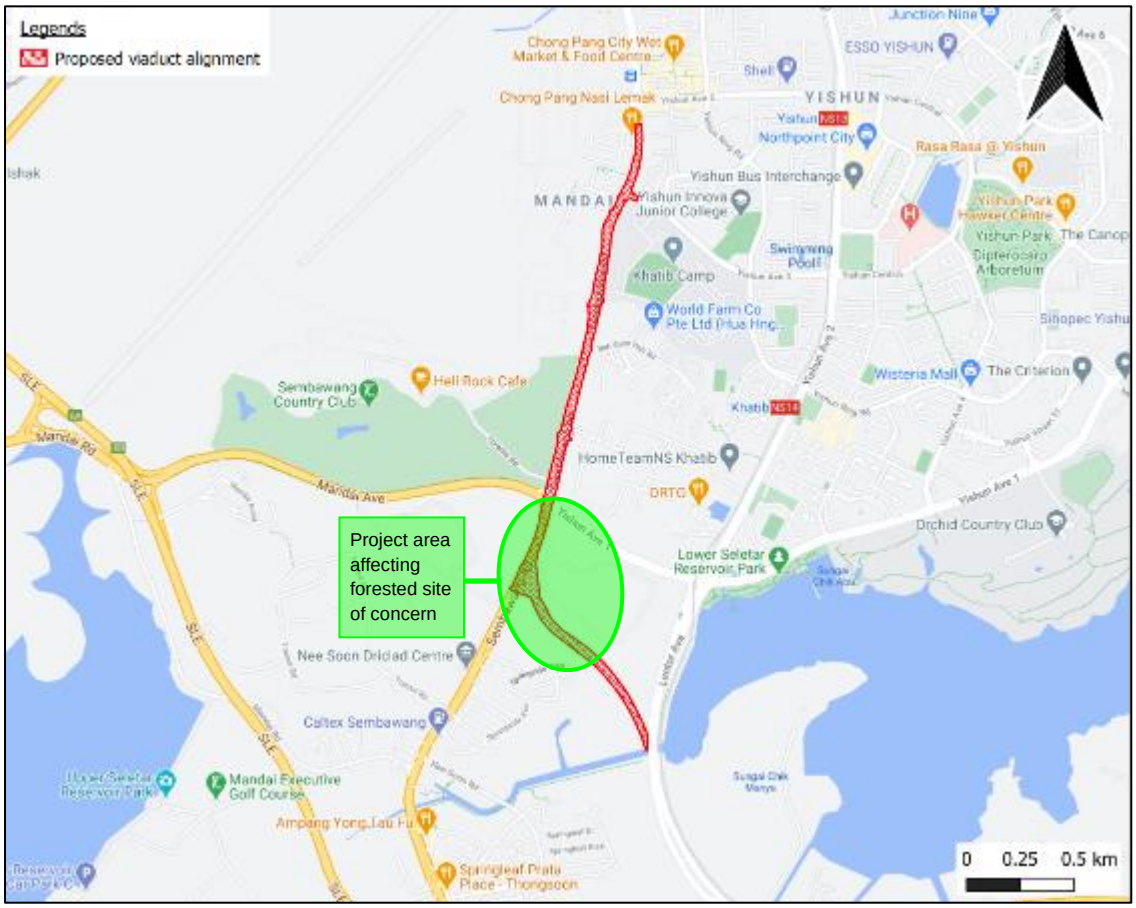


**Figure 2.1.** Location plan of proposed viaduct project

## 2.2 Land Use History

### 2.2.1 The Gambier Years

The original land use of Gambier and Pepper production in this area occurred during the 1800's. The Chan Chu Kang village (Situated at the current site of Springleaf Nature Park) was the gambier production centre for the Sungei Seletar catchment and was situated less than 1 km southwest of the study site. There is little doubt that the study site was part of the extensive gambier and pepper farms that covered the area. As

gambier production consumed all of the standing timber in the vicinity of a plantation for purpose of firewood for boiling the gambier leaves as well as to fire the pepper kilns, by the later 1800's most of Singapore island suited to gambier production had been exhausted and the planters, under encouragement of the Sultan, moved to the new state of Johor to continue their occupation. The land thus abandoned reverted to Lalang and brushwood due to the depletion of soil nutrients by the gambier crop.[1]

### 2.2.2 Establishment of the Para Rubber Crop

Former gambier lands remained as vast areas of Lalang and brushwood for many years until the early 1900's when the South American rainforest tree *Hevea brasiliensis* (Para Rubber) was developed as a tree of economic importance by Henry Ridley[2]. By 1920 much of the former gambier lands including the project area were cleared and planted with rubber. The project area is shown to be under rubber plantation in the 1924 topographic map of Singapore (Figure 2.2).

### 2.2.3 The Occupation Years

During the Japanese occupation (1942–1945), many of the rubber plantations were cleared for various reasons including i) to obtain timber for building, ii) firewood, and most importantly iii) to free up areas for the growing of vegetables. For the project site east of Sembawang Road, the original rubber plantation was cleared for construction of the Seletar POW camp (Figure 2.3). The area west of Sembawang Road and adjacent to Mandai Avenue was partially cleared during this period (Figure 2.4). However, the area was never replanted with rubber and through the subsequent years (Figure 2.5 to Figure 2.7) it is apparent that further clearing had occurred. This is significant as this area was found to be covered in native dominated forest with very little rubber content.

### 2.2.4 The Post-occupation Years

After the occupation, the POW camp was demolished and fresh rubbers were planted by the Bukit Sembawang Rubber Company as can be seen in Figure 2.5 and Figure 2.6.

In an NAS Oral History interview[3], Douglas Hiorns[4] pointed out that after the war, many of the former rubber areas were never replanted due to the nature of crops grown during the occupation years having denuded the soils of the necessary nutrients required to support a new crop of rubber. He also mentioned that after the war much of rubber lands west of Sembawang Road were compulsorily acquired by the government for military purposes. The lack of rubber plantation in the western section of the study area is most likely due partly to wartime clearing (Figure 2.4) and subsequently to compulsory acquisition of land (for Nee Soon Army Camp).

[1] O'Dempsey, A. J. (2014). Singapore's Changing Landscape since c. 1800. In T. Barnard, Nature Contained (pp. 17-48). Singapore: NUS Press.

[2] Henry Ridley was the first director of the Singapore Botanic Gardens. He developed a tapping technique for the extraction of latex which did not soon kill the tree. The ability to continuously tap the latex of trees over many years enabled its development as a crop.

[3] Hiorns, Douglas. Special Project (Oral History) Accession number 000799, National Archives Singapore.

[4] Douglas Hiorns was the Manager of the Bukit Sembawang Rubber Company which operated throughout Sembawang.

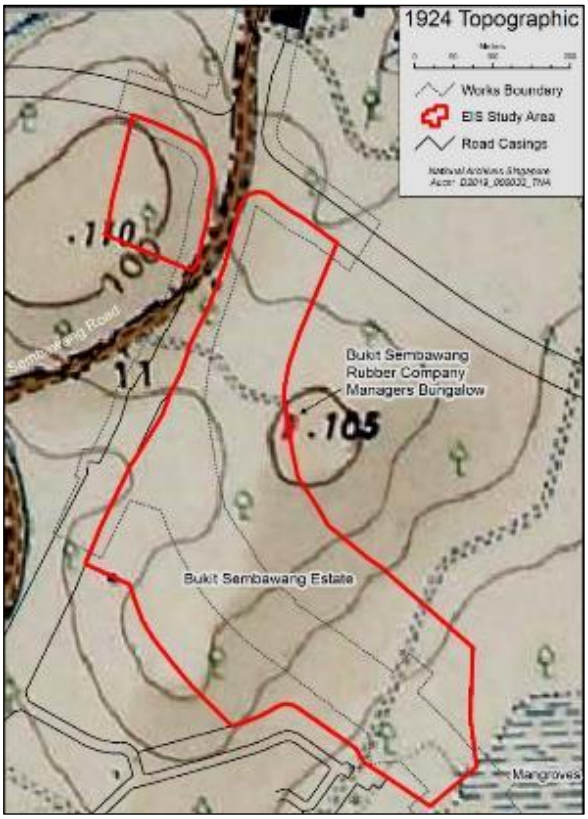


**Figure 2.2.** 1924 topographic map (NAS)

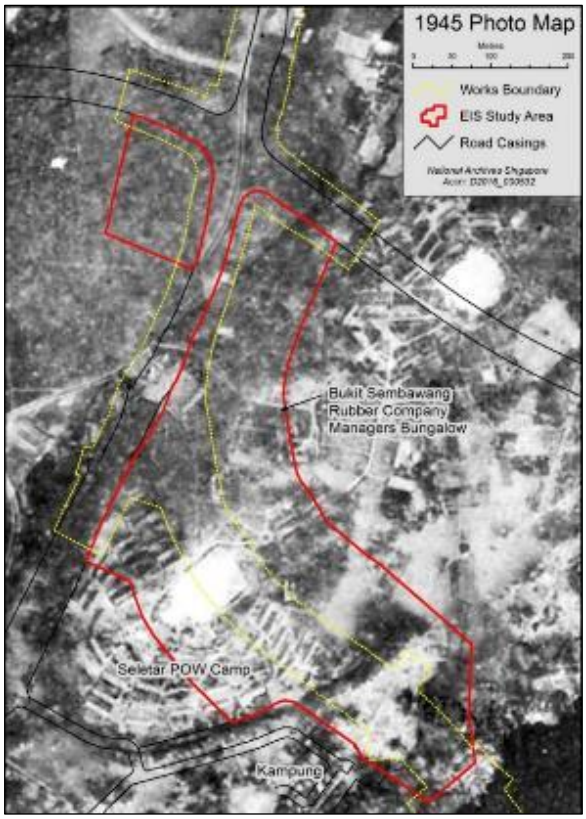


**Figure 2.3.** 1945 Aerial photo mosaic (NAS)


**Figure 2.4.** 1945 Aerial photo map showing partially cleared western section of study area

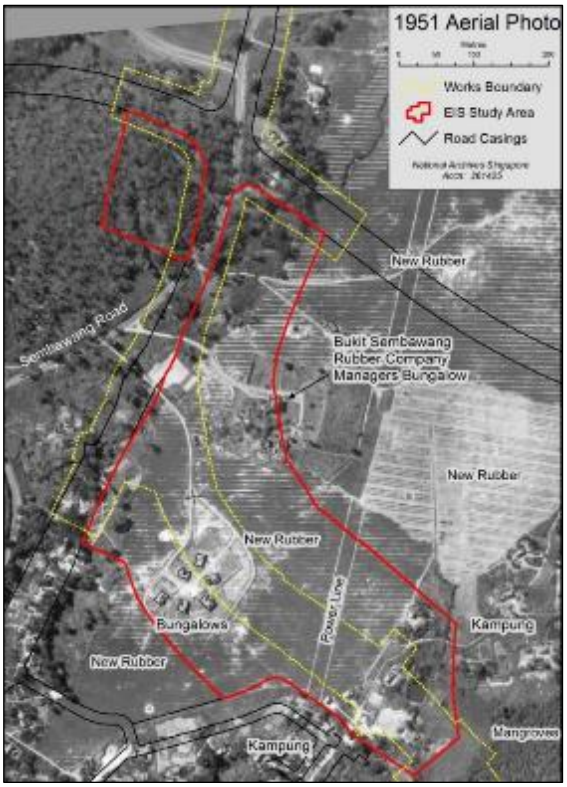


**Figure 2.5.** 1951 Aerial photo (NAS)


**Figure 2.6.** 1969 Aerial photo (NAS)

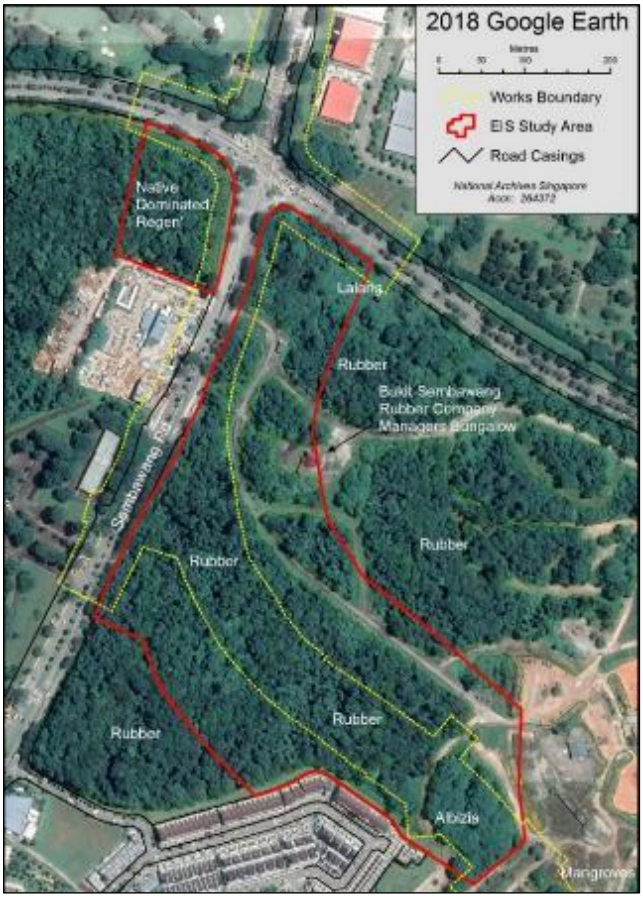


**Figure 2.7.** 2018 Google Earth image

## 2.3 Existing Land Use

The project site is located within an area that is bounded by Lentor Avenue, Yishun Ave 1 and Sembawang Road as shown in Figure 2.8. The area is currently used as a MINDEF training ground.

According to the URA Master Plan[5], the project site is zoned as a Reserve Site and is located within the Yishun Planning Area and Springleaf Planning Sub-zone.

The site consists mostly of secondary forest habitat with a mix of introduced and native plant species. Given its forested area and connection to similar areas in its south, it houses mainly forest-dependent biodiversity, including mammals and birds. Its proximity (~1.5 km) to Central Catchment Nature Reserve and surrounding forests also makes it a suitable site for other animal groups, particularly volant fauna (i.e. animals that can fly or glide).


**Figure 2.8.** URA Master Plan detailing planned land use of project study area

[5] Last Revised Date – 3 Jul 2020

Existing land uses neighboring the project site are as follow:

**North** : Sembawang Country Club Golf Course
**East** : Forested area and Open vegetated land
**South** : Open vegetated land and Residential area (Brooks Signature @ Springside)
**West** : Nee Soon Camp (Defense area)

## 2.4 Proposed Development

### 2.4.1 Project Footprint

The project site was identified as a suitable corridor to link the southern viaduct section along Lentor Avenue to the northern viaduct section along Sembawang Road. The main consideration is to minimise the impact on the existing and future developments at Lentor and Sembawang.

The viaduct corridor along the project site was aligned to minimise the impact on the MINDEF training area and to meet the geometric design requirements to achieve an expressway design speed of 90 km/hr for the proposed NSC viaduct. Its alignment within Sembawang Woods was determined based on safety and land use considerations. It cannot be located further north as (1) the entry ramp would then be too close to the junction and lead to unsafe weaving of traffic; and (2) it would impact MINDEF's training ground. It also cannot be located further south given the need for adequate set-back distance to the residential areas in Springleaf.

The project's work activity comprises the construction of a road viaduct leading from Sembawang Road to Lentor Avenue and a slip road starting from Sembawang Road merging with the proposed viaduct. Figure 2.9 shows the total footprint of project of within Sembawang forested area (in red).

The length of the viaduct within the Sembawang forested area is approximately 800 m which will be fully elevated structure. The elevation of viaduct from ground level will be approximately 20 m within Sembawang forested area. The slip road will start with at-grade level at Sembawang Road and ramp up to reach and merge with elevated viaduct. The slip road is approximately 360 m long. The site plan of proposed viaduct alignment (superimposed on the topography map of the project area) within Sembawang forested area is presented in **Appendix A.** Also, a new access road is to be constructed from Sembawang Road to provide access to MINDEF training area as part of this project. The site plan of this access road is included in **Appendix A**.

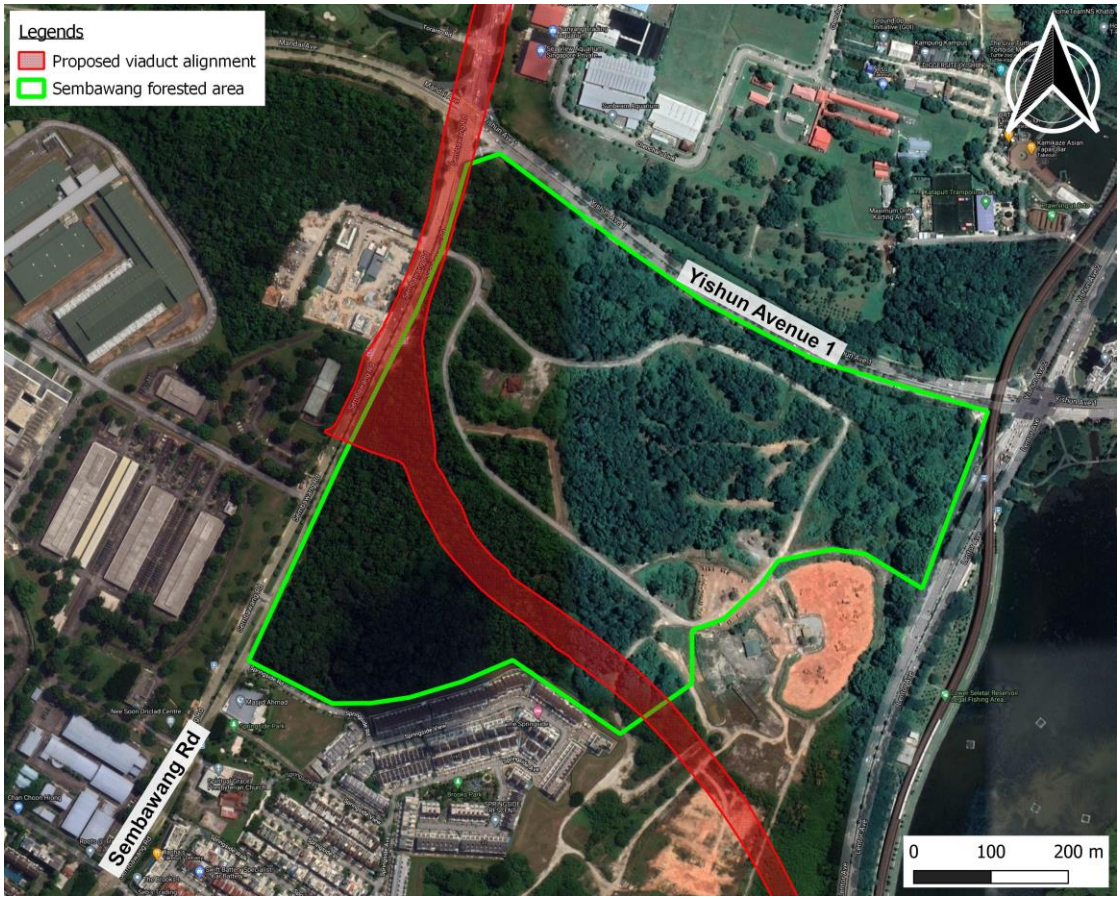


**Figure 2.9.** Proposed viaduct alignment within Sembawang forested area

### 2.4.2 Project Design

As per the preliminary concept design, the viaduct's super structures will be constructed in segments through precast twin-cell box girder type design that will be supported on a substructure of reinforced concrete piers. Large-diameter bored concrete piles will make up the pier foundation. Total 13 piers for main viaduct and 6 piers for slip road will be installed within Sembawang forested area.

The typical span length between two piers is approximately 40–50 m. The average height of viaduct will be approximately 20 m above ground level. Figure 2.10 shows the cross-section of a typical viaduct pier with dimensions while Figure 2.11 shows the cross-section of a typical slip road ramp structure. **Figure 2.12** depicts the viaduct from the 3D perspective.

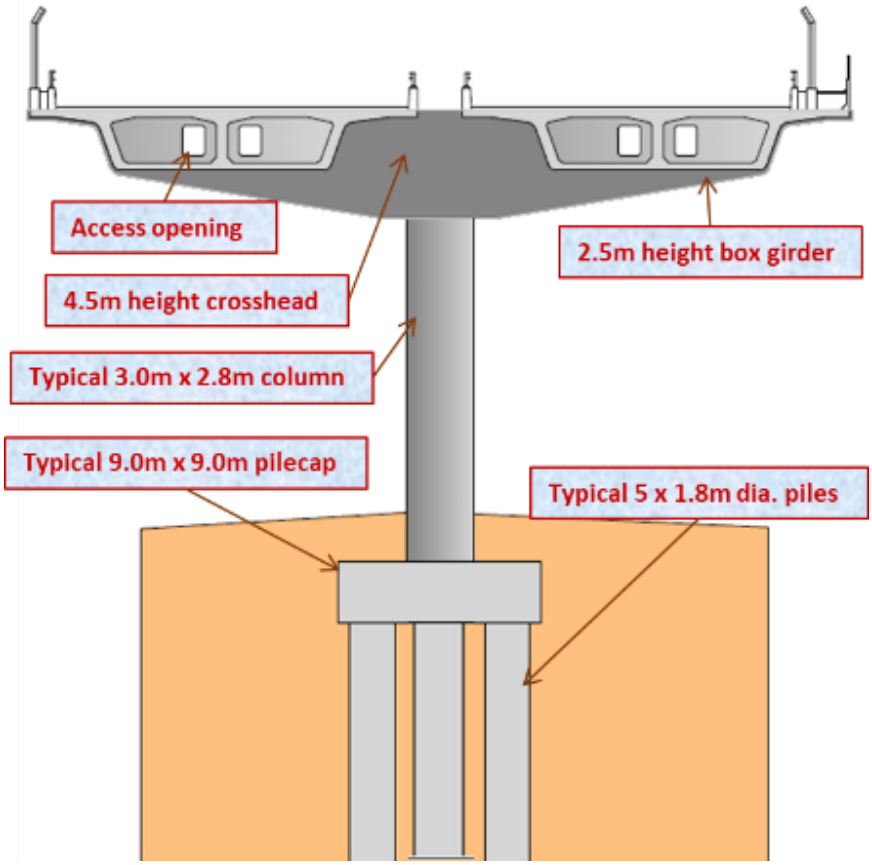


**Figure 2.10.** Cross-section view for pier of typical span

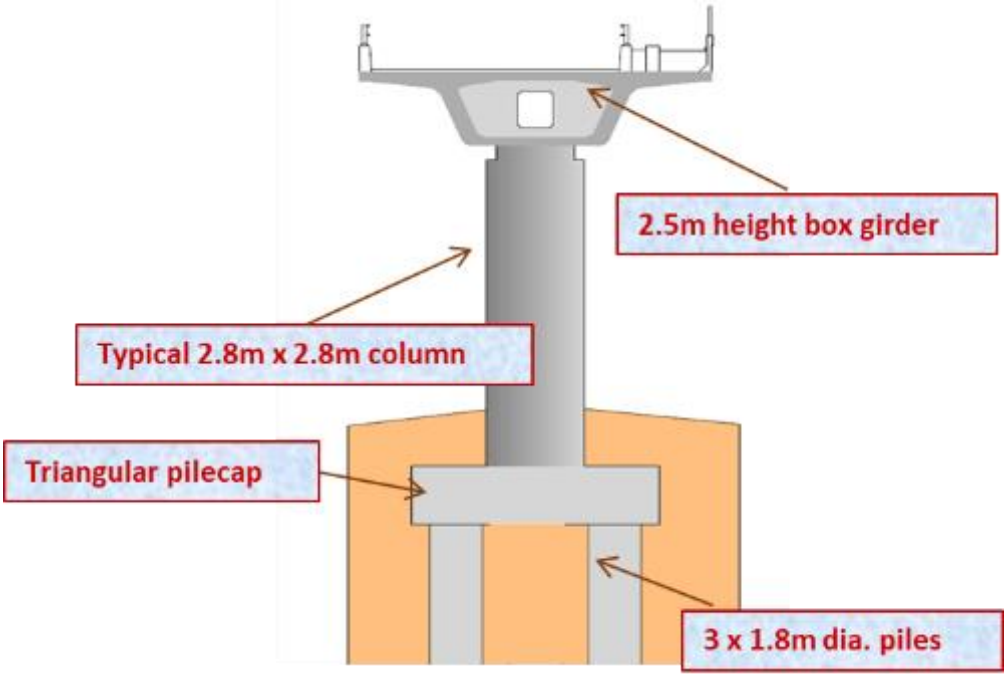


**Figure 2.11.** Cross-section view for typical slip road ramp structure

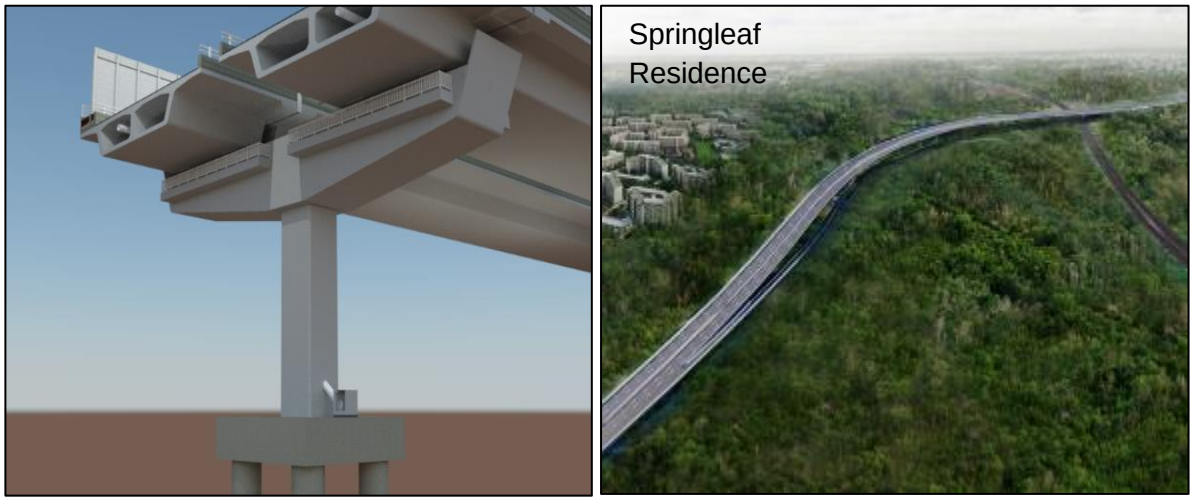


**Figure 2.12.** 3D perspective view of the viaduct

Table 2.1 presents the stage wise planned construction methodology and anticipated equipment usage to construction the viaduct and slip road.

**Table 2.1**. Planned construction methodology and anticipated equipment usage

| Stage | Activity | Planned Construction Method | Equipment Use |
|---|---|---|---|
| Stage 1 | Site Setup | • Site preparation and Vegetation clearance<br>• Hoarding setup | • Excavator<br>• Lorry crane<br>• Haul truck<br>• Chain saw |
| | Soil investigation works | • Mobilization of drilling rig<br>• Rotary drilling work for boreholes<br>• Backfilling of borehole | • Drilling rig<br>• Excavator<br>• Lorry crane<br>• Haul truck |
| Stage 2 | Construction of Sub-structure<br><br>Pile-cap & Stump below ground | • Temporary drain & ECM system installation<br>• Installation of Bored Pile<br>• Installation of sheet pile wall<br>• Braced Excavation with ERSS for pile-cap<br>• RC work for pile-cap (Cast in-situ method)<br>• RC work for stump for Column connection<br>• Backfilling of pile-cap to ground level<br>• Extraction of ERSS & sheet piles | • Hydraulic breaker<br>• Piling rig<br>• Vibro hammer<br>• Excavator<br>• Haul truck<br>• Launching girder<br>• Hanger beam and lifter system<br>• Air compressor<br>• Water pump<br>• Mobile crane<br>• Lorry crane<br>• Trailer<br>• Silo tank<br>• Concrete pump<br>• Concrete truck<br>• Generator<br>• Welding machine |
| Stage 3 | Construction of Pier Column & Cross Head (Precast element) | • Installation of support system<br>• Lifting and Installation of column<br>• Installation of precast crosshead shell (center part)<br>• RC work of crosshead (center part)<br>• Installation of precast crosshead shell (2 sides)<br>• RC work of crosshead (2 sides)<br>• RC work for ramp approach slab (at grade part) | |
| Stage 4 | Construction of Superstructure | • Installation of segments by launcher (Main line) | |

| Stage | Activity | Planned Construction Method | Equipment Use |
|---|---|---|---|
| | (Precast Element) | • Installation of segments by lifter (Ramp)<br>• Road decking work (Parapet wall, Road surface, planter box, lane marking, etc.)<br>• Permanent drain system | |
| Stage 5 | Reinstatement of ground | • Removal of hoarding and housekeeping<br>• Restore the ground condition | |

At each pier location, soil investigation will be carried out. Figure 2.13 shows proposed locations of soil investigation points within Sembawang forested area which will be located within project boundary (i.e. alignment footprint).

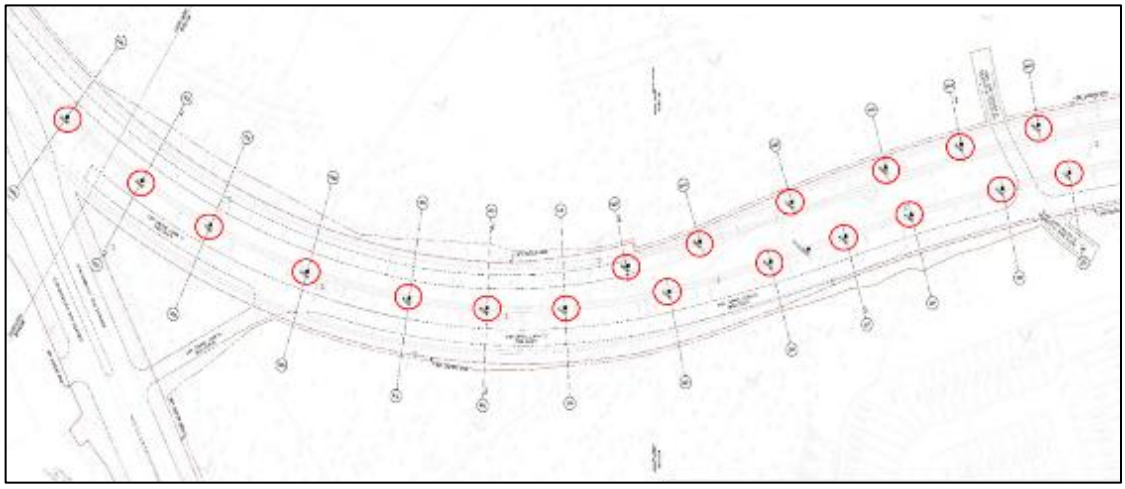

**Figure 2.13.** Proposed soil Investigation locations within Sembawang forested area (red circles)

### 2.4.3 Construction Activities Associated with Proposed Project

Expected activities during the preparation stage of construction include the erection of hoarding and vegetation clearance within project boundary (i.e. alignment footprint) to facilitate the construction access and for the latter construction of foundation. Soil investigation will be carried out as part of pre-construction activities at each pier location as noted earlier.

Excavation & soil cutting as well as backfilling are expected due to the sloping terrain of the project area. Piling for the foundation is expected for the installation of columns to support the elevated super structure. Lastly, hoisting and laying of the precast box girder and other construction material are also expected. The total duration of activities in the project area within the locations is estimated to be 64 months.

All the construction activities expected to take place during execution of this project is summarized below:

- Land clearing, earth works, and general construction activities (e.g. soil mixing clearing and preparation, trench excavation, backfill, compaction, spoil handling and transport, building of permanent structures);

- Vehicle movements and emissions (as a result of equipment, materials and personnel movement in and out of construction work areas);
- Stockpiling and materials handling (delivery, unloading, and use of construction aggregates, etc.);
- Use of high impact stationary and mobile equipment such as pile drivers, vibro hammers, rotary drilling, mobile cranes, haul trucks, excavators, dozers, etc. leading to variable and sporadic noise levels, typically repeating over time;
- Minor equipment/ plant maintenance activities potentially leading to accidental leaks or spills;
- Workforce activities leading to generation of general waste;
- Storage and disposal of solid and liquid waste; and
- Use of hazardous materials potentially leading to accidental spills & leakage.

### 2.4.4 Operational Activities Associated with Project

Operational activities associated with the proposed development will include mainly road traffic using the viaduct and night lighting.

# 3 EIS APPROACH

## 3.1 Singapore's EIA Context

Singapore adopts a systematic framework to determine and mitigate the potential impact of any new development on the environment. In general, development projects are required to undergo a thorough evaluation process that addresses the development's potential impact on traffic, public health, heritage, and the environment. In addition, proposed development projects near sensitive areas, such as Nature Reserves, Nature Areas, marine and coastal areas, other areas of significant biodiversity or with potential trans-boundary impact, are subject to greater scrutiny.

For such projects, Technical Agencies (such as the National Parks Board, National Environment Agency, Maritime and Port Authority of Singapore, and Singapore Food Agency) are consulted more extensively, in which the developer sets out the relevant locational and environmental factors, make a considered statement on the potential impacts of the project based on these factors, and also indicate the measures that will be taken to minimize negative impact on the surrounding environment.

This is intended to help set the grounds (on a reasonable basis) on the potential impacts (whether it will cause substantial pollution of or significant and harmful change), and is also consistent with principles of the screening stage in international EIA practices. Government agencies will assess the impact of the project and recommend whether further environmental studies are required.

Due to the potential impacts, it is deemed that a comprehensive study compromising impact analysis, assessment, and mitigation management is required for this proposed development. For this EIS, an Inception Report illustrating the scope of EIS was submitted to the Client and relevant Technical Agencies in advance of the commencement of the EIS to confirm the scope.

## 3.2 Scope of EIS

This EIS is conducted as per the TOR set forth in scope of work provided by Client and scoping consultation process with Technical Agencies. As noted earlier, an Inception Report describing the scope of EIS was submitted to the relevant Technical Agencies prior to the commencement of the EIS study. The Inception Report is provided in **Appendix B**.

The salient points of EIS scope as follows:

- Establishment of baseline data, which include data source and data collection methodology.
- Biodiversity survey – Flora
- Biodiversity survey – Fauna
- If any stream is found within the study area, hydrological and water quality impact assessment will be required.
- To address the noise impact on biodiversity, noise monitoring is to be carried out.

- Impact assessment of the road corridor and the construction shall include:
  - Scale and effects of vegetation removal from excavation, site clearance, and construction;
  - Possibilities of compaction and erosion;
  - Impact to the watercourses in Sembawang area;
  - Impact of road construction activities on wildlife, in particular birds and mammals, and their movements;
  - Impact of the proposed road when operational on the wildlife, in particular birds and mammals, and their movements;
  - Impact on ecological connectivity within Sembawang forested area; and
  - Significance of the above for species conservation and overall well-being of vegetation in the immediate vicinity of the proposed route.
- Recommend mitigation measures for impacts due to the construction and operational activities of the proposed project.
- Develop an Environmental Monitoring and Management Plan (EMMP) during construction; and
- To engage and liaise with relevant agencies—e.g. URA, MPA, and NParks—on the conduct of the EIS and shall record and incorporate the agencies' comments into EIS report.

## 3.3 Applicable Singapore and International Legislations

Table 3.1 lists relevant legislation, regulations and guidelines that govern the various environmental parameters within Singapore. The latest legislations and relevant subsidiary regulations can be accessed from the website of Singapore Statutes Online (SSO) (n.d.) at https://sso.agc.gov.sg/.

**Table 3.1**. List of applicable Singapore legislations, regulations, and guidelines

| Parameter | Legislation, Regulations and Guidelines |
|---|---|
| General | • Environmental Protection and Management Act, 2002<br>• Environmental Public Health Act, rev. 2002<br>• Singapore Code of Practice on Pollution Control (SS593: 2013) |
| Biodiversity | • The Wildlife Act 2020<br>• The Parks and Trees Act 2006<br>• The Parks & Trees Regulations 2006<br>• The Parks & Trees Preservation Order 1998<br>• Parks & Trees (Composition of Offences Regulations) 2006<br>• Parks & Trees (Planning Areas) Notifications 2006<br>• Parks & Trees (Heritage Road Green Buffers) Order 2006<br>• Singapore Red Data Book, Second Edition, 2008<br>• IUCN Red List of Threatened Species to assess species vulnerability (2020)<br>• CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora, also known as the Washington Convention) 1983 |

| Parameter | Legislation, Regulations and Guidelines |
|---|---|
| Noise | • Environmental Protection and Management Act 2002, Part VIII Noise Control<br>• Environmental Protection and Management (Control of Noise at Construction Sites) Regulations 2008<br>• Environmental Protection and Management (Boundary Noise Limits for Factory Premises) Regulations 2008<br>• NEA Code of Practice on Pollution Control SS 593 (2013)<br>• LTA Best Environmental Practices: Noise Control at LTA Sites (2013)<br>• Code of Practice for Noise Control on Construction and Demolition Sites SS602 (2014) |
| Surface Water Quality | • Sewerage and Drainage Act 2001<br>• Sewerage and Drainage (Surface Water Drainage) Regulations 2007<br>• Sewerage and Drainage (Trade Effluent) Regulations revised 2007<br>• LTA Best Environmental Practices: Earth Control Measures (2014)<br>• Environmental Protection and Management Act 2002, Part V on water pollution<br>• Environmental Protection and Management Act (Trade Effluent) Regulations 2008<br>• PUB Code of Practice on Surface Water Drainage (2018)<br>• LTA, Best Environmental Practices: Water Resource Management at LTA Sites (2011)<br>• PUB Handbook on Managing Urban Runoff (2013)<br>• NEA Code of Practice on Pollution Control SS 593 (2013)<br>• PUB Guidebook on Erosion and Sediment Control at Construction Sites (2018) |
| Ambient Air Quality | • Environmental Protection and Management Act 2002, Part IV on Air Pollution Control<br>• Environmental Protection and Management (Vehicle Emissions) Regulations 2008<br>• Environmental Protection and Management (Prohibition on Use of Open Fires) Order 2008<br>• Environmental Protection and Management (Air Impurities) Regulations 2008<br>• NEA Singapore Ambient Air Quality Targets (2011)<br>• NEA Code of Practice on Pollution Control SS 593 (2013) |
| Waste Management | • Environmental Protection and Management Act 2002, Part VII on Hazardous Substances<br>• Environmental Protection and Management (Hazardous Substances) Regulations 2008<br>• Environmental Public Health (General Waste Collection) Regulations 2000<br>• Environmental Public Health (Toxic Industrial Waste) Regulations 2000<br>• Best Environmental Practices: Construction Waste Management at LTA Sites (2009)<br>• NEA Code of Practice on Pollution Control SS 593 (2013) |
| Vector Control | • NEA guidelines on “Rainwater Collection System and Mosquito Prevention<br>• Control of Vectors and Pesticides Act 2002<br>• Environmental Public Health Act (EPHA) 2002<br>• LTA Best Environmental Practices: Vector Control at LTA Sites (2019) |

## 3.4 EIS Study Area and Environmental Aspects

The EIS study area denotes the area where construction and operation activities of the proposed viaduct project are predicted to have impacts on the various environmental aspects within Sembawang forested area. The proposed study area covers the 100m area on both sides of proposed viaduct alignment (i.e. project boundary). This is in line with the project TOR requirement as well as acceptable local practice. The width of viaduct alignment varies between 40 to 60 m within Sembawang forested area as per preliminary design. Figure 3.1 below shows the extent of the proposed study area.

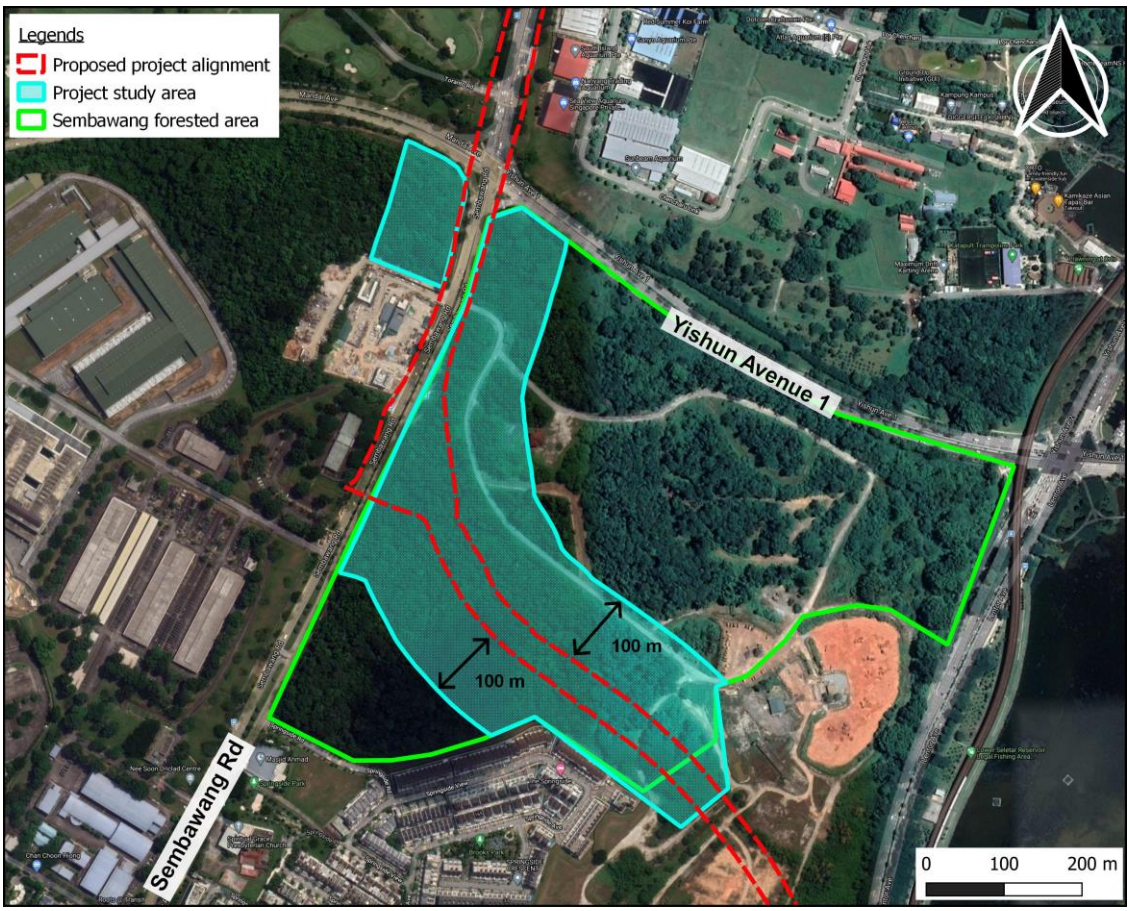


**Figure 3.1.** Extent of project study area

For this proposed project, the environmental aspects to be studied are biodiversity, hydrology & water quality, ambient air quality, noise, light, waste management and vector control. Brief description of each environmental aspect and explanation of its relevance is illustrated below. The identified sensitive receptors are further discussed in the next section.

***Biodiversity***

The biodiversity aspect includes the flora and fauna groups inhabiting the project site that may be impacted by future construction and operation of the road. Fauna groups surveyed include birds, mammals, reptiles, amphibians, butterflies, and odonates (dragonflies and damselflies). Fish, molluscs, and decapod crustaceans within natural streams were also surveyed.

***Noise***

Many fauna species are sensitive to noise. Given the diverse community of fauna within the project site, baseline noise levels will be established where future construction and operation activities will be concentrated.

***Hydrology & Water Quality***

This aspect concerns waterbodies within the project study area that may be impacted during the construction and operational stages of the viaduct.

***Ambient Air Quality***

Construction activities are known to release dust and other particulate matters that may harm the health of sensitive receptors in the surrounding area, in this case flora and fauna species living and contractors working on the site. Vehicular emissions during operational phase may also yield similar effects as (albeit lesser in terms of magnitude) construction activities.

***Light***

Increased artificial light during the night either from construction activities or the operation of the road disrupts circadian cycles of animals and distorts the day-night cycle of plants. This may lead to increased predation pressure by diurnal carnivores on nocturnal animals, exhaustion from insects attracted to artificial light, and the alteration of breeding and sleeping cycles of various animals. The distortion of day-night cycles in plants may also lead to altered growth rates and flowering cycles, thus affecting floristic communities. It is necessary to ensure that light levels during the project's construction and operational phases do not adversely affect ecological communities on the site.

***Waste Management***

The main impacts in relation to the storage, handling, transport and disposal of waste include deterioration of the environment and health & safety risks with regards to hazardous waste, if they are not managed properly

***Vector Control***

Possibility of vector borne diseases in Singapore's warm tropical climate is always present. The type of in Singapore includes mosquito, rodent, fly, rat, flea etc. As the majority of vector-borne diseases in Singapore are transmitted by mosquitoes, mosquito control during construction activities will be focus of the assessment.

## 3.5 Identification of Sensitive Receptors

Table 3.2 lists the identified sensitive environmental receptors that may be affected during the development of the proposed project.

**Table 3.2**. Identified sensitive receptors

| Aspects | Sensitive receptors |
|---|---|
| Biodiversity | • Native flora and fauna of international conservation significance (i.e. classified as Critically Endangered, Endangered, or Vulnerable according to IUCN (The IUCN Red List of Threatened Species, 2020) classification system) in the proposed project site<br>• Native flora and fauna of national conservation significance (i.e. classified as Critically Endangered, Endangered, and/or Vulnerable according to Singapore Red Data Book or other relevant local status publications) in the proposed project site<br>• Habitats with high ecological value (i.e. environments that support species of conservation significance) |
| Hydrology & Water Quality | • Aquatic flora and fauna within the proposed project site<br>• Surface waterways that support habitats of conservation significance |
| Ambient Air Quality | • Flora and fauna within the proposed project site<br>• People working on the site, e.g. construction workers<br>• Resident community along Springside Avenue and Springside View |
| Noise | • Fauna species that are susceptible to noise pollution (e.g. species that require a quiet environment to find prey and those with acute hearing)<br>• People working on the site, e.g. construction workers<br>• Residents community along Springside Avenue and Springside View |
| Light | • Species that are susceptible to light pollution (e.g. nocturnal fauna) |

## 3.6 Preliminary Identification of Potential Impacts

This section discusses potential environmental impacts arising from the construction and operational phases of the project based on the project description and study area.

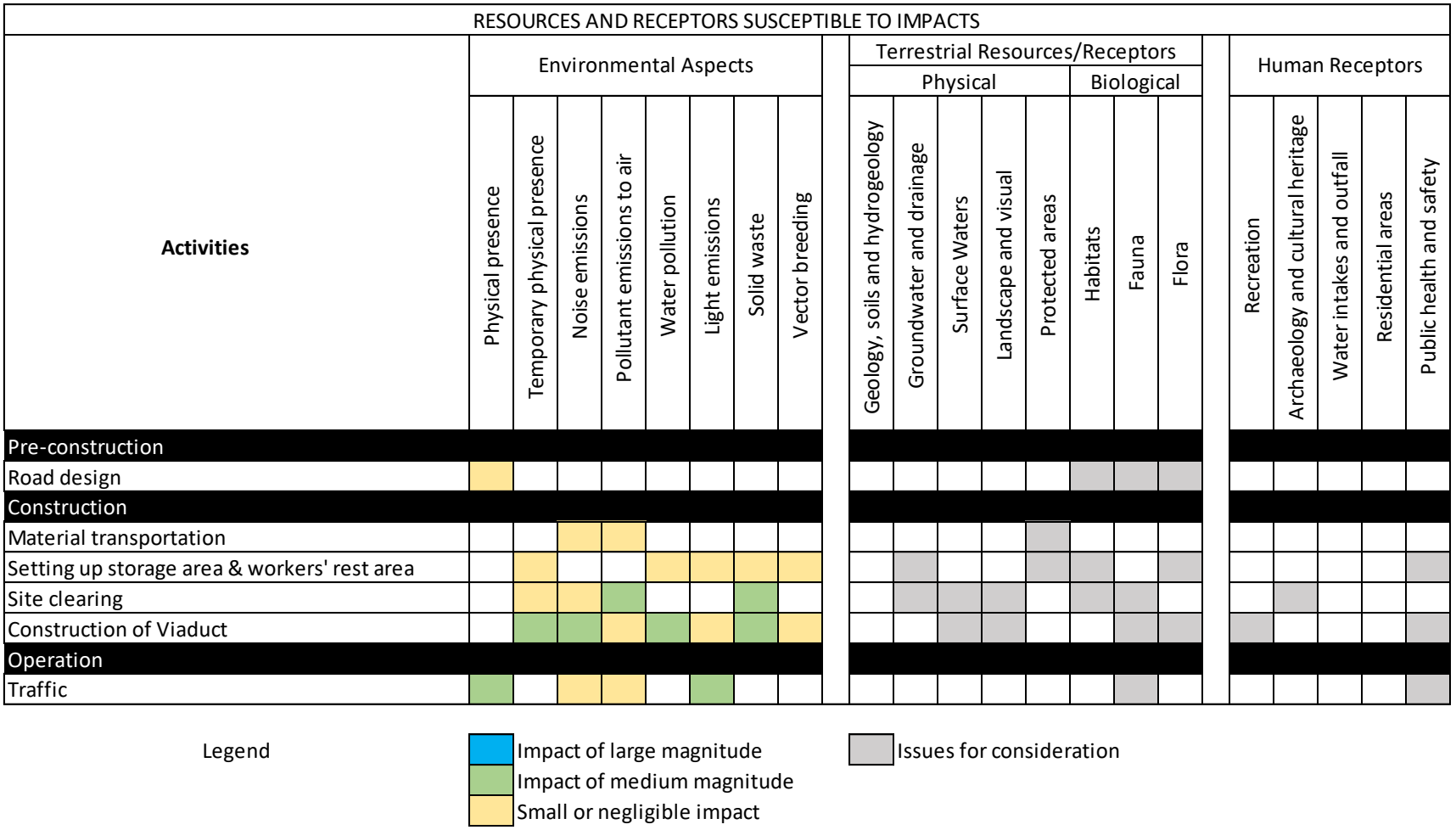


**Figure 3.2.** Potential environmental impacts

## 3.7 Impact Assessment Methodology

### 3.7.1 Identification of Impacts

The proposed project involves the development of a new viaduct across the study area. This may involve clearance of vegetation for the project footprint, as well as working spaces (access routes, storage space for construction equipment and materials). These may result in several potential impacts on the natural environment. These include direct loss of species due to vegetation clearance and other construction activities, as well as indirect impacts, such as fragmentation of habitats, isolation of populations due to reduced connectivity and animal movements, increased edge effects (higher temperature, light, noise and pollution levels on the edges compared to the interior of a forest resulting in retraction or loss of species sensitive to these disturbances), increased human disturbance to the surrounding habitat due to increased accessibility and noise, light and air pollution during the construction and operation phases of the project, and subsequently by the vehicles on the road.

An assessment of the impacts of the project includes:

- Scale and effects of vegetation removal from excavation, site clearance, and construction;
- Possibilities of compaction and erosion;
- Impact to the watercourses in Sembawang area;
- Impact of road construction activities on wildlife, in particular birds and mammals, and their movements;
- Impact of the proposed road when operational on the wildlife, in particular birds and mammals, and their movements;
- Impact on ecological connectivity within Sembawang forested area; and
- Significance of the above for species conservation and overall well-being of vegetation in the immediate vicinity of the proposed route.

### 3.7.2 Assessment of Impacts

Based on the impact analysis of construction and operational activities of the proposed road project, suitable mitigation measures are recommended to lower the magnitude of negative impacts on the environment to within acceptable levels.

Potential impacts were quantified using the Rapid Impact Assessment Matrix (RIAM) method, which is a system of scoring in which impacts of each project activity are evaluated against environmental receptors (adapted from Pastakia & Barber, 1998). The RIAM assessment attributes values to each condition based on its importance (I), magnitude (M), permanence (P), reversibility (R), and cumulativity (C).

The parameters are tabulated in Table 3.3.

**Table 3.3.** List of parameters and respective scores assigned in RIAM method

| Parameter | Description | Score |
|---|---|---|
| **Importance (I)** | Important to national/international interests | 5 |
| | Important to regional/national interests | 4 |
| | Important to areas immediately outside the local condition | 3 |
| | Important to the local condition (within a large direct impact area) | 2 |
| | Important only to the local condition (within a small direct impact area) | 1 |
| **Magnitude (M)** | Major positive benefit or change | +4 |
| | Moderate positive benefit or change | +3 |
| | Minor positive benefit or change | +2 |
| | Slight positive benefit or change | +1 |
| | No change/status quo | 0 |
| | Slight negative disadvantage or change | -1 |
| | Minor negative disadvantage or change | -2 |
| | Moderate negative disadvantage or change | -3 |
| | Major negative disadvantage or change | -4 |
| **Permanence (P)** | No change/Not applicable | 1 |
| | Temporary | 2 |
| | Permanent | 3 |
| **Reversibility (R)** | No change/Not applicable | 1 |
| | Reversible or controllable through Environmental Management and Monitoring Plan | 2 |
| | Irreversible | 3 |
| **Cumulativity (C)** | No change / Not applicable | 1 |
| | Non-cumulative/single | 2 |
| | Cumulative/synergistic | 3 |

Given the ambiguity in the nature of assessing the 'magnitude' component, we use the following criteria to aid the assessment, tabulated in Table 3.4.

**Table 3.4.** Description of the value of magnitudes in RIAM method

| Magnitude | Description |
|---|---|
| Major positive benefit or change | A major positive benefit or change refers to significant improvements in baseline conditions and a significant reduction of stress or improvement in the baseline states of sensitive receptors. |
| Moderate positive benefit or change | A moderate positive benefits or change refer to significant improvements in local baseline conditions, which may lead to a moderate reduction of stress to sensitive receptors or improvement in their baseline state. |
| Minor positive benefit or change | A minor positive benefit or change implies that positive changes to baseline conditions are discernable but local. These changes may lead to local and limited reduction of stress to sensitive receptors. |
| Slight positive benefit or change | A slight positive benefit or change implies that changes in baseline conditions are unlikely to be detectable on-site, and thus are unlikely to cause discernable reduction of stress to sensitive receptors. |
| No change/status quo | No change/status quo implies that changes in the baseline conditions are not expected, and unlikely to cause any stress to sensitive receptors. |

| Magnitude | Description |
|---|---|
| Slight negative disadvantage or change | A slight negative disadvantage or change implies that changes in baseline conditions are unlikely to be detectable in the field, and thus are unlikely to cause discernable stress to sensitive receptors. |
| Minor negative disadvantage or change | A minor negative disadvantage or change implies that negative changes to baseline conditions are discernable but local. These may also refer to changes that are approaching thresholds for established standards or guidelines. These changes may lead to a local and limited increase in stress to sensitive receptors. |
| Moderate negative disadvantage or change | A moderate negative disadvantage or change refer to significant adverse changes in local baseline conditions. These may also refer to changes that are very close to exceeding established standards or guidelines or causing significant ecological impacts. These changes may lead to a moderate increase of stress to sensitive receptors. |
| Major negative disadvantage or change | A major negative disadvantage or change refers to significant adverse changes in baseline conditions. These may also refer to changes that exceed established standards or guidelines or causing a complete loss of certain habitats or ecological components. These changes may lead to an unacceptable increase of stress to sensitive receptors. |

These values will then contribute to the condition's environmental score, where:

$$Environmental\ Score\ (ES)\ =\ I * M * (P + R + C).$$

The ES attained for each condition will then correlate to a measure of its impact, which are tabulated in Table 3.5

**Table 3.5**. List of ES range along with the degree of impact associated with each range

| Range | Impact |
|---|---|
| 116 to 180 | Major positive change/impact |
| 81 to 115 | Moderate positive change/impact |
| 37 to 80 | Minor positive change/impact |
| 7 to 36 | Slight positive impact |
| -6 to +6 | No impact / Status quo / Not applicable |
| -7 to -36 | Slight negative change/impact |
| -37 to -80 | Minor negative change/impact |
| -81 to -115 | Moderate negative change/impact |
| -116 to -180 | Major negative change/impact |

### *Mitigation Measures*

In general, mitigation measures follow two concepts:

- ALARP: "As Low as Reasonably Practical"
- BATNEEC: "Best Available Technology Not Entailing Excessive Costs"

The first concept is a hierarchy of actions that aims to find anything that can be done to avoid, minimise, or reduce the predicted/potential adverse (negative) environmental impacts, as practically feasible and reasonable.

The second concept comes in when discussing whether or not to adopt certain available technology that could address/reduce environmental impacts.

## 3.8 Project Team

The team involved in the fieldwork, analysis, impact assessment, and report preparation for this project are listed in Table 3.6.

**Table 3.6.** List of EIS project team members

| No | Name | Designation |
|---|---|---|
| 1 | Mr Tan Seng Chuan | Project Director |
| 2 | Mr Komal Pujara | Project Manager / EIS Lead |
| 3 | Ms Holly Siow | Lead Ecologist |
| 4 | Ms Tabitha Hui | Biodiversity Consultant |
| 5 | Mr Nick Baker | Bat Expert |
| 6 | Mr Anthony O'Dempsey | Flora Expert |
| 7 | Ms Henrietta Woo | Fauna Expert (Ornithologist) |
| 8 | Mr Jefferson | Environment Consultant |

# 4 BIODIVERSITY

## 4.1 Introduction

The project site is located in abandoned rubber plantation adjacent to Sembawang Road, Yishun Ave 1 and Mandai Avenue. The geographic coordinates for the study area are Latitude 1°24'34" and Longitude 103°49'21". The site is situated approximately 1.5 km from Central Catchment Nature Reserve (CCNR) and is surrounded by substantial forest and grassland areas with direct connection to the CCNR via the channel connecting the Upper Seletar and Lower Seletar reservoirs and passing through Springleaf Nature Park (Figure 4.1). This connection adjoins the CCNR in the vicinity of the Nee Soon Swamp forest that is core conservation area within the nature reserve.

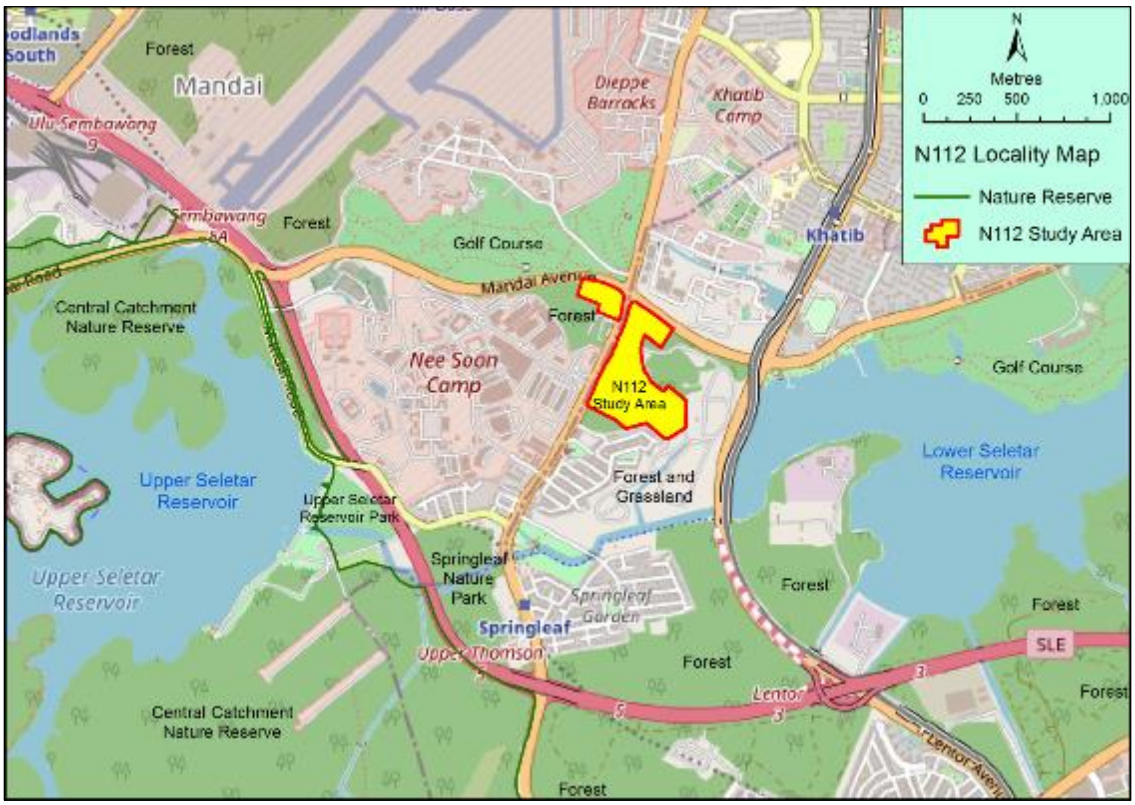


**Figure 4.1.** Project locality and spatial context

Historically, the land use on the site included Gambir and Rubber plantations, kampongs, and even a prisoner of war (POW) camp during the Japanese Occupation. Currently, habitat types on this site are reflective of its history, consisting of native-dominated regenerated forests, old rubber plantations, and mixed native and exotic regenerated forests. The site is now used by several fauna species of conservation value, including the Sunda Pangolin (*Manis javanica*), Straw-headed Bulbul (*Pycnonotus zeylanicus*), and Red Legged Crake (*Rallina fasciata*).

This following section describes the methodology of field surveys that were carried out to establish the baseline for biodiversity and identify the existing sensitive receptors within project study area. The results of these surveys are then analysed and discussed

to assess the likely impacts of the proposed development to the receptors. Measures to mitigate these impacts are recommended for implementation during construction and operation phase of project.

## 4.2 Baseline Methodology

### 4.2.1 Desktop Review

A desktop review to collect secondary data was conducted. This included a thorough review of publicly available literature on the ecology and biodiversity of the site, as well as other publicly available material, which may include land use and other maps, photographs, and environmental data found on government websites.

***Conventions***

The species' local conservation status was mainly based on *Singapore Red Data Book* (Davison, Ng, & Ho, 2008). For flora, *The Checklist of the Total Vascular Plant Flora of Singapore* (Chong, Tan, & Corlett, 2009) was also referred to. Conservation status for odonates was derived from *The Dragonflies of Singapore: An updated checklist and revision of the national conservation statuses* (Ngiam & Cheong, 2016). On the other hand, the global conservation status was derived from the IUCN Red List of Threatened Species (IUCN, 2020).

A species is considered to be of conservation value if its conservation status is listed as Vulnerable, Endangered, or Critically Endangered.

**Table 4.1** Conservation status for flora & fauna species and their respective definitions, adapted from IUCN Red List (2020) and Singapore Red Data Book (Davison, Ng, & Chew, 2008).

| **Conservation Status** | **Definition** |
|---|---|
| **Global** | |
| Extinct (EX) | There is no reasonable doubt that the last individual has died. Exhaustive surveys in known and/or expected habitat, at appropriate times, throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form. |
| Extinct in the Wild (EW) | Known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. Exhaustive surveys in known and/or expected habitat, at appropriate times, throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form. |
| Critically Endangered (CR) | Considered to be facing an extremely high risk of extinction in the wild. |
| Endangered (EN) | Considered to be facing a very high risk of extinction in the wild. |
| Vulnerable (VU) | Considered to be facing a high risk of extinction in the wild. |
| Near Threatened (NT) | Does not qualify as Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future. |

| | |
|---|---|
| Least Concern (LC) | Does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category. |
| Data Deficient (DD) | Inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat. |
| Not Evaluated (NE) | Not yet been evaluated against the criteria. |
| **Local** | |
| Presumed Nationally Extinct (NE) | This species is extinct in Singapore but still survives outside Singapore. It has not been recorded with the last 30 years (plants) and 50 years (animals). |
| Critically Endangered (CR) | There are fewer than 50 mature individuals, or if more than 50 mature individuals but less than 250, with some evidence of decline or fragmentation. |
| Endangered (EN) | There are fewer than 250 mature individuals, and no other evidence of decline or fragmentation. |
| Vulnerable (VU) | There are fewer than 1000 mature individuals, but more than 250 and there may or may not be any other evidence of decline, small range size, or fragmentation. |

### 4.2.2 Flora

***Flora Field Assessment***

Transects were conducted throughout the study area and its extremities with the aim of achieving comprehensive coverage of all flora habitats that occupy the study site.

For each transect:

- GPS positions are recorded on regular basis;
- Species encountered are recorded with reference to the GPS identifiers;
- Photographs taken where required.

While some plant species have official conservation statuses (Extinct or Critically Endangered) in Singapore, they are not considered significant findings due to their persistence from cultivation. In this report, these cultivated species shall be assessed as if they were common native species, and their official conservation statuses are indicated in [square brackets] in the species checklist in **Appendix C**:

| **Family** | **Species** | **Conservation Status** | **Comment** |
|---|---|---|---|
| Myrtaceae | *Syzygium myrtifolium* | [Extinct] | Cultivated as urban hedge tree |
| Phyllanthaceae | *Baccaurea motleyana* | [Critically Endangered] | *Rambai* (Cultivated Fruit Tree) |
| Sapindaceae | *Nephelium lappaceum* | [Critically Endangered] | *Rambutan* (Cultivated Fruit Tree) |

The flora study transects conducted are illustrated in Figure 4.2.

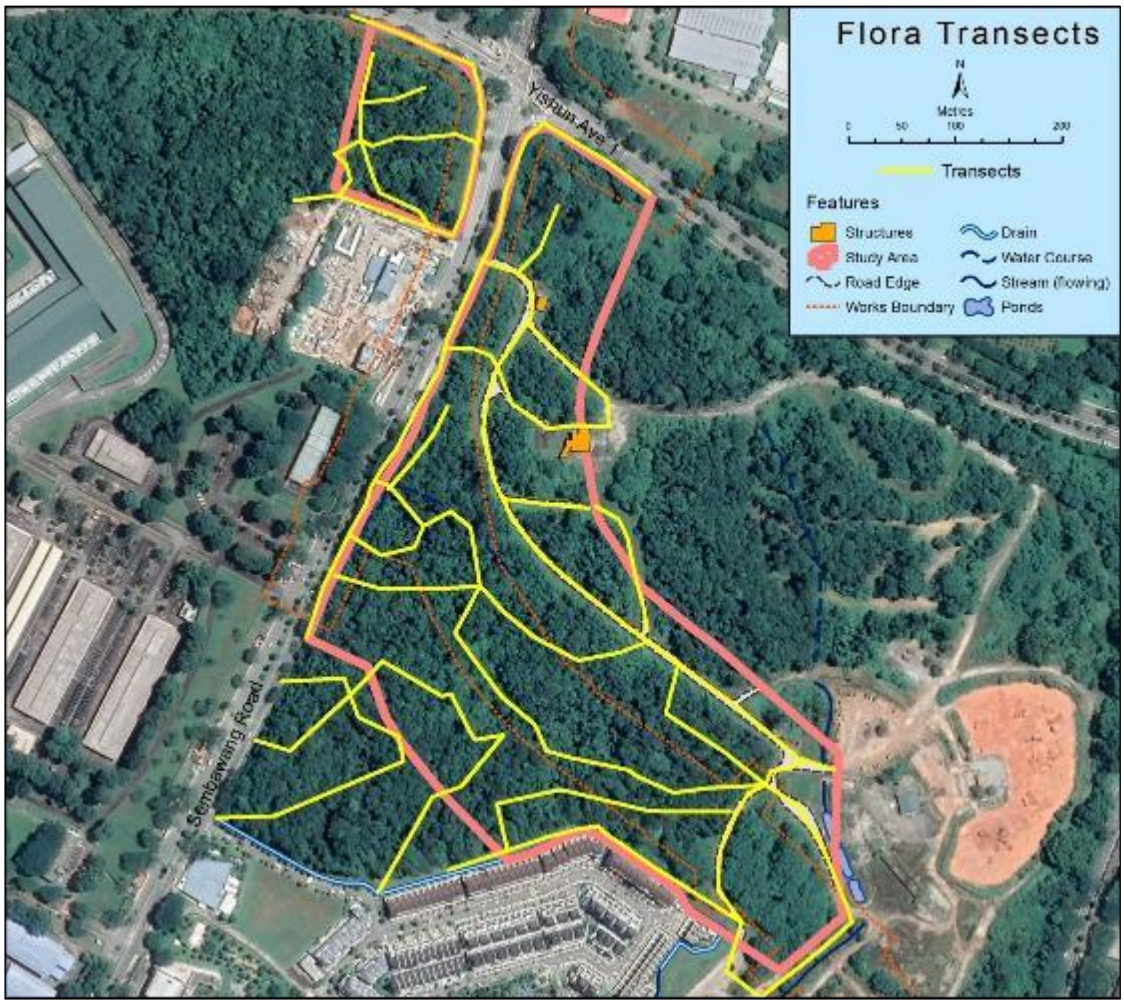


**Figure 4.2.** Flora study transect map

***Species Identification***

In general, most species that were encountered during the flora survey were not fertile and identifications were achieved by vegetative features, which may result in a degree of uncertainty for species that require fertile specimens to reliably identified. Uncommon species were identified / verified with reference to the Biodiversity Online web site hosted by Lee Kong Chian Natural History Museum (LKCNHM) as well as through consultation with various experts in the community. **Appendix D** compiles the photos of plant species identified on the project site.

***Vegetation Mapping***

Based on the data collected on plant species and vegetation structure, the project site was mapped according to the types of habitat present. The map also includes significant topographic features such as roads, waterbodies, and fences.

### 4.2.3 Fauna

***Visual Encounter Surveys***

A baseline fauna survey was conducted along systematic transects in the area, following available trails and roads that spanned the length of the proposed road (Figure 4.3).

Since a large proportion of the target groups, particularly mammals, are predominantly nocturnal, both diurnal and nocturnal surveys were conducted. Three day transects and three night transects were carried out. For diurnal surveys, each transect was surveyed by at least two observers at points located 100 m apart, for approximately 10 minutes at each point. Night transects were done with at least three observers walking at a regular slow pace throughout the length of each transect. Each day transect was conducted four times, and each night transect was conducted three times.

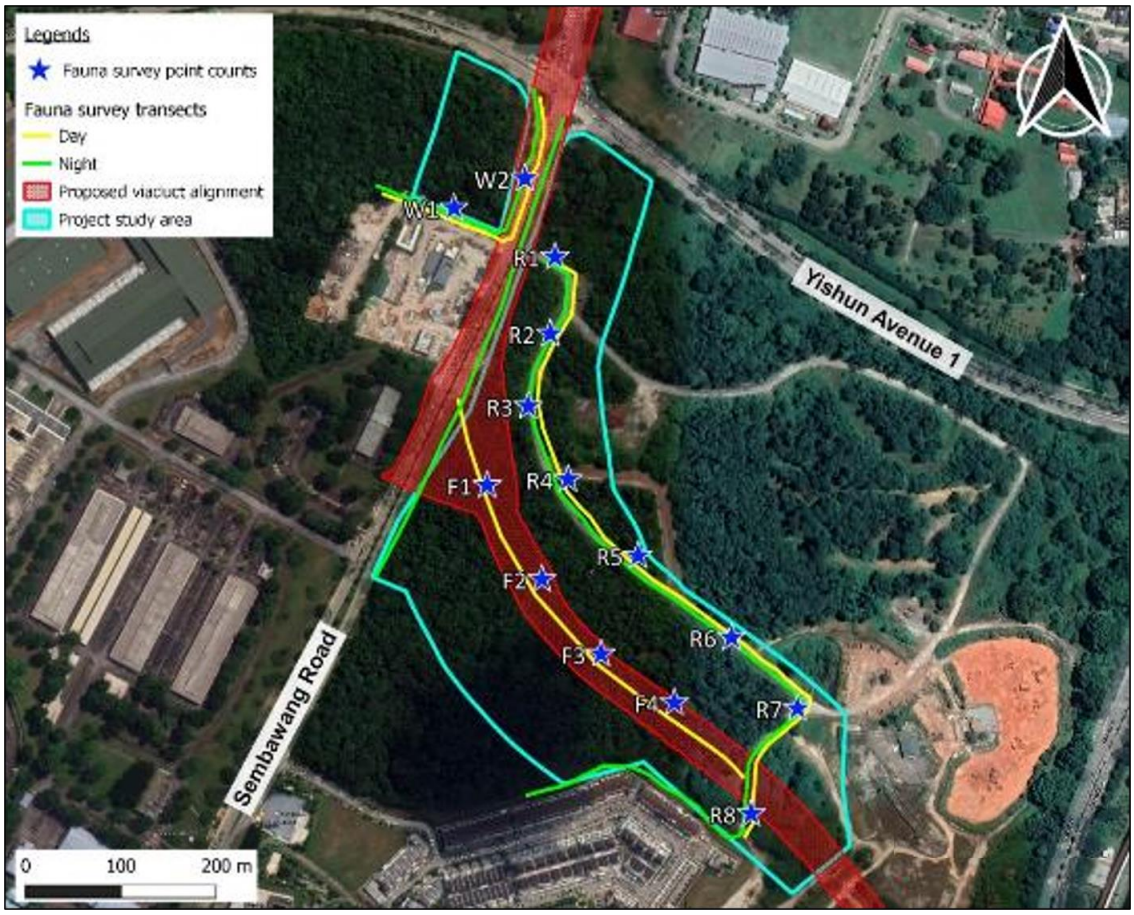


**Figure 4.3.** Fauna visual encounter survey map

***Camera Trapping***

Five camera traps were deployed throughout the study area from 25 June to 20 August 2020. Three additional camera traps were deployed between 11 September to 28 September 2020 (see Table 4.2 for GPS coordinates and Figure 4.4 for their location on the map). These remotely activated cameras are equipped with infrared sensors that are triggered by animal movements. Camera trapping is particularly useful for elusive or rare animals that are not often observed during visual encounter surveys. They also allow for 24-hour monitoring of the study site. The cameras used in this study take colour photos during the day and black and white photos at night using an infrared flash, the use of the latter avoids the problem of blinding or spooking the animals.

Cameras were deployed in areas with expected high animal activity, such as grasses,

shrubs, watering holes, fruiting trees, grasses, and fallen branches and logs (Figure 4.5). These areas were indicated by animal tracks, scats, wallows, markings, and trails. Cameras were set to take a sequence of three photos each time they were triggered, with a 5 second interval between each sequence. One of the cameras was also set to take videos lasting 10 second each time it was triggered. Cameras were secured to tree trunks 30cm above the ground, which is just below the shoulder height of the largest species expected to be present, the Wild Boar (*Sus scrofa*). Setting the cameras at this height optimises the focal area of the cameras for capturing smaller animals.

**Table 4.2.** Camera traps' coordinate within project study area

| ID | Latitude | Longitude |
|---|---|---|
| CAM1 | 1.409255 | 103.821781 |
| CAM2 | 1.411816 | 103.823388 |
| CAM3 | 1.407384 | 103.824687 |
| CAM4 | 1.412406 | 103.822236 |

| ID | Latitude | Longitude |
|---|---|---|
| CAM5 | 1.410196 | 103.822986 |
| CAM6 | 1.409769 | 103.821875 |
| CAM7 | 1.408653 | 103.822806 |
| CAM8 | 1.407675 | 103.823550 |

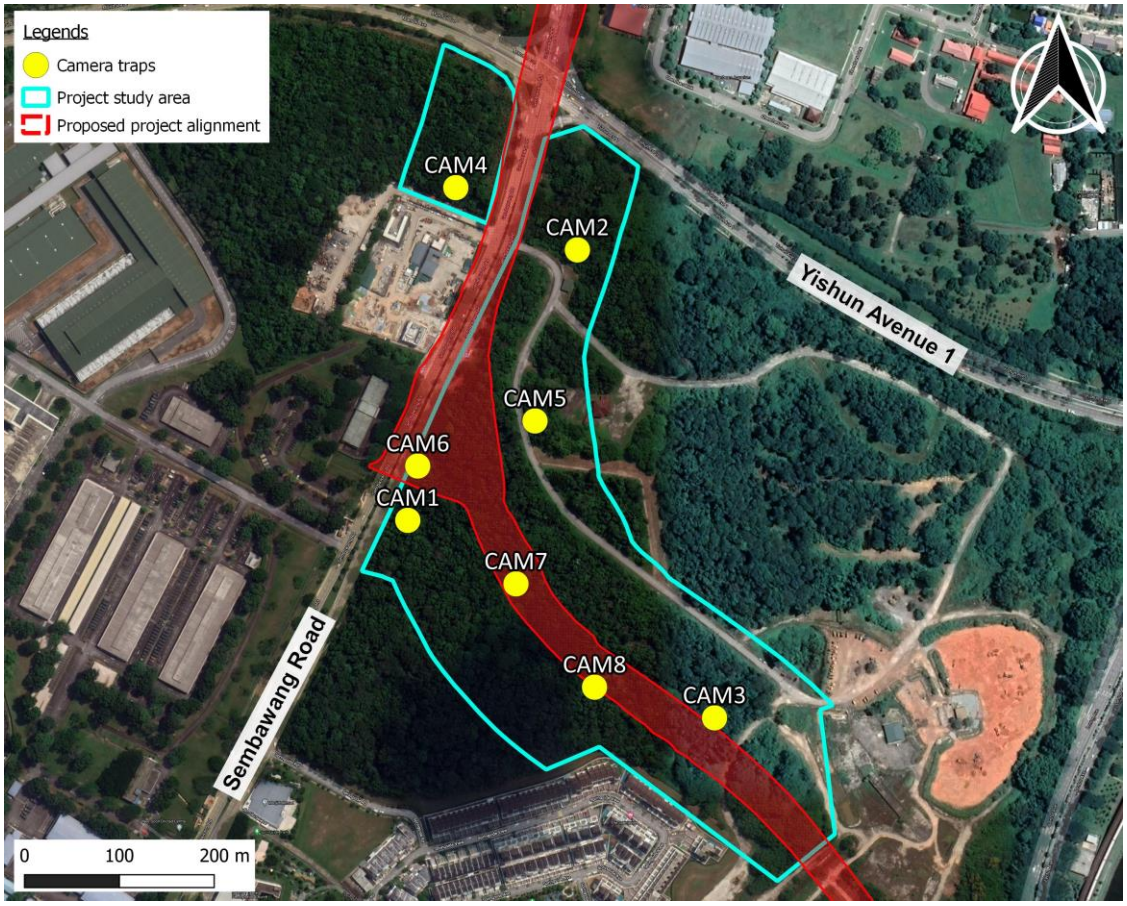


**Figure 4.4.** Location of the camera traps within the project study area

**Figure 4.5.** Example of camera trap setup

***Small Mammal Trapping***

Live trapping of target groups using cage and Elliott traps (see Figure 4.6 for an example of the setup) is an effective tool to capture species diversity, abundance, population structure, and distribution. It is also an effective method to capture animals that are too small to be detected and identified definitively using camera traps. Five cages and five Elliott traps were set throughout the study area (see Table 4.3 for the GPS coordinates and Figure 4.7 for the location on the map). They were checked and rebaited with bananas, peanut butter, and vanilla-scented oats for three consecutive mornings and evenings to assess the diversity, abundance, and movements of both nocturnal and diurnal mammals. Captured individuals were identified in terms of species, sex, and age class before released at the trap site.

**Figure 4.6.** Example of cage trap (left) and Elliott trap (right) setup

**Table 4.3.** Coordinates of small mammal traps within project study area

| Trap ID | Latitude | Longitude |
|---|---|---|
| CAGE1 | 1.409255 | 103.821781 |
| CAGE2 | 1.411816 | 103.823388 |
| CAGE3 | 1.407384 | 103.824687 |
| CAGE4 | 1.412406 | 103.822236 |
| CAGE5 | 1.410196 | 103.822986 |

| Trap ID | Latitude | Longitude |
|---|---|---|
| ELL1 | 1.411037 | 103.823291 |
| ELL2 | 1.410145 | 103.822971 |
| ELL3 | 1.412381 | 103.822415 |
| ELL4 | 1.410549 | 103.822503 |
| ELL5 | 1.407324 | 103.824710 |

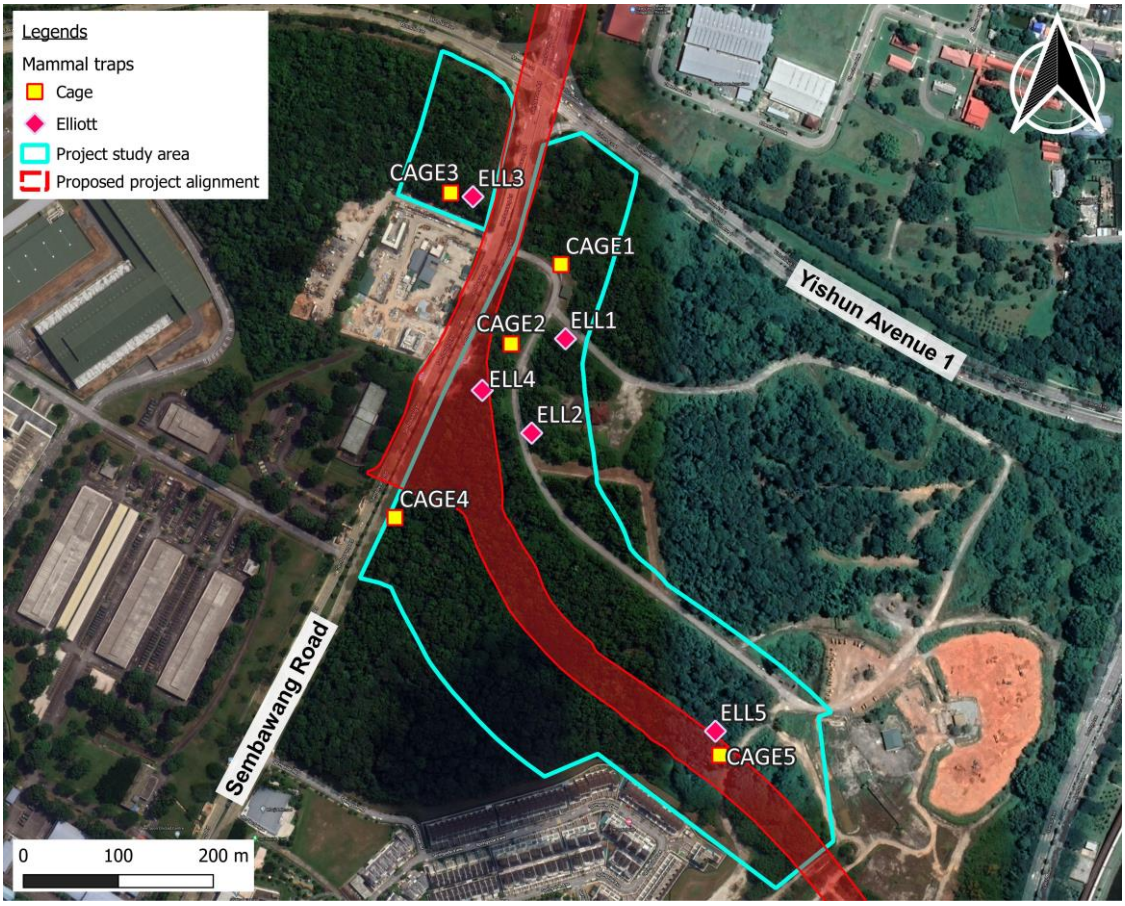


**Figure 4.7.** Location of small mammal traps within project study area

### *Acoustic Bat Surveys*

A Song Meter SM4BAT FS c/w SMM-U1 microphone, manufactured by Wildlife Acoustics, was used for all in-situ recordings in forest habitat: this device can record up to 250 kHz. The detector can be fixed to a tree or other structure and left in place overnight. Audio settings in forest were as follow:

**Table 4.4.** Audio settings used for bat detection

| | | | |
|---|---|---|---|
| **Gain** | Forest: 12 decibels<br>Non-forest: no gain | **Min Trigger Frequency** | 20 kHz |
| **16k High Filter** | On | **Trigger Level** | 12 decibels |
| **Sample Rate** | 500 kHz | **Trigger Window** | 5 seconds |
| **Min Duration** | 0.3 ms | **Max (file) length** | 10 seconds |
| **Max Duration** | None | **Compression** | None |

Table 4.5 tabulates the GPS coordinates and Figure 4.8 maps the location of acoustic bat survey recordings within the project study area.

**Table 4.5.** Coordinates of acoustic bat recording within project study area

| ID | Latitude | Longitude |
|---|---|---|
| Bat Station 1A/1B | 1.409919 | 103.8219 |
| Bat Station 1C | 1.409883 | 103.8221 |
| Bat Station 2 | 1.408617 | 103.8225 |
| Bat Station 3 | 1.40745 | 103.824 |
| Bat Station 4 | 1.41267 | 103.8219 |
| Dusk Survey 1 | 1.410281 | 103.8233 |
| Dusk Survey 2 | 1.407455 | 103.8253 |

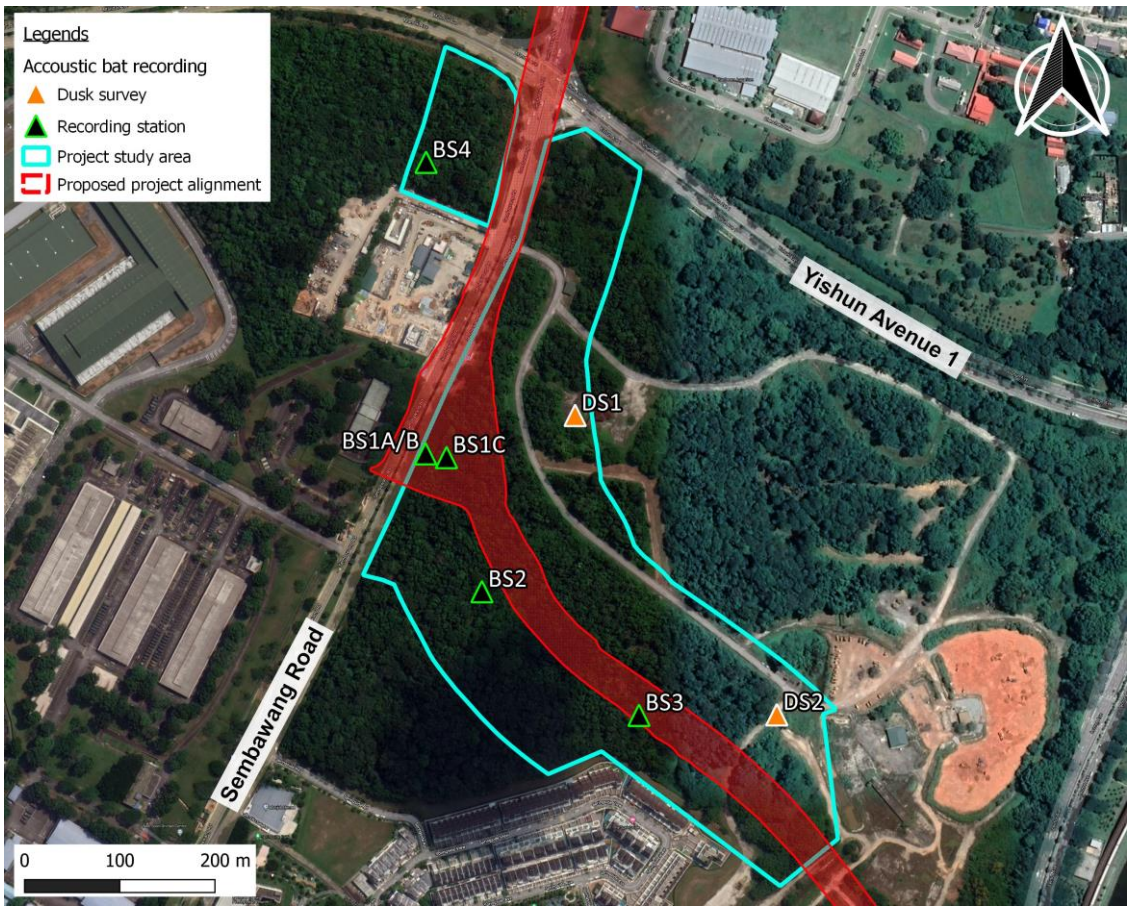


**Figure 4.8.** Location of acoustic bat recording within project study area

Careful review, file deletion (of insect calls and faint calls of the ubiquitous *Scotophilus kuhlii*), and analysis of final data files (.wav format) was undertaken using Kaleidoscope v5.1.9 software. All files were viewed manually: automatic batch filters were not used.

Besides overnight acoustic surveys, in-person dusk surveys were also conducted. For dusk surveys an EchoMeter Touch detector (which can detect acoustic activity up to 120 kHz) was also used as a visual aid to correlate visual sightings of bats with real-time screen output on a tablet device.

***Aquatic Surveys***

Two surveys (one day, one night) were conducted in each of the two streams present on the project site (Figure 4.9). Stream surveys were conducted through the use of hand nets. Fish, molluscs, and decapod crustaceans were trapped and identified to family level or higher. All specimens were released after identification.

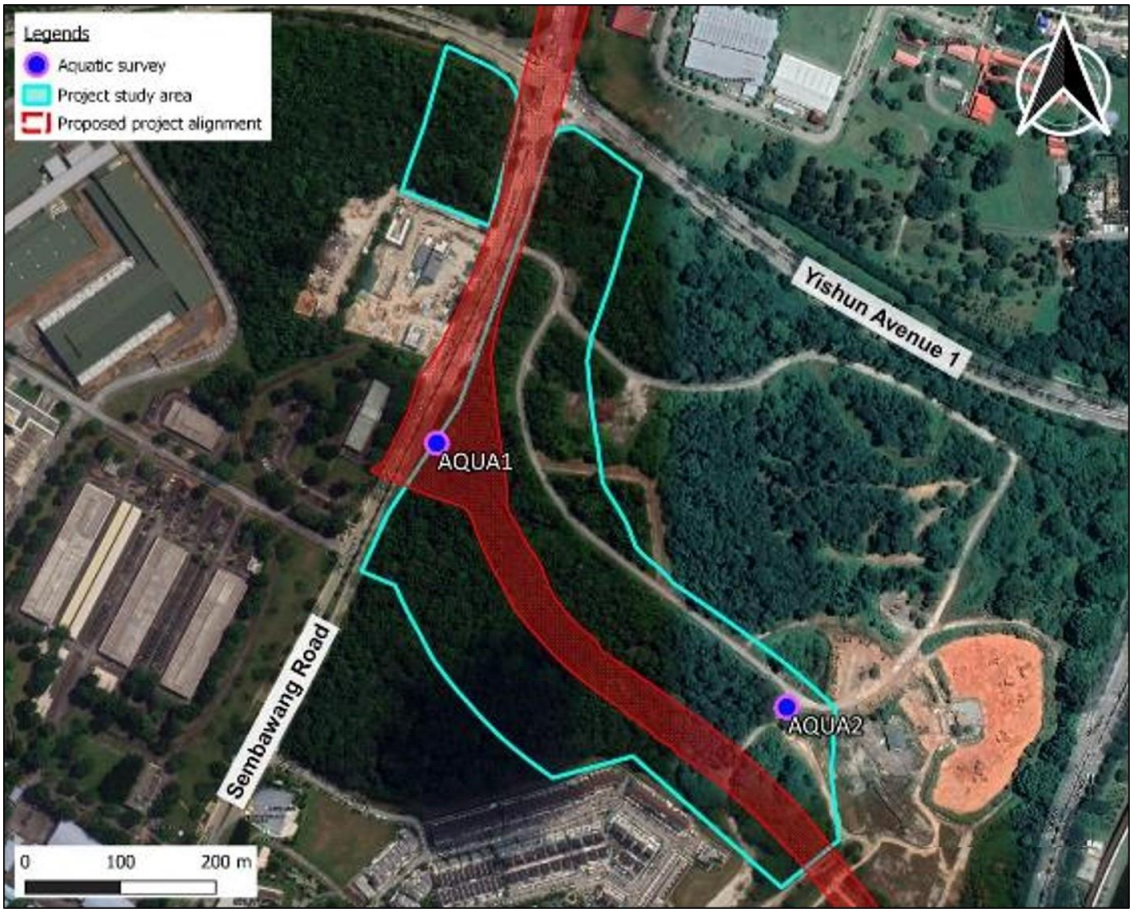


**Figure 4.9.** Location of aquatic survey within project study area

## 4.3 Baseline Results and Discussion

### 4.3.1 Flora

***Flora Field Assessment***

**Appendix C** and **D** respectively report the full list of flora sightings and photographs of observed plants. A total of 64 plant species were recorded during field surveys.

The study area is dominated by the following three broad floral habitats, which was evident based on historical land use of the project site.

- **Rubber Plantation:** Which persists on the east side of Sembawang Road along with minor habitat variations including herbaceous growth along the internal roadsides, Mixed Exotic/Native forest where rubber was not planted after the occupation and Albizia forest in a former agricultural / aquaculture area to the southeast of the site.

- **Native Dominated Regenerated Forest** (pre-war rubber plantation subsequently cleared) that persists on the west of Sembawang Road. Along with it are minor habitat variations, including a Mixed Exotic/Native forest that was recently disturbed along its outer edges and a very recently reforested zone immediately adjacent road edges where trees had been removed for safety consideration of the public.

- **Reforested area** adjacent to Sembawang Road and Mandai Avenue. This area was reforested recently by NParks after trees bordering the roads were cleared for public safety.

As demonstrated in Figure 4.10, the forest located west of Sembawang Road consists of 78% native and 22% exotic & naturalised species, while the forest on the east comprises of 58% native and 42% exotic & naturalised species. Much of the exotic and naturalised species were located at the more disturbed margins of the forest. Notably, the eastern forest is dominated by *Hevea brasiliensis* (Para Rubber) due to its past usage as rubber plantation. There is no particular dominant species in the native-dominated in the west in the same sense as *Hevea brasiliensis* is in the eastern fore, but its prominent species include *Cyrtophyllum fragrans, Ixonanthes reticulata,* and *Elaeocarpus petiolatus.*

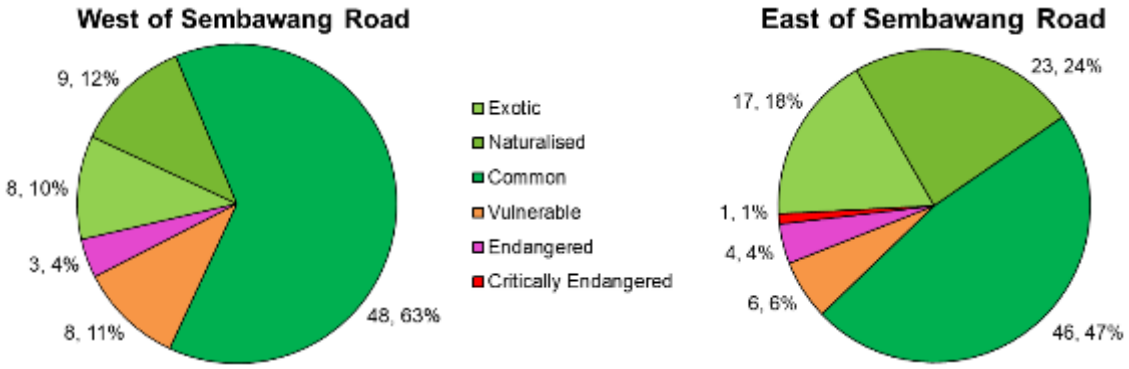


**Figure 4.10.** Proportion of species in the forests by conservation status

The project site east of Sembawang Road is dominated by exotic and naturalised species, in particular *Hevea brasiliensis (*Para Rubber*)* and to a lesser extent *Elaeis guineensis* (Oil Palm*)*, and also houses a small number of species of conservation value. These include the endangered nutmegs *Horsfielia sarcosa* and *Knema malayana* (single instances of which were encountered during the surveys), the critically endangered climber *Agelaea macrophylla* (which occurs on the eastern slopes closest to Sembawang Road where the stream is) and endangered tree *Aporosa subcordata* (that occurs as seedlings and saplings throughout the southern extent of study area). The vulnerable tree fern *Cyathea latebrosa* dominates the area around the short stream.

The conservation of the forest west of Sembawang Road should be preserved as it has the highest conservation value and every effort should be taken to minimise disturbance to this area. Species of conservation concern found include the endangered *Artabotrys suaveolens*, *Callicarpa longifolia,* and *Pandanus atrocarpus* as well as the vulnerable

*Plectocomia elongata*, *Cyathea latebrosa*, *Phytocrene bracteata, Oxyceros longiflorus*, and *Gynochthodes cf. coriacea.* It is noted that the native dominated forest west of Sembawang Road will not be directly impacted by the works due to its setback from the road, however edge effects could impact the forest edge resulting in infiltration of undesirable exotic species.

The reforested area immediately adjacent to Sembawang Rd (west) contains a number of species of conservation concern including the vulnerable *Palaquium obovatam* and endangered species *Cratoxylum cochinchinense* and *Ardisia elliptica*. *Leea rubra* which is considered Nationally Extinct in the wild is now extensively cultivated and is prominent within the reforested area. It is likely that this reforested area will be impacted by construction works and species recovery should be considered prior to clearing.

***Vegetation Mapping***

Eight distinct habitats that exist within the broad characterizations discussed above were identified for the habitat map, images of each are depicted in Figure 4.11.

Native-dominated forest edge

Reforested area

Managed grass along forest edge

Albizia forest

Forest edge with herbaceous growth

Rubber plantation

**Figure 4.11**. Habitat types in project site

A description of each of these classes can be found in Table 4.6 while their locations within the study site are found in Figure 4.12.

**Table 4.6.** Habitat class descriptions

| **Habitat** | **Description** |
|---|---|
| Albizia Forest | There is an area dominated by *Falcataria mollucana* but also features *Acacia auriculiformis*, *Caryota mitis*, and *Terminalia catappa* as prominent species, |
| Herbaceous | The herbaceous areas are mainly lalang areas to the north of the site as well as internal roadside grass areas, |
| Managed Grass | The footpaths adjacent to Sembawang Road, Mandai Ave include grass that is maintained regularly. |
| Mixed Regen | Mixed Exotic and Native Regenerated forest distinct from abandoned rubber plantation. The former bungalow and power-line areas fall under this category. |
| Native Dominated | The native dominated forest is situated to the west of Sembawang Road. As name suggested the species content is mainly native species. The areas were formerly rubber plantation prior to WW2 and was subsequently cleared and never replanted with rubber. The full species list is found in Table 4.9 below. |
| Pond | Pond areas are found to the southeast end of the study area, |
| Reforested area | A strip of land adjacent to Sembawang Rd and Mandai Ave was cleared for public safety reason. The cleared area was reforested by NParks with native species, most of which have conservation status. The species list for this category is found in Table 4.9 below. |
| Rubber Plantation | The majority of the area east of Sembawang Road is former rubber plantation. It includes a very short stream to the western side adjacent to Sembawang Road. There are occasional species of conservation concern throughout. The full species list for this category is found in Table 4.7 below. |

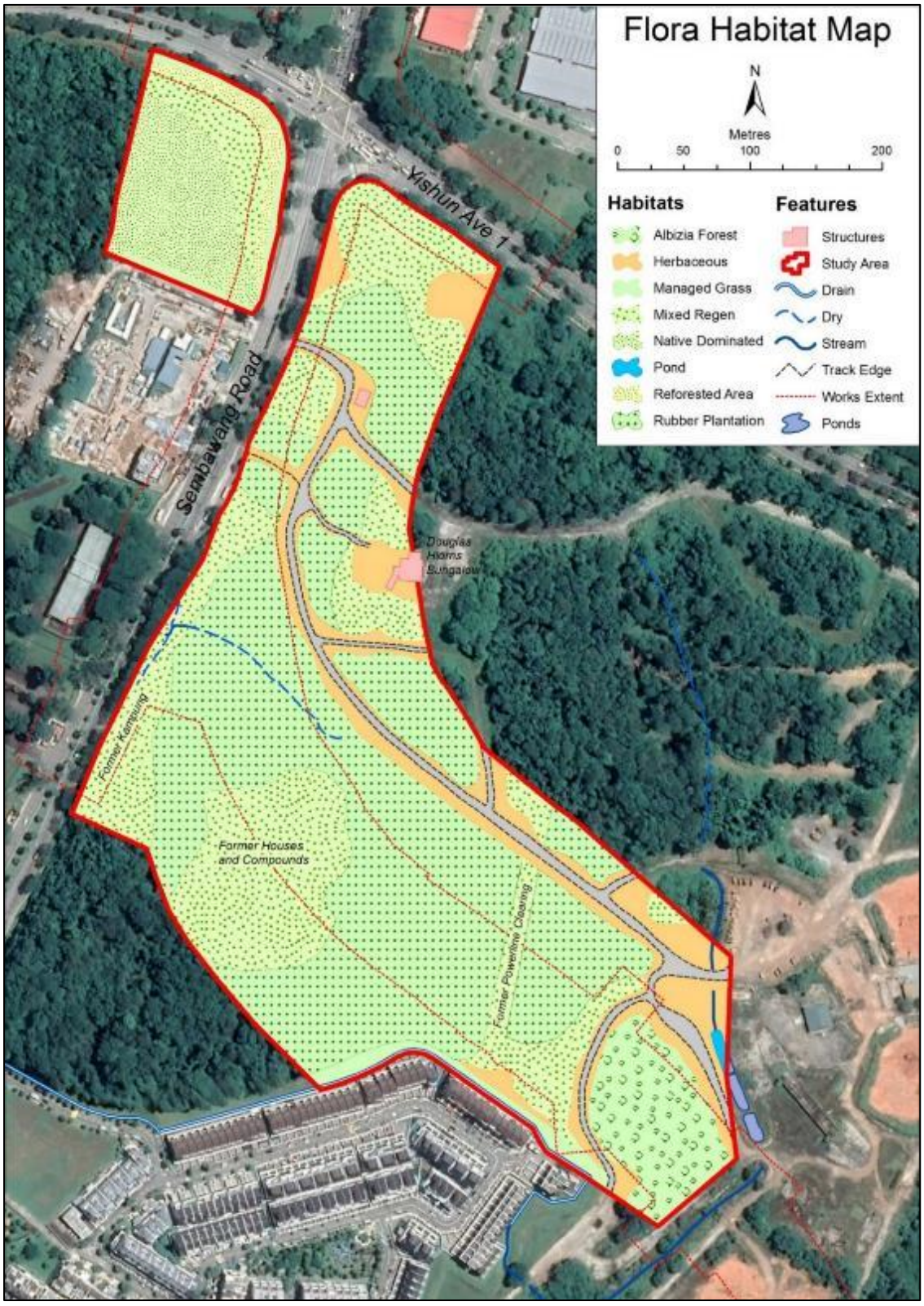


**Figure 4.12.** Habitat map of project study area

### *Species of Conservation Status*

Due to the distinction between the three main habitat groups we list the species of conservation status for each separately.

Forest East of Sembawang Road

**Table 4.7.** Species with conservation status located east of Sembawang Road

| Species | Conservation Status | Type | Comment |
|---|---|---|---|
| *Agelaea macrophylla* | Critically Endangered | Climber | Encountered about the stream area adjacent to Sembawang Road |
| *Aporosa subcaudata* | Endangered | Tree | Abundant as seedlings and small trees within the rubber plantation |
| *Baccaurea motleyana* | [Critically Endangered] | Tree | Abundant as mature trees and seedlings throughout the rubber plantation |
| *Bridelia stipularis* | Vulnerable | Shrub | One instance found next to internal road (rubber plantation) |
| *Callicarpa longifolia* | Endangered | Shrub | One instance found at forest edge - southern end rubber plantation |
| *Cyathea latebrosa* | Vulnerable | Tree | Found sparsely throughout, concentrated within stream area |
| *Cyrtosperma merkusii* | Vulnerable | Herb | Found within former bungalow area (persistent from cultivation) |
| *Ficus aurata* | Vulnerable | Tree | Found mainly adjacent to Sembawang Rd |
| *Horsfieldia sucosa* | Endangered | Tree | One instance found in rubber plantation as sapling |
| *Knema malayana* | Endangered | Tree | One instance found as small sapling in vicinity of stream area |
| *Mangifera odorata* | Vulnerable | Tree | One instance of large tree at SE study area, occasional seedlings throughout rubber plantation |
| *Nephelium lappaceum* | [Critically Endangered] | Tree | Occasionally encountered as seedlings and saplings - considered persistent from cultivation |
| *Oxyceros longiflorus* | Vulnerable | Climber | Occasionally encountered within rubber plantation |
| *Syzygium myrtifolium* | [Extinct] | Tree | Occasionally encountered as seedlings and saplings – considered persistent from cultivation |

Forest West of Sembawang Road

**Table 4.8.** Species with conservation status located west of Sembawang Road

| Species | Conservation Status | Type | Comment |
|---|---|---|---|
| *Ardisia elliptica* | Endangered | Tree | Seedlings found - possible progeny reforested species |
| *Artabotrys suaveolens* | Endangered | Climber | Found only in the native dominated forest west of Sembawang Rd. |
| *Cyathea latebrosa* | Vulnerable | Tree | Found sparsely throughout |
| *Ficus aurata* | Vulnerable | Tree | Encountered occasionally throughout |
| *Gynochthodes cf coriacea* | Vulnerable | Climber | One instance encountered at forest edge (later lost in tree fall) |
| *Nephelium lappaceum* | [Critically Endangered] | Tree | Occasionally encountered as seedlings and saplings - considered persistent from cultivation |
| *Oxyceros longiflorus* | Vulnerable | Climber | Occasionally encountered throughout |
| *Pandanus atrocarpus* | Endangered | Tree | One cluster found within native dominated forest |
| *Phytocrene bracteata* | Vulnerable | Climber | One instance found (later lost to tree fall) |
| *Plectocomia elongata* | Vulnerable | Climber | Occasionally encountered at forest edge |
| *Syzygium myrtifolium* | [Extinct] | Tree | Occasionally encountered as seedlings and saplings - considered persistent from cultivation |

Reforestation Area

**Table 4.9**. Species with conservation status located within reforestation area

| Species | Conservation Status | Type | Comment |
|---|---|---|---|
| *Palaquium obovatum* | Vulnerable | Tree | Planted throughout reforestation area |
| *Cratoxylum cochinchinense* | Endangered | Tree | Planted throughout reforestation area |
| *Ardisia elliptica* | Endangered | Tree | Planted occasionally in reforestation area |
| *Leea rubra* | Extinct | Shrub | Planted extensively throughout reforestation area |

### *Locations of Conservation Status Species*

Flora species of conservation value that were found along transects were mapped out on the study site. The ID tags in Table 4.10 correspond to the locations on Figure 4.13.

**Table 4.10**. Coordinates (WGS84) for conservation status species

| ID | Species | Conservation Status | Longitude | Latitude |
|---|---|---|---|---|
| 1 | *Horsfieldia sucosa* | Endangered | 103.823987 | 1.407531 |
| 2 | *Baccaurea motleyana* | Critically Endangered | 103.824031 | 1.407447 |
| 3 | *Agelaea macrophylla* | Critically Endangered | 103.821971 | 1.409948 |
| 4 | *Agelaea macrophylla* | Critically Endangered | 103.821856 | 1.409152 |
| 5 | *Knema malayana* | Endangered | 103.822050 | 1.410001 |
| 6 | *Cyrtosperma merkusii* | Vulnerable | 103.822839 | 1.408355 |
| 7 | *Aporosa subcaudata* | Endangered | 103.823189 | 1.407938 |
| 8 | *Mangifera odorata* | Vulnerable | 103.823792 | 1.407596 |
| 9 | *Mangifera odorata* | Vulnerable | 103.822110 | 1.409904 |
| 10 | *Cyathea Latebrosa* | Vulnerable | 103.822013 | 1.409949 |
| 11 | *Aporosa subcordata* | Endangered | 103.822184 | 1.409003 |
| 12 | *Aporosa subcaudata* | Endangered | 103.822698 | 1.407454 |
| 13 | *Aporosa subcaudata* | Endangered | 103.822139 | 1.408340 |
| 14 | *Aporosa subcaudata* | Endangered | 103.821923 | 1.408526 |
| 15 | *Aporosa subcaudata* | Endangered | 103.822415 | 1.409018 |
| 16 | *Aporosa subcaudata* | Endangered | 103.823554 | 1.407350 |
| 17 | *Aporosa subcaudata* | Endangered | 103.824835 | 1.407633 |
| 18 | *Mangifera odorata* | Vulnerable | 103.824738 | 1.406945 |
| 19 | *Bridelia stipularis* | Vulnerable | 103.822957 | 1.411114 |
| 20 | *Aporosa subcaudata* | Endangered | 103.823209 | 1.408716 |
| 21 | *Aporosa subcaudata* | Endangered | 103.822319 | 1.408210 |
| 22 | *Aporosa subcaudata* | Endangered | 103.822644 | 1.407878 |
| 23 | *Aporosa subcaudata* | Endangered | 103.821779 | 1.408267 |
| 24 | *Agelaea macrophylla* | Critically Endangered | 103.822035 | 1.409394 |
| 25 | *Ficus aurata* | Vulnerable | 103.823022 | 1.412352 |
| 26 | *Ficus aurata* | Vulnerable | 103.823036 | 1.412482 |
| 27 | *Ficus aurata* | Vulnerable | 103.822251 | 1.409705 |
| 28 | *Aporosa subcaudata* | Endangered | 103.823835 | 1.409108 |
| 29 | *Mangifera odorata* | Vulnerable | 103.824174 | 1.407642 |
| 30 | *Pandanus atrocarpus* | Endangered | 103.821757 | 1.413077 |

| ID | Species | Conservation Status | Longitude | Latitude |
|---|---|---|---|---|
| 31 | *Ardisia elliptica* | Endangered | 103.821949 | 1.412805 |
| 32 | *Artabotrys suaveolens* | Endangered | 103.822150 | 1.412848 |
| 33 | *Artabotrys suaveolens* | Endangered | 103.821902 | 1.413198 |
| 34 | *Callicarpa longifolia* | Endangered | 103.822085 | 1.412286 |
| 35 | *Plectocomia elongata* | Vulnerable | 103.822179 | 1.412272 |
| 36 | *Plectocomia elongata* | Vulnerable | 103.822006 | 1.412437 |
| 37 | *Cyathea latebrosa* | Vulnerable | 103.821711 | 1.412790 |
| 38 | *Oxyceros longiflorus* | Vulnerable | 103.821884 | 1.412596 |
| 39 | *Oxyceros longiflorus* | Vulnerable | 103.823576 | 1.407657 |
| 40 | *Ficus aurata* | Vulnerable | 103.822042 | 1.412813 |
| 41 | *Ficus aurata* | Vulnerable | 103.821819 | 1.413281 |
| 42 | *Ficus aurata* | Vulnerable | 103.822129 | 1.412403 |
| 43 | *Ficus aurata* | Vulnerable | 103.822273 | 1.412921 |
| 44 | *Phytocrene bracteata* | Vulnerable | 103.821848 | 1.412475 |
| 45 | *Gynochthodes cf coriacea* | Vulnerable | 103.822265 | 1.412244 |

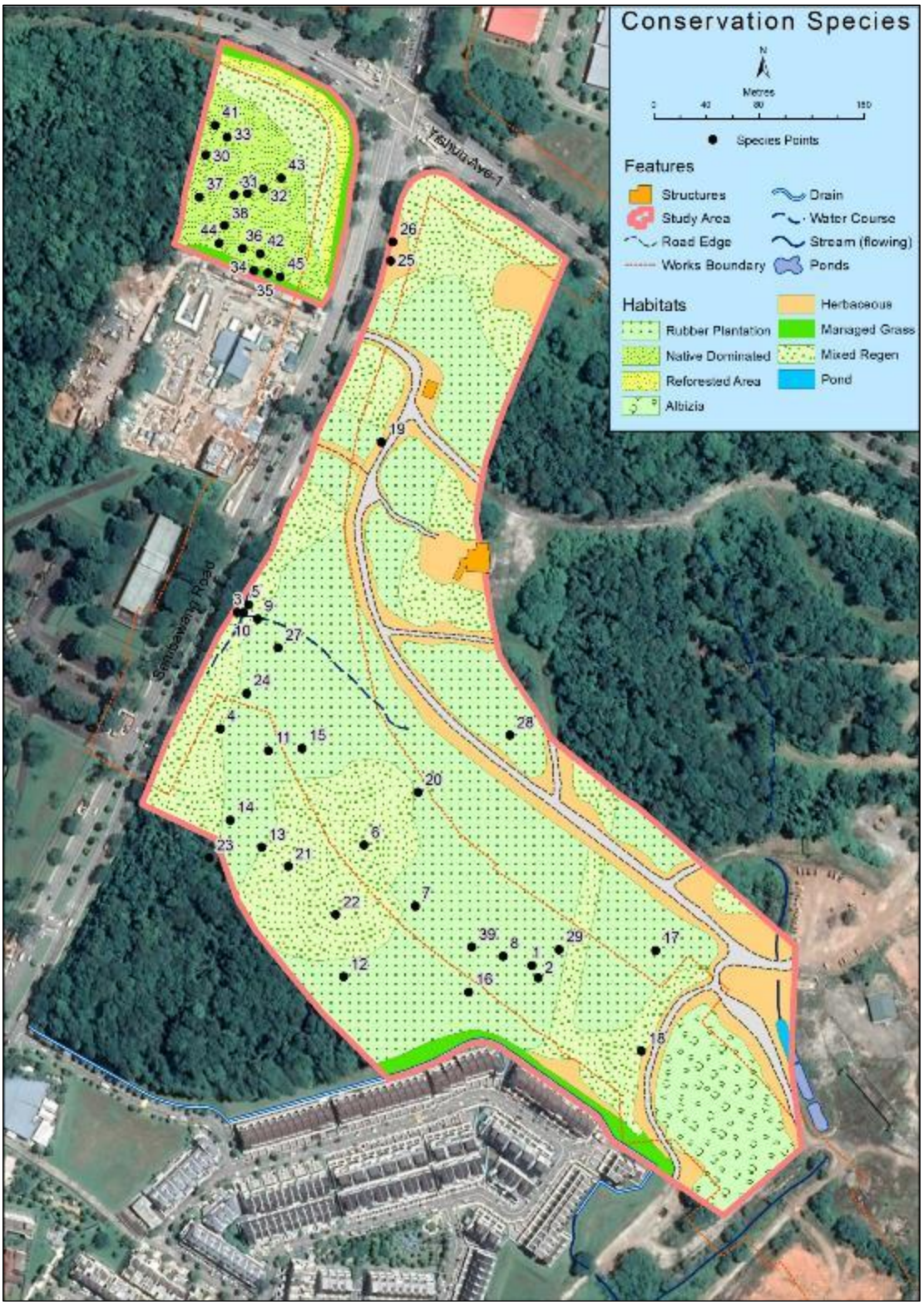


**Figure 4.13.** Map showing locations of species of conservation status

### 4.3.2 Fauna

The complete list of fauna sightings and photographs of observed animals can be found respectively in **Appendix C** and **Appendix E**. Locations of encounter with threatened fauna species are depicted in Figure 4.14 below.

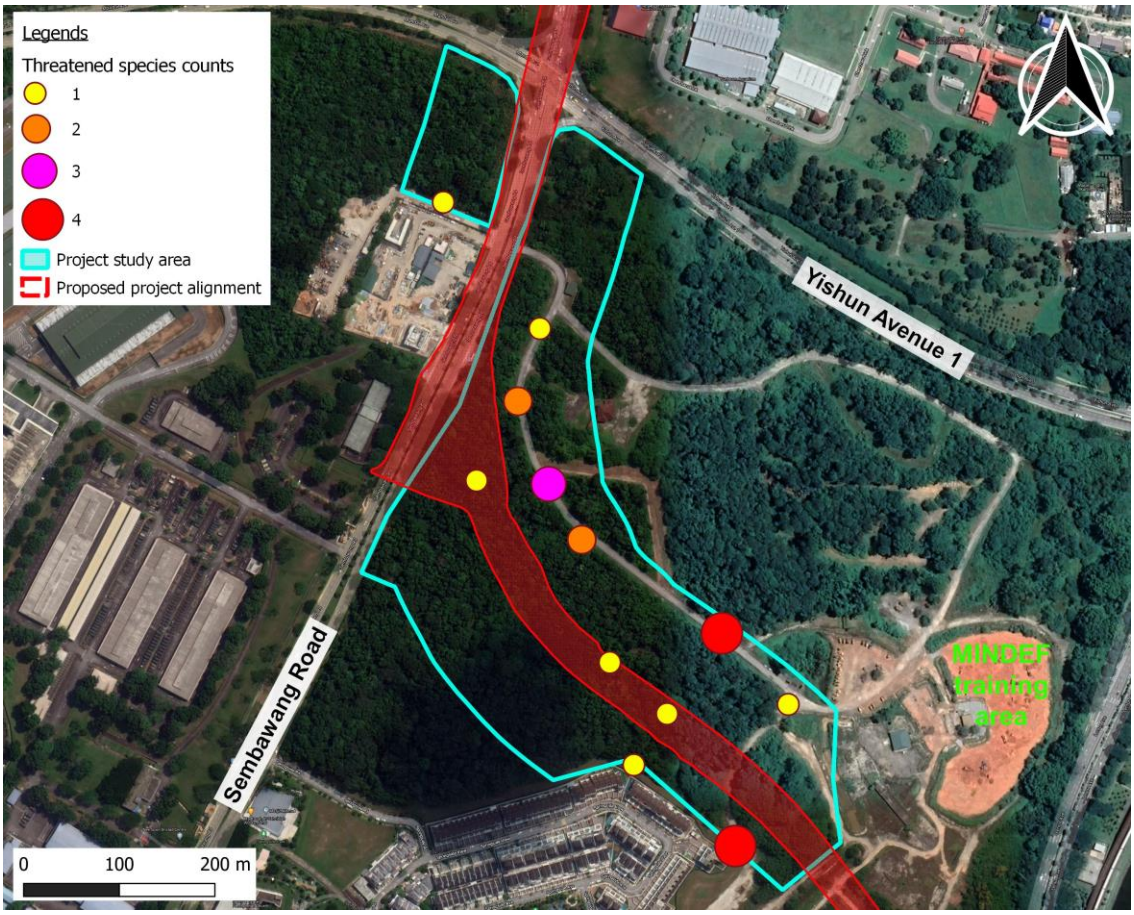


**Figure 4.14.** Locations of encounter with threatened fauna species

#### *Birds*

At least 59 species were observed, of which 8 are locally threatened and 5 are globally threatened or near threatened (see Figure 4.15 for the distribution of number of species of the locally threatened bird species at each point count location). Locally threatened species include the Endangered Blue-crowned Hanging Parrot (*Loriculus galgulus*), Red-wattled Lapwing (*Vanellus indicus*), Changeable Hawk-eagle (*Nisaetus cirrhatus*), Purple Heron (Ardea purpurea), Oriental Magpie-robin (*Copsyschus saularis*), Red Junglefowl (*Gallus gallus*), and Straw-headed Bulbul (*Pycnonotus zeylanicus*); and the Vulnerable Red-legged Crake (*Rallina fasciata*). The Straw-headed Bulbul is also listed as globally critically endangered. Other globally threatened or near-threatened species include the Vulnerable Javan Myna (*Acridotheres javanicus*) and Long-tailed Parakeet (*Psittacula longicauda*) and the Near Threatened Chestnut-bellied Malkoha (*Phaenicophaeus sumatranus*) and Red-breasted Parakeet (*Psittacula alexandri*). However, both Javan Myna and Red-breasted Parakeet are introduced to Singapore.

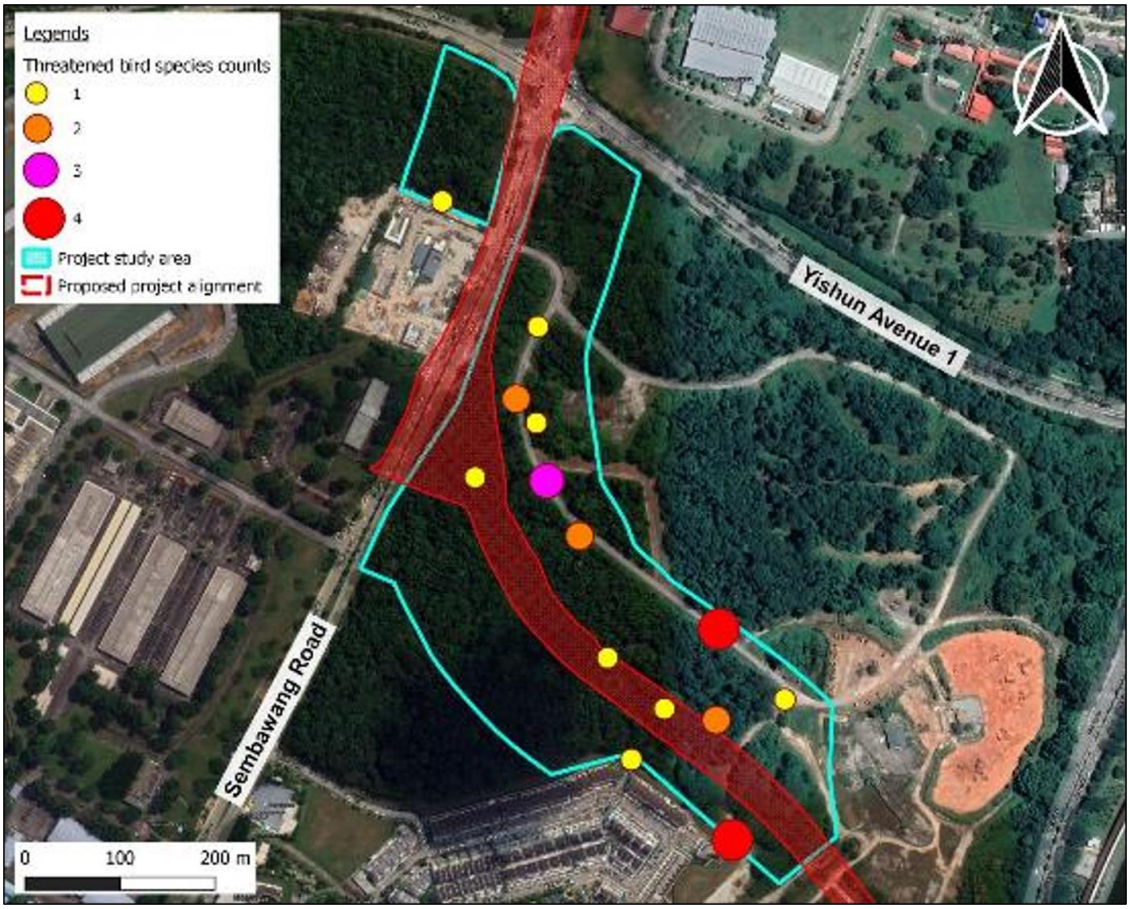


**Figure 4.15.** Distribution of threatened bird species in project study area

On-site observation of several forest species, including the Chestnut-bellied Malkoha, Red-legged Crake, Rufous-tailed Tailorbird (*Orthotomus sericeus*), and Straw-headed Bulbul indicates the site's importance as habitat and foraging ground for such species.

The Straw-headed Bulbul is also a noteworthy species given its globally critically endangered status. While populations Straw-headed Bulbuls on Singapore's mainland have been stable over the past few years, this species' numbers in the rest of Southeast Asia have been declining (Yong et al, 2018). Singapore is an important stronghold of this species, and its habitat need to be preserved for its continued persistence.

***Mammals***

A total of 15 mammal species, including the locally and globally critically endangered Sunda Pangolin (*Manis javanica*) and the locally endangered Black-bearded Tomb Bat (*Taphozous melanopogon*), were recorded in the site. **Appendix C** lists these species.

A total of 8 bat species were recorded on the site, including 7 microchiropterans that were confidently interpreted using sonograms (see **Appendix F** for the explanation and examples of the sonograms). The eighth species, the Common Fruit Bat (*Cynopterus brachyotis*), was recorded through visual observation.

**Table 4.11.** Presence of bat species in each acoustic/dusk survey in the project study area

| Species | Singapore Status | Fixed Acoustic Recording Station | | | | Dusk Survey | | |
|---|---|---|---|---|---|---|---|---|
| | | BS-1 (A,B,C) | BS-2 | BS-3 | BS-4 | DSK-1 | DSK-2 | DSK-3 |
| | | 6 nights | 3 nights | 4 nights | 2 nights | 1.5 hrs | 1.5 hrs | 1.5 hrs |
| ***Narrow-space Foragers ("Forest Bats")*** | | | | | | | | |
| Blyth's Horseshoe Bat<br>*Rhinolophus lepidus**<br>Family: Rhinolophidae | Restricted, common | V | V | V | - | - | - | - |
| ***Trawling Foragers*** | | | | | | | | |
| Hasselt's Large-footed Myotis<br>*Myotis hasseltii*<br>Family: Vespertilionidae | Widespread, common | V | - | - | - | - | - | - |
| ***Forest Edge and Gap Foragers*** | | | | | | | | |
| Whiskered Myotis<br>*Myotis muricola*<br>Family: Vespertilionidae | Widespread, common | V | V | V | V | V | V | V |
| Lesser Yellow House Bat<br>*Scotophilus kuhlii*<br>Family: Vespertilionidae | Widespread, common | V | - | V | V | V | V | V |
| Greater Bamboo Bat<br>*Tylonycteris robustula*<br>Family: Vespertilionidae | Widespread, common | V | V | - | - | - | - | V |
| Black-bearded Tomb Bat<br>*Taphozous melanopogon*<br>Family: Emballonuridae | Widespread, rare | V | - | - | - | - | V | V |
| ***Open Space Foragers*** | | | | | | | | |
| Pouched Tomb Bat<br>*Saccolaimus saccolaimus*<br>Family: Emballonuridae | Widespread, common | V | V | V | V | V | V | - |

Species with "*" is considered as notable finding. Singapore status follows Baker & Lim (2012).

Most of the species encountered are common and not forest-dependent. The Back-bearded Tomb Bat is considered widespread but rare (Baker and Lim, 2012). However, this bat is likely to be more common than previously thought, or there might have been a recent expansion in their population, as this species is easily recorded in several parts of Singapore and is able to adapt well to urbanised areas (N. Baker, pers. comm.).

Another microchiropteran species found, the Blyth's Horseshoe Bat (*Rhinolophus lepidus*), is considered a notable finding. This species is forest-dependent, and on Singapore Island, appears limited to the Central Catchment Nature Reserves, and some contiguous forest patches including peripheral nature parks. It is suspected that the culvert beneath Sembawang Rd ('Sungei Botak') is used for foraging by this species, but there is no evidence of a roost there: the exit of the culvert was monitored one night at dusk, but no bats were seen to emerge.

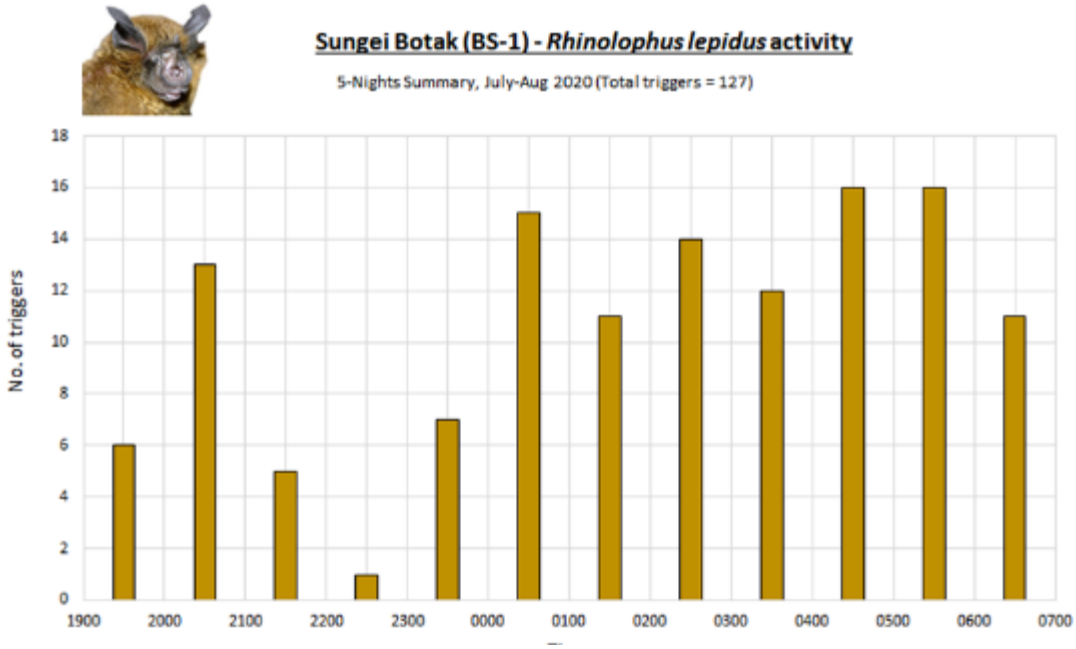


**Figure 4.16.** Search-phase activity of *Rhinolophus lepidus* based on complete dataset of 127 sonograms recorded at BS-1

There was a number of feral dogs (*Canis lupus familiaris*) throughout the site, a species introduced to Singapore. This might require management attention and consideration to remove the dogs from this critical wildlife area as they are known to negatively affect wildlife populations (Young, et al., 2011; Hennings, 2016) through predation, disturbance and disease spread. However, feral dogs do not always have negative impacts on native ecosystems (Hughes & Macdonald, 2013). With the global move towards evidence-based environmental management, a rigorous scientific study to assess the impacts of feral dogs on developments should be carried out before implementing mitigation measures such as culling, removal, or trap, neuter and release of feral dogs.

There was no evidence of Wild Pigs (Sus scrofa) within the project site, either from visual encounter surveys, camera traps, or evidence through scat or wallows.

*Small Mammal Trapping*

After 3 consecutive days and nights of live trapping with 10 cage and Elliott traps, a total of 13 animals were caught. This includes 11 Common Treeshrews (*Tupaia glis*), 1 Plantain Squirrel (*Callosciurus notatus*), and 1 Oriental House Rat (*Rattus tanezumi*). *Rattus tanezumi* is closely related to the black rat (*Rattus rattus*) but is native to Singapore. These species are all common and adapted to urban environments. They were also observed during visual encounter surveys and in camera trap photos.

***Herpetofauna***

A total of 19 herpetofauna (10 reptile and 9 amphibian) species were found on the project site. All species are considered widespread and common except the Green Crested Lizard (*Bronchocela cristatella*), which is widespread but uncommon, and the Clouded Monitor (*Varanus nebulosus*), a species common in certain parts of Singapore. The Clouded Monitor was found on the western side of Sembawang Road. There were also

encounters of both the adults and tadpoles of the Malayan Giant Frog at both streams. This species, while relatively common near stream habitats in Singapore, is listed as globally near-threatened. Four of the species recorded have been introduced to Singapore: Changeable Lizard (*Calotes versicolor*), Banded Bullfrog (*Kaloula pulchra*), Gunther's Frog (*Sylvirana guentheri*), and East Asian Ornate Chorus Frog (*Microhyla fissipes*).

The absence of any herpetofauna species of conservation value is expected due to the nature of herpetofauna. Reptiles are generally elusive and are not observed frequently in surveys. More importantly, herpetofauna species diversity is dependent largely on the variety and quality of habitats present at the site. In particular, most amphibians have specific requirements for waterbodies where they live out the larval stage of their lives. As such, most herpetofauna, particularly amphibians of conservation value on mainland Singapore are restricted to mature forests in the Central Nature Reserves and its surrounding forests. While some herpetofauna of conservation significance may be found in this project site, their numbers are likely to be low.

***Terrestrial Invertebrates***

A total of 36 butterfly species and 10 odonates (dragonflies and damselflies) were encountered during the diurnal biodiversity surveys.

Of the butterflies surveyed, three species are considered Moderately Rare in Singapore. These include the Ancyra Blue (*Catopyrops ancyra*), the Cabbage White (*Pieris canidia canidia*) and the Conjoined Swift (*Pelopidas conjunctus conjunctus*). There was also one likely sighting of an apparently rare butterfly, the Colon Swift (*Caltoris cahira*). This species is not part of official species lists for Singapore.

All odonate species encountered are common in Singapore. Odonate diversity was quite low, but this was likely due to the dearth of waterbodies on the project site, where dragonflies lay their eggs and live out the larval stage of their lives. Water quality surveys of the two waterbodies on the site found low levels of dissolved oxygen, particularly at the stream adjacent to Sembawang Road ('Sungei Botak'), which recorded a low of 2.32 mg/L. The general threshold for supporting aquatic biodiversity in waterbodies is 4 mg/L (see section on Water Quality for further analysis).

While not part of official survey target groups, the Green Tree Snail (*Amphidromus atricallosus temasek*) was also encountered on the site. This species is listed as locally endangered (listed as *Amphidromus atricollis perakensis* in the SRDB) and found in forested areas in only a handful of sites in Singapore.

***Aquatic Fauna***

A total of two fish species were found from surveys of aquatic fauna from the two waterbodies on the project site. Both species, the Mosquitofish (*Gambusia holbrookii*) and the Oriental Swamp Eel (*Monopterus albus*) are common, with the Mosquitofish being an introduced species. Snails from 4 families (Lymnaeidae, Planorbidae, Physidae, and Thiaridae) were also collected from the surveys.

Aquatic biodiversity was surprisingly low, particularly for the stream close to Sembawang Road, where no fish species were recorded. However, as explained in the section on odonates, this is also likely caused by the water quality parameters, particularly the low dissolved oxygen levels. which are unable to support most aquatic fauna.

### *Camera Trapping*

Five camera traps (Cam 1–5) were deployed for a total of 56 days from 25 June to 20 August 2020 with additional 3 camera traps (Cam 6–8) deployed for 17 days from 11 to 28 September 2020. Cam 6 was deployed adjacent to Sungei Botak to monitor fauna movement through the culvert running under the road. Photos were taken daily during the duration of the survey, except for Cam 3 that malfunctioned and stopped taking photos on 3 August 2020, thus losing 17 days of data collection. As the camera traps took a sequence of three photos each time they were triggered, the photos were separated according to their respective sequences. Sequences separated by more than five minutes were assumed to be independent sightings.

190 independent sightings (Table 4.12) identified from more than 799 photos of 15 identified fauna species (Figure 4.17) were collected from the 8 camera traps. 30 detections were made of animals that could not be identified to species level. These unidentified detections were not counted towards the total the overall species count.

**Table 4.12.** Number of sightings from each camera by species (* = locally threatened species)

| Species | Cam1 | Cam2 | Cam3 | Cam4 | Cam5 | Cam6 | Cam7 | Cam8 |
|---|---|---|---|---|---|---|---|---|
| Asian House Rat | 0 | 1 | 0 | 1 | 7 | 0 | 0 | 0 |
| Buffy Fish Owl* | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Common Palm Civet | 1 | 0 | 1 | 2 | 0 | 0 | 0 | 0 |
| Common Treeshrew | 1 | 0 | 10 | 0 | 0 | 3 | 0 | 1 |
| Feral Dog | 1 | 1 | 15 | 0 | 0 | 0 | 1 | 0 |
| Javan Myna | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| Long-tailed Macaque | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| Olive-backed Sunbird | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Olive-winged Bulbul | 0 | 0 | 0 | 0 | 0 | 21 | 0 | 0 |
| Plantain Squirrel | 4 | 2 | 10 | 8 | 11 | 1 | 3 | 2 |
| Red Junglefowl* | 0 | 0 | 4 | 0 | 6 | 0 | 0 | 0 |
| Slaty-breasted Rail | 0 | 1 |  | 0 | 0 | 0 | 0 | 0 |
| Sunda Pangolin* | 0 | 1 | 1 | 1 | 0 | 2 | 0 | 0 |
| White-breasted Waterhen | 0 | 11 | 0 | 0 | 1 | 0 | 0 | 0 |
| White-crested Laughing Thrush | 0 | 0 | 6 | 2 | 0 | 10 | 0 | 1 |
| Unidentified Bat | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Unidentified Bird | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Unidentified Mammal | 0 | 0 | 0 | 1 | 2 | 0 | 2 | 2 |
| Unidentified Rat | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 5 |
| Unidentified (Other) | 0 | 3 | 0 | 0 | 6 | 2 | 1 | 3 |
| **Total Number of Detections** | **9** | **20** | **50** | **15** | **34** | **41** | **7** | **14** |

| Species | Cam1 | Cam2 | Cam3 | Cam4 | Cam5 | Cam6 | Cam7 | Cam8 |
|---|---|---|---|---|---|---|---|---|
| Total Number of Species | 5 | 6 | 9 | 5 | 5 | 5 | 2 | 3 |

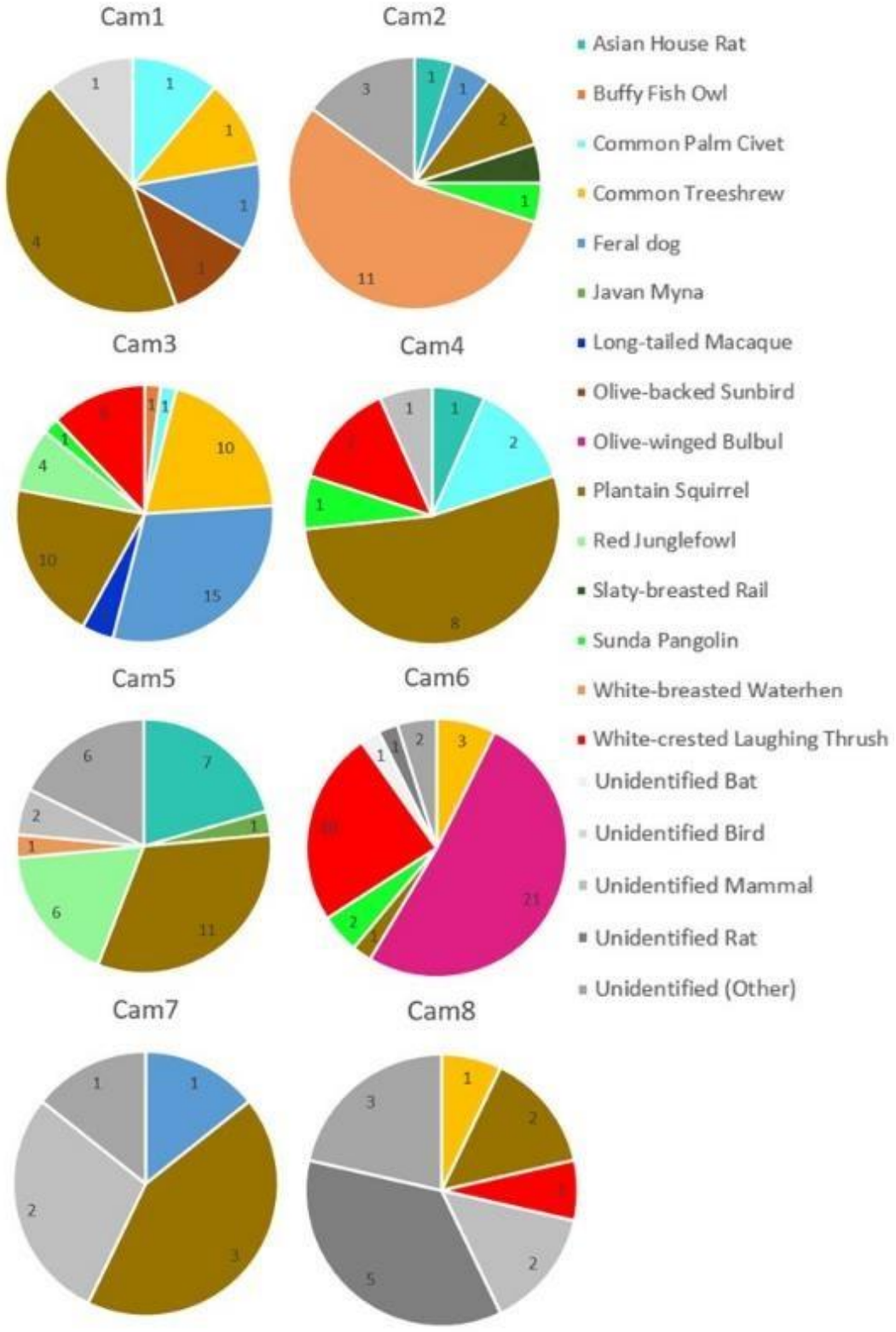


**Figure 4.17.** Proportion of species sightings captured by each camera

Of all the cameras, Camera 3 caught the highest number of species (a total of 9 species), despite the fact that this camera malfunctioned, causing it to take 17 fewer days of footage than the initial 5 cameras. The reason for a higher number of species present is likely to be because of the distance of this camera from Sembawang Road, leading to the lowest levels of anthropogenic disturbance, particularly noise and light from, on the area.

The species most commonly recorded was the Plantain Squirrel (*Callosciurus notatus*), with a total of 41 detections captured across all 8 camera traps.

The cameras captured three threatened species: the locally critically endangered Buffy Fish Owl (*Ketupa ketupu*), found in Camera 3, the locally and globally critically endangered Sunda Pangolin (*Manis javanica*), which was found in Cameras 2, 3, 4, and 6, and the locally endangered Red Junglefowl (*Gallus gallus*), captured by Cameras 3 and 5.

The presence of the Sunda Pangolin indicates that it utilises a quite a large part of the forest. It is presumed that these sightings are of at least two individuals, given that they were found on both the eastern and western sides of Sembawang Road. However, it is unclear if the sightings of this species on two separate cameras in the eastern forest were of the same species. The home range of a Sunda Pangolin in Singapore needs to be better established, but a study done on one female individual in Singapore has tagged its home range to 6.97 ha (Lim & Ng, 2008). Using this estimate, the sightings in the eastern side of Sembawang Road might have been of different individuals, leading to the presumption that there are at least three individuals using the study area.

Camera 6 was facing the stream habitat ('Sungei Botak') and the culvert which passed under Sembawang Road. Both the Sunda Pangolin and an unidentified bat species were seen within the culvert. As mentioned in the results, the culvert is likely used as a foraging area for bats and Sunda Pangolins, but there is no evidence of it being used as a roosting site or connection for the area across the road. Sungei Botak was also used by several species, including the Olive-winged Bulbul and White-crested Laughing Thrush, which were both seen with wet feathers, presumably from using the stream.


**Figure 4.18** Buffy Fish Owl captured by Camera 3


**Figure 4.19.** Long-tailed Macaque captured by Camera 3


**Figure 4.20.** Sunda Pangolin at the entrance of the culvert, captured by Camera 6

### 4.3.3 Summary of Flora and Fauna Baseline

At least 113 flora species and 142 fauna species (birds, mammals, reptiles, amphibians, lepidoptera, and odonates) were observed in the project study area.

The site was formed on land previously used for villages and plantations, which is not unlike many secondary regrowth forests in Singapore. Floristically, the area west of Sembawang Road, which comprises largely of native-dominated regenerated forest, is of conservation importance, and contains some threatened plant species, including the vulnerable *Palaquium obovatum* and endangered species *Cratoxylum cochinchinense* and *Ardisia elliptica*. The area east of Sembawang Road where most of the project footprint is placed, comprises of fewer threatened species. However, some individuals of the tree fern *Cyathea latebrosa* are found near the stream within the footprint. Since their retention in this area is unlikely to be feasible, translocation of some individuals is recommended.

In terms of fauna, this area consists of several threatened species of birds and mammals, probably due to its proximity and connectivity to other forested areas in the region. These threatened species are largely forest-dependent, and it is important that any future development works in this patch are done sensitively to minimise impacts to populations within the forested areas. All developments should also aim to maintain connectivity between populations in this patch and surrounding patches.

There was a presence of feral dogs and Long-tailed Macaques found in the site. These animals may pose a human-wildlife conflict issue, and should be properly managed, particularly during the construction period.

## 4.4 Impact Assessment

### 4.4.1 Identification of Sources of Potential Impacts

The pre-construction, construction, and operational phases of the road viaduct project may impact the natural environment. The main activity that may impact the sensitive biodiversity receptors is vegetation clearance, which may result in species mortality (for both flora and fauna) and habitat loss (mainly for fauna). Sources of impacts during the different phases of the project are identified as the following:

***Pre-Construction Phase***

- Design and layout of viaduct (permanent)

***Construction Phase***

- Clearance of vegetation for site access, storage of equipment, setting up of temporary hoarding, and other forms of working space (temporary)
- Clearance of vegetation for soil investigation works (temporary)
- Clearance of vegetation and damage to habitats due to construction of viaduct and slip road (permanent)
- Backfilling/excavation of soil for slip road, viaduct, and associated infrastructure (permanent)
- Heavy construction activities such as piling (temporary)

***Operational Phase***

- Fragmentation of habitats due to position of slip road and road viaduct (permanent)
- Increase in human disturbance, traffic, and pollution to the area due to increased accessibility to the site (permanent)

### 4.4.2 Identification of Potential Impacts

This section summarises the potential impacts affecting biodiversity receptors that may take place during the pre-construction, construction, and post-construction phases.

*Species Disturbance and Mortality*

For the purpose of impact assessment, focus is given to species that are either rare or globally/locally threatened according to the local and international databases. Section 4.3 discussed the composition of flora and fauna on the project site. Given the proximity of the site to several other forested areas, the project site contains a number of species of conservation value, both flora and fauna.

Species mortality will be most prominent along the project footprint, where the whole alignment of the viaduct and slip road will be cleared of vegetation. Approximately 600 trees are likely to be affected by the viaduct project. Seventeen flora species of conservation value are found within the project footprint (Table 4.13). Of these, we recommend the transplanting of four species, *Agelaea macrophylla* (climber), *Cyathea latebrosa* (tree fern), *Knema malayana* (seedling), and *Horsfieldia sucosa* (small tree).

**Table 4.13.** List of threatened flora species in the project study area

| No | Species | Conservation Status |
|---|---|---|
| 1 | *Baccaurea motleyana* | [Critically Endangered] |
| 2 | *Agelaea macrophylla* | Critically Endangered |
| 3 | *Horsfieldia sucosa* | Endangered |
| 4 | *Knema malayana* | Endangered |
| 5 | *Aporosa subcaudata* | Endangered |
| 6 | *Pandanus atrocarpus* | Endangered |
| 7 | *Ardisia elliptica* | Endangered |
| 8 | *Artabotrys suaveolens* | Endangered |
| 9 | *Callicarpa longifolia* | Endangered |
| 10 | *Cyrtosperma merkusii* | Vulnerable |
| 11 | *Cyathea latebrosa* | Vulnerable |
| 12 | *Mangifera odorata* | Vulnerable |
| 13 | *Plectocomia elongata* | Vulnerable |
| 14 | *Oxyceros longiflorus* | Vulnerable |
| 15 | *Ficus aurata* | Vulnerable |
| 16 | *Phytocrene bracteata* | Vulnerable |
| 17 | *Gynochthodes cf coriacea* | Vulnerable |

Given that the project footprint is largely within mixed regenerated forest, and that the native-dominated forest west of Sembawang Road will remain relatively untouched, mortality of plants of conservation value will largely be avoided. However, individuals of the locally Vulnerable tree fern *Cyathea latebrosa*, which are found close to the stream, are within the project footprint, and should be transplanted prior to development.

The project site contains several fauna species of conservation value. Significance should be placed on non-volant animals of conservation value. This project site is home to the critically endangered Sunda Pangolin that utilizes much of the site. Sunda Pangolins are known to use hollows in trees to sleep and are thus not often detected during the day. Injury and death of such species may take place in the event that individuals are trapped within working boundaries when vegetation clearance commences.

The presence of several threatened bird species such as the endangered Straw-headed Bulbul and Changeable Hawk Eagle can be found on this site. These species are particularly vulnerable while they are nesting. These species will be impacted if schedules of vegetation clearance do not consider the possibility of nesting birds.

*Loss of Habitats and Connectivity between Habitats*

Vegetation clearance leads to the loss of habitats for fauna species and reduction of foraging habitat, food sources, roosting, breeding and nesting sites, and other resources needed for the continued survival of a species. It is expected that most species found on this site will be able to disperse to surrounding habitats not affected by the works.

There is a short, naturalized stream within the project footprint that is likely to be backfilled during project development. While these works involve the removal of the stream habitat, stream surveys showed this stream to be species-poor in terms of aquatic fauna. However non-aquatic species, including birds, were seen using this stream. The Malayan Giant Frog, an amphibian species that tends to be found near natural stream habitats, were also sighted several times along the banks of the stream. The stream leads to a culvert which crosses Sembawang Road. However, while Sunda Pangolins were also caught on camera trap foraging at the entrance of the culvert, there is no evidence of this species using the culvert to cross the road.

Should there be plans for waterway diversion, it is recommended that the new diversion utilizes a natural bank design, so as to act as an alternative habitat for species that use the current stream for breeding or foraging.

Loss of connectivity between habitats due to the viaduct and slip road may lead to reduced movement between populations on either side of the road. Such fragmentation of populations can in turn lead to reduced gene flow and local extinctions of species. There will also be a new access road for MINDEF as part of the development. However, this access road will not be used frequently as it will not be accessible to general traffic, and as such, impacts on connectivity to fauna species are likely to be relatively low.

*Edge Effects*

Vegetation clearance may also have indirect impacts to ecology, including the creation of edge effects in the surrounding habitats, where forest edges are exposed to abiotic and biotic changes due to vegetation clearance. The edge effect may lead to changes in microclimates, forest structure, and ecological interactions. Gradual deterioration of habitats and changes in flora and fauna communities on either side of the road viaduct due to edge effects may also occur.

*Changes in Soil and Topography*

Vegetation plays an important role in soil stability. Where vegetation clearance has taken place, soil will be left vulnerable to erosion, particularly during rainy periods. Erosion may lead to siltation of waterbodies, and also the runoff of nutrients in topsoil, leading to lowered nutrient levels of the remaining soil on the site.

Where there are planned earthworks within the project footprint, impacts to habitats, including streams and other localized habitats, and species are likely to be felt. Impacts on the biodiversity may go beyond the actual footprint of working boundaries due to indirect impacts caused by associated works such as backfilling, compaction, and soil excavation.

*Invasive Species*

Invasive species have many impacts on biodiversity, including the displacement of native species (Peh, 2010), hybridization of distinct populations (Vuillaume et al., 2015; Peh, 2010), and degradation of ecosystem services (Çinar, 2014).

In the case of construction activities, invasive plants are sometimes introduced through seeds embedded in construction equipment and the boots of construction personnel.

*Human–Wildlife Conflict*

There is a presence of numerous feral dogs within the project site. Given that most of the forested area will remain undeveloped and inaccessible to the general public, human wildlife issues are most probably during the construction phase. If measures are not taken to ensure dogs are not able to enter the working area, attacks on construction personnel are possible during the construction phase.

*Potential Roadkill*

The project site is located along and adjacent to Sembawang Road, which is busy at most times of the day. During the construction phase, if measures are not taken, animals are likely to run across Sembawang Road, particularly during periods of high disturbance such as tree felling and heavy construction. This may lead to an increased incidence of roadkill, which poses negative impacts on both the wildlife present on the site as well as drivers along the road.

Based on the assessment above, some of the potential impacts on site's biodiversity are deemed to be permanent in nature while the others are short-term and reversible. Appropriate measures are to be proposed to mitigate these impacts.

Additionally, critical impacts of other physical parameters are discussed in their relevant chapters. Impacts of noise on biodiversity are addressed in Chapter 5, impacts on water quality are discussed in Chapter 6, impacts of air quality on biodiversity are discussed in Chapter 7, and impacts of night lighting on biodiversity are addressed in Chapter 8.

### 4.4.3 Evaluation of Potential Impacts

Table 4.14 summarises the impacts with their corresponding Environmental Scores before and after the implementation of mitigation measures, which are elaborated in the following section.

## 4.5 Mitigation Measures

Mitigation measures should be available to reduce the impacts of the works on the environment. Most measures are covered in this chapter, but mitigation measures for biodiversity are also covered in relevant chapters on physical parameters.

***Pre-construction and Construction Phase***

Direct impacts on important habitats, in this case the native-dominated regenerated forest on the west of Sembawang Road, should be avoided. Direct impacts to other habitats should be minimised where possible. The design of access routes, storage areas, and other working areas should also aim to minimise the amount of land area used. All working areas should be hoarded up so as to prevent any inadvertent damage to these habitats. Where the stream habitat will be backfilled, an alternative route for the flow of water should be established. Where feasible, this diversion should consist of naturalised banks so as to act as a replacement habitat for the backfilled stream.

Indirect impact to the important habitats should also be avoided. Care must be taken to ensure that soil erosion or sediment runoff does not affect adjacent habitats, particularly

waterbodies. As such, proper Earth Control Measures (ECMs) should be in place. As far as possible, the project should utilise construction materials that are inert so as not to release chemicals into surrounding habitats.

Trees identified for retention at the boundaries of the working area should be demarcated by Tree Protection Zones (TPZs) determined by ISA-certified arborist (see Figure 4.21 for diagram example). Where feasible, other trees of conservation value in construction footprint can be salvaged and transplanted to other sites or near the project site.

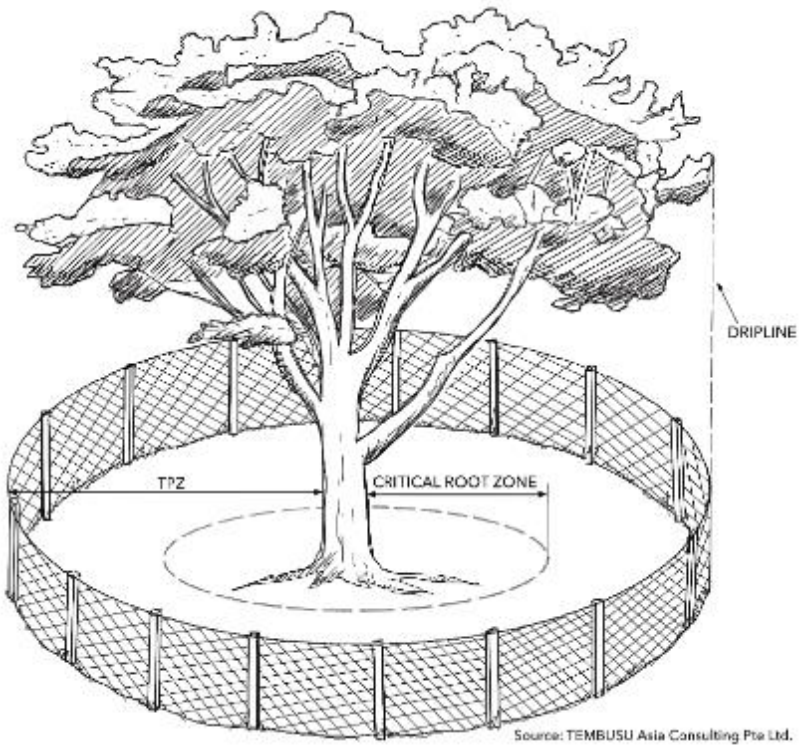


**Figure 4.21.** Diagram of a hoarding demarking a Tree Protection Zone

Given the nature of the project, the clearance of some areas with threatened plant species is unavoidable. In such cases, we recommend the salvaging of sapling and small individuals of plants of conservation value. We recommend the transplanting of four species, *Agelaea macrophylla* (climber), *Cyathea latebrosa* (tree fern), *Knema malayana* (seedling), and *Horsfieldia sucosa* (small tree).

Mortality of fauna species of conservation value should be avoided. In general, the fauna of conservation value recorded include birds and mammals that are highly motile, hence the works should not greatly affect their survivability. However, some measures can be put in place to further decrease species mortality. Prior to any tree felling, the project site should be inspected for active bird nests or holes, and chicks should be allowed to fledge prior to tree felling. Tree hollows should also be inspected for species of conservation value such as the Sunda Pangolin, and such species should be translocated prior to tree felling. Trees should be felled in stages to give time for less motile fauna to move into other forested areas. Tree felling works are also to avoid the nesting period of many birds (between the months of February and July).

Mortality from roadkills of highly motile fauna species such as Sunda Pangolins and feral dogs must also be avoided. Currently, Sunda Pangolins are using the project site, including the stream, as foraging ground. Prior to any site clearance, these animals should be herded away from the site. Hoarding should also be erected to prevent re-entry of the animals into the project site.

It is recommended to maintain the connectivity for highly motile species using the site during construction phase. It can be accomplished through provision of openings across the project boundary to allow animals to cross throughout the construction phase. This will help maintain connectivity between forested patches on both sides of the project footprint. As confirmed with the Contractor, the wildlife connectivity corridors will be provided and maintained during construction phase within the forested area. As per the Site Utilization Plan, the width of corridor will be 6m and will provide passage for animals to cross the project site. The Site Utilization Plan is presented in **Appendix G**.

Replanting should utilise native plant species to prevent the possibility of invasive species from invading the adjacent forested areas.

The presence of many feral dogs may pose a threat to human health and safety. Dependence on humans for food could lead to aggressive behaviour in wild animals. To prevent wild animals from scavenging on construction site, areas for food consumption, storage, and waste disposal should be demarcated and managed. The personnel should also be briefed on what to do should they encounter specific wild animals.

***Operation Phase***

As per the layout plan, the proposed viaduct will be constructed 20 m above ground level, supported by piers spaced 40–50 m apart. As such, spatial connectivity will be maintained below the viaduct level, allowing animals to cross. It is recommended that the area under the viaduct is planted with shade tolerant shrubs to make it more conducive to fauna that are forest dependent.

Where the slip road enters the forested area before it joins with the viaduct, signages can be placed at locations where the road starts to cross the vegetated area in both directions to alert drivers to the possibility of crossing by small animals such as monkeys, rodents, and snakes. Physical barriers should also be erected along the slip road to reduce the possibility of roadkill.

Although the new access road is likely to be used infrequently, to be prudent, we recommend the erection of signages on the access road to alert drivers of potential animal crossings.

Mitigation measures involving the impacts of noise, water quality, air quality, and light to biodiversity are addressed in their respective chapters.

In summary, the mitigation measures that should be implemented to mitigate the impacts on sensitive biodiversity receptors are as follow:

- Ensure road layout avoids targeted sensitive receptors where possible
- Erect temporary hoarding prior to vegetation clearance
- Waterway diversion (if applicable) should incorporate natural bank design where possible
- Identify trees and plants to be transplanted
- Establish Tree Protection Zones (TPZ) for trees to be retained
- Visually inspect trees and holes for nesting birds and species of conservation value prior to felling
- Retain corridors between forested areas to allow for animal movement
- Replant new planting verges with native plant species
- Reinstate habitats where possible upon completion of works
- Implement proper ECMs to prevent impact to adjacent habitats
- Ensure equipment, vehicles, and footwear are clean prior to commencing works
- Establish designated areas for food and waste disposal
- Demarcate and manage areas for food consumption, storage, and waste disposal
- During the construction phase, conduct information sessions for workers on what to do upon encountering wildlife
- Incorporate signs and fences to prevent illegal entry into vegetated areas
- Regularly monitoring of trees and vegetation health during construction phase within project site
- Erect signages during the operational phase to alert drivers of potential animal crossings
- Erect physical barriers along slip road to prevent animals from crossing

A stakeholder consultation session was conducted with various Nature Groups to discuss the anticipated environmental impacts and to brief them on recommended mitigation measures as detailed above.

**Table 4.14.** Environmental Scores of the identified impacts on site's biodiversity with corresponding mitigation measures

| Phase | Impact component | Predicted impact before mitigation | | | | | | | Mitigation measures | Predicted impact after mitigation | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | I | M | P | R | C | ES | Impact | | I | M | P | R | C | ES | Impact |
| ***Ecology*** | | | | | | | | | | | | | | | | |
| Pre-Construction | Flora and fauna damage and mortality due to vegetation clearance for temporary working space | 3 | -3 | 2 | 3 | 2 | -63 | Minor negative | • Erect temporary hoarding<br>• Identify trees to be transplanted<br>• Establish Tree Protection Zones (TPZ) for trees to be retained<br>• Visually inspect trees and holes for nesting birds and animals prior to felling | 3 | -3 | 2 | 3 | 2 | -63 | Minor negative |
| | Loss of habitats due to vegetation clearance for temporary working space | 3 | -3 | 2 | 2 | 2 | -54 | Minor negative | • Erect temporary hoarding to limit vegetation clearance<br>• Reinstate habitats where possible upon completion of works | 3 | -2 | 2 | 2 | 2 | -36 | Slight negative |
| | Loss of connectivity for fauna due to habitat fragmentation from vegetation clearance | 3 | -2 | 2 | 2 | 2 | -36 | Slight negative | • Retain corridors between forested areas to allow for animal movement | 3 | -2 | 2 | 2 | 2 | -36 | Slight negative |
| Construction | Flora and fauna mortality due to vegetation clearance for building of viaduct and associated infrastructure | 3 | -3 | 3 | 3 | 3 | -81 | Moderate negative | • Erect temporary hoarding<br>• Identify trees to be transplanted<br>• Replant new roadside verge with selected native species<br>• Establish Tree Protection Zones (TPZ) for trees to be retained<br>• Visually inspect trees for nesting birds prior to felling | 3 | -2 | 3 | 3 | 3 | -54 | Minor negative |
| | Loss of habitats due to vegetation clearance for building of viaduct and associated infrastructure | 3 | -3 | 3 | 3 | 3 | -81 | Moderate negative | • Erect temporary hoarding to limit vegetation clearance<br>• Reinstate habitats where possible upon completion of works | 3 | -2 | 3 | 3 | 3 | -54 | Minor negative |
| | Indirect impact on habitats including waterbodies due to soil erosion | 2 | -3 | 3 | 2 | 2 | -42 | Minor negative | • Implement proper Earth Control Measures (ECMs) | 2 | -2 | 3 | 2 | 2 | -28 | Slight negative |
| | Impact on native species due to the introduction of invasive species | 2 | -2 | 3 | 3 | 3 | -36 | Slight negative | • Ensure equipment, vehicles, and footwear used are clean prior to commencing works. | 2 | -2 | 3 | 3 | 3 | -36 | Slight negative |

| Phase | Impact component | Predicted impact before mitigation | | | | | | | Mitigation measures | Predicted impact after mitigation | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | I | M | P | R | C | ES | Impact | | I | M | P | R | C | ES | Impact |
| | | | | | | | | | • Use native plants for replanting of roadside verges | | | | | | | |
| | Loss of connectivity for fauna due to habitat fragmentation from vegetation clearance | 3 | -3 | 3 | 3 | 2 | -72 | Minor negative | • Retain corridors between forested areas to allow for animal movement | 2 | -2 | 2 | 2 | 2 | -24 | Slight negative |
| | Impacts to flora and fauna due to illegal encroachment of vegetated areas by construction personnel | 2 | -2 | 2 | 2 | 3 | -28 | Slight negative | • Incorporate signs prohibiting entrance into vegetated areas.<br>• Erect fences to prevent illegal entry | 2 | -2 | 2 | 2 | 3 | -28 | Slight negative |
| Operation | Roadkill or road injury to fauna attempting to cross the slip road | 3 | -2 | 2 | 2 | 2 | -36 | Slight negative | • Erect physical barriers to prevent fauna from crossing the road<br>• Erect signages to alert drivers about potential animal crossings | 3 | -1 | 2 | 2 | 2 | -18 | Slight negative |
| ***Human Health and Safety*** | | | | | | | | | | | | | | | | |
| Pre-construction / Construction | Attacks of construction personnel by animals including feral dogs and Long-tailed Macaques | 3 | -4 | 2 | 3 | 2 | -84 | Moderate negative | • Establish designated areas for food and waste disposal<br>• Conduct information sessions on what to do upon encountering wildlife | 3 | -3 | 2 | 3 | 2 | -63 | Minor negative |
| | Impact to health of personnel due to tick/ mite bites from feral dogs | 3 | -3 | 2 | 3 | 2 | -63 | Minor negative | • Implement proper use of Personal Protective Equipment (PPE) | 3 | -2 | 2 | 3 | 2 | -42 | Minor negative |
| | Injury caused by tree falls due to damaged roots | 3 | -4 | 2 | 3 | 2 | -84 | Moderate negative | • Establish Tree Protection Zones (TPZ) for trees to be retained<br>• Regularly monitor health of trees on project site | 3 | -3 | 2 | 3 | 2 | -63 | Minor negative |
| Operation | Increase in road accidents due to wildlife crossing slip road | 3 | -4 | 2 | 2 | 2 | -72 | Minor negative | • Erect signages to alert drivers of potential animal crossings. | 3 | -3 | 2 | 2 | 2 | -54 | Minor negative |

# 5 NOISE

## 5.1 Introduction

The project study area is largely vegetated with an internal network of roads for MINDEF usage. Main source of noise comes from the traffic in Sembawang Road at the west of the site, with occasional source being the activities conducted by MINDEF in the area. Identified sensitive noise receptors include fauna species that are susceptible to noise pollution (e.g. those which require a quiet environment to find prey and those with acute hearing); people who will be working on the site, e.g. construction workers; and residents of housing complex on Springside Crescent, Springside Avenue, and Springside View.

## 5.2 Relevant Environmental Legislation, Guidelines and Standards

The Environmental Protection and Management (Control of Noise at Construction Sites) Regulation 2008 prescribes the maximum noise levels permissible at construction sites for different days of the week, different periods of the day, and different types of premises affected. The permissible levels are listed in Table 5.1.

**Table 5.1.** Maximum permissible noise levels from construction sites (source: SSO)

| Types of affected buildings | Leq | 7 am – 7 pm | 7–10 pm | 10 pm – 7 am |
|---|---|---|---|---|
| ***Mondays–Saturdays*** | | | | |
| (a) Hospitals, schools, institutions of higher learning, homes for aged sick, etc. | Leq 12 hrs | 60 dBA | 50 dBA | |
| | Leq 5 mins | 75 dBA | 55 dBA | |
| (b) Residential buildings located less than 150 m from the construction site | Leq 12 hrs | 75 dBA | - | |
| | Leq 1 hr | - | 65 dBA | 55 dBA |
| | Leq 5 mins | 90 dBA | 70 dBA | 55 dBA |
| (c) Buildings other than those in (a) and (b) above | Leq 12 hrs | 75 dBA | 65 dBA | |
| | Leq 5 mins | 90 dBA | 70 dBA | |
| ***Sundays and Public Holidays*** | | | | |
| (a) Hospitals, schools, institutions of higher learning, homes for aged sick, etc. | Leq 12 hrs | 60 dBA | 50 dBA | |
| | Leq 5 mins | 75 dBA | 55 dBA | |
| (b) Residential buildings located less than 150m from the construction site | Leq 12 hrs | 75 dBA | - | |
| | Leq 5 mins | 75 dBA | 55 dBA | |
| (c) Buildings other than those in (a) and (b) above | Leq 12 hrs | 75 dBA | 65 dBA | |
| | Leq 5 mins | 90 dBA | 70 dBA | |

**No Work Rule on Sundays and Public Holidays**

In addition to the setting of the permissible noise limits, NEA has also implemented a rule prohibiting work on Sundays and Public Holidays (PH) for construction sites located within 150 m away from residential premises and noise sensitive premises as follows:

a) Construction Work Commenced on or After 1st September 2010
   - No work allowed from 10:00 pm on Saturday/eve of Public Holiday to 10:00 am on Sunday/Public Holiday

b) Construction Work Commenced on or After 1st September 2011
   - No work allowed from 10.00pm on Saturday/eve of Public Holiday to 7.00am on the following Monday/day after the Public Holiday

## 5.3 Baseline Methodology

The SINGLAS-accredited ASTAR Laboratory Pte Ltd was appointed to conduct the baseline noise monitoring survey, which was carried out on 3–10 August 2020. Three (3) monitoring locations were chosen based on the factors of site access, relevance to project activity, and equipment security. Type 1 noise meter—Rion NL-52 Sound Level Meter—was installed at each location to record the sound pressure level (Leq) with 5-minute sampling intervals for seven (7) consecutive days, yielding the data of Leq 12 hrs, Leq 1 hr, and Leq 5 mins.

Station N1 was located within 150 m of the residential buildings on Springside Crescent, Springside Avenue, and Springside View, hence its monitoring results were compared with type (b) noise limits of EPM (Control of Noise at Construction Sites) Regulation 2008. Noise levels recorded at Stations N2 and N3 were compared with type (c) limits. The complete baseline noise monitoring report is available as **Appendix H** of this report. Table 5.2 lists down the coordinates of the monitoring locations, while shows Figure 5.1 the photographs of on-site monitoring equipment setup and Figure 5.2the location map.

**Table 5.2.** Coordinates of noise monitoring stations

| Noise Monitoring Station | Latitude | Longitude |
|---|---|---|
| N1 | 1.4069194 | 103.8248833 |
| N2 | 1.4099420 | 103.8229030 |
| N3 | 1.4122220 | 103.8220890 |

**Figure 5.1.** Setup of the ambient noise monitoring equipment

From left to right: Station N1, Station N2, and Station N3.

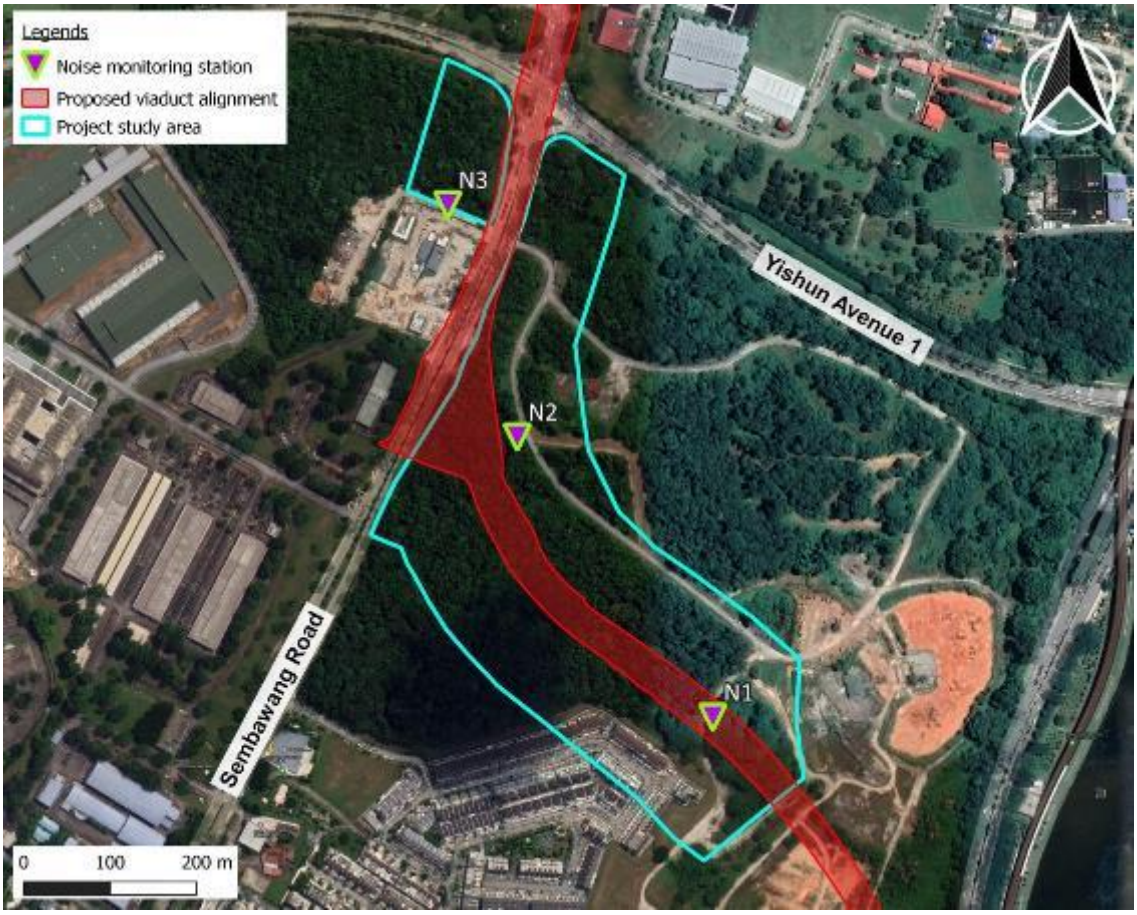


**Figure 5.2.** Location of noise monitoring stations within project study area

## 5.4 Baseline Results and Discussion

The baseline noise level complies with Singapore's noise regulations as evident from the monitoring results respectively in Table 5.3 and Figure 5.3 for Station N1, Table 5.4 and Figure 5.4 for Station N2, and Table 5.5 and Figure 5.5 for Station N3. A noise level exceedance was recorded at 6:55 am on 5 August 2020 at Station N1, which is deemed negligible in terms of frequency and magnitude (55.2 dBA compared with 55 dBA limit).

**Table 5.3.** Summary of the baseline Leq 5 mins noise monitoring results at Station N1

| Date | Monitoring Period | Noise Level (dBA) | | | Maximum Permissible Noise Levels (dBA) |
|---|---|---|---|---|---|
| | | Min. Leq 5 mins | Median Leq 5 mins | Max. Leq 5 mins | Leq 5 mins |
| Mon, 3/8/2020 | 10 am – 7 pm | 46.3 | 49.8 | 59.6 | 90 |
| | 7 pm – 10 pm | 48.4 | 51.9 | 53.4 | 70 |
| | 10 pm – 7 am | 46.8 | 49.8 | 54.8 | 55 |
| Tue, 4/2/2020 | 7 am – 7 pm | 44.9 | 48.9 | 63.2 | 90 |
| | 7 pm – 10 pm | 46.5 | 51.3 | 54.0 | 70 |
| | 10 pm – 7 am | 45.9 | 50.0 | 55.2 | 55 |

| Date | Monitoring Period | Noise Level (dBA) | | | Maximum Permissible Noise Levels (dBA) |
|---|---|---|---|---|---|
| | | Min. Leq 5 mins | Median Leq 5 mins | Max. Leq 5 mins | Leq 5 mins |
| Wed, 5/8/2020 | 7 am – 7 pm | 45.0 | 48.6 | 57.9 | 90 |
| | 7 pm – 10 pm | 46.8 | 50.2 | 56.0 | 70 |
| | 10 pm – 7 am | 45.7 | 50.1 | 54.4 | 55 |
| Thu, 6/8/2020 | 7 am – 7 pm | 45.1 | 49.3 | 58.2 | 90 |
| | 7 pm – 10 pm | 47.3 | 50.9 | 54.1 | 70 |
| | 10 pm – 7 am | 45.7 | 49.3 | 52.6 | 55 |
| Fri, 7/8/2020 | 7 am – 7 pm | 43.9 | 48.6 | 60.4 | 90 |
| | 7 pm – 10 pm | 46.9 | 50.7 | 57.6 | 70 |
| | 10 pm – 7 am | 46.6 | 49.5 | 53.3 | 55 |
| Sat, 8/8/2020 | 7 am – 7 pm | 44.0 | 47.8 | 52.4 | 90 |
| | 7 pm – 10 pm | 46.7 | 49.7 | 51.7 | 70 |
| | 10 pm – 7 am | 45.6 | 49.2 | 52.3 | 55 |
| Sun, 9/8/2020 | 7 am – 7 pm | 41.6 | 46.3 | 71.4 | 90 |
| | 7 pm – 10 pm | 49.3 | 51.8 | 54.4 | 70 |
| | 10 pm – 7 am | 46.4 | 49.2 | 54.2 | 55 |
| Mon, 10/8/2020 | 7 am – 10 am | 45.2 | 47.0 | 53.3 | 90 |

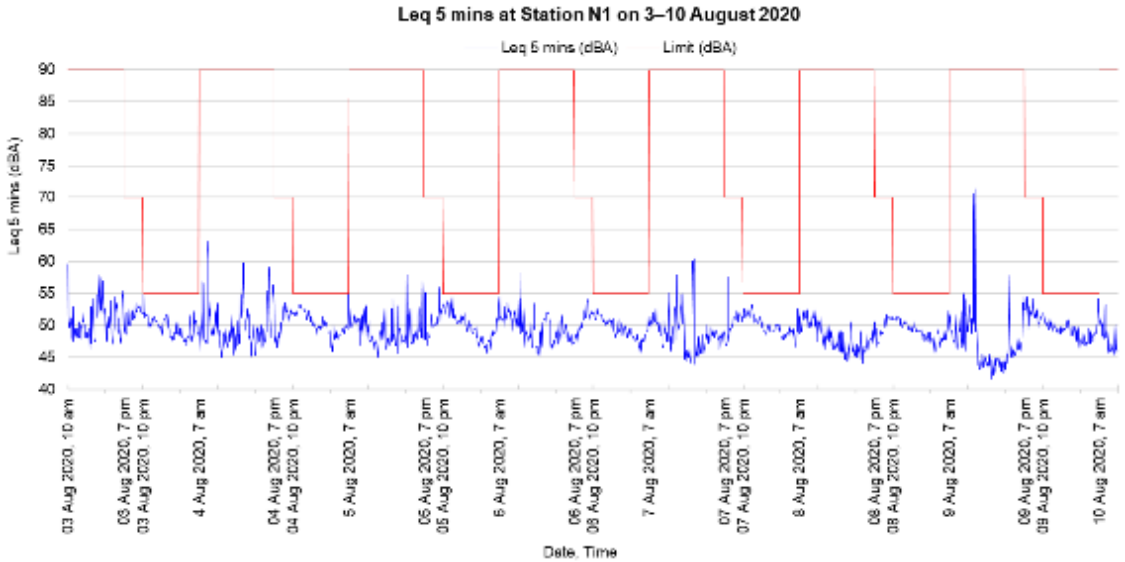


**Figure 5.3.** Baseline Leq 5 mins noise monitoring results at Station N1 over one-week period

**Table 5.4.** Summary of the baseline Leq 5 mins noise monitoring results at Station N2

| Date | Monitoring Period | Noise Level (dBA) | | | Maximum Permissible Noise Levels (dBA) |
|---|---|---|---|---|---|
| | | Min. Leq 5 mins | Median Leq 5 mins | Max. Leq 5 mins | Leq 5 mins |
| Mon, 3/8/2020 | 10 am – 7 pm | 51 | 54.2 | 67.6 | 90 |
| | 7 pm – 7 am | 49.2 | 52.6 | 56.5 | 70 |
| Tue, 4/2/2020 | 7 am – 7 pm | 51.6 | 54.1 | 62.9 | 90 |
| | 7 pm – 7 am | 50.1 | 52.9 | 58.6 | 70 |
| Wed, 5/8/2020 | 7 am – 7 pm | 51 | 53.2 | 58.5 | 90 |
| | 7 pm – 7 am | 50.2 | 53.1 | 57 | 70 |
| Thu, 6/8/2020 | 7 am – 7 pm | 51 | 53.6 | 77.1 | 90 |
| | 7 pm – 7 am | 51.1 | 53.5 | 61 | 70 |
| Fri, 7/8/2020 | 7 am – 7 pm | 49.9 | 53.7 | 62.6 | 90 |
| | 7 pm – 7 am | 51.1 | 53.4 | 57.1 | 70 |
| Sat, 8/8/2020 | 7 am – 7 pm | 49.7 | 52.3 | 72.5 | 90 |
| | 7 pm – 7 am | 50.5 | 52.9 | 57.1 | 70 |
| Sun, 9/8/2020 | 7 am – 7 pm | 48.8 | 51.8 | 69.2 | 90 |
| | 7 pm – 7 am | 49.3 | 53.1 | 56.4 | 70 |
| Mon, 10/8/2020 | 7 am – 10 am | 49.1 | 50.9 | 53.4 | 90 |

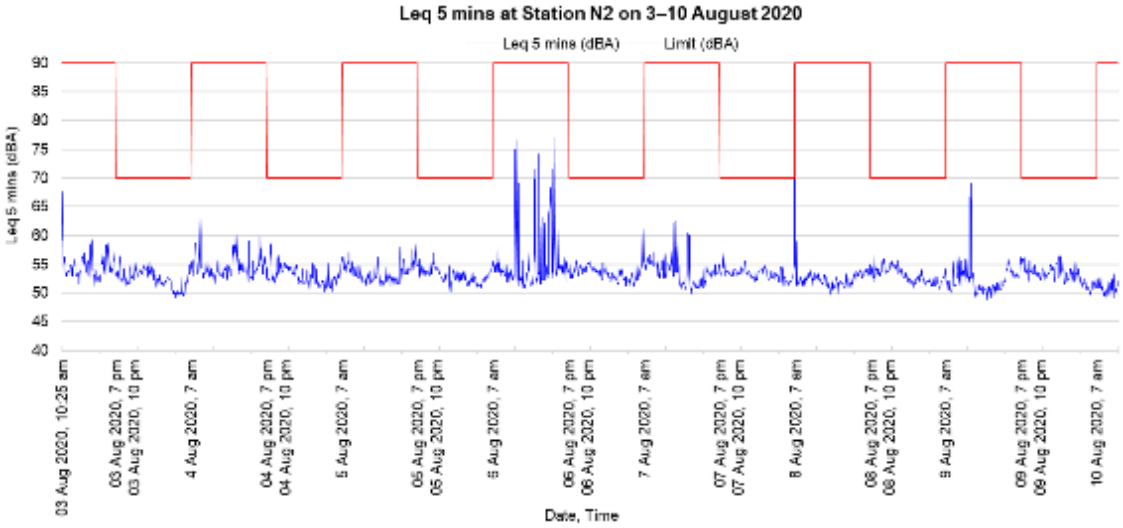


**Figure 5.4.** Baseline Leq 5 mins noise monitoring results at Station N2 over one-week period

**Table 5.5.** Summary of the baseline Leq 5 mins noise monitoring results at Station N3

| Date | Monitoring Period | Noise Level (dBA) | | | Maximum Permissible Noise Levels (dBA) |
|---|---|---|---|---|---|
| | | Min. Leq 5 mins | Median Leq 5 mins | Max. Leq 5 mins | Leq 5 mins |
| Mon, 3/8/2020 | 1 pm – 7 pm | 54.6 | 56.1 | 61.5 | 90 |
| | 7 pm – 7 am | 48.3 | 54.3 | 59.5 | 70 |

| Date | Monitoring Period | Noise Level (dBA) | | | Maximum Permissible Noise Levels (dBA) |
|---|---|---|---|---|---|
| | | Min. Leq 5 mins | Median Leq 5 mins | Max. Leq 5 mins | Leq 5 mins |
| Tue, 4/2/2020 | 7 am – 7 pm | 53.9 | 56.3 | 64.1 | 90 |
| | 7 pm – 7 am | 48.8 | 53.6 | 59.4 | 70 |
| Wed, 5/8/2020 | 7 am – 7 pm | 54.1 | 56 | 60.9 | 90 |
| | 7 pm – 7 am | 48.2 | 54.4 | 58.7 | 70 |
| Thu, 6/8/2020 | 7 am – 7 pm | 53.3 | 55.6 | 59.7 | 90 |
| | 7 pm – 7 am | 47.5 | 52.5 | 57.6 | 70 |
| Fri, 7/8/2020 | 7 am – 7 pm | 53.7 | 55.9 | 60.3 | 90 |
| | 7 pm – 7 am | 50.1 | 53.4 | 57.6 | 70 |
| Sat, 8/8/2020 | 7 am – 7 pm | 53.4 | 55.4 | 58.5 | 90 |
| | 7 pm – 7 am | 48.9 | 52.6 | 57.7 | 70 |
| Sun, 9/8/2020 | 7 am – 7 pm | 52.2 | 54 | 69.8 | 90 |
| | 7 pm – 7 am | 49.4 | 52.8 | 64.7 | 70 |
| Mon, 10/8/2020 | 7 am – 1 pm | 51.8 | 54.1 | 63.8 | 90 |

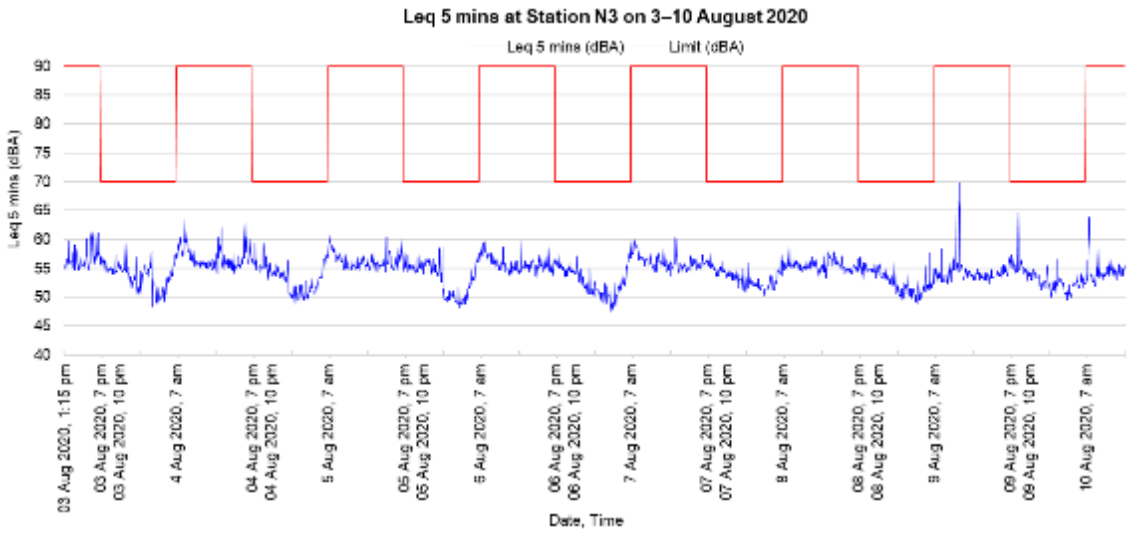


**Figure 5.5.** Baseline Leq 5 mins noise monitoring results at Station N3 over one-week period

## 5.5 Impact Assessment

### 5.5.1 Identification of Potential Impacts

Noise can lead to annoyance due to interference with communication or disturbance to receptors involved in leisure activities, as well as sleep disturbance. The effects of noise may vary with the individual receptor and is dependent on many factors such as the activity that the receptor is engaged in, as well as the duration of noise exposure.

A residential community along Springside Avenue and Springside View—i.e. Brooks

Signature @ Springside—is located approximately 40m away from project boundary. It is a private residential development comprising 114 units of terrace houses and bungalows. Residents of this development are considered as noise sensitive receptors in the context of this project's implementation. There are no schools or hospital in the vicinity of project site.

Additionally, the site is vegetated and is inhabited by many fauna species (see Chapter 4) which may be sensitive to noise. Some of these species, particularly nocturnal species which rely on their hearing for movement, communication, and foraging, are likely to be impacted by increased noise levels. Chronic and frequent noise such as traffic noise interferes with animals' abilities to detect important sounds, whereas intermittent and unpredictable noise such as piling, honking from vehicles and machinery and shouting is often perceived as a threat (Francis & Barber, 2013). This can alter species' behaviour and impair their ability to forage and avoid predation, leading to decreased survivability.

***Pre-Construction and Construction Phase***

Airborne noise levels generated by construction equipment will vary greatly depending on the type of equipment, model and condition of equipment, and duration of operation. The airborne noise levels will be affected by distance, locations (either stationary or mobile sources) and variations in the power of the equipment. The airborne noise levels will also be affected by noise characteristics (either continuous or intermittent noise) of the equipment.

The following activities are identified as potential sources of noise during the pre-construction and construction phases:

- Site clearing, earthworks, and general construction activities (e.g. clearing and preparation, trench excavation, backfill, soil mixing, compaction, spoil handling and transport, building of permanent structures);
- Stockpiling and materials handling (delivery, unloading and use of construction aggregates etc.);
- Vehicle movements from the equipment, materials, and personnel movement in and out of construction work areas; and
- Use of high-impact stationary and mobile equipment such as pile drivers, mobile cranes, excavators, dozers, etc. leading to variable and sporadic noise levels, typically repeating over time.

Main sources of airborne noise emissions i.e. construction equipment/vehicles during construction activities and its typical sound power levels[6] are presented in Table 5.6 below.

**Table 5.6.** List of construction activities with potential sources of noise

| Potential Sources of Noise | Typical A-weighted Sound Power Levels dB(A) |
|---|---|
| Rotary Bored Piling rig | 112–124 |
| Hydraulic Breaker | 110–119 |

[6] Singapore Standard SS602: 2014 – Code of Practice for Noise Control on Construction and Demolition Sites

| Potential Sources of Noise | Typical A-weighted Sound Power Levels dB(A) |
|---|---|
| Crawler Crane (80 hp) | 100–115 |
| Lorry Crane (10 t) | 118–120 |
| Air Compressor (50 hp) | 93–107 |
| Compactor (300 hp) | 117–124 |
| Bulldozer (55hp) | 101–108 |
| Excavator (60 hp) | 103–116 |
| Vibro hammer | 119–130 |
| Dump Truck (20 t) | 102–107 |
| Air compressor (50 hp) | 93–107 |
| Water pump | 99–105 |
| Road Roller (10 t) | 98–106 |
| Generator (110 kVA) | 108 |
| Concrete pump | 102–107 |
| Concrete Mixer | 89–93 |
| Electric Drill | 94 |
| Welding set | 96 |

The increase in noise levels during construction phase may impact the species inhabiting the project site and surrounding environment. The frequency and loudness of noise produced by pre-construction and construction works may interfere with the communication calls of certain animal groups, particularly birds. A large number of birds use calls to communicate between members for the purposes of territory marking, courtship, mating, and predator alarms. Increased environmental noise may mask the birds' song and impact their courting (Swaddle & Page, 2007). Arthropod abundance may also be impacted by the noise pollution due to cascading effects within the ecological network, as well as direct impacts for insects such as crickets that rely on audio signals for mating. This could also result in indirect negative impacts on plants that rely on these organisms for pollination or seed dispersal, or have prey-predator relationships with other impacted species (Bunkley, McClure, Kawahara, Francis, & Barber, 2017).

For fauna receptors which are located within a short distance of the project boundary within Sembawang forested area, noise levels experienced can be dominated by the nearest noise source. As per viaduct design, main work activity will be concentrated as each pier location including installation of bored concrete piles, cast in-situ pile cap work, installation of column and crossheads. As the typical span length between two piers is approximately 40–50 m, the noise generating activities will be concentrated at these locations rather than whole project site within Sembawang forested area. Most likely fauna receptors will avoid these areas. In addition, construction vehicles and equipment will also be operational for shorter periods of time. For example, the excavator which generates high noise levels will likely be operational only during site clearance, which occurs in the initial phase of construction.

Particular attention needs to be paid to nocturnal animals. Many nocturnal animals rely

more on other senses besides sight to navigate, and increased noise levels may impact their movement and other activities. For example, insectivorous bats rely on sound to locate and catch their prey. This process might be affected by night time construction noise, which could fall within the spectrum of their auditory signals (Bunkley, McClure, Kawahara, Francis, & Barber, 2017). It is anticipated that night work will be avoided as far as practicable within Sembawang forested area which will help to reduce the impact.

On the other hand, the noise from on-site construction works may also impact construction personnel on site. Prolonged exposure to high noise levels are known to be detrimental to human health and well-being, with short-term deafness as one of the possible impacts. However, this can be mitigated with strict individual PPE policy implementation for all construction personnel aided by other recommended mitigation measures.

Furthermore, the residents of Brooks Signature @ Springside would also be exposed to construction noises that may affect their health and well-being as well, albeit at a varied rate compared with on-site personnel. In general, noise is attenuated over distance from the source due to the dissipation of sound energy through the atmosphere. As noted, this residential development is approximately 40m away from nearest project boundary. Considering sound propagation principles over distance and typical noise levels generated from construction equipment, it is anticipated that noise from the project construction worksite will attenuate to acceptable levels.

***Operation Phase***

After the viaduct construction is completed, vehicular noise from road traffic is expected to increase the ambient noise levels of the surrounding environment, especially during the peak hours from 6.30am to 9am and from 5pm to 7.30pm.

From an ecological point of view, fauna species, particularly those living in close proximity to the viaduct, are likely to be most impacted by the increased noise levels. For example, it was found that the breeding density of birds was found to drop sharply at the road edge where the traffic noise increase above certain levels (Reijnen, Foppen, & Meeuwsen, 1996). Furthermore, future traffic noises may discourage the movement of wildlife from one side of the viaduct to another side.

Noise levels during the operational stage will increase in comparison with the current conditions but is likely to be significantly less than during the construction stage. Residents of Brooks Signature @ Springside will experience increased noise levels, but human tends to accustom with continuous background noise levels. Hence, these noise levels may not have significant long-term impacts on their health or wellbeing.

Based on the assessment above, the potential noise impacts from the project on the site are deemed to be moderate but can be mitigated with appropriate mitigation measures.

### 5.5.2 Evaluation of Potential Impacts

Table 5.7 summarises the impacts with their corresponding Environmental Scores before and after the implementation of mitigation measures, which are elaborated in the following section.

## 5.6 Mitigation Measures

***Pre-Construction and Construction Phase***

The noise impact from the construction activities should be mitigated at source, if possible, in order to meet the construction noise limits specified by the NEA. Good site practices and noise management can be expected to considerably reduce the pre-construction and construction noise impact. The following recommendations should be considered during the pre-construction and construction phases:

*Specific mitigation measures*

- Night works are to be avoided as far as practicable.
- For soil investigation works, to use acoustic enclosures on rig engines and install a silencer at the exhaust pipe of the engines throughout the drilling operations and to erect portable hoarding around drilling rigs.
- For piling work, to consider the use of quieter piling methods.
- Noise barrier shall be along the project boundary near Springside residential area to protect the sensitive receptors.
- Additionally, to consider erection of temporary 4m high acoustic barriers around piling equipment. To consider use of a temporary barrier which will allow for relocation as the piling activity moves around site.
- Use of silent piler for sheet piling work in the Sembawang forested area.
- Use hydraulic and electric tools in place of pneumatic equipment such as concrete breakers.
- Generators are to be placed as far away as possible from residential receptors.
- Acoustic enclosures could be considered for where necessary specific plant such as compressors, generators, drilling tools etc.
- Means of improving the sound reduction for any exhaust systems in bulldozers, dump trucks and excavators should be considered.
- All noise and acoustic barriers should be able to achieve at least 10dBA noise reduction from source noise levels.
- Construction personnel to be trained in noise-reduction behaviours such as reducing the drop height of materials. Daily toolbox briefings should include reminders on the need to implement noise-reduction behaviours.
- All construction personnel should be educated about sensitive ecological nature of work areas before commencing the work
- To communicate with residential receptors of the proposed piling works including the proposed working hours, and the expected level and duration of noise.

*Other mitigation measures (Best Practices)*

- Prior to commencement of construction works, install hoarding along project

boundary within Sembawang forested area.

- Where alternatives are available, only equipment and vehicles that emit lower noise levels are to be used.
- Care shall be taken when loading or unloading vehicles, dismantling scaffolding or moving materials to reduce impact noise.
- Start-up plant and vehicles sequentially rather than all together;
- Usage of modern and well-maintained equipment, with silencers or mufflers.
- Intermittently-used vehicles and machinery are to be shut down between work periods or be throttled down to a minimum noise level emission.
- Where possible, vehicles and machinery known to emit high levels of noise in one direction are to be orientated away from sensitive receptors and scheduled for operation during the least sensitive parts of the day (i.e. late morning to late afternoon).
- Only well-maintained machineries should be operated on-site and should be serviced regularly during construction.
- Noise level monitoring throughout all phases to ensure that the construction noises remain within acceptable limits.
- Maintain a complaints procedure to log and track response to complaints received from residents.

The following measure is to be implemented specifically for human receptors:

- Personnel are to wear appropriate Personal Protective Equipment (PPE) all the time while on the construction site.

***Operation Phase***

The following measures can be considered to mitigate the impacts:

- For slip road, roadside planting including thick hedge should be considered which can reduce the amount of noise entering the forest.
- To consider installation of noise barrier at viaduct edges to prevent spill over to the forested area.

Effective implementation of these mitigation measures should be able to reduce the noise impacts from project on sensitive receptors to acceptable levels.

A stakeholder consultation session was conducted with various Nature Groups to discuss the anticipated environmental impacts and to brief them on recommended mitigation measures as detailed above.

**Table 5.7.** Environmental Scores of the identified noise impacts with corresponding mitigation measures

| Phase | Impact component | Predicted impact before mitigation | | | | | | | Mitigation measures | Predicted impact after mitigation | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | I | M | P | R | C | ES | Impact | | I | M | P | R | C | ES | Impact |
| ***Ecology*** | | | | | | | | | | | | | | | | |
| Pre-construction / Construction | Disturbance to fauna species in and around the project site | 3 | -2 | 2 | 2 | 3 | -42 | Minor negative | • Night works are to be avoided as far as possible<br>• Quieter equipment and vehicles with low noise levels to be used<br>• For piling work, to consider the use of quieter piling methods<br>• Acoustic enclosures to be considered for compressors, generators, drilling tools etc.<br>• All noise and acoustic barriers to be able to achieve at least 10dBA noise reduction from source noise levels. | 3 | -1 | 2 | 2 | 3 | -21 | Slight negative |
| Operation | Disturbance to fauna species in and around the project site | 3 | -2 | 3 | 2 | 3 | -48 | Minor negative | • To consider measures such as thick hedge to reduce noise spilling into the surrounding environment | 3 | -1 | 3 | 2 | 3 | -24 | Slight negative |
| ***Human Health and Safety*** | | | | | | | | | | | | | | | | |
| Pre-construction / Construction | Impact to construction workers due to exposure to high noise levels of construction activities | 2 | -3 | 2 | 2 | 2 | -36 | Slight negative | • Personnel are to wear appropriate Personal Protective Equipment (PPE) at all times while on the construction site<br>• Quieter equipment and vehicles with low noise levels to be used | 2 | -2 | 2 | 2 | 2 | -24 | Slight negative |
| | Impact to residential community due to noise pollution from construction activities | 2 | -3 | 2 | 2 | 2 | -36 | Slight negative | • Night works are to be avoided as far as possible<br>• Quieter equipment and vehicles with low noise levels to be used<br>• Erection of temporary 4m high acoustic barriers around piling equipment<br>• Acoustic enclosures to be considered for compressors, generators, drilling tools etc. | 2 | -2 | 2 | 2 | 2 | -24 | Slight negative |

| Phase | Impact component | Predicted impact before mitigation | | | | | | | Mitigation measures | Predicted impact after mitigation | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | I | M | P | R | C | ES | Impact | | I | M | P | R | C | ES | Impact |
| | | | | | | | | | • All noise and acoustic barriers to be able to achieve at least 10dBA noise reduction from source noise levels. | | | | | | | |

# 6 HYDROLOGY AND WATER QUALITY

## 6.1 Introduction

The project study area is located within the Lower Seletar Reservoir catchment area (Figure 6.1), one of the 17 water catchments in Singapore. The reservoir was created by damming the Sungei Seletar at its mouth. It has a surface area of approximately 360 ha, allowing it to store up to 9.5 million $m^3$ of water. The Lower Seletar Reservoir is approximately 300 m away from project study area.

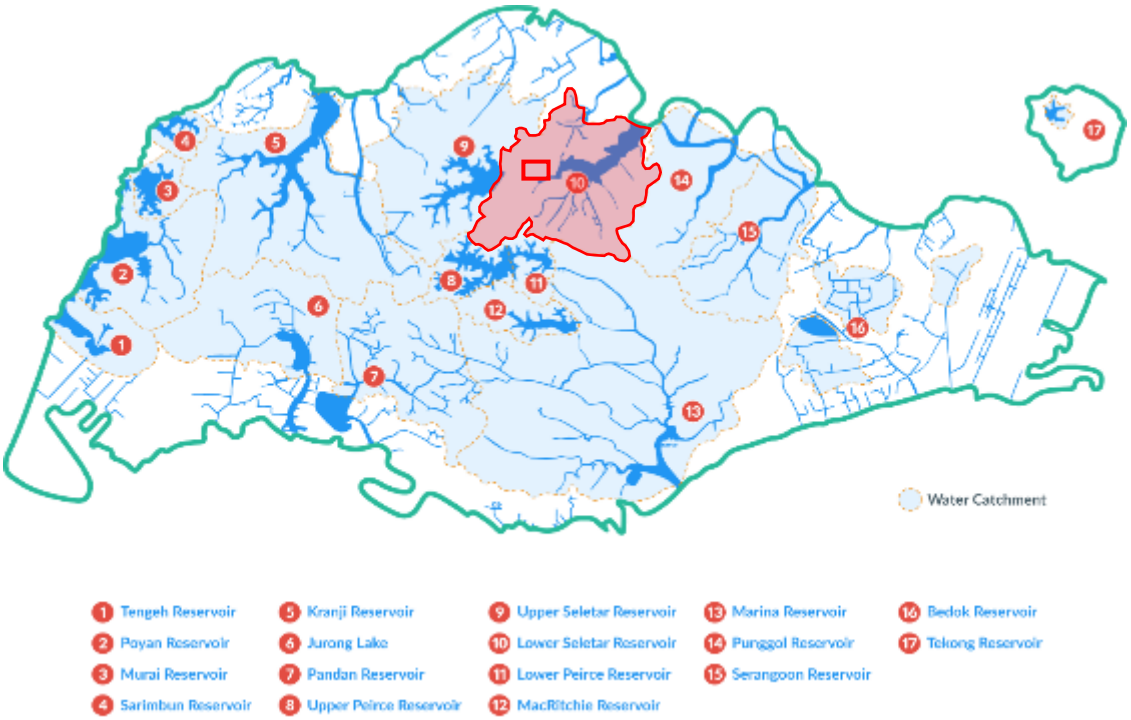


**Figure 6.1.** Catchment areas of Singapore (Public Utilities Board, 2019)

Approximate location of the project site is demarcated in the red box within the Lower Seletar Reservoir catchment area (shaded red).

The elevation of the site varies greatly, reaching about 20 m above sea level. The rainfall in the study area is either intercepted by vegetation or falls directly on the ground surface. There is no regular stormwater drain network within project study area.

Two small natural streams are identified in the project study area (Figure 6.2). The first one is located near Sembawang Road and colloquially called Sungei Botak. Figure 6.3 presents the photograph of the stream. It appears to originate in middle of project study area and feeds into a culvert built under Sembawang Road. Flow at this stream was observed to be slow. The culvert continues south-eastward along Sembawang Road before turning left after Ahmad Ibrahim Mosque. From there, the culvert goes roughly straight perpendicular to Sembawang Road and ends in an outflow perpendicular to Springside Avenue. The second stream originates from the eastern side outside project study area and ends in small ponds in MINDEF training area. Figure 6.4 presents the

photograph of the stream. Due to its position, the stream is inferred to be fed by runoff from the surrounding areas.

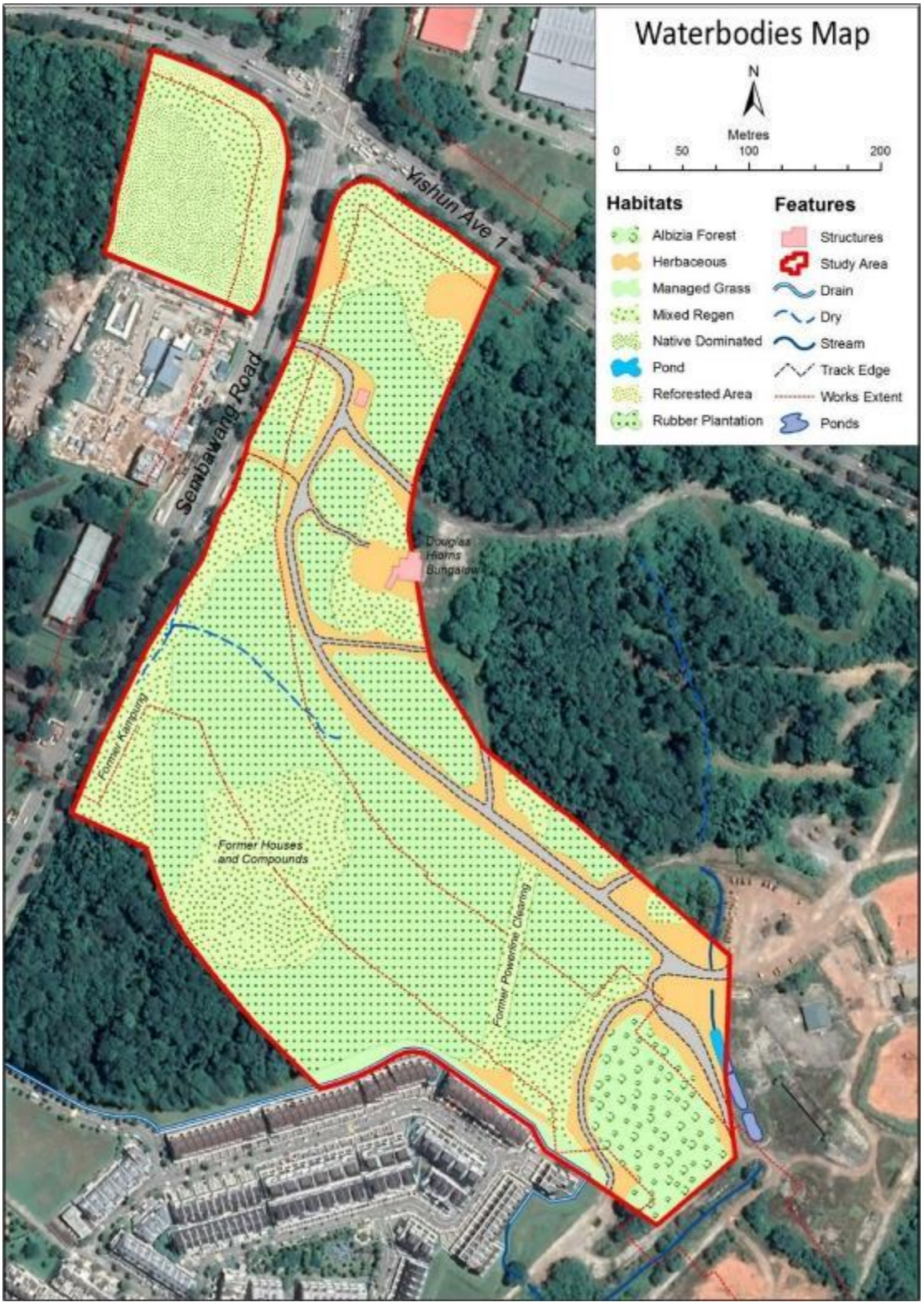


**Figure 6.2.** Overview of waterbodies within project study area

**Figure 6.3.** Natural stream near Sembawang Road (i.e. Sungei Botak)

**Figure 6.4.** Natural stream in MINDEF training area

## 6.2 Relevant Environmental Legislation, Guidelines and Standards

The Sewerage and Drainage Act 2001 authorizes PUB to construct, maintain and improve sewerage and drainage systems, to regulate the discharge into these systems, and to issue codes of practice or specifications.

Sewerage and Drainage (Surface Water Drainage) Regulation 2007 specifies a maximum discharge limit for total suspended solids (TSS) as 50 milligrams per liter (mg/L) of the discharge. This regulation also requires every contractor to comply with the Code of Practice (COP) on Surface Water Drainage.

Sewerage and Drainage (Trade Effluent) Regulation 2007 requires the contractor to obtain approval from PUB for discharge of trade effluent into a public sewer. The trade effluent discharge nature or type must be approved by PUB. Effluent quality must comply with the water quality specified in the regulations, and if required by PUB, must be treated prior to discharge.

The discharge of wastewater into open drains, canals and rivers is regulated by the Environmental Protection and Management (EPM) Act 2002 and the EPM (Trade Effluent) Regulation 2008. The Act and its regulations prescribe allowable limits for trade effluent discharge to controlled watercourse and are administered by NEA.

COPs and guidelines relevant to public utilities and watercourse are listed below.

- COP for Environmental Control Officers;
- COP on Surface Water Drainage 2018;
- COP on Pollution Control (SS 593: 2013);
- Guidebook for Qualified Erosion Control Professional (QECP) 2006;
- Guidebook on Erosion and Sediment Control at Construction Sites 2018; and
- Guidebook for Best Environmental Practices: Water Resource Management at LTA Sites 2011.

## 6.3 Baseline Methodology

As noted earlier, there are two (2) natural water streams observed in project study area where surface water quality sampling was carried out. Sampling was conducted at the accessible point of these two streams (Table 6.1, Figure 6.5). Dry weather samples were collected on 3 August 2020 while the wet weather samples were collected on 12 August 2020. The SINGLAS-accredited Astar Laboratory Pte Ltd, was appointed to analyse the collected water samples. Figure 6.6 depicts the surface water sampling activities.

**Table 6.1.** Coordinate of surface water quality sampling locations

| ID | Coordinates | | Date of Sampling | |
|---|---|---|---|---|
| | | | Dry Weather | Wet Weather |
| WS1 | 1.410022 | 103.822033 | 03/08/2020 | 12/08/2020 |
| WS2 | 1.407535 | 103.825334 | | |

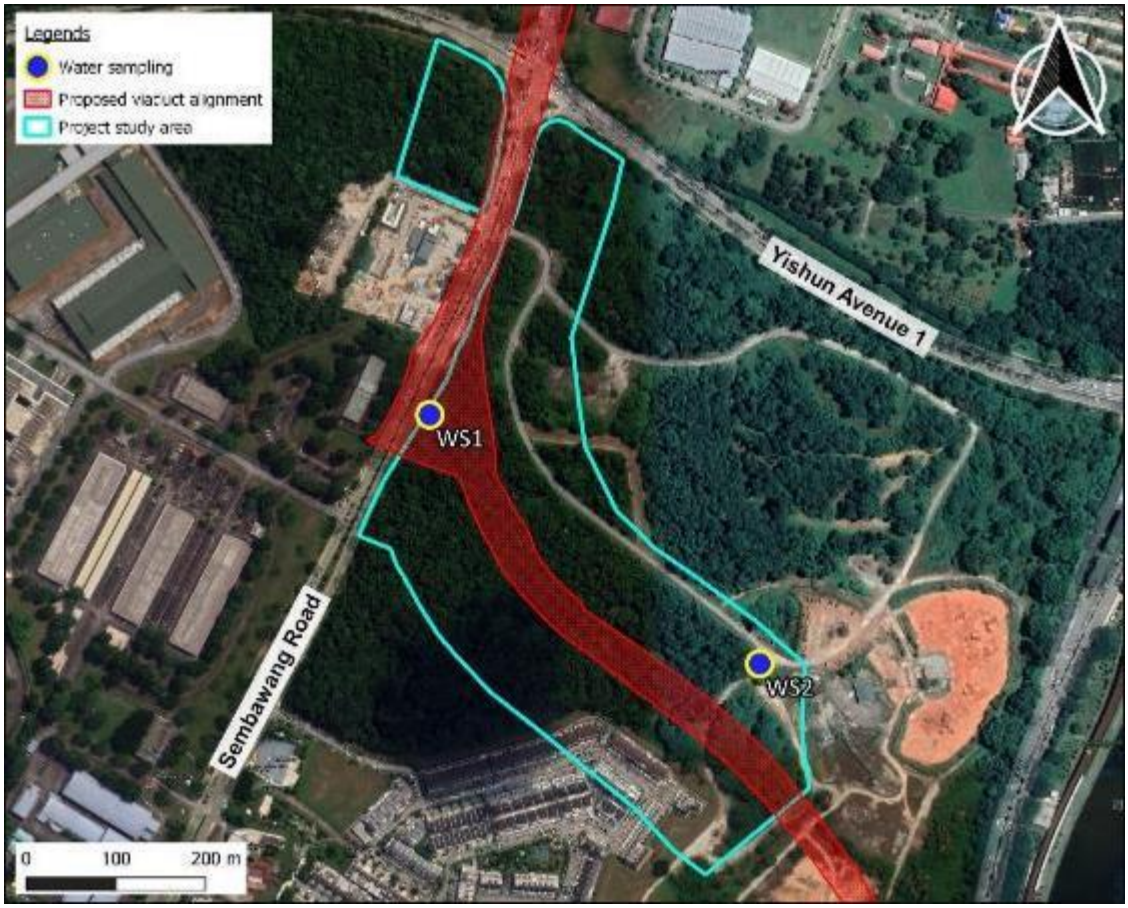


**Figure 6.5.** Location of surface water quality sampling in project study area

**Figure 6.6.** Surface water sampling activities

## 6.4 Baseline Results and Discussion

The results of surface water quality analysis in comparison with the relevant standards are given in Table 6.2. The laboratory analysis reports are provided in **Appendix I**.

The main standard used for surface water quality comparison is the Allowable Limits for Trade Effluent Discharge under EPM (Trade Effluent) (National Environment Agency, 2020). Wherever the limits for Watercourse are not available, the analysis results are compared with the limits for Controlled Watercourse[7]. For the parameter of Dissolved Oxygen, Vietnam's National Technical Regulation QCVN 38: 2011/TTBTNMT on Surface Water Quality for Protection of Aquatic Lives (2011) is used for comparison.

**Table 6.2.** Results of surface water quality samples

| Parameter | Unit | WS1 | | WS2 | | Allowable Limits |
|---|---|---|---|---|---|---|
| | | Dry | Wet | Dry | Wet | |
| Temperature | °C | 25.9 | 24.5 | 25.8 | 24.6 | 45 [1,2] |
| pH at 25°C | pH unit | 6.2 | **5.44** | **5.8** | 6.11 | 6–9 [1,2] |
| Dissolved Oxygen | mg/L | **2.32** | 9.04 | 5.19 | 7.95 | ≥ 4 [3] |
| Total Dissolved Solids | mg/L | 126 | 51.3 | 79 | 98.3 | 1,000 [2] |
| Total Suspended Solids | mg/L | 10 | 7.7 | 9.5 | 33.7 | 50 [1] |
| Total Nitrogen | mg/L | 0.3 | 0.3 | 0.7 | 0.2 | 20 [2] |
| Total Phosphorus | mg/L | 0.15 | < 0.01 | 0.08 | < 0.01 | 5 [1] |
| Biochemical Oxygen Demand (5 days at 20°C) | mg/L | **52** | 25 | 33 | 20 | 50 [1] |
| Oil & Grease | mg/L | < 1 | < 1 | < 1 | < 1 | 10 [1] |
| Ammonia | mg/L | < 0.1 | < 0.1 | < 0.1 | < 0.1 | – |
| Cadmium (as Cd) | mg/L | < 0.01 | < 0.01 | < 0.01 | < 0.01 | 0.1 [1] |
| Copper (as Cu) | mg/L | < 0.01 | < 0.01 | < 0.01 | < 0.01 | 0.1 [1] |
| Lead (as Pb) | mg/L | < 0.1 | < 0.01 | < 0.1 | < 0.01 | 0.1 [1] |
| Zinc (Zn) | µg/L | < 0.1 | 0.03 | 0.11 | 0.03 | 1 [1] |
| Enterococcus | cfu / 100 mL | 66 | < 1 | 1 | 204 | – |

Note: **Bolded** values denote non-conformity of the respective water quality standard.
[1] NEA's Allowable Limits for Trade Effluent Discharge to Watercourse guideline
[2] NEA's Allowable Limits for Trade Effluent Discharge to Controlled Watercourse guideline
[3] Vietnam's National Technical Regulation on Surface Water Quality for Protection of Aquatic Lives (QCVN 38: 2011/TTBTNMT) (2011)

In general, the water quality of the streams within the project study area complied with NEA's Allowable Limits for Trade Effluent Discharge guidelines, except for parameters of pH and Dissolved Oxygen (DO).

The pH results for wet weather sample of WS1 and dry weather sample of WS2 are 5.44 and 5.8 respectively, indicating acidic water. In contrast, the pH range of NEA's (2020) standard is 6–9. These outliers can be expected as the water in Singapore's streams is generally acidic due to several factors, including those of natural (low buffering related to acidic granite) and anthropogenic (acid rain) (Nguyen, Wasson, & Ziegler, 2018).

[7] Defined as "a watercourse from which water supplied by PUB under the Public Utilities Act is obtained but does not include a watercourse from which water is pumped into a main of the PUB" (National Environment Agency, 2020).

DO measures the amount of oxygen dissolved in the water and is an indicator of water quality. Higher DO levels generally indicate better water quality. The DO concentrations above of 4 mg/L is considered ideal for the survival of aquatic lives (Ministry of Natural Resources and Environment of Vietnam, 2011). Dry weather sample of WS1 shows DO level less than 4 mg/L, which implies less favourable condition for aquatic life. However, as this result is only indicative, long-term data are required to arrive on the conclusion of water quality.

## 6.5 Impact Assessment

### 6.5.1 Identification of Potential impacts

***Pre-Construction and Construction Phase***

*Soil Erosions and Surface Runoff*

Impacts to hydrology and water streams within study area will potentially arise during construction phase as considerable amounts of site clearance and earthworks will be required for the construction of viaduct and slip road. Substantial adverse impacts to drainage pattern could occur from soil erosion and sediment transport during storm events. Effects would be greatest in areas of exposed, disturbed soils such as access trails within study area. This impact could worsen if there are soil stockpiles left unprotected within construction area. Run-off containing particulates will increase the concentrations of sediments, suspended solids and other contaminants and can increase burden on existing drainage system along Sembawang Road.

In addition, other non-storm related effects could contribute sediment to drainage system, including:

- Land clearance and site preparation of construction work areas.
- Run-off from exposed soil surface and earth working areas.
- Run-off from dust suppression sprays.
- Earthworks e.g. excavation or backfilling.

Entry of significant amounts of silt into water streams will potentially affect the local ecology if proper mitigation measures are not implemented.

*Disturbance to local drainage pattern*

The small natural stream (colloquially called Sungei Botak) near Sembawang Road falls within project footprint area and is likely to be affected. The area is slated to be backfilled to cater for construction of new access road into the forested site. As this stream helps to drain water into a culvert built under Sembawang Road, the loss of this drain may disturb local drainage pattern.

*Oil & Fuel Spillage and Waste Disposal*

The construction activities may require the onsite storage and handling of potential polluting material such as Bentonite, fuel, lubricant, cement, packaging materials etc. Following sources can affect the water quality within project area.

- Fuel and lubricants from maintenance of construction vehicles and equipment.
- Effluent from bentonite slurry

- Concrete washout, and excess grouting materials from construction activities.
- Illegal dumping of debris and rubbish such as packaging, construction materials and refuse; and
- Accidental spillage of liquids stored on-site e.g. oil/grease, solvents.

Construction runoff may cause physical, biological and chemical effects to the receiving waters. The physical effects include potential blockage of drainage channels and increased concentrations of suspended solids in the drainage channels. Runoff containing significant amounts of bentonite, concrete and cement-derived material may cause primary chemical effects such as increasing turbidity and discoloration, elevation in pH, and accretion of solids. A number of secondary effects may also result in toxic effects to water biota due to elevated pH values, and reduced decay rates of microorganisms and photosynthetic rate due to the decreased light penetration.

If effluents are discharged directly to the stormwater drains, similar effects to those from construction runoff could occur (i.e. downstream physical, biological and chemical effects to the receiving waters).

No hazardous chemicals as specified under EPM (Hazardous Substances) regulations are expected to be used in the construction activities at project site within Sembawang forested area. It is expected that contractor will deploy adequate portable chemical toilets for construction personnel. These toilets shall be cleaned and maintained by approved sanitary waste collector. Hence, no impact is expected from sewage discharge to water quality.

The impacts and effects on water quality from the construction activities is expected to be controlled with the implementation of a well-designed temporary drainage system and proposed mitigation measure provided in next section.

Overall, the potential impacts have been considered to be negative, direct, short term, reversible, avoidable, local and of minor magnitude.

***Operation Phase***

Operation stage activities will include the routine servicing and maintenance of road corridor. However, it is anticipated that such activities do no generate significant amounts of silt or construction debris. The small area will have decreased ground permeability to water due to the development of a sealed slip road within project site, which may have impacts on water flow, increasing risks of flooding. However, risks of flooding will be mitigated through well designed roadside drainage along the slip road to take care of the runoff from impermeable surface.

Based on the assessment above, the potential impacts on site's hydrology are deemed to be temporary in nature. Appropriate measures are to be proposed to mitigate these impacts.

### 6.5.2 Evaluation of Potential Impacts

Table 6.3 summarises the impacts with their corresponding Environmental Scores before and after the implementation of mitigation measures, which are elaborated in the following section.

## 6.6 Mitigation Measures

In order to mitigate impacts to hydrology and water streams, the following measures can be adopted.

***Pre-Construction and Construction Phase***

*Earth Control Measures (ECM)*

Appropriate ECM plan is to be prepared and endorsed by a Qualified Erosion Control Professional (QECP) before the commencement of the construction works. The ECM should include:

- Earth control measures are to be implemented by the contractor according to the QECP endorsed plans before staring the work.
- Proper sediment control measures designed to capture and retain silt are to be implemented which may include perimeter cut-off drains, perimeter silt fence, silt traps and silt treatment systems.
- QECP to review ECM plan implementation regularly during construction to ensure that the measures put in place remain effective.
- Regular monitoring of ECM treatment plant performance is to be carried out by Environmental Control Officer (ECO).
- Regular maintenance of ECM is to be carried out.
- The contractor shall access weather forecast from the NEA website to take ECM actions before rain events.
- After rain events, earth control measures in the field to be inspected and maintained over the course of construction.
- To ensure that site discharges are treated to the allowable limits (namely, 50 mg/L of TSS for a normal watercourse and 30 mg/L for a controlled watercourse) before discharge into a public drain.
- Exposed earth areas shall be reduced by phasing earth works and effective scheduling of construction activities to minimise bare surfaces, planning of site layout and effective site drainage systems to facilitate flow. Measures may include the use of paving, erosion control blankets and canvas covers.
- ECM should only be removed after completion of the works. The QECP should authorize removal of the ECM.

*Disturbance to local drainage pattern*

- Contractor to assess feasibility of diversion of affected natural drain (i.e. Sungei Botak) to divert the drainage flow to existing culvert near Sembawang Road with due consideration of final site arrangement.
- To consult authorities (i.e. PUB) before finalizing design of diversion of drainage.

*Chemical & Fuel Spillage and Waste Disposal*

- To ensure that bentonite is contained within the working area and does not enter any watercourses or surface water drains.
- Bentonite storage silos and supply lines should be located as far as possible from surface water drains or watercourses.
- Storage silos should have secondary containment.
- Areas where bentonite is mixed should be surrounded with a small wall or contained within a bund. This will help to control the slurry produced and prevent it from entering surface water drains or watercourses.
- Bentonite use should be monitored so that excessive use could be identified to prevent bentonite materials from escaping into the ground and potentially polluting groundwater.
- Waste bins to be provided within the construction work area for proper disposal of construction debris and rubbish. Foreign material should not be illegally disposed at the water bodies but removed from site by a licensed waste collector.
- All liquids should be properly labelled and stored in appropriate containers at safe location on site. Personnel handling these liquids should also be suitably trained.
- Vehicle fueling and major maintenance to be minimised within the project area.
- Appropriate concrete wash out areas should be provided and should not be performed in or near any water body.
- Water used for dust control should not be allowed to cause erosion within the work area or to run offsite.
- Excess loose soil and rock to be contained prior to the commencement of the works.

With the adoption of the necessary mitigation measures, the potential impacts during construction activities of the road project are considered to be negligible.

A stakeholder consultation session was conducted with various Nature Groups to discuss the anticipated environmental impacts and to brief them on recommended mitigation measures as detailed above.

***Operation Phase***

The operation phase impact is assessed to be insignificant, therefore no mitigation measure is proposed.

**Table 6.3.** Environmental Scores of the identified impacts on site's hydrology & water quality with corresponding mitigation measures

| Phase | Impact component | Predicted impact before mitigation | | | | | | | Mitigation measures | Predicted impact after mitigation | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | I | M | P | R | C | ES | Impact | | I | M | P | R | C | ES | Impact |
| ***Ecology*** | | | | | | | | | | | | | | | | |
| Pre-construction / Construction | Impact to terrestrial habitats due to erosion of topsoil | 2 | -3 | 2 | 2 | 2 | -36 | Slight negative | • Implementation of proper Earth Control Measures (ECMs) | 2 | -2 | 2 | 2 | 2 | -24 | Slight negative |
| | Impact to water quality and aquatic habitat due to sediment runoff and siltation | 2 | -3 | 2 | 2 | 2 | -36 | Slight negative | • Implementation of proper Earth Control Measures (ECMs) | 2 | -2 | 2 | 2 | 2 | -24 | Slight negative |
| | Disturbance to local drainage pattern due to impact to natural stream (i.e. Sungei Botak) | 2 | -3 | 3 | 2 | 2 | -42 | Minor negative | • To divert the drainage flow to existing culvert near Sembawang Road to cater for the hydrological patterns on the site. | 2 | -3 | 3 | 2 | 2 | -42 | Minor negative |
| ***Human Health and Safety*** | | | | | | | | | | | | | | | | |
| Pre-construction / Construction | Impact to water quality due to accidental spillage of construction materials, fuel, and solvents | 2 | -2 | 2 | 2 | 2 | -24 | Slight negative | • Disposal of waste into water streams is strictly prohibited<br>• Waste bins to be provided within the construction work area.<br>• Foreign material to be removed from site by a licensed waste collector<br>• Contractor to provide adequate portable chemical toilets for construction personnel<br>• Vehicle fuelling and major maintenance to be minimised within the project area | 2 | -1 | 2 | 2 | 2 | -12 | Slight negative |

# 7 AMBIENT AIR QUALITY

## 7.1 Introduction

The main air pollution sources in Singapore are stationary sources such as industries, power stations and refineries and mobile sources such as motor vehicles and visiting marine vessels. The NEA monitors air quality in Singapore and publishes the 24-hour Pollutant Standards Index (PSI) reading which provides an indication of the air quality at any point of time.

Currently there is not any stationary source of air pollution in forested area within project study area. The nearest source of air pollution outside project study area includes movement of vehicles within MINDEF training area and exhaust emissions from vehicular traffic along the Sembawang Road and Yishun Avenue 1. While the project study area is just next to Sembawang Road, its natural setting, and the presence of closed forest as well as other vegetated habitat types contribute to the relatively good prevailing air quality of the area.

The air quality at the project study area will potentially be affected by activities associated with viaduct construction, especially from an increase in airborne particulates and heavy-vehicle exhaust emissions. Once the construction is complete, exhaust emissions from motor vehicles using the new viaduct will become the new source of air pollution in the area.

## 7.2 Relevant Environmental Legislation, Guidelines and Standards

### 7.2.1 Singapore Ambient Air Quality Targets

Singapore national air quality targets are pegged to the World Health Organization Air Quality Guidelines (WHO AQGs). The targets are provided in Table 7.1.

**Table 7.1.** Singapore ambient air quality targets for 2020

| Pollutant | Singapore Targets |
|---|---|
| Sulphur Dioxide ($SO_2$) | • 24-hour mean: 50 µg/m$^3$ (WHO Interim Target)<br>• Annual mean: 15 µg/m$^3$ (Sustainable Singapore Blueprint, 2015) |
| Particulate Matter ($PM_{2.5}$) | • 24-hour mean: 37.5 µg/m$^3$ (WHO Interim Target)<br>• Annual mean: 12 µg/m$^3$ (Sustainable Singapore Blueprint, 2015) |
| Particulate Matter ($PM_{10}$) | • 24-hour mean: 50 µg/m$^3$ (WHO Final)<br>• Annual mean: 20 µg/m$^3$ |
| Ozone | • 8-hour mean: 100 µg/m$^3$ (WHO Final) |
| Nitrogen Dioxide ($NO_2$) | • 1-hour mean: 200 µg/m$^3$ (WHO Final)<br>• Annual mean: 40 µg/m$^3$ |
| Carbon Monoxide (CO) | • 1-hour mean: 30 mg/m$^3$ (WHO Final)<br>• 8-hour mean: 10 mg/m$^3$ |

## 7.3 Baseline Data from Secondary Sources

As mentioned earlier, NEA monitors air quality in Singapore and publishes the 24-hour Pollutant Standards Index (PSI) reading. These data were obtained from the website www.data.gov.sg for the period 2017–2019 to understand the baseline air quality status. Data from northern Singapore covering the project study area is used. The average daily $PM_{2.5}$ ranges from 11.5 µg/m$^3$ to 23.6 µg/m$^3$, well under Singapore's 2020 target of 37.5 µg/m$^3$. All other pollutants were measured to be lower than the respective Unhealthy PSI sub-index threshold. The results show that project study area enjoyed good air quality.

**Table 7.2.** Monthly average of ambient air pollutants in northern Singapore in 2017–2019

| Concentration (µg/m$^3$) | 2020 SG target | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Avg. 24-hr $SO_2$** | 50 | 4.6 | 3.5 | 5.6 | 7.3 | 10.2 | 10.8 | 8.7 | 7.6 | 8.5 | 8.9 | 8 | 4.7 |
| **Avg. 24-hr $PM_{2.5}$** | 37.5 | 11.5 | 13.1 | 15.5 | 16.4 | 16.1 | 13.4 | 14.7 | 16.5 | 23.6 | 17.6 | 14.6 | 11.6 |
| **Avg. 24-hr $PM_{10}$** | 50 | 22.8 | 25 | 25.1 | 26.5 | 26.1 | 23.4 | 26.2 | 29.3 | 37.3 | 29.8 | 25.7 | 23.6 |
| **Avg. 8-hr $O_3$** | 100 | 32.8 | 38.1 | 37.5 | 30.9 | 25.5 | 19.6 | 25.5 | 28.6 | 30.5 | 25.9 | 24 | 32.7 |
| **Avg. 1-hr $NO_2$** | 200 | 17.4 | 12.6 | 19.6 | 29.3 | 34.6 | 29.7 | 28.1 | 25.2 | 28.1 | 32.6 | 29.7 | 19.5 |
| **Avg. 1-hr CO** | 30,000 | 0.51 | 0.5 | 0.5 | 0.65 | 0.65 | 0.54 | 0.5 | 0.54 | 0.69 | 0.7 | 0.59 | 0.55 |

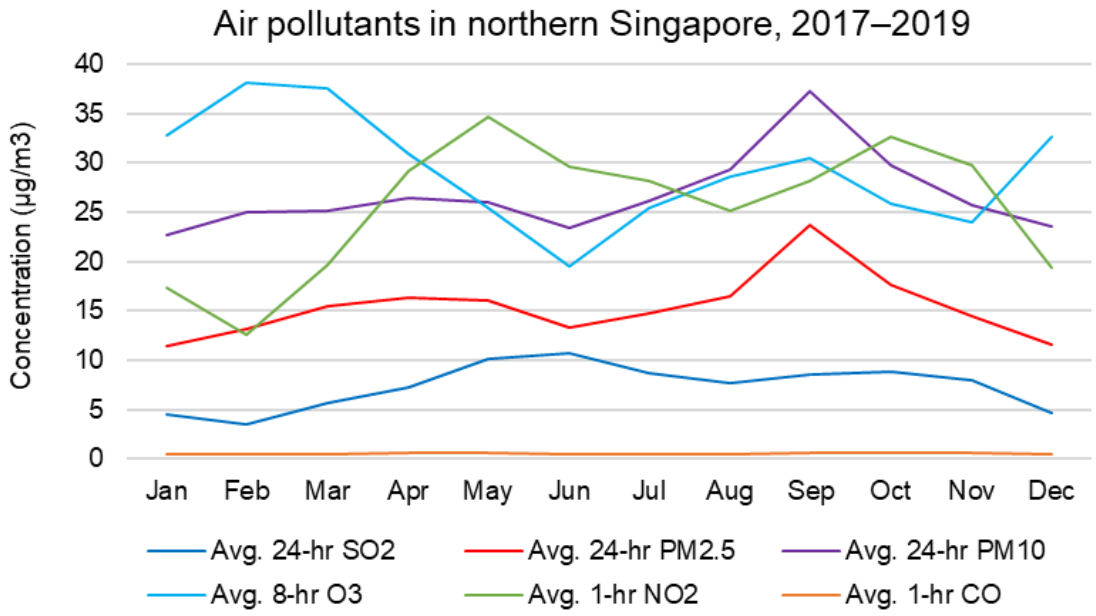


**Figure 7.1.** Monthly ambient air pollutants variation in Singapore in 2017–2019

## 7.4 Impact Assessment

### 7.4.1 Identification of Potential Impacts

There is a residential community i.e. Brooks Signature @ Springside is located within study area along Springside Ave and Springside View. It is a private residential development comprises 114 units of Terrace houses and Bungalows. Residents of this community are considered as air sensitive receptors in context of this project implementation. There are no schools or hospital in the vicinity of project site.
As the project site is an SEMBAWANG FORESTED AREA, the concerned flora and fauna are identified as air sensitive receptors as well.

***Pre-Construction and Construction Phase***

Construction activities have the potential to result in adverse impacts on air quality leading to significant effects on sensitive receptors within project area if not managed properly. Potential sources of impacts include:

- Fugitive dust emissions from viaduct construction works
- Exhaust emissions from construction machinery and transport vehicles as a result of equipment, materials and personnel movement in and out of construction work areas.
- Odour emission

*Fugitive dust emissions from construction works*
The following road construction works are expected to create dust emission:

- Site clearing
- Soil investigation work
- Soil excavation for viaduct foundation and slip road alignment
- Temporary stacking of excavated soil within project site
- Erection of temporary (i.e. site office) structures
- Bored piling work
- Earth work for pile cap
- Backfill, soil mixing and compaction
- Cutting and grinding work for pile head
- Vehicle movements on access roads

Fugitive dust emissions from construction activities are unavoidable to be generated during soil excavation, backfill activities and vehicle movements within the construction site on unpaved surfaces. These fugitive dust emissions are expected to have a moderate and direct impact on local air quality and affect air sensitive receptor located near dust generating construction activities (i.e. construction workers).

Additionally, deteriorated air quality also has negative impacts on biodiversity. For example, particulate matter settling on leaves may cause leaf injury thought abrasion or chemical interactions. Dust particles entering stomata may also reduce photosynthetic functions. Dust landing directly on soil may affect nutrient cycling processes (Grantz, Garner, & Johnson, 2003).

The existing literature on the effect of construction dust on birds in particular is limited, with most studies examining effects of air pollution on wildlife in general, rather than the effect of construction dust on birds specifically. Since the avian respiratory system, unlike the mammalian respiratory system, is characterized by unidirectional airflow and cross-current gas exchange, this makes them more susceptible to high concentrations of pollutants in the air. Studies have shown that birds exposed to urban air pollution may exhibit a build-up of cellular and mineral debris leading to characteristic conditions of pneumonia (Sanderfoot & Holloway, 2017).

The impact duration of fugitive emissions of construction dust is anticipated to be short term and expected to vary significantly from day to day depending upon the duration of dust-generating construction activities within project site. Actual concentrations of fugitive dust emissions from construction site will depend on length of operations, effectiveness of control measures and ambient weather conditions (e.g. rainfall, wind speeds and directions). Extent of fugitive emissions is considered to be local, within the project as forested area around project study area will act as barrier for further dispersion. Also, the impacts are reversible when dust-generating construction activities stop.

Hence, fugitive dust emissions impact is considered to be unavoidable, of local importance, having a local geographical extent, short term duration, reversible, and with minor impact magnitude.

*Exhaust emissions from construction machinery and heavy vehicles*

It is anticipated that the viaduct construction activities potentially use fuel-burning (i.e. mainly diesel) machinery such as piling rig, road roller machine, asphalt mixing plant, mobile cranes, generator sets, and other heavy vehicles such as grader, dozer, excavator, front-end loader and haul truck that may cause exhaust emission. These exhaust emissions can cause direct and negative effects on local air quality by potentially increasing the concentrations of CO, NO2, SO2, O3, PM10 and PM2.5. This could cause the local air quality to deteriorate.

The impact is expected to be short term depending on the duration of operation of machinery and heavy vehicles. The geographical extent of exhaust emissions is considered to be local, within the project study area, even its dispersion will be affected by a number of factors such as ambient weather and wind direction. Air quality impacts due to exhaust emissions of fuel burning machinery and vehicles are reversible when they stop operating.

There is a possibility of traffic diversions at Sembawang Road during viaduct construction work that may increase traffic congestion and vehicular waiting times at the project site. This can indirectly cause negative impacts to local air quality due to increase in vehicle exhaust emissions. However, it is noted that contractor will be implementing proper traffic management plan as part of authority requirement and will be maintaining 3 lanes both sides of Sembawang Road. Hence, the impact is expected to be insignificant and can be well managed with proper traffic diversion management plan.

Hence, the overall impact is considered to be of local importance, moderate magnitude,

with a local geographical extent, short term duration and reversible.

*Odor emissions*

During construction works, it is anticipated that odors generated at the site would be minimal. The potential impact is anticipated to be short term, indirect and insignificant as it would be assumed to be managed by suitable waste management mitigation measures discussed in Chapter 9.

***Operation Phase***

During operation phase, exhaust emissions from motor vehicles using this new viaduct will become the new source of air pollution in the area.

Based on the assessment above, the potential impacts on the ambient air quality of the site are deemed to be minor and temporary. Appropriate measures are required to mitigate these impacts.

### 7.4.2 Evaluation of Potential Impacts

Table 7.3 summarises the impacts with their corresponding Environmental Scores before and after the implementation of mitigation measures, which are elaborated in the following section.

## 7.5 Mitigation Measures

***Pre-Construction and Construction Phase***

For site dust control, the contractor shall prepare and implement the dust control plan covering following dust suppression measures:

- Use of hoarding at project boundary within Sembawang forested area to minimise dust generation by attenuating wind forces.
- To avoid stockpiles of soil and dusty materials at project site within Sembawang forested area as far as possible.
- If unavoidable, stockpiles of soil should be located away as far as possible from sensitive residential receptors (i.e. Brooks Signature @ Springside).
- Provide additional dust screen at project boundary near residential community (i.e. Brooks Signature @ Springside).
- Any soil or stockpiles of dusty material should be properly stored, covered entirely with impervious sheeting or dampened with water to maintain entire surface wet by contractor.
- Soil stockpiles shall not be higher than 0.6 times the nearest hoarding height.
- Excavations should be backfilled or reinstated as soon as practicable following completion of the construction work.
- Material transport of inert solids (excavated materials) should be enclosed using impervious sheeting, minimising the visual dust impacts as well.
- Use of regular watering to reduce dust emissions from exposed site surfaces, particularly during dry weather on open areas.
- Open burning of construction and other wastes are not allowed at the worksite as this is an offence under the Environmental Pollution Control regulation.

- Personal protective equipment such as mask shall be worn during the severe air pollution and/or dust exposure periods by construction personnel.
- Avoid soil disturbing works during dry and/or windy conditions.
- Stabilize/cover all stockpiled materials for longer than one month by turfing, erosion blanketing or other method.
- Vehicle on-site speed restrictions should be imposed to prevent dust being stirred up by vehicle movements.

Other mitigation measures that need to be taken by the contractor include:

- Provide vehicle washing facilities before the construction site exit.
- Paved the area between construction site exit and the vehicle washing facilities.
- Maintain road surface in the construction site wet (e.g. using sprinkler).
- Proper maintenance of construction vehicles and fuel burning equipment
- Intermittently used vehicles and machinery are to be shut down between work periods to minimum exhaust emission

Additionally, Contractor shall strictly follow the *Appendix B – Particular Specification Safety, Health and Environment* (2018) and *Guidebook for Best Environmental Practices for Construction Waste Management at LTA Sites* (2009) during the project execution.

A stakeholder consultation session was conducted with various Nature Groups to discuss the anticipated environmental impacts and to brief them on recommended mitigation measures as detailed above.

***Operation Phase***

In Singapore, NEA regulates the type and quality of fuel that can be used and also sets minimum exhaust emission standards for all vehicles. The EPM (Vehicular Emissions) Regulations 2008 stipulate the exhaust emission standards for diesel- and petrol-driven vehicles. They also stipulate a mandatory periodic test for in-use vehicles by approved vehicle examiners to demonstrate compliance with exhaust emission standards. With this regulatory mechanism in place to deal with exhaust emission of vehicles, no other mitigation measures are proposed.

The recommended measures above, when implemented effectively, shall mitigate the potential impacts on the ambient air quality of the site to acceptable levels.

**Table 7.3.** Environmental Scores of the identified impacts on site's ambient air quality with corresponding mitigation measures

| Phase | Impact component | Predicted impact before mitigation | | | | | | | Mitigation measures | Predicted impact after mitigation | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | I | M | P | R | C | ES | Impact | | I | M | P | R | C | ES | Impact |
| ***Ecology*** | | | | | | | | | | | | | | | | |
| Pre-construction / Construction | Impact to biodiversity due to generation of fugitive dust | 2 | -2 | 2 | 2 | 2 | -24 | Slight negative | • To implement dust suppression plan<br>• Use of hoarding at project boundary within Sembawang forested area to minimise dust generation by attenuating wind forces.<br>• To avoid stockpiles of soil and dusty materials at project site within Sembawang forested area as far as possible.<br>• Stockpiles of dusty material should be properly stored, covered entirely with impervious sheeting<br>• Use of regular watering to reduce dust emissions from exposed site surface | 2 | -1 | 2 | 2 | 2 | -12 | Slight Negative |
| ***Human Health and Safety*** | | | | | | | | | | | | | | | | |
| Pre-construction / Construction | Impact on construction workers due to generation of fugitive dust and exhaust emissions from construction machineries | 2 | -3 | 2 | 2 | 2 | -36 | Slight Negative | • To implement dust suppression plan<br>• Personal protective equipment i.e. face mask to be worn during dust exposure<br>• Stockpiles of dusty material to be properly stored, covered entirely with impervious sheeting, or dampened with water<br>• Use of regular watering to reduce dust emissions from exposed site surfaces<br>• Proper maintenance of construction vehicles and fuel burning equipment<br>• Intermittently-used vehicles and machinery are to be shut down between work periods | 2 | -2 | 2 | 2 | 2 | -24 | Slight Negative |
| | Impact on residential community due to generation of fugitive dust | 2 | -2 | 2 | 2 | 2 | -24 | Slight Negative | • To implement dust suppression plan<br>• Provide dust screen at project boundary near residential community | 2 | -1 | 2 | 2 | 2 | -12 | Slight Negative |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | • Stockpiles of dusty material to be properly stored, covered entirely with impervious sheeting, or dampened with water<br>• Use of regular watering to reduce dust emissions from exposed site surface | | | | | | | |
| | Impact due to generation of odour | 1 | -1 | 2 | 2 | 2 | -6 | No Impact | • Refer Section 9.4 | 1 | -1 | 2 | 2 | 2 | -6 | No Impact |
| Operation | Impact due to exhaust emission from traffic | 3 | -2 | 3 | 2 | 2 | -42 | Minor Negative | • Existing exhaust emission standards | 3 | -1 | 3 | 2 | 2 | -21 | Slight Negative |

# 8 LIGHT

## 8.1 Introduction

Given its status as a highly urbanised city-state, high levels of light pollution are already being faced throughout Singapore. While unavoidable in cities, such lighting often has adverse impacts on the natural environment.

Currently, the only parts of project site that have artificial lighting are those located along Sembawang Road for traffic purpose. The rest of the site, especially forested area (i.e. MINDEF area), do not have any artificial lights.

## 8.2 Impact Assessment

### 8.2.1 Identification of Potential Impacts

Impacts to flora and fauna from light pollution should be avoided particularly for sensitive or threatened species highlighted in Chapter 4. Alteration of natural cycles of light and dark by artificial light sources can negatively impact the ecosystem. Increased artificial light during the night disrupts circadian cycles of animals and distorts the day-night cycle of plants. This may lead to increased predation pressure by diurnal carnivores on nocturnal animals, exhaustion from insects attracted to artificial light, disorientation and disruption of foraging by birds, and the alteration of breeding and sleeping cycles of various animals. As a whole, these effects derive from changes in orientation or disorientation, and attraction or repulsion from the altered light environment, which in turn may affect foraging, reproduction, migration, and communication behaviour.

Many groups of insects, such as moths, are attracted to lights as a result of their innate navigational behaviour. Visual communication within and between species can also be influenced by artificial lighting. Insects such as fireflies communicate through bioluminescent signals, which can only be achieved in the absence of background light (Longcore & Rich, 2004). The cumulative effects of such behavioral changes induced by artificial night lighting can have the potential to disrupt key ecosystem functions (Longcore & Rich, 2004).

***Pre-construction and Construction Phase***

During the pre-construction and construction stage, the source of impacts includes artificial lighting used to illuminate the project site, particularly if night works are conducted. Impacts of light on forested areas will be further exacerbated by vegetation clearance leading to open edges, thus allowing more light to enter these areas. It is assumed that all construction activities will be limited to daytime as far as possible, as such any light impacts during the construction phase are expected to be negligible. Any lights that were turned on for construction works should be turned off when not in use.

***Operational Phase***

During the operational stage, sources of light impacts will be derived from the operation of the viaduct and slip road. These would include streetlamps to illuminate the viaduct & slip road and headlights from vehicles utilising the slip road.

Based on the assessment above, the potential light impacts on the site are deemed to be permanent but minor. Appropriate measures are required to mitigate these impacts.

### 8.2.2 Evaluation of Impacts

Table 8.1 summarises the impacts with their corresponding Environmental Scores before and after the implementation of mitigation measures, which are elaborated in the following section.

## 8.3 Mitigation Measures

Where lighting is necessary for traffic safety reasons at viaduct and slip road, mitigation measures can be taken to ensure minimal impact on sensitive wildlife.

***Pre-construction and Construction Phase***

During the pre-construction design phase, lamp designs for street lighting must be carefully considered to ensure minimal impact on the natural environment. In the case for streetlights, such lights may be shielded, facing downwards and away from any heavily vegetated areas. This will eliminate light spill, which is light that falls outside the area intended to be lit. Examples of ideal shielded lighting can be seen in Figure 8.1 below (Australia Department of the Environment and Energy, 2019).

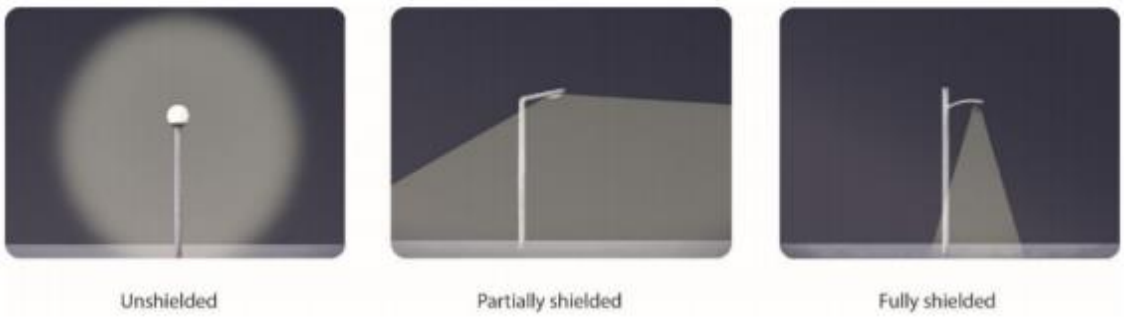


**Figure 8.1.** Example of shielded lamp posts

Furthermore, the lighting layout should use only the minimum number and intensity of lights needed to provide safe and secure illumination for the area required to meet road safety standards. This minimum amount of light required to illuminate the road alignment should be assessed during the detailed design phase.

During the construction phase, if works are carried out beyond daytime, it can introduce artificial light to the natural environment of project study area. Where possible, it is recommended that construction works be kept to the daytime working hours (i.e. 8 am

to 6 pm) and night works (i.e. after 6 pm) are minimized to reduce unnecessary stress to biodiversity that are sensitive to light. Where reasonable and practical, all artificial lights should be turned off outside working hours.

***Operational Phase***

During operational phase of the project, the impacts of light on the surrounding forested areas can be mitigated through proper designing of roadside lighting system as recommended earlier. Further, the impact can be reduced through appropriate roadside buffer planting for at-grade section of slip road within forested area. The presence of thick and tall hedge plants could minimise the amount of light that enters the forested area, thus reducing its impact on sensitive flora and fauna within the forest (Figure 8.2).


**Figure 8.2.** Example of hedge planting using *Murraya paniculata*

The recommended measures above, when implemented effectively, shall mitigate the potential light impacts at the site to acceptable levels.

As such, the summary of mitigation measures that can be used include:

- Construction works to be limited to daylight hours as far as practicable.
- All unnecessary lights should be turned off outside construction working hours.
- Any installed temporary lighting during construction phase for night work shall be directed inward toward project site (i.e. directly away from forested areas).
- Permanent lighting for road safety should be designed to be downward facing and directed away from forested areas.
- To minimum number and intensity of permanent lights.
- Roadside planting should include thick hedge plants which can reduce the amount of light entering the forest.

A stakeholder consultation session was conducted with various Nature Groups to discuss the anticipated environmental impacts and to brief them on recommended mitigation measures as detailed above.

**Table 8.1.** Environmental Scores of the identified light impacts with corresponding mitigation measures

| Phase | Impact component | Predicted impact before mitigation | | | | | | | Mitigation measures | Predicted impact after mitigation | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | I | M | P | R | C | ES | Impact | | I | M | P | R | C | ES | Impact |
| ***Ecology*** | | | | | | | | | | | | | | | | |
| Pre-construction / Construction | Disturbance to the flora and fauna due to light from construction activities | 2 | -3 | 2 | 2 | 1 | -30 | Slight negative | • Construction works to be limited to daylight hours as far as practicable<br>• All unnecessary lights should be turned off outside working hours<br>• Any installed temporary lighting during construction phase for night work shall be directed inward toward project site (i.e. directly away from forested areas) | 2 | -2 | 2 | 2 | 1 | -20 | Slight negative |
| Operation | Disturbance to the flora and fauna due to operation phase lighting | 2 | -3 | 3 | 2 | 3 | -48 | Minor negative | • Permanent lighting for road safety should be designed to be downward facing and directed away from forested areas<br>• Roadside planting should include thick hedge plants which can reduce the amount of light entering the forest | 2 | -2 | 3 | 2 | 3 | -24 | Slight negative |

# 9 WASTE MANAGEMENT

## 9.1 Introduction

The main impacts related to waste storage, handling, transport, and disposal include:

- Deterioration of the environment (e.g. visual, water quality, biodiversity impacts, increase vectors, contamination etc.); and
- Health and safety risks with regards to hazardous wastes if they are not managed properly.

The main sources of potential impacts during the project activities are identified as the following:

- Waste management requirement for cut vegetation (e.g. from site clearance)
- Waste management requirement for excavated material
- Waste management requirement for other construction waste
- Waste management requirement for general waste
- Waste management requirement for hazardous waste

There are legislations implemented and enforced by the Singapore government for management of general and hazardous wastes which are discussed in next section. Table 9.1 provides anticipated types of waste likely to be generated during construction.

**Table 9.1** Types of waste likely to be generated during construction phase

| Solid Waste Type | Source Activity | Classification |
|---|---|---|
| Cut vegetation | Site clearance | Non-hazardous |
| Excavated material | Excavation | Non-hazardous |
| Plastic/wooden planks | Packaging material | Mixed |
| Scrap metal | Form/temporary work | Non-hazardous |
| General waste | Construction workers | Non-hazardous |
| Hazardous waste | Maintenance activity | Hazardous |

## 9.2 Relevant Environmental Legislation, Guidelines and Standards

The Environmental Public Health (EPHA) Act, 2002 set up the regulatory framework for waste management through following regulations:

- Environmental Public Health (General Waste Collection) Regulations, 2000
- Environmental Public Health (Toxic Industrial Wastes) Regulations, 2000

The Environmental Public Health (General Waste Collection) Regulations set out the requirements for the management of non-hazardous general waste and the duties of generators and companies collecting such wastes. General waste must be managed in an environmentally sound manner and collected by an NEA-licensed general waste collector.

The Environmental Public Health (Toxic Industrial Wastes) Regulations set requirements for the generation, management, and disposal of wastes characterised as hazardous,

such as oily sludge, solvents and asbestos containing materials. NEA has set out a list of specific wastes which are classified as Toxic Industrial Wastes (TIW) under the Schedule of this regulation. Special requirements apply to these TIWs with the key provisions includes appointment of a licensed TIW collection company to collect and treat the waste.

The Code of Practice for Environmental Control Officers (ECO) stipulates the role of occupiers of construction sites and of the ECO, and their responsibilities pertaining to waste management at construction sites.

The LTA's 'Guidebook for Best Environmental Practices for Construction Waste Management at LTA Sites 2009' specifies that all construction waste should be managed as per the Singapore legislation. The waste produced at LTA sites must also follow the Code of Practice for Environmental Control Officers and the Authority's General Specification.

## 9.3 Impact Assessment

### 9.3.1 Identification of Potential Impacts

***Pre-Construction and Construction Phase***

*Cut Vegetation*

As discussed in Chapter 4 of Biodiversity, potentially large number of trees will be affected during the implementation of this project. Similarly, other vegetation, such as bushes and grassland will need to be cleared within footprint of the project boundary.

Where cutting is required, the waste vegetation needs to be properly managed to prevent fire risks. The preferred disposal route for this type of material is for the extraction of timber for use in the wood industry. Large stumps will require off-site transport for disposal at local disposal sites. The contractor shall not be permitted to dispose of cut vegetation by burning, as specified in the EPM (Prohibition on Use of Open Fires) Order.

*Excavated Material*

Due to the nature of construction work involved (i.e. pile foundation), no significant volumes of spoil are expected to be generated from this project. Based on preliminary information, the quantity of excavated material generated per pier location will be 200 cubic meters. The excavation for slip road construction may generate around 700 cubic meters of soil. Most of excavated material is expected to be utilized to backfill within project area. Surplus excavated material can be used in reinstatement/restoration activities of slope within project area, otherwise collected by a licensed industrial waste collected for further treatment/disposal.

*Other Construction Waste*

Other construction wastes will likely include:

- Broken rock or concrete
- Ferrous and non-ferrous scrap metal items
- Wooden planks, boards, pallets, formwork
- Packaging or wrapping materials such as plastic sheeting, corrugated

- Cardboard, paper
- Sacks and bags
- Metal or plastic containers and cans.

If not managed properly, the storage, handling, transport and disposal of construction wastes has the potential to result in visual, water, dust, noise and general environmental deterioration. In the event of inappropriate management methods, the disposal of construction waste is unlikely to raise any long-term concerns due to the inert nature of these types of materials. However, it is good practice to segregate different categories of construction waste at source to facilitate recycling/disposal. It is expected that general refuse will be handled, stored, managed and collected for appropriate disposal/treatment in accordance with the EPHA and the EPH (General Waste Collection) Regulations and there shall be no significant adverse impact to the environment.

*General Waste*

General waste will include debris, litter and wastes generated by the construction workers. The storage and handling of general refuse has the potential to give rise to a variety of adverse impacts. These include odour problems if the waste is not collected regularly (i.e. daily), windblown litter, water quality impacts if waste enters watercourses, visual impacts as well as the attraction of pests, disease vectors and scavenging animals (insects, rodents etc.) to the site if waste materials are incorrectly stored onsite. The number of workers on site and subsequently the estimated volume general refuse is unknown at this time. Quantities of general refuse produced by workers are typically in the range of 0.5 – 1 kg per person per day. It is expected that general refuse will be handled, stored, managed and collected for appropriate disposal/ treatment in accordance with the EPHA and EPH (General Waste Collection) Regulations and there shall be no adverse impact to the environment.

*Hazardous Waste*

Hazardous wastes include those listed in the EPHA and EPH (Toxic Industrial Wastes) Regulations. Hazardous wastes are likely to arise principally as a result of maintenance activities for construction machinery and heavy vehicles at the construction site. Estimates of the quantities of hazardous waste are not available during preparation of this report. Types of hazardous construction waste generated include:

- Waste oils and used oil filters
- Paints and solvent residues
- Off-specification chemicals
- Oily water
- Drums, containers, packaging or wrapping materials, or soil contaminated with the TIW.

Hazardous construction wastes can pose serious environmental problems such as air, water, and land pollution unless they are handled, stored, transported and disposed of in an appropriate manner. Potential hazards may include:

- Toxic / adverse health effects on the workforce
- Adverse effects on water quality/ surface water resources, soil and groundwater in the event of spills and leaks

- Fire hazards

The generation of the hazardous construction wastes mentioned above is unavoidable. However, their environmental impact is not expected to raise long-term or irreversible negative effects as hazardous wastes are not routinely generated in big quantities by construction activities. In addition, hazardous wastes will not be generated after the construction phase of the Project has been completed.

The overall significance associated with the generation of hazardous construction wastes is considered minor as the impact is short term.

***Operation Phase***

During the operation of the project, all construction activities associated with the development will have been completed (other than any maintenance of road as required). Considering this, no waste or hazardous materials management impacts have been identified.

### 9.3.2 Evaluation of Potential Impacts

Table 9.2 summarises the impacts with their corresponding Environmental Scores before and after the implementation of mitigation measures, which are elaborated in the following section.

## 9.4 Mitigation Measures

***Pre-Construction and Construction Phase***

The various options within waste management can be categorised in terms of preference from an environmental perspective. The options considered to be more preferable have the least impacts and are more sustainable in a long-term context. Hence, the hierarchy is as follows:

- Avoidance and minimization, i.e. not generating waste through changing or improving processes.
- Reuse or recycling of materials, thus avoiding disposal.
- Disposed in a safe and appropriate manner through licensed waste collection and disposal contractors.

It is recommended that the following guidelines and procedures are adopted:

- The contractor should be contractually obligated to develop a solid waste management plan to manage the collection, recycling and ultimate disposal of all generated wastes in an environmentally responsible manner.
- Timber/wood from cut vegetation can be recovered for use in the wood industry as far as possible.
- Surplus excavated material and inert wastes (soil, broken rock etc.) shall be reused within project site as backfill, landscaping, erosion control and restoration features wherever practicable.
- Scrap metals (e.g. welding rods, end caps, off-cuts etc.) can be recovered and sent for recycling as scrap.

- Other inert general waste will be collected and disposed through licensed waste collector.
- General refuse generated on-site must be stored in enclosed bins separate from construction and hazardous wastes. A licensed general waste collector shall be employed by the Contractor to remove general refuse, on a daily or every second day basis to minimise odour, pest and litter impacts.
- Chemical toilet facilities/ septic tank system with collection of accumulated waste for off-site disposal by a licensed general waste collector.
- All non-hazardous wastes that are generated must be handled and disposed of in accordance with the requirements of the EPHA and the EPH (General Waste Collection) Regulations.
- Any hazardous wastes that are generated must be handled and disposed of in accordance with the requirements of the EPHA and the EPH (Toxic Industrial Wastes) Regulations.
- Disposal of hazardous waste must be through a licensed waste collector for hazardous waste.

Additionally, the Contractor shall strictly follow the *Guidebook for Best Environmental Practices for Construction Waste Management at LTA Sites (2009)* during the project execution.

The recommended measures above, when implemented effectively, shall mitigate the potential impacts of waste management to acceptable levels.

**Table 9.2.** Environmental Scores of the identified waste management impacts with corresponding mitigation measures

| Phase | Impact component | Predicted impact before mitigation | | | | | | | Mitigation measures | Predicted impact after mitigation | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | I | M | P | R | C | ES | Impact | | I | M | P | R | C | ES | Impact |
| ***Ecology*** | | | | | | | | | | | | | | | | |
| Pre-construction / Construction | Disposal of cut vegetation | 2 | -2 | 2 | 2 | 2 | -24 | Slight Negative | • To develop solid waste management plan<br>• Timber/wood to be recovered for use in the wood industry as far as possible | 2 | -1 | 2 | 2 | 2 | -12 | Slight Negative |
| | Disposal of excavated material | 2 | -3 | 2 | 2 | 2 | -36 | Slight Negative | • To develop solid waste management plan<br>• Surplus excavated material to be reused within project site as fill, landscaping, erosion control and restoration wherever practicable<br>• To follow the *Guidebook for Best Environmental Practices for Construction Waste Management at LTA Sites* (2009) | 2 | -2 | 2 | 2 | 2 | -24 | Slight Negative |
| | Disposal of general waste material | 1 | -2 | 2 | 2 | 2 | -12 | Slight Negative | • Scrap metals to be recovered and sent for recycling as scrap<br>• Inert general waste to be collected and disposed through licensed waste collector<br>• All non-hazardous wastes to be handled and disposed of in accordance with EPH (General Waste Collection) Regulations<br>• To follow the *Guidebook for Best Environmental Practices for Construction Waste Management at LTA Sites* (2009) | 1 | -1 | 2 | 2 | 2 | -6 | No Impact |
| ***Human Health and Safety*** | | | | | | | | | | | | | | | | |
| Pre-construction / Construction | Disposal of hazardous waste | 1 | -3 | 2 | 2 | 2 | -18 | Slight Negative | • All hazardous wastes to be handled and disposed of in accordance with EPH (Toxic Industrial Wastes) Regulations<br>• Disposal of hazardous waste to be conducted by a licensed waste collector for hazardous waste | 1 | -2 | 2 | 2 | 2 | -12 | Slight Negative |

# 10 VECTOR CONTROL

## 10.1 Introduction

As Singapore has warm tropical climate, the possibility of vector borne diseases is always present. Vectors are organisms that transmit disease. According to NEA, the five main vectors in Singapore and the diseases that they could transmit are summarized in Table 10.1. As the majority of vector-borne diseases in Singapore are transmitted by mosquitoes, vector control management shall mainly focus on mosquito control during construction activities.

**Table 10.1.** Common vectors in Singapore

| Vector | Disease |
|---|---|
| Mosquitoes | – Dengue and Dengue Hemorrhagic Fever<br>– Chikungunya<br>– Zika<br>– Malaria<br>– Japanese Encephalitis<br>– Filariasis |
| Rat Flea | – Plague |
| Rodent | – Rat Bite Fever<br>– Leptospirosis<br>– Murine Typhus |
| Cockroach | – Cholera<br>– Food-Borne Diseases |
| Fly | – Cholera<br>– Typhoid and Para Typhoid<br>– Salmonellosis<br>– Dysentery |

*Source: https://www.nea.gov.sg/our-services/pest-control/overview*

## 10.2 Relevant Environmental Legislation, Guidelines and Standards

The Control of Vectors and Pesticides Act, 2002 is the main legislation for control of vectors with the prime objective to prevent related diseases such as dengue fever in Singapore. It aims to prevent the propagation of vectors and stipulates the prohibition of creation of any condition favorable to the propagation and harboring of vectors. Under Part V of the Act, only companies that are registered with NEA as vector control operators are allowed to be engaged to conduct any vector control treatment or activity. Employees of vector control operators are required to be licensed as vector control technicians or vector control workers to conduct any vector control activity. All public health pesticide/repellent products intended for use against the five vectors (namely rodents, mosquitoes, flies, cockroaches, and rat fleas) must be registered prior to local sales in Singapore as per this Act.

The Environmental Public Health Act, 2002 stipulates requirements pertaining to vector control such as public cleansing, public nuisances, and insanitary premises.

NEA has also promulgated the Employment of Environmental Control Officers Orders and Code of Practice for Environmental Control Officers which require construction site occupiers to employ either a part-time or full-time Environmental Control Officer, depending on the contract sum of the construction works. The Code of Practice for Environmental Control Officers sets out requirements on environmental health management of construction sites in the areas of vector control.

## 10.3 Impact Assessment

### 10.3.1 Identification of Potential Impacts

***Pre-construction and Construction Phase***

The main impact is the potential to cause an increase in the vector population in surrounding areas including residential community at Springside Ave and Springside View road during construction stage. There is a likelihood of vector-borne diseases affecting humans.

An increase in vectors may be caused by:

- Storage of water on the construction site (e.g. water for washing)
- Pooled water on the construction site (e.g. potholes, access roads with puddles, equipment)
- Creation of stagnant conditions during drainage diversion
- Entrainment of debris, refuse and silts in stormwater run-off resulting choked drains and stagnant drainage
- Storage and improper management of garbage and food waste
- Poor cleanliness and unsanitary conditions

The assessment of the potential impacts is described below.

*Increase in Number of Mosquitos*

Project construction activities have the potential to create suitable breeding conditions for mosquito populations. Specifically, without control measures construction work can create pools of water due to site conditions (e.g. vehicle potholes), construction work (e.g. trenches) and storage of equipment and wastes favouring the breeding of mosquito populations. The likelihood of mosquitoes breeding without control measures in place is high.

*Increase in Number of Other Vectors*

During the construction, construction personnel will generate domestic waste and food waste that if not managed, can attract other vectors (e.g. rats, flies and cockroaches). A lack of correct and secure disposal of these wastes would create suitable breeding conditions for these vectors. The likelihood of rats, flies and cockroaches breeding without control measures in place is high.

Fleas require a host (e.g. rodents or other mammal) in order to breed and therefore fleas are considered to be directly relevant to the construction of the Project. With control of other vectors, fleas and related diseases are not likely to occur.

*Increase in the Incidence of Dengue-Fever & Other Vector-related Diseases*

If the number of mosquitoes increase in the construction works areas, the likelihood of a dengue outbreak occurring in the vicinity of the project can increase. Therefore, it is important to prevent mosquitoes breeding at the construction works areas. There is a residential community at Springside Ave and Springside View road in immediate surrounding of the project area. Hence residents of this community can be exposed to vectors if proper control measures are not implemented.

If the number of rats, flies and cockroaches increases in the construction works areas, the likelihood of nuisance issues and vector-related diseases could increase. These impacts associated with these vectors can quickly change from nuisance to vector-disease levels. As well as diseases, rats can also damage equipment.

***Operation Phase***

During the operation of the project, all construction activities associated with the development will have been completed (other than road maintenance work). Considering this, no vector related impacts have been identified.

Based on the assessment above, the potential vector impacts are deemed to be minor and can be mitigated through appropriate measures.

### 10.3.2 Evaluation of Potential Impacts

Table 10.2 summarises the impacts with their corresponding Environmental Scores before and after the implementation of mitigation measures, which are elaborated in the following section.

## 10.4 Mitigation Measures

***Pre-construction and Construction Phase***

*Increase in Number of Mosquitoes*

It is essential that the construction contractor proactively implements requirements specified in the LTA's Guidebook on Vector Control at LTA Sites (2019). Source reduction and effective drainage are proposed to be the main forms of mosquito control, with the following mitigation measures to be implemented:

- Before construction commences, the construction contractor shall engage a vector control operator registered with NEA to prepare and implement vector management plan.
- Before construction starts, a Vector Management Plan shall be submitted to NEA.
- The construction contractor shall form an in-house vector control team to check construction sites for breeding of mosquitoes using the "three zone-method" developed by LTA. This method divides each construction site to a maximum of three zones and search and destroy activity is to be conducted at one zone per day for a more concentrated effort to eliminate mosquito breeding on site. Focusing on one zone per day, each zone will be combed at least twice a week.
- During the daily checks, particular attention shall be made to discarded receptacles and building wastes; building materials, canvas sheets, equipment

and machinery; puddles on the ground levels; water storage drums, tanks and containers; bulk storage containers; trenches; lift wells; drains and channels temporarily constructed to drain off water; air handling units and air conditioners; and, flat roofs of temporary buildings.

- Empty receptacles, pails, basins and other containers shall be kept indoors.
- Construction worksite shall be kept free of litter; construction wastes shall be disposed promptly into bulk waste containers and the containers shall be emptied daily.
- Building materials shall be stored under shelter as far as practicable; materials shall be stored at least 60 cm above the ground to allow water collected below to be treated by the vector control operator.
- Air-handling units shall be stored under shelter or, the overflow pipe shall be uncapped to allow rainwater to drain out.
- Stagnant water shall be pumped from the works areas and ground depressions shall be covered with earth.
- Anti-mosquito oil and insecticides including BTI shall be applied into stagnant water at least once a week. The application should be repeated after rain as the oil and insecticides would be washed away by the rain.
- Thermal fogging shall not be carried out due to location of project site within forested area.
- Any significant increase in numbers of vectors shall be reported to the NEA and investigated.

*Increase in Number of Other Vectors*

Rats, flies and cockroaches shall also be targeted for active preventative measures to reduce their breeding habitats (waste disposal areas and wet areas). General cleanliness and waste disposal protocols will control these vector populations and worker hygiene can help reduce insect attraction. The following mitigation shall be implemented:

- Worksite shall be kept litter-free and refuse bins shall always be covered tightly.
- Construction workers' food provisions shall be stored in rodent-proof rooms or cabinets.
- All food items shall be adequately covered and stored at least 60 cm above the ground.
- The in-house vector control team and the vector control operator should check for rodent burrows every week. Active burrows should be treated with rodenticides for three consecutive days or until the rats are all dead (i.e. no more dead rats found), and then sealed with compacted earth.
- Sanitary waste/domestic waste should be removed from the site in accordance with Singapore's legislation promptly.
- Any significant increase in numbers of vectors shall be reported to the NEA and investigated.

*Increase in the Incidence of Dengue-Fever & Other Vector-related diseases*

The mitigation to control mosquito numbers and other vectors will mitigate this secondary impact on increase of dengue. Additionally, the following mitigation is proposed:

- During construction, vector control shall be undertaken as per the NEA Guidebook for "Scope of Works for Mosquito Control" and the LTA Guidebook

on Vector Control at LTA Sites (2019).

- If required, assistance shall be provided to the authorities to investigate outbreaks of vector-borne diseases at the construction site.
- Weekly monitoring of the NEA's dengue cluster map shall be undertaken to determine if the workers at construction areas are at risk.

With the implementation of the mitigation measures proposed, it is expected that the impacts can be reduced along with the potential for vector borne diseases.

***Operation Phase***

The operation phase impact is assessed to be insignificant, therefore no mitigation measure is proposed.

**Table 10.2.** Environmental Scores of the identified vector control impacts with corresponding mitigation measures

| Phase | Impact component | Predicted impact before mitigation | | | | | | | Mitigation measures | Predicted impact after mitigation | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | I | M | P | R | C | ES | Impact | | I | M | P | R | C | ES | Impact |
| ***Human Health and Safety*** | | | | | | | | | | | | | | | | |
| Pre-construction / Construction | Increase in the number of mosquitoes | 2 | -2 | 2 | 2 | 2 | -24 | Slight Negative | • Contractor to engage an NEA-registered vector control operator to prepare and implement vector management plan<br>• An in-house vector control team to check construction sites for breeding of mosquitoes using LTA's "three zone-method"<br>• Construction worksite to be kept free of litter; construction wastes shall be disposed promptly into bulk waste containers and the containers shall be emptied daily | 2 | -1 | 2 | 2 | 2 | -12 | Slight Negative |
| | Increase in the number of other vectors (e.g. flies and rodents) | 2 | -2 | 2 | 2 | 2 | -24 | Slight Negative | • Worksite shall be kept litter-free and refuse bins shall always be covered tightly.<br>• Construction workers' food provisions shall be stored in rodent-proof rooms or cabinets<br>• In-house vector control team and vector control operator to check for rodent burrows every week | 2 | -1 | 2 | 2 | 2 | -12 | Slight Negative |
| | Increase in incidence of dengue fever and vector-related diseases (*secondary impact)* | 1 | -2 | 2 | 2 | 2 | -12 | Slight Negative | • To implement mitigation measures to control mosquito numbers and other vectors<br>• To aid the authorities to investigate outbreaks of vector-borne diseases if required | 1 | -1 | 2 | 2 | 2 | -6 | No Impact |

# 11 SUMMARY OF IMPACT ASSESSMENT & MITIGATION MEASURES

**Table 11.1.** Summary of Environmental Scores of the identified impacts with corresponding mitigation measures

| Phase | Aspects | Impact component | Predicted impact before mitigation | | | | | | | Mitigation measures | Predicted impact after mitigation | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | I | M | P | R | C | ES | Impact | | I | M | P | R | C | ES | Impact |
| ***Ecology*** | | | | | | | | | | | | | | | | | |
| Pre-construction / Construction | Biodiversity (Pre-Construction) | Flora and fauna damage and mortality due to vegetation clearance for temporary working space | 3 | -3 | 2 | 3 | 2 | -63 | Minor negative | • Erect temporary hoarding<br>• Identify trees to be transplanted<br>• Establish Tree Protection Zones (TPZ) for trees to be retained<br>• Visually inspect trees and holes for nesting birds and animals prior to felling | 3 | -3 | 2 | 3 | 2 | -63 | Minor negative |
| | | Loss of habitats due to vegetation clearance for temporary working space | 3 | -3 | 2 | 2 | 2 | -54 | Minor negative | • Erect temporary hoarding to limit vegetation clearance<br>• Reinstate habitats where possible upon completion of works | 3 | -2 | 2 | 2 | 2 | -36 | Slight negative |
| | | Loss of connectivity for fauna due to habitat fragmentation from vegetation clearance | 3 | -2 | 2 | 2 | 2 | -36 | Slight negative | • Retain corridors between forested areas to allow for animal movement | 3 | -2 | 2 | 2 | 2 | -36 | Slight negative |
| | Biodiversity (Construction) | Flora and fauna mortality due to vegetation clearance for building of viaduct and associated infrastructure | 3 | -3 | 3 | 3 | 3 | -81 | Moderate negative | • Erect temporary hoarding<br>• Identify trees to be transplanted<br>• Replant new roadside verge with selected native species<br>• Establish Tree Protection Zones (TPZ) for trees to be retained<br>• Visually inspect trees for nesting birds prior to felling | 3 | -2 | 3 | 3 | 3 | -54 | Minor negative |
| | | Loss of habitats due to vegetation clearance for building of viaduct and associated infrastructure | 3 | -3 | 3 | 3 | 3 | -81 | Moderate negative | • Erect temporary hoarding to limit vegetation clearance<br>• Reinstate habitats where possible upon completion of works | 3 | -2 | 3 | 3 | 3 | -54 | Minor negative |
| | | Indirect impact on habitats including waterbodies due to soil erosion | 2 | -3 | 3 | 2 | 2 | -42 | Minor negative | • Implement proper Earth Control Measures (ECMs) | 2 | -2 | 3 | 2 | 2 | -28 | Slight negative |

| Phase | Aspects | Impact component | Predicted impact before mitigation | | | | | | | Mitigation measures | Predicted impact after mitigation | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | I | M | P | R | C | ES | Impact | | I | M | P | R | C | ES | Impact |
| | | Impact on native species due to the introduction of invasive species | 2 | -2 | 3 | 3 | 3 | -36 | Slight negative | • Ensure equipment, vehicles, and footwear used are clean prior to commencing works.<br>• Use native plants for replanting of roadside verges | 2 | -2 | 3 | 3 | 3 | -36 | Slight negative |
| | | Loss of connectivity for fauna due to habitat fragmentation from vegetation clearance | 3 | -3 | 3 | 3 | 2 | -72 | Minor negative | • Retain corridors between forested areas to allow for animal movement | 2 | -2 | 2 | 2 | 2 | -24 | Slight negative |
| | | Impacts to flora and fauna due to illegal encroachment of vegetated areas by construction personnel | 2 | -2 | 2 | 2 | 3 | -28 | Slight negative | • Incorporate signs prohibiting entrance into vegetated areas<br>• Erect fences to prevent illegal entry | 2 | -2 | 2 | 2 | 3 | -28 | Slight negative |
| | Noise | Disturbance to fauna species in and around the project site | 3 | -2 | 2 | 2 | 3 | -42 | Minor negative | • Night works are to be avoided as far as possible<br>• Quieter equipment and vehicles with low noise levels to be used<br>• For piling work, to consider the use of quieter piling methods<br>• Acoustic enclosures to be considered for compressors, generators, drilling tools etc.<br>• All noise and acoustic barriers to be able to achieve at least 10dBA noise reduction from source noise levels. | 3 | -1 | 2 | 2 | 3 | -21 | Slight negative |
| | Hydrology & Water Quality | Impact to terrestrial habitats due to erosion of topsoil | 2 | -3 | 2 | 2 | 2 | -36 | Slight negative | • Implementation of proper Earth Control Measures (ECMs) | 2 | -2 | 2 | 2 | 2 | -24 | Slight negative |
| | | Impact to water quality and aquatic habitat due to sediment runoff and siltation | 2 | -3 | 2 | 2 | 2 | -36 | Slight negative | • Implementation of proper Earth Control Measures (ECMs) | 2 | -2 | 2 | 2 | 2 | -24 | Slight negative |
| | | Disturbance to local drainage pattern due to impact to natural stream (i.e. Sungei Botak) | 2 | -3 | 3 | 2 | 2 | -42 | Minor negative | • To divert the drainage flow to existing culvert near Sembawang Road to cater for the hydrological patterns on the site. | 2 | -3 | 3 | 2 | 2 | -42 | Minor negative |
| | Ambient Air Quality | Impact to biodiversity due to generation of fugitive dust | 2 | -2 | 2 | 2 | 2 | -24 | Slight negative | • To implement dust suppression plan<br>• Use of hoarding at project boundary within Sembawang forested area to | 2 | -1 | 2 | 2 | 2 | -12 | Slight Negative |

| Phase | Aspects | Impact component | Predicted impact before mitigation | | | | | | | Mitigation measures | Predicted impact after mitigation | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | I | M | P | R | C | ES | Impact | | I | M | P | R | C | ES | Impact |
| | | | | | | | | | | minimise dust generation by attenuating wind forces.<br>• To avoid stockpiles of soil and dusty materials at project site within Sembawang forested area as far as possible.<br>• Stockpiles of dusty material should be properly stored, covered entirely with impervious sheeting<br>• Use of regular watering to reduce dust emissions from exposed site surface | | | | | | | |
| | Light | Disturbance to the flora and fauna due to light from construction activities | 2 | -3 | 2 | 2 | 1 | -30 | Slight negative | • Construction works to be limited to daylight hours as far as practicable<br>• All unnecessary lights should be turned off outside working hours<br>• Any installed temporary lighting during construction phase for night work shall be directed inward toward project site (i.e. directly away from forested areas) | 2 | -2 | 2 | 2 | 1 | -20 | Slight negative |
| | Waste Management | Disposal of cut vegetation | 2 | -2 | 2 | 2 | 2 | -24 | Slight Negative | • To develop solid waste management plan<br>• Timber/wood to be recovered for use in the wood industry as far as possible | 2 | -1 | 2 | 2 | 2 | -12 | Slight Negative |
| | | Disposal of excavated material | 2 | -3 | 2 | 2 | 2 | -36 | Slight Negative | • To develop solid waste management plan<br>• Surplus excavated material to be reused within project site as fill, landscaping, erosion control and restoration wherever practicable<br>• To follow the *Guidebook for Best Environmental Practices for Construction Waste Management at LTA Sites* (2009) | 2 | -2 | 2 | 2 | 2 | -24 | Slight Negative |
| | | Disposal of general waste material | 1 | -2 | 2 | 2 | 2 | -12 | Slight Negative | • Scrap metals to be recovered and sent for recycling as scrap | 1 | -1 | 2 | 2 | 2 | -6 | No Impact |

| Phase | Aspects | Impact component | Predicted impact before mitigation | | | | | | | Mitigation measures | Predicted impact after mitigation | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | I | M | P | R | C | ES | Impact | | I | M | P | R | C | ES | Impact |
| | | | | | | | | | | • Inert general waste to be collected and disposed through licensed waste collector<br>• All non-hazardous wastes to be handled and disposed of in accordance with EPH (General Waste Collection) Regulations<br>• To follow the *Guidebook for Best Environmental Practices for Construction Waste Management at LTA Sites* (2009) | | | | | | | |
| Operation | Biodiversity | Roadkill or road injury to fauna attempting to cross the new road | 3 | -2 | 2 | 2 | 2 | -36 | Slight negative | • Erect physical barriers to prevent fauna from crossing the road<br>• Install animal detection system to alert drivers to wildlife about to cross the road | 3 | -1 | 2 | 2 | 2 | -18 | Slight negative |
| | Noise | Disturbance to fauna species in and around the project site | 3 | -2 | 3 | 2 | 3 | -48 | Minor negative | • To consider measures such as thick hedge to reduce noise spilling into the surrounding environment | 3 | -1 | 3 | 2 | 3 | -24 | Slight negative |
| | Light | Disturbance to the flora and fauna due to operation phase lighting | 2 | -3 | 3 | 2 | 3 | -48 | Minor negative | • Permanent lighting for road safety should be designed to be downward facing and directed away from forested areas<br>• Roadside planting should include thick hedge plants which can reduce the amount of light entering the forest | 2 | -2 | 3 | 2 | 3 | -24 | Slight negative |
| ***Human Health and Safety*** | | | | | | | | | | | | | | | | | |
| Pre-construction / Construction | Biodiversity | Attacks of construction personnel by animals including feral dogs and Long-tailed Macaques | 3 | -4 | 2 | 3 | 2 | -84 | Moderate negative | • Establish designated areas for food and waste disposal<br>• Conduct information sessions on what to do upon encountering wildlife | 3 | -3 | 2 | 3 | 2 | -63 | Minor negative |
| | | Impact to health of personnel due to tick/ mite bites from feral dogs | 3 | -3 | 2 | 3 | 2 | -63 | Minor negative | • Implement proper use of Personal Protective Equipment (PPE) | 3 | -2 | 2 | 3 | 2 | -42 | Minor negative |

| Phase | Aspects | Impact component | Predicted impact before mitigation | | | | | | | Mitigation measures | Predicted impact after mitigation | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | I | M | P | R | C | ES | Impact | | I | M | P | R | C | ES | Impact |
| | | Injury caused by tree falls due to damaged roots | 3 | -4 | 2 | 3 | 2 | -84 | Moderate negative | • Establish Tree Protection Zones (TPZ) for trees to be retained<br>• Regularly monitor health of trees on project site | 3 | -3 | 2 | 3 | 2 | -63 | Minor negative |
| | Noise | Impact to construction workers due to exposure to high noise levels of construction activities | 2 | -3 | 2 | 2 | 2 | -36 | Slight negative | • Personnel are to wear appropriate Personal Protective Equipment (PPE) at all times while on the construction site<br>• Quieter equipment and vehicles with low noise levels to be used | 2 | -2 | 2 | 2 | 2 | -24 | Slight negative |
| | | Impact to residential community due to noise pollution from construction activities | 2 | -3 | 2 | 2 | 2 | -36 | Slight negative | • Night works are to be avoided as far as possible<br>• Quieter equipment and vehicles with low noise levels to be used<br>• Erection of temporary 4m high acoustic barriers around piling equipment<br>• Acoustic enclosures to be considered for compressors, generators, drilling tools etc.<br>• All noise and acoustic barriers to be able to achieve at least 10dBA noise reduction from source noise levels. | 2 | -2 | 2 | 2 | 2 | -24 | Slight negative |
| | Hydrology & Water Quality | Impact to water quality due to accidental spillage of construction materials, fuel, and solvents | 2 | -2 | 2 | 2 | 2 | -24 | Slight negative | • Disposal of waste into water streams is strictly prohibited<br>• Waste bins to be provided within the construction work area.<br>• Foreign material to be removed from site by a licensed waste collector<br>• Contractor to provide adequate portable chemical toilets for construction personnel<br>• Vehicle fuelling and major maintenance to be minimised within the project area | 2 | -1 | 2 | 2 | 2 | -12 | Slight negative |
| | Ambient Air Quality | Impact on construction workers due to generation of fugitive dust and exhaust | 2 | -3 | 2 | 2 | 2 | -36 | Slight Negative | • To implement dust suppression plan<br>• Personal protective equipment i.e. face mask to be worn during dust exposure | 2 | -2 | 2 | 2 | 2 | -24 | Slight Negative |

| Phase | Aspects | Impact component | Predicted impact before mitigation | | | | | | | Mitigation measures | Predicted impact after mitigation | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | I | M | P | R | C | ES | Impact | | I | M | P | R | C | ES | Impact |
| | | emissions from construction machineries | | | | | | | | • Stockpiles of dusty material to be properly stored, covered entirely with impervious sheeting, or dampened with water<br>• Use of regular watering to reduce dust emissions from exposed site surfaces<br>• Proper maintenance of construction vehicles and fuel burning equipment<br>• Intermittently-used vehicles and machinery are to be shut down between work periods | | | | | | | |
| | | Impact on residential community due to generation of fugitive dust | 2 | -2 | 2 | 2 | 2 | -24 | Slight Negative | • To implement dust suppression plan<br>• Provide dust screen at project boundary near residential community<br>• Stockpiles of dusty material to be properly stored, covered entirely with impervious sheeting, or dampened with water<br>• Use of regular watering to reduce dust emissions from exposed site surface | 2 | -1 | 2 | 2 | 2 | -12 | Slight Negative |
| | | Impact due to generation of odour | 1 | -1 | 2 | 2 | 2 | -6 | No Impact | • Refer to Section 9.4 | 1 | -1 | 2 | 2 | 2 | -6 | No Impact |
| | Waste Management | Disposal of hazardous waste | 1 | -3 | 2 | 2 | 2 | -18 | Slight Negative | • All hazardous wastes to be handled and disposed of in accordance with EPH (Toxic Industrial Wastes) Regulations<br>• Disposal of hazardous waste to be conducted by a licensed waste collector for hazardous waste | 1 | -2 | 2 | 2 | 2 | -12 | Slight Negative |
| | Vector Control | Increase in the number of mosquitoes | 2 | -2 | 2 | 2 | 2 | -24 | Slight Negative | • Contractor to engage an NEA-registered vector control operator to prepare and implement vector management plan<br>• An in-house vector control team to check construction sites for breeding of mosquitoes using LTA's "three zone-method" | 2 | -1 | 2 | 2 | 2 | -12 | Slight Negative |

| Phase | Aspects | Impact component | Predicted impact before mitigation | | | | | | | Mitigation measures | Predicted impact after mitigation | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | I | M | P | R | C | ES | Impact | | I | M | P | R | C | ES | Impact |
| | | | | | | | | | | • Construction worksite to be kept free of litter; construction wastes shall be disposed promptly into bulk waste containers and the containers shall be emptied daily | | | | | | | |
| | | Increase in the number of other vectors (e.g. flies and rodents) | 2 | -2 | 2 | 2 | 2 | -24 | Slight Negative | • Worksite shall be kept litter-free and refuse bins shall always be covered tightly.<br>• Construction workers' food provisions shall be stored in rodent-proof rooms or cabinets<br>• In-house vector control team and vector control operator to check for rodent burrows every week | 2 | -1 | 2 | 2 | 2 | -12 | Slight Negative |
| | | Increase in incidence of dengue fever and vector-related diseases (*secondary impact)* | 1 | -2 | 2 | 2 | 2 | -12 | Slight Negative | • To implement mitigation measures to control mosquito numbers and other vectors<br>• To aid the authorities to investigate outbreaks of vector-borne diseases if required | 1 | -1 | 2 | 2 | 2 | -6 | No Impact |
| Operation | Biodiversity | Increase in road accidents due to wildlife crossing slip road | 3 | -4 | 2 | 2 | 2 | -72 | Minor negative | • Erect signages to alert drivers of potential animal crossings. | 3 | -3 | 2 | 2 | 2 | -54 | Minor negative |
| | Ambient Air Quality | Impact due to exhaust emission from traffic | 3 | -2 | 3 | 2 | 2 | -42 | Minor Negative | • Existing exhaust emission standards | 3 | -1 | 3 | 2 | 2 | -21 | Slight Negative |

# 12 ENVIRONMENTAL MANAGEMENT FRAMEWORK

## 12.1 Objectives

The Environmental Management and Monitoring Plan (EMMP) is a systematic approach to mitigate environmental impacts and monitor the implementation of these mitigation measures to ensure that propose road project being implemented by the Client will not cause any significant adverse impact to the site and the surrounding environment. It is also a useful tool to assess whether the mitigation measures taken are effective to reduce or mitigate the potential impacts caused by this project to minimal and acceptable levels during the construction.

## 12.2 General Scope of the EMMP

Before the start of construction works, the Client shall ensure that the appointed Contractor must establish a detailed Construction EMMP (CEMMP), which is to be implemented and monitored during the construction phase. The CEMMP to include the identified mitigation measures of this EIS (Chapter 11), and shall address the methodologies of the construction works prior to their commencement. This should include the engagement of an ecological specialist to design and implement ecological mitigation measures recommended in this report. The CEMMP should also include waste management practices including restricting use & spillage of chemicals during construction phase into surrounding forested area.

At all times, Client should ensure that an EMMP Specialist is available, primarily during the construction phase, to supervise impact mitigation and monitoring activities for the project. Table 12.1 provides the recommended EMMP for this project. The environmental monitoring locations which is to be finalised during CEMMP formulation in consultation with relevant stakeholders. A final compliance audit should be done after construction to confirm that no residual impacts are observed.

Environmental monitoring comprises of compliance inspections for prescribed mitigation measures and ambient environmental data collection (if needed), generally requiring sample collection and analysis. The environmental monitoring activities should also ensure that the project does not cause any significant long-term environmental impacts, in particular cumulative impacts, and that the existing environmental conditions and biodiversity is maintained. A detailed environmental monitoring checklist can be developed as part of CEMMP to monitor and record site implementation.

Monthly environmental monitoring reports with all monitoring results (compliance and ambient monitoring), identified problems and additional actions taken to mitigate these problems should be prepared and submitted to the relevant authorities during the construction phase. Each subsequent monthly monitoring reports should report on successful or failed follow-up actions until a problem has been effectively mitigated.

## 12.3 Contingencies for Failed Mitigating Measures

The regular and continual environmental monitoring may result in observations of failed or inadequate mitigation measures. In the event that a failure is discovered that failure must be reported by the EMMP Specialist to Contractor's Project Manager within shortest possible time.

The project manager will then be responsible for ensuring adequate follow-up activities. This may include:

- On-site consultation with the EMMP Specialist
- Arranging an immediate appropriate response on advice of EMMP Specialist
- Discussions with the relevant authorities (i.e. NEA, NParks, PUB)

In the event of violation of relevant standards/ regulations, it is recommended that site environmental management practices are reviewed immediately, and the appropriate mitigation action taken immediately to reduce impacts to acceptable levels.

## 12.4 Environmental Management and Monitoring Plan

Table 12.1 provides the draft Environmental Management and Monitoring Plan recommended for this project. Contractor shall appropriately finalise the monitoring locations in consultation with relevant stakeholders.

**Table 12.1.** Recommended Environmental Management and Monitoring Plan for construction phase

| Monitoring Category | Impact | Monitoring Parameters | Monitoring Method | Location | Standards / Criteria | Time / Duration / Frequency | Implementation | Supervision |
|---|---|---|---|---|---|---|---|---|
| **Biodiversity Monitoring**<br>• Avoiding clearance of vegetation outside working boundaries<br>• Minimization of disturbance to sensitive species<br>• Retaining connectivity between habitats | <u>On-site Visual and Compliance Monitoring</u> | | | | | | | |
| | Habitat Loss | • Hoarding to be erected prior to vegetation clearance to demarcate working boundaries<br>• Reinstatement of habitats upon work completion where required<br>• Retain vegetated buffer between construction areas and waterbodies | • Visual monitoring<br>• Compliance check | Entire project site (within forested area) | • Proper installation of temporary hoarding/ barriers<br>• Absence of vegetation clearance outside working boundaries | • Continuous during construction phase<br>• Monthly compliance monitoring | • Contractor, ECO<br>• Ecologist<br>• Arborist | CCW |
| | Species Mortality | • Properly designated Tree Protection Zones (TPZ) prior to construction<br>• Visual inspection of trees and holes for nesting birds prior to felling<br>• Wildlife shepherding prior to vegetation clearance | • Visual monitoring<br>• Compliance check | Entire project site (within forested area) | • Proper TPZ installation<br>• Retention of tree health<br>• Absence of mechanical damage on trees<br>• Absence of nesting birds<br>• Absence of large mammals species | • Continuous during construction phase<br>• Monthly compliance monitoring<br>• Prior to vegetation clearance (for wildlife shepherding) | • Contractor, ECO<br>• Ecologist<br>• Arborist | CCW |

| Monitoring Category | Impact | Monitoring Parameters | Monitoring Method | Location | Standards / Criteria | Time / Duration / Frequency | Implementation | Supervision |
|---|---|---|---|---|---|---|---|---|
| | Loss of Habitat Connectivity | • Retain forested buffers between cleared areas. | • Visual monitoring<br>• Compliance check around buffer planting locations | Entire project site (within forested area) | • No vegetation clearance within buffer areas | • Continuous during construction phase<br>• Monthly compliance monitoring | • Contractor, ECO<br>• Ecologist | CCW |
| | Human-wildlife conflict | • Briefing to On-site workers on dos and don'ts, as well as notes on safety.<br>• Areas are to be demarcated for food consumption and storage. | • Visual monitoring<br>• Compliance check | Entire project site (within forested area) | • No injuries due to wild animals | • Continuous during construction phase<br>• Monthly compliance monitoring | • Contractor, ECO<br>• Ecologist | CCW |
| **Noise Monitoring**<br><br>• Minimization of biodiversity disturbance due to construction noise<br><br>• Minimization of nuisances to human due to construction noise | <u>On-site Visual and Compliance Monitoring</u> | | | | | | | |
| | Disturbance to biodiversity and human due to construction noise | • Noise barriers around construction work areas<br>• Utilization of quieter equipment and vehicles with low noise levels<br>• PPE use by construction personnel at all times while on the construction site | • Visual monitoring<br>• Compliance check | Entire project site (within forested area) | • Environmental Protection and Management (Control of Noise at Construction Sites) 2008 | • Continuous during construction phase<br>• Monthly compliance monitoring | • Contractor, ECO | CCW |

| Monitoring Category | Impact | Monitoring Parameters | Monitoring Method | Location | Standards / Criteria | Time / Duration / Frequency | Implementation | Supervision |
|---|---|---|---|---|---|---|---|---|
| | On-site Physical Noise Monitoring | | | | | | | |
| | Noise generated from construction work | • Noise levels | • Sound level meter | Entire project site (within forested area) | • Environmental Protection and Management (Control of Noise at Construction Sites) 2008 | • 24x7 continuous boundary noise monitoring during entire construction phase<br>• Monthly noise report | • Contractor, ECO | CCW |
| **Water Quality Monitoring**<br><br>• Minimization of impact to waterbodies due to contaminated site run-off<br><br>• Minimization of impact to terrestrial habitats due to erosion of topsoil | On-site Visual and Compliance Monitoring | | | | | | | |
| | ECM non-compliance | • Verify implementation of ECM Plan<br>• Perimeter cut-off drains, perimeter silt fence, silt traps, sedimentation basin and silt treatment system | • Visual monitoring<br>• Compliance check<br>• ECM checklist | Construction area with earthworks | • ECM Plan designed by a Qualified Erosion Control Professional (QECP) | • Daily compliance monitoring<br>• Monthly compliance monitoring | • Contractor, ECO<br>• QECP | CCW |
| | On-site Physical Water Quality Monitoring | | | | | | | |
| | ECM discharge (sediment runoff) | • Total Suspended Solids (TSS) | • Grab sampling & lab analysis | Final ECM discharge point | • Less than 50mg/L for TSS<br>• Sewerage and Drainage (Surface Water Drainage) Regulation 2007 | • Once a month<br>• Monthly water quality report | • Contractor, ECO | CCW |
| **Air Quality Monitoring** | On-site Visual and Compliance Monitoring | | | | | | | |
| | Fugitive dust | • Verify | • Visual monitoring | Entire project site | • Approved Dust | • Daily | • Contractor, | CCW |

| Monitoring Category | Impact | Monitoring Parameters | Monitoring Method | Location | Standards / Criteria | Time / Duration / Frequency | Implementation | Supervision |
|---|---|---|---|---|---|---|---|---|
| • Minimization of human health & biodiversity impacts due to dust pollution<br>• Minimization of human health impacts due to exhaust emissions | emissions | implementation of dust suppression plan<br>• Regular watering to reduce dust emissions from exposed site surfaces<br>• Clean roadways at the site entry/exit points<br>• Implementation of vehicular speed limit within site<br>• Covered stockpiles<br>• Use of PPE (face mask) by construction personnel | • Compliance check | (within forested area) | suppression plan<br>• Guidebook for Best Environmental Practices for Construction Waste Management at LTA Sites (2009) | compliance monitoring<br>• Monthly compliance monitoring | ECO | |
| | Exhaust emission from construction machineries operations | • Maintenance frequency of vehicles and machineries | • Visual monitoring<br>• Compliance check | All construction areas | • No visible exhaust plume, dark smoke etc. | • Daily compliance monitoring<br>• Monthly compliance monitoring | • Contractor, ECO | CCW |
| | Open burning of construction and other wastes | • Open burning incident | • Visual monitoring<br>• Compliance check | Entire project site (within forested area) | • Environmental Protection and Management (Prohibition on the Use of Open Fires) Order 2008 | • Daily compliance monitoring<br>• Monthly compliance monitoring | • Contractor, ECO | CCW |

| Monitoring Category | Impact | Monitoring Parameters | Monitoring Method | Location | Standards / Criteria | Time / Duration / Frequency | Implementation | Supervision |
|---|---|---|---|---|---|---|---|---|
| | On-site Physical Air Quality Monitoring | | | | | | | |
| | Particulate matter emission from construction activities | • $PM_{2.5}$ and $PM_{10}$ | • Dust sampler | Construction areas with earthworks | • Singapore Ambient Air Quality Targets | • One day (24 hr) monitoring<br>• Once a Month<br>• Monthly air quality report | • Contractor, ECO | CCW |
| **Light Impact Monitoring**<br><br>• Minimization of light pollution impacts on ecological processes | On-site Visual and Compliance Monitoring | | | | | | | |
| | Light pollution affecting sensitive species | • Appropriate positioning of lights<br>• Scheduling of activity during nightworks<br>• Turn off all unnecessary lights outside working hours | • Visual monitoring<br>• Compliance check | Entire project site (within forested area) | • Absence of nightworks<br>• All artificial lights to be downward facing, turned away from forested areas | • Daily compliance monitoring<br>• Monthly compliance monitoring | • Contractor, ECO<br>• Ecologist | CCW |
| **Vector Monitoring**<br><br>• Minimizing the impacts due to increase in vector related diseases | On-site Visual and Compliance Monitoring | | | | | | | |
| | Increase in the Incidence of vectors & related diseases | • Verify implementation of vector control management plan<br>• Engagement of NEA registered vector control operator<br>• Appointment of an in-house vector control team | • Visual monitoring<br>• Compliance check | Entire project site (within forested area) | • Vector control management plan<br>• Control of Vectors and Pesticides Act, 2002<br>• Best Environmental Practices: Vector Control at LTA Sites (2019) | • Daily compliance monitoring<br>• Monthly vector control report | • Contractor, ECO | CCW |

| Monitoring Category | Impact | Monitoring Parameters | Monitoring Method | Location | Standards / Criteria | Time / Duration / Frequency | Implementation | Supervision |
|---|---|---|---|---|---|---|---|---|
| **Waste Management Monitoring**<br><br>• Minimizing the impacts due to improper disposal of hazardous and general waste | <u>On-site Visual and Compliance Monitoring</u> | | | | | | | |
| | Improper disposal of hazardous waste lead to land pollution | • Engagement of NEA licensed waste collector for hazardous waste<br>• Record of waste disposal | • Visual monitoring<br>• Compliance check | • Entire project site (within forested area) | • Environmental Public Health (Toxic Industrial Wastes) Regulation, 2000 | • Daily compliance monitoring<br>• Monthly waste disposal report | • Contractor, ECO<br>• QECP | CCW |
| | Improper disposal of construction waste lead to land pollution | • Verify implementation of solid waste management plan<br>• Engagement of NEA licensed general waste collector<br>• Record of waste disposal | • Visual monitoring<br>• Compliance check | • Construction waste storage location<br>• General waste storage location | • Environmental Public Health (General Waste Collection) Regulation, 2000<br>• Guidebook for Best Environmental Practices for Construction Waste Management at LTA Sites 2009 | • Daily compliance monitoring<br>• Monthly waste disposal report | • Contractor, ECO | CCW |

# 13 REFERENCES


Australia Department of the Environment and Energy. (2019). *National Light Pollution Guidlines for Wildlife.* Australia: Australian Government.

Baker, N., & Lim, K. (2012). *Wild Animals of Singapore.* Singapore: Draco Publishing and Distribution Pte. Ltd. and Nature Society (Singapore).

Bunkley, J. P., McClure, C. J., Kawahara, A. Y., Francis, C. D., & Barber, J. R. (2017). Anthropogenic noise changes arthropod abundances. *Ecology and Evolution, 7*(9), 2977-2985. doi:10ad.1002/ece3.2698

Chong, K. Y. (2009). *Checklist of the Total Vascular Plant Flora of Singapore.* Singapore: Raffles Museum of Biodiversity and Research and Department of Biological Sciences, National University of Singapore.

Chong, K. Y., Tan, H. T., & Corlett, R. T. (2009). *A Checklist of the Total Vascular Plant Flora of Singapore: Native, Naturalised, and Cultivated Species.* (H. T. Tan, Ed.) Singapore: Raffles Museum of Biodiversity Research, National University of Singapore. Retrieved from https://lkcnhm.nus.edu.sg/app/uploads/2017/04/flora_of_singapore_tc.pdf

Çinar, M. E. (2014). Impacts of invasive alien marine species on ecosystem services and biodiversity: a pan-European review. *Aquatic Invasions, 9*(4), 391-423.

Davison, G. W., Ng, P. K., & Ho, H. C. (2008). *The Singapore Red Data Book: Threatened Plants and Animals of Singapore* (2nd ed.). Singapore: Nature Society (Singapore).

Davison, G., Ng, P., & Chew, H. (2008). *The Singapore Red Data Book: Threatened plants and animals of Singapore.* Singapore: Nature Society.

Francis, C., & Barber, J. (2013). A framework for understanding noise impacts on wildlife: an urgent conservation priority. *Frontiers in Ecology and Environment*, 11(6): 305-313.

Grantz, D., Garner, J., & Johnson, D. (2003). Ecological effects of particulate matter. *Environment Internaional, 29*(2-3), 213 - 239.

Greenery & Development Planning Branch. (2018). *Guidelines on Greenery Provision and Tree Conservation for Developments* (Version 2 ed.). Singapore: National Parks Board. Retrieved from https://www.nparks.gov.sg/-/media/nparks-real-content/partner-us/developers-architects-and-engineers/gdp-handbook-2018-apr-3.pdf

Hennings, L. (April, 2016). *The impacts of dogs on wildlife and water quality: A literature review.* Oregon: Metro Parks and Nature. Retrieved from Metro: https://www.oregonmetro.gov/sites/default/files/2017/09/28/impacts-of-dogs-on-wildlife-water-quality-science-review.pdf

Hughes, A. C., Satasook, C., Bates, P. J., Soisook, P., Sritongchuay, T., Jones, G., & Bumrungsri, S. (2011). Using echolocation calls to identify Thai bat species: Vespertilionidae, Emballonuridae, Nycteridae and Megadermatidae. *Acta Chiropterologica, 13*(2), 447–455.

Hughes, J., & Macdonald, D. (2013). A review of the interactions between free-roaming domestic dogs and wildlife. *Biological Conservation, 157*, 341-351.

International Union for Conservation of Nature and Natural Resources (IUCN). (March, 2020). *The IUCN Red List of Threatened Species*. Retrieved 19 March, 2020, from http://www.iucnredlist.org

IUCN. (2020). *The IUCN Red List of Threatened Species*, Version 2020-1. Retrieved from The IUCN Red List of Threatened Species

Legislation Division of the Attorney-General's Chambers. (n.d.). *Singapore Statutes Online*. Retrieved January, 2020, from Singapore Statutes Online: https://sso.agc.gov.sg/

Lim, K. (2009). *The Avifauna of Singapore.* Singapore: The Nature Society (Singapore).

Lim, N. T. (2008). Home range, activity cycle and natal den usage of a female Sunda Pangolin Manis javanica (Mammalia: Pholidota) in Singapore. *Endangered Species Research, 4*, 233 - 240.

Longcore, T., & Rich, C. (2004). Ecological Light Pollution. *Frontiers in Ecology and the Environment/ Volume 2, Issue 4*.

Low, B. W., Kwik, J., Leong, Y. S., & Low, E. (2015). *Limited Environmental Impact Study of Lorong Halus Ponds.* Singapore: Public Utilities Board.

Ministry of Natural Resources and Environment of Vietnam. (12 December, 2011). *Circular No. 43/2011/TT-BTNMT of December 12, 2011, providing for national technical standards on environment.* Retrieved 27 August, 2020, from Legal document search & search system: https://vanbanphapluat.co/circular-no-43-2011-tt-btnmt-providing-for-national-technical-standards

Ministry of the Environment and Water Resources & Ministry of National Development. (2015). *Publications: Sustainable Singapore Blueprint.* Singapore: Ministry of the Environment and Water Resources & Ministry of National Development. Retrieved from Website of Sustainable Singapore Blueprint: https://www.mewr.gov.sg/docs/default-source/module/ssb-publications/41f1d882-73f6-4a4a-964b-6c67091a0fe2.pdf

National Environment Agency. (20 February, 2020). *Allowable Limits for Trade Effluent Discharge to Watercourse or Controlled Watercourse*. Retrieved from The National Environment Agency: https://www.nea.gov.sg/our-services/pollution-control/water-quality/allowable-limits-for-trade-effluent-discharge-to-watercourse-or-controlled-watercourse

Ngiam, R. W. (2009). The biology and distribution of Pseudagrion rubriceps rubriceps Selys, 1876 (Odonata: Zygoptera: Coenagrionidae) in Singapore. *Nature in Singapore, 2*, 209 - 214.

Ngiam, R. W., & Cheong, L. F. (2016). The dragonflies of Singapore: An updated checklist and revision of the national conservation statuses. *Nature in Singapore, 9*, 149 - 163.

Ngiam, R., & Cheong, L. (2016). The dragonflies of Singapore: An updated checklist and revision of the national conservation statuses. *Nature in Singapore, 9*, 149-163.

Nguyen, C. T., Wasson, R. J., & Ziegler, A. D. (2018). The hydro-geomorphic status of Nee Soon freshwater swamp forest catchment of Singapore. *Gardens' Bulletin Singapore, 70*((Suppl. 1)), 33–48. doi:doi: 10.26492/gbs70(suppl.1).2018-03

Pastakia, C., & Barber, J. R. (1998). The Rapid Impact Assessment Matrix (RIAM) for EIA. *Environmental Impact Assessment Review*, 461-482.

Peh, K. S. (2010). Invasive species in Southeast Asia: the knowledge so far. *Biodiversity and Conservation, 19*(4), 1083 - 1099.

Pottie, S. A., Lane, D. J., Kingston, T., & Lee, B. P. (2005). The microchiropteran bat fauna of Singapore. *Acta Chiropterologica, 7*(2), 237–247.

Public Utilities Board. (2 September, 2019). *Water from Local Catchment*. Retrieved January, 2020, from Public Utilities Board website: https://www.pub.gov.sg/watersupply/fournationaltaps/localcatchmentwater

Public Utilities Board. (n.d.). *Lorong Halus Wetland*. Retrieved January, 2020, from Active, Beautiful, Clean Waters Programme: https://www.pub.gov.sg/abcwaters/explore/loronghaluswetland

Reijnen, R., Foppen, R., & Meeuwsen, H. (1996). The effects of traffic on the density of breeding birds in Dutch agricultural grasslands. *Biological Conservation*, 75: 255-260.

Swaddle, J., & Page, L. (2007). High levels of environmental noise erode pair preferences in zebra finches: implications for noise pollution. *Animal Behaviour, 74*, 363–368. doi:10.1016/j.anbehav.2007.01.004

Taylor, D. L., Leung, L. K., & Gordon, I. J. (2009). The impact of feral pigs (Sus scrofa) on an Australian lowland tropical rainforest. *Wildlife Research, 38*(5), 437-445.

Technical Committee of the Working Group on Habitat Fragmentation caused by Transport Infrastructure. (2016). *Technical Prescriptions fo Wildlife Crossing and Fence Design* (2nd ed.). Madrid: Ministry of Agriculture, Food and the Environment (Spain). Retrieved from http://www.trameverteetbleue.fr/sites/default/files/references_bibliographiques/technical_prescriptions_wildlife_crossing_tcm7-437077.pdf

Teo, R. C. (2018). First record of the long-winged tomb bat in Singapore. In *Singapore Biodiversity Records* (pp. 59–61). Singapore: Lee Kong Chian Natural History Museum, National University of Singapore. doi:ISSN 2345-7597

The Nature Society (Singapore). (March, 2009). *Feedback for the Inter-Ministerial Committee Project on Sustainable Singapore: Lively and Liveable City.* Retrieved February, 2020, from The Nature Society (Singapore) website: https://www.nss.org.sg/report/dd603a22-7SustainableSingaporeProjectNatureSocietyReportFinal.pdf

Theng, M., & Sivasothi, N. (2016). The smooth-coated otter Lutrogale perspicillata (Mammalia: Mustelidae) in Singapore: establishment and expansion in natural and semi-urban environments. *IUCN Otter Spec. Group Bull, 33*(1), 37 - 49.

Vuillaume, B., Valette, V., Lepais, O., Grandjean, F., & Breuil, M. (2015). Genetic evidence of hybridization between the endangered native species Iguana delicatissima and the invasive Iguana iguana (Reptilia, Iguanidae) in the Lesser Antilles: management implications. *PloS One, 10*(6). Retrieved from https://doi.org/10.1371/journal.pone.0127575

Yong, D. L. (2018). Significance of the globally threatened Straw-headed Bulbul Pycnonotus zeylanicus populations in Singapore: a last straw for the species? *Bird Conservation International, 28*(1), 133 - 144.

Young, J. K., Olson, K. A., Reading, R. P., Amgalambaatar, S., & Berger, J. (2011). Is wildlife going to the dogs? Impacts of feral and free-roaming dogs on wildlife populations. *Bioscience, 61*(2), 125-132.