OLD JURONG ROAD ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

Final Report

27 January 2026

Intended for
Urban Redevelopment Authority

Document type
TAC/24021/Final Report

TEMBUSU
Asia

Description **Final Report for Old Jurong Road Environmental Impact Assessment (EIA)**

Project Ref **TAC/24021/Final Report**

Rev No	Date	Description	Prepared by	Checked by	Approved by
00	10/10/2025	Issued for submission to Client	AC, BWH, FY, JL, JYW, LSY, ML, SP, ST, TK, LFY	EC	SCT
01	12/11/2025	Revised as per comments received	AC, BWH, JYW, LSY	EC	SCT
02	14/11/2025	Revised as per comments received	AC	EC	SCT
03	15/12/2025	Revised as per comments received	AC, LSY	EC	SCT
04	27/01/2026	Revised as per comments received	LSY	AC	SCT

TEMBUSU Asia Consulting Pte Ltd
1 Commonwealth Lane #06-06
One Commonwealth Building
Singapore 149544
T +65 6238 4009
F +65 6570 5254
Co. Reg. No. 201732581C

CONTENT

FIGURES

TABLES

ABBREVIATIONS

Abbreviation	Definition
µg/m3	micrograms per cubic metre
ACRES	Animal Concerns Research and Education Society
APHA	American Public Health Association
ASR	Air Sensitive Receptor
BBNC	Bukit Batok Nature Corridor
BBNP	Bukit Batok Nature Park
BH	Borehole
BIA	Biodiversity Impact Assessment
BOD5	Biological oxygen demand
BTNR	Bukit Timah Nature Reserve
CCNR	Central Catchment Nature Reserve
CCTV	Closed Circuit Television
CF	Constant frequency
CFU	Colony Forming Unit
CITES	The Convention on International Trade in Endangered Species of Wild Fauna and Flora
cm	centimetre
CR	Critically Endangered
CSA	Core Sensitive Area
dB	Decibel
DD	Data Deficient
EBS	Environmental Baseline Study
ECM	Earth Control Measures
EIA	Environmental Impact Assessment
EMMP	Environmental Management and Monitoring Plan
EN	Endangered
EPHA	Environmental Public Health Act
EPM	Environmental Protection and Management
ES	Environmental Score
EW	Extinct in the Wild
FM	Frequency-modulated
g	grams
GESS	German European School Singapore
GPS	Global Positioning System
ha	hectares
hr	hour
Hz	Hertz
ID	Identity
Inc.	Incorporated
ISA	International Society of Arboriculture
IUCN	International Union for the Conservation of Nature
kHz	kilohertz
KTM	Keretapi Tanah Melayu

Abbreviation	Definition
LC	Least Concern
LCR	Landscape Company Register
Leq	Equivalent continuous sound level
LMP	Light Management Plan
m	metre
mg/L	milligram per litre
mins	minutes
mL	millilitre
mm	millimetre
m/s	metre per second
ms	millisecond
MSS	Meteorological Service Singapore
n.d.	no date
NDOSF	Native-dominated Old Secondary Forest
NDYSF	Native-dominated Young Secondary Forest
NE	Not Evaluated
NEA	National Environment Agency
NEx	Presumed Nationally Extinct
NLB	National Library Board
NParks	National Parks Board
NSR	Noise Sensitive Receptor
NT	Near Threatened
NTU	Nephelometric Turbidity Unit
NUS	National University of Singapore
OPR	Optical Particle Counter
PM	Particulate matter
ppt	Parts per thousand
PUB	Public Utilities Board
QCF	Quasi-constant frequency
RIAM	Rapid Impact Assessment Matrix
RRNP	Rifle Range Nature Park
s	seconds
SAC - SINGLAS	Singapore Accreditation Council – Singapore Laboratory Accreditation Scheme
SIDS	Silt Imagery Detection System
SPWG	Singapore Pangolin Working Group
SRDB3	3rd edition Singapore Red Data Book
SSO	Singapore Statutes Online
TAC	TEMBUSU Asia Consulting Pte Ltd
TDS	Total Dissolved Solids
TN	Total Nitrogen
TOC	Total Organic Carbon
TP	Total Phosphorus
TPZ	Tree Protection Zone
TSS	Total Suspended Solids

Abbreviation	Definition
UKAS M-CERTS	United Kingdom Accreditation Service Monitoring Certification Scheme
URA	Urban Redevelopment Authority
VU	Vulnerable
WAV	Waveform Audio File Format
WSQ	Workforce Skills Qualifications

GLOSSARY

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 local level (e.g., Singapore’s Red Data Book).

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.

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.

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 in the case of *Kerivoula hardwickii*.

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*).

Odonates: 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.

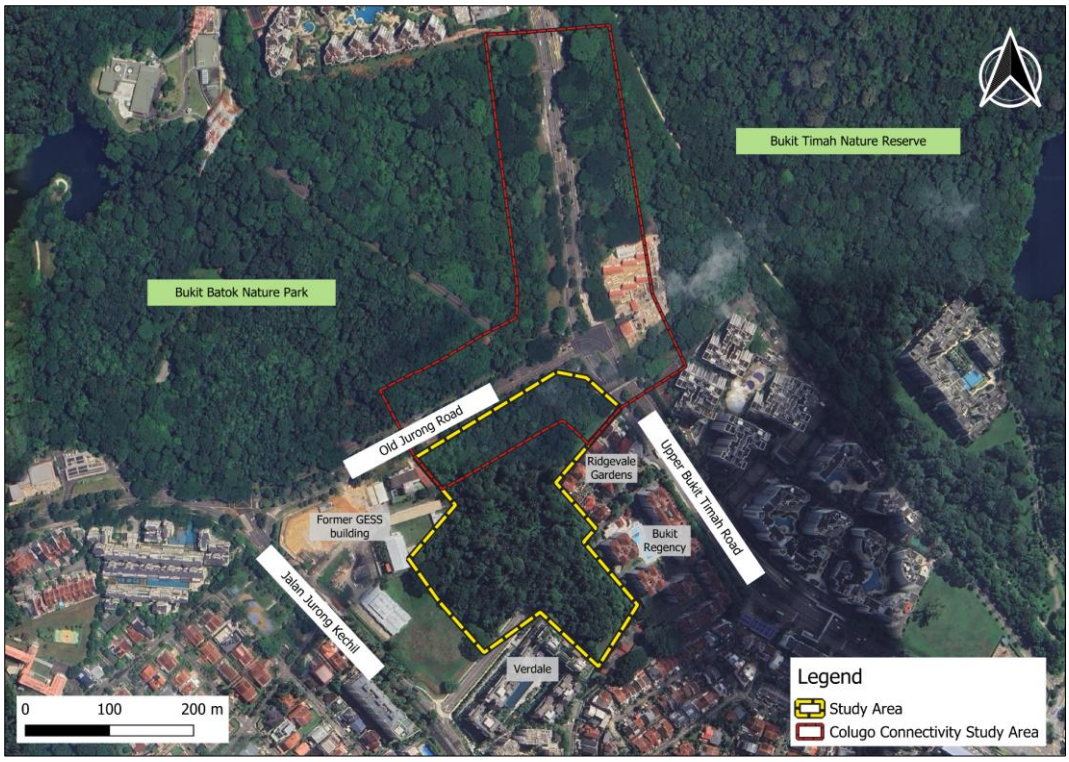
Species: The standard classification of living organisms. It is defined as a group of living organisms consisting of similar individuals capable of exchanging genes or interbreeding. It is represented by the second word of the scientific name of an organism. For example, the scientific name of a long-tailed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

Taxa: In reference to a specific taxonomic group. In increasing 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.

EXECUTIVE SUMMARY

The Urban Redevelopment Authority (URA) is studying future development plans for a vegetated plot of land in the Bukit Timah Planning Area in Singapore. The study area is approximately 5.5 ha, located in close vicinity to the Bukit Timah Nature Reserve (BTNR), and across Old Jurong Road from Bukit Batok Nature Park (BBNP). The northern portion of the study area is bounded by Old Jurong Road and BBNP; buildings to the west formerly operated by the German European School Singapore (GESS) and a childcare centre that have since been demolished to make way for a residential development that is under construction; and residential developments toward the east and south. The potential works being studied in the development area entail civil engineering works such as vegetation clearance, earthworks, roadworks, drainage, sewerage, and building works.



URA has commissioned TEMBUSU Asia Consulting Pte Ltd (TAC) to conduct an Environmental Impact Assessment (EIA) on the study area, specifically within the vegetated patch and waterways. An environmental study report containing the results from the Environmental Baseline Study (EBS), impact assessment, and Environmental Management and Monitoring Plan (EMMP) has been submitted to URA, National Parks Board (NParks), and other relevant technical agencies for review and approval prior to the commencement of any development works within the study area.

This Final Report includes the findings of the baseline study, encompassing the following environmental and physical aspects:

- Terrestrial Habitat and Flora Biodiversity
- Terrestrial and Aquatic Fauna Biodiversity
- Groundwater Levels, Surface Water Quality, Noise and Air Quality
- Colugo Connectivity Study

An impact assessment on flora, fauna and habitat sensitive receptors is also included, as well as mitigations measures to reduce these impacts.

A summary of the main findings is provided below.

Terrestrial Habitat and Flora Biodiversity

The study area can be divided into five habitat types: native-dominated young secondary forest, abandoned land forest, urban vegetation, scrubland and urban area (road reserve) based on the species composition at canopy level. Among the abandoned land forest, three patches adding up to 1.52 ha (27.6% of the study area) had been identified to have dense clusters of late-successional forest species which are associated with native-dominated old secondary forest habitat and demonstrates high future habitat and biodiversity value. The terrestrial flora baseline survey recorded a total of 205 flora species, of which 136 were native, 64 were non-native, and five species were uncertain in origin. 54 of the 62 total species of conservation significance were assessed to be at least partially of native regeneration. There were 12 keystone flora species, all of which are *Ficus* species, with a total of 133 individuals. Most of the flora species of conservation significance were seedlings or saplings occurring at understorey of abandoned land forest habitats with no corresponding mature parent plants in the study area, which suggests the seed dispersal and thus genetic exchange are likely from nearby forest patches such as BTNR and BBNP.

Terrestrial and Aquatic Fauna Biodiversity

The current study recorded a total of 113 terrestrial fauna species, mainly comprising of bird (54 species) and butterfly (25 species) species. Other mammal, reptile, amphibian, odonate and mollusc species were found in smaller numbers with fewer than 16 species per taxon, possibly due to their elusive nature and/or lack of suitable habitat types. Six species of local conservation significance were recorded, comprising of four vulnerable (VU) birds—the changeable hawk-eagle (*Nisaetus cirrhatus*), large-billed crow (*Corvus macrorhynchos*), Oriental magpie-robin (*Copsychus saularis*) and Swinhoe's white-eye (*Zosterops simplex*); one endangered (EN) bird—the straw-headed bulbul (*Pycnonotus zeylanicus*); and one critically endangered (CR) non-volant mammal—the Sunda pangolin (*Manis javanica*).

Combining habitat mapping, flora and fauna survey findings, three core sensitive areas (CSAs) are identified which consists of Zone A (1.08 ha), Zone B (0.81 ha) and Zone C (0.18 ha), with buffer zones adjoining these three zones that add up to 1.04 ha. The total CSA and buffer zones amount to 3.11 ha (53% of study area). These areas are observed to have high biodiversity and ecological value as evident from the high flora and fauna diversity, and the areas are in the midst of forest succession in which the abandoned land vegetation is expected to be gradually replaced by native-dominated old secondary forests (NDOSF) habitat type in several decades.

Groundwater Levels, Surface Water Quality, Noise and Air Quality

Five boreholes (i.e., BH1, BH2, BH3, BH4, BH5) were installed to measure baseline groundwater levels. Groundwater levels at all boreholes, except for BH3, were observed to be less than 2 m below ground level. Four surface water quality sampling points (i.e., WQ1, WQ2, WQ3, WQ4), all drains, were identified and surveyed for baseline water quality. Sampling point WQ2 did not have sufficient water for sampling on both dry weather sampling trips, and WQ4 did not have sufficient water for sampling on all three sampling trips. In-situ

surface water quality readings did not show any exceedances across all sampling points, except for pH levels at WQ1 (5.36) on a dry weather sampling trip; and at WQ03 on a dry weather (5.61) and wet weather (5.5) sampling trip. Similarly, all ex-situ surface water quality results were within the maximum permissible limits under the National Environment Agency (NEA) Allowable Limits for Trade Effluent Discharge to Watercourse or Controlled Watercourse, except for Total suspended solids (TSS) (threshold value of 50 mg/L) recorded on a dry weather sampling trip at WQ1 (103 mg/L) and WQ3 (302 mg/L); and biological oxygen demand (BOD5) (threshold value of 50 mg/L) at WQ1 on both dry weather sampling trips (1168 mg/L and 108 mg/L). Baseline ambient noise quality assessment was conducted at three noise monitoring stations (i.e., N1, N2, N3). Sensitive receptors include workers, flora and fauna, and residents. Noise levels were largely within permissible limits, except for some exceedances during 7pm–7am (Sunday) and 10pm–7am (Monday–Saturday). Baseline air quality assessment was conducted at three air quality monitoring stations (i.e., A1, A2, A3). Results at all three stations complied with Singapore Ambient Air Quality Targets (NEA, 2023).

Colugo Connectivity Study

A colugo connectivity study was undertaken to study existing connectivity for the Malayan colugo between BBNP, BTNR and the study area, and determine the importance of the study area in facilitating crossing between BBNP and BTNR. There were 2352 feasible glide paths in the colugo connectivity study area pre-development, with a mean minimum departure tree height of 16.03m. There is both a higher quality and density of feasible glide paths involving trees in the study area, especially across Old Jurong Road. Should the study area be fully developed with no retained trees, the number of feasible glide paths decreases by 53.1% from 2352 to 1104. Should trees in the part of the study area be retained, the loss of feasible glide paths is greatly reduced, with a decrease by 4.2% from 2352 to 2253 for Scenario B compared to pre-development.

Impact Assessment

Assuming that all the study area will be cleared, the Environmental Score (ES) is evaluated to be in the range of slight negative to major negative during pre-construction and construction stage. For the flora aspect, there will be major negative impacts in terms of (i) habitat loss and (ii) change in species composition; and moderate negative impacts in (i) loss in ecological connectivity and (ii) species mortality and injury. For fauna, there will be major negative impacts in terms of (i) habitat loss and (ii) species mortality and injury (non-volant fauna); and moderate negative impacts in (i) loss in ecological connectivity (non-volant fauna and Malayan colugo), (ii) roadkill or road injury to fauna attempting to cross the road (non-volant fauna), (iii) noise and ground-borne vibration disturbance and (iv) light disturbance. For habitat, moderate negative impacts are in the form of (i) habitat loss, (ii) loss in ecological connectivity and (iii) disruption and reversal of forest succession process. The ES evaluated for the operation phase ranges from major negative to slight positive. For the fauna aspect, there will be major negative impacts in the form of changes in species composition.

For the purposes of this Final Report, residual impacts are assessed for two scenarios: one scenario assuming the study area is fully developed (Scenario A), and one Proposed Retained Area (PRA) scenario (Scenario B) where the layout and the comparison between scenarios are detailed in Table 1.1. A summary of the predicted impacts without mitigation and with mitigation for the two scenarios are shown in Table 1.2.

Table 1.1. Comparison of Scenario A and B

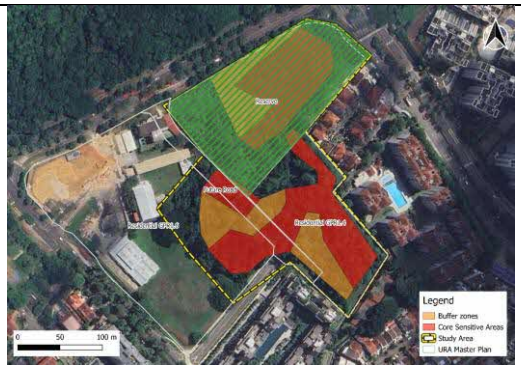
Scenario A	Scenario B
	
Proposed Retained Area = 0 ha	Proposed Retained Area = 2.40 ha (44.0% of study area)
• Maintains 24.1% (397 out of 1645 in study area) of feasible glide paths for colugos (via roadside and centre divider trees)	• 40.8% (0.85 ha) of Core Sensitive Area retained • Maintains 94.0% (1546 out of 1645 in study area) of feasible glide paths for colugos as all trees (except three affected by road works) adjacent to Upper Bukit Timah Road and Old Jurong Road are retained • Retention of 240 large trees, of which 86 are native • Retention of 35 native flora species of conservation significance, including unusual findings such as critically endangered *Palaquium microphyllum* and *Glochidion singaporense* • 33% (44) of trees that are identified as keystone flora species (*Ficus* sp.) are retained, ensuring some supply of food for fauna species

Table 1.2. Summary of impact assessment

Sensitive Receptor	Predicted Impacts Without Mitigation		Predicted Impacts With Mitigation			
			Scenario A		Scenario B	
	ES	ES Impact	ES	ES Impact	ES	ES Impact
Pre-Construction/ Construction Phase						
Flora	-28 to -144	Slight Negative to Major Negative	-14 to -144	Slight Negative to Major Negative	-14 to -72	Slight Negative to Minor Negative
Fauna	-14 to -144	Slight Negative to Major Negative	-7 to -144	Slight Negative to Major Negative	-7 to -108	Slight Negative to Moderate Negative
Habitat	-81 to -108	Moderate Negative	-81 to -108	Moderate Negative	-16 to -54	Slight Negative to Minor Negative

Sensitive Receptor	Predicted Impacts Without Mitigation		Predicted Impacts With Mitigation			
			Scenario A		Scenario B	
	ES	ES Impact	ES	ES Impact	ES	ES Impact
Operation Phase						
Flora	-32	Slight Negative	-16	Slight Negative	-16	Slight Negative
Fauna	-48 to -144	Minor Negative to Major Negative	-32 to -144	Slight Negative to Major Negative	-32 to -72	Slight Negative to Minor Negative
Habitat	9	Slight Positive	9	Slight Positive	9 to -16	Slight Positive to Slight Negative

A summary of key mitigation measures to be implemented is shown below.

Table 1.3. Summary of key mitigation measures to be implemented

Phase	Key mitigation measures
Pre-Construction/ Construction	• Retention of as much of the Proposed Retained Area (PRA) as practicable • Phased/ directional clearance of vegetation • Wildlife shepherding/ active translocation of wildlife • Visual inspections of trees and holes for nesting birds and animals prior to felling • As far as practicable, avoid the commencement of tree felling during the peak bird breeding period (March to July) • Physically tag trees to be retained, felled, and transplanted on site • Establish Tree Protection Zones (TPZ) for trees to be retained • Identify plants to be salvaged/transplanted • Monitor tree and vegetation health regularly • Install hoarding around the work site • Conduct daily checks of ECM blankets and pits • Ensure ECM blankets are made of biodegradable material with no plastic mesh netting • Conduct biodiversity awareness trainings for workers • Implement dust suppression plan • Install 6m to 12m noise barrier along boundary of the site during construction • Implement Light Management Plan (LMP) if night works are necessary • Implement PUB-approved ECM Plan • Emergency spill kits to be present to handle any chemical spillages
Operation	• Use shielded lights that are directed downwards and away from the PRA • Adjust the number and intensity of lights abutting the forest to minimum levels required for safety and security • Use motion-activated lighting in areas less frequently visited • Buffer planting with hedges along the boundary of the PRA • Planting of native, fauna-attracting species as part of the landscaping • Wildlife-proof refuge centre and bins • Educational signages on wildlife

1 INTRODUCTION

1.1 Project Background

The Urban Redevelopment Authority (URA) is studying future development plans for a vegetated plot of land in the Bukit Timah Planning Area. The approximately 5.5 ha study area comprises of regrowth secondary forest and sits across Old Jurong Road from Bukit Batok Nature Park (BBNP). Potential works in the development area are assumed to entail civil engineering works such as site clearance, earthworks, roadworks; drainage, sewerage, and building works.

URA has commissioned TEMBUSU Asia Consulting Pte Ltd (TAC) to conduct an Environmental Impact Assessment (EIA) on the study area, specifically within the vegetated patch and waterways. An environmental study report containing the results from the Environmental Baseline Study (EBS), impact assessment, and Environmental Management and Monitoring Plan (EMMP) has been submitted to URA, National Parks Board (NParks), and other relevant technical agencies for review and approval prior to the commencement of any development works within the study area.

1.2 Objectives of the Final Report

This report delivers the result of the EBS conducted which provides information gathered from the desktop study, terrestrial habitat mapping, tree mapping and tagging, terrestrial flora baseline study, terrestrial fauna baseline study, surface water quality baseline study, aquatic fauna baseline study, hydrological survey, ground water level survey, ambient noise level and air quality baseline survey. The report presents the identified Core Sensitive Areas (CSAs) based on the combined findings of habitat mapping and flora and fauna baseline studies. An impact assessment on flora, fauna and habitat sensitive receptors is also presented in this report, along with mitigation measures to reduce negative impacts. An EMMP consolidating the mitigation and monitoring strategy required for this project is also included.

1.3 EIA Study Area

The study area (Figure 1.1) is located in the Central West region of mainland Singapore, south of the Bukit Batok district in close vicinity to BBNP and Bukit Timah Nature Reserve (BTNR) (Figure 1.2).

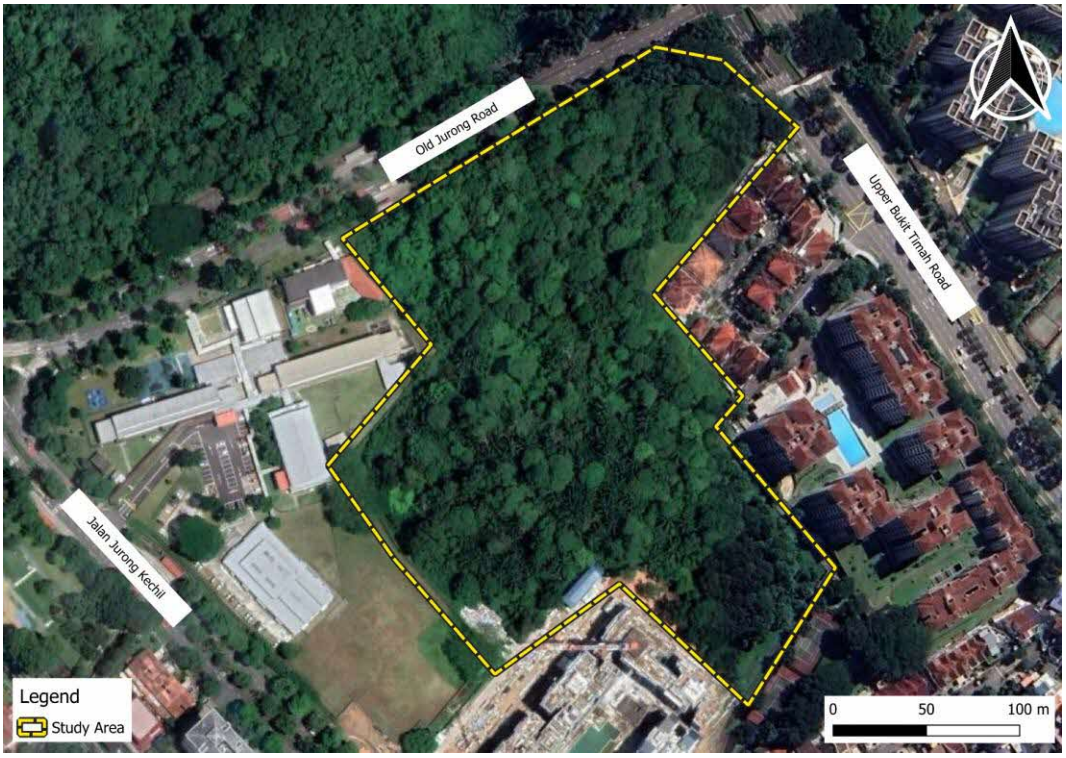


Figure 1.1. The study area and surrounding infrastructure developments

Figure 1.2. Location of study area in the context of the larger area and nature spaces

2 DESKTOP STUDY

A desktop study was conducted to collect secondary data, comprising a thorough review of publicly available literature and material on land use history, current land use, hydrological conditions, biodiversity and ecological connectivity of the study area. A chronological account of the land use history was derived from, and materials made available through Historical Maps of Singapore by the National University of Singapore (NUS, 2024).

Other resources studied in this section include Environmental Baseline Studies (EBS), media releases, and information provided by statutory boards (URA, NParks, National Library Board (NLB)). As previous EBSs encompassing the development area were not found, studies performed at nearby areas were examined and discussed in relation to the available knowledge of the study area and vascular plant flora of BTNR and BBNP (Neo, et al., 2013; Turner & Chua, 2011).

2.1 Historical Land Use

The earliest record of the study area in 1885 showed that it was located between the regions of West Bukit Timah, mostly covered by gambier and pepper plantations, and East Bukit Timah, consisting of the forested Bukit Timah hill (Survey Department, Singapore, 1885). Chinese gambier and pepper plantations were established in Singapore before European settlement in 1819, with estimates suggesting they began in the late 1790s on newly cleared forested land (Jackson, 1965; Corlett, 1992). In 1903, the large-scale cultivation of rubber (*Hevea brasiliensis*) trees was introduced in Singapore. While the year in which rubber plantations had spread into the study area is unclear, a rubber plantation was established in Bukit Timah and surrounding areas, which by 1910 had encompassed 16 ha (Lum & Sharp, 1996). From the 1950s, rubber cultivation in Bukit Batok began to be either cleared or abandoned (Neo, et al., 2013).

In 1943, a section of the study area was recorded to consist of “belukar” (Figure 2.1), or degraded, species-poor secondary rainforest that typically develops on previously farmed land. The other section of the study area and its general vicinity consisted of plantations, with buildings of unspecified purpose scattered within the boundary. In 1953, the study area’s vegetation was documented as “unclassified and mixed tree cultivation”, and from 1966 onwards, the vegetation in the study area was recorded as “sundry tree cultivation”, suggesting that fruit and ornamental trees dominated after the plantations were abandoned (Yee A. T., Chong, Neo, & Tan, 2016). One record shows a Buddhist temple in the study area in 1993 (Figure 2.1), though it no longer appears on maps in following years.

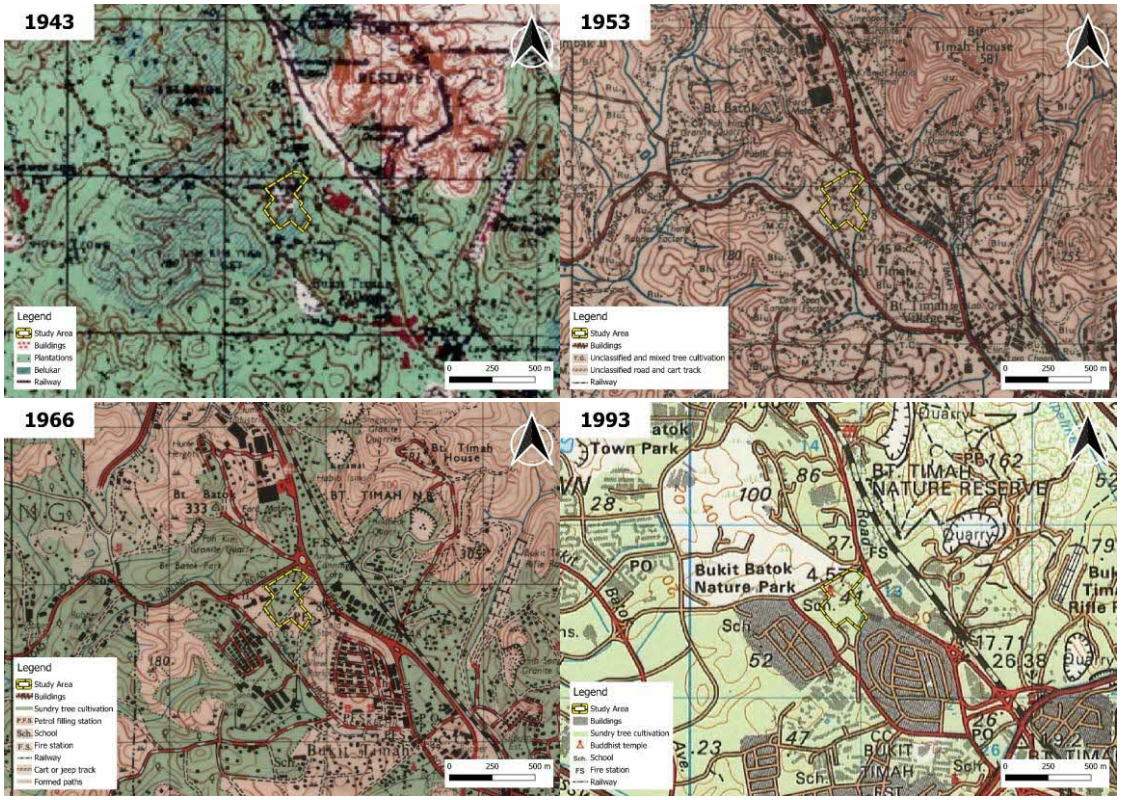


Figure 2.1. Historical maps showing study area and its vicinity, from years 1943, 1953, 1966 and 1993[1]

Both public and private housing developments in the Bukit Batok area began in the 1970s (The Straits Times, 1975) and the surrounding land was built up over the years (The Straits Times, 1985; The Straits Times, 1996), although the study area itself was not developed for a residential purpose by the government, remaining vegetated long after surrounding plantations made way for buildings.

To the north-east of the project site, the Singapore-Johor Railway, known as the Keretapi Tanah Melayu (KTM) Railway Line, previously traversed Singapore from North to South in the 1900s (The Straits Times, 1903). The KTM Railway stopped operations in 2011 and has been repurposed into the 24 km-long Rail Corridor (Figure 2.2), an ecologically important green passage for both wildlife movement and human recreation (NParks, 2024).

Figure 2.2. Map of the Rail Corridor. Study area demarcated with arrow (Photo from URA).

To the east of the study area, the BTNR was established in 1883 as a forest reserve, and the hill was further protected by the Nature Reserves Ordinance that came into force in 1951 (NParks, n.d.). The Bukit Timah Fire Station between BTNR and the project site was in use from the 1950s to 2005, and the buildings are currently being redeveloped into an environmentally sustainable community node expected to open in 2025 (URA, 2021). To the north, Bukit Batok Nature Park (BBNP) has been designated as a public park since the 1950s (Neo, et al., 2013). The school adjacent to the site, Bukit Batok East Primary School, was established in 1959 and relocated to new premises in 2001 after a merger with Bukit Batok West Primary School (Ministry of Education, n.d.). The campus was then operated by the German European School Singapore (GESS) from 2008 to 2018 (GESS, n.d.). Part of the former school site has since been sold for residential development and the school buildings have been demolished.

Presently, the study area consists of vegetated land with none of the original buildings left within its boundaries. Private housing lines the southern and eastern boundary. The vegetation is expected to include regenerating secondary forested areas and abandoned land forest with cultivated trees. Due to the presence of BTNR to its east serving as one of the largest areas of primary rainforest left in Singapore (NParks, n.d.), the reserve could potentially be a source for seed dispersal of native flora species into the study area, promoting natural regeneration. Given its proximity to the neighbouring BTNR and BBNP as well as the Rail Corridor, the study area may also serve as a green passage where volant animals may move between parks and reserves with the help of trees “connecting” forest patches, thereby promoting ecological connectivity.

2.2 Flora Biodiversity Literature Review

The study area is located in close proximity to BTNR and BBNP. They are likely to be the source of seed dispersal and natural regeneration for the forest in the study area, and as such, similar species may be found in the study area.

BTNR consists of primary and secondary forests with rich flora diversity with at least 1250 flora species (Ho, et al., 2019). It is home to many locally threatened native flora such as the vulnerable crescent tree (*Aporosa benthamiana*), blue laurel (*Litsea umbellata*), bayam badak (*Strombosia javanica*) and dedali paya (*Xanthophyllum vitellinum*), endangered *Alangium griffithii* and critically endangered beaked kandis (*Garcinia nigrolineata*) (Ho, et al., 2019; Turner & Chua, 2011).

BBNP consists of secondary forests and also has locally threatened native flora such as the vulnerable *Goniophlebium percussum*, nyatoh puteh (*Palaquium obovatum*) and critically endangered crenate-leaved xanthophyllum (*Xanthophyllum ellipticum*), belinjau (*Gnetum gnemon*) (Neo, et al., 2013).

2.3 Fauna Biodiversity Literature Review

Due to limited information about the biodiversity within the study area, a wider search on the surrounding area was carried out. These searches in neighbouring nature parks and reserves on iNaturalist, a crowdsourced biodiversity database, found species of conservation significance such as the globally endangered straw-headed bulbul (*Pycnonotus zeylanicus*), the locally endangered blue-eared kingfisher (*Alcedo meninting*), and the lesser mousedeer (*Tragulus kanchil*) which is also endangered locally and restricted to the CCNR and BTNR. The neighbouring forests – BTNR to the east and BBNP to the north of the site – are also home to forest-dependent species such as the brown boobook (*Ninox scutulata*), an uncommon resident found in secondary and primary forest habitats, the critically endangered rhinoceros frog (*Limnonectes plicatellus*) and the locally endangered Horsfield's flying squirrel (*Iomys horsfieldii*) (NParks, pers. comm., October 2024; Teo & Thomas, 2019).

To the east of the project site, the nearby Rail Corridor has undergone habitat enhancement with extensive tree and shrub planting to facilitate wildlife movement (NParks, n.d.). The green passage has been studied by BioBlitz, a biodiversity survey led by NParks and conducted by members of the public. The 2018 survey results recorded observations of forest species such as the common birdwing (*Troides helena cerberus*), the straw-headed bulbul (*Pycnonotus zeylanicus*), and the greater racket-tailed drongo (*Dicrurus paradiseus*) (NParks, n.d.), suggesting that the Rail Corridor acts as a green passage for wildlife between major green spaces such as parks and reserves. The project site potentially acts as a stepping stone between larger forested patches in Singapore.

The critically endangered Sunda pangolin (*Manis javanica*) has been recorded near the project site. This species faces heavy poaching in Southeast Asia for its scales and meat, which are used in traditional medicine; however, in Singapore, roadkill is the greatest threat to pangolins (Challenger, et al., 2019). Pangolins often wander out of forested areas into nearby residences and onto roads (NParks, n.d.). According to data

from the Animal Concerns Research and Education Society (ACRES) and the Singapore Pangolin Working Group (SPWG) (pers. comm., October 2024), pangolins have been recorded inside condominiums surrounding the project site three times and sighted on or beside nearby roads at least five times since 2015. Notably, over the years, there were five instances where the pangolin sighted was injured, likely due to road accidents. In August 2025, a dead pangolin was also observed by a member of public on the centre divider along Old Jurong Road (Low, 2025). The stray pangolins may have originated from the nearby forests of BBNP and BTNR, where they are known to inhabit (NParks, n.d.).

Malayan colugos (*Galeopterus variegatus*), arboreal mammals found only in Southeast Asia, have been observed to use trees surrounding the site to move between forest patches. Searches conducted on iNaturalist found numerous observations of Malayan colugos near the site, including the neighbouring forested areas of BBNP and the Central Catchment Nature Reserve (CCNR), along Jalan Jurong Kechil and within nearby condominium estates. Colugo roadkill was found on the central road divider along Jalan Jurong Kechil between Sherwood condominium and the project site (Goh & Tang, 2023); colugo sightings have also been reported along Old Jurong Road between BBNP and the project site (ACRES, pers. comm., October 2024). Given that previous EIAs have also recorded Malayan colugos in BBNP (NParks, pers. comm., October 2024), this suggests that the colugos use roadside trees as part of their glide paths to travel over roads between forest patches in the area. Although Malayan colugos are classified by the International Union for Conservation of Nature (IUCN) as Least Concern, their population is decreasing due to habitat destruction and fragmentation (Boeadi & Steinmetz, 2008).

2.4 Ecological Connectivity

Habitat fragmentation refers to the process in which a large, continuous area of habitat is broken up into smaller, isolated patches due to human infrastructure such as roads (Franklin, Noon, & George, 2002). Fragmentation has been found to reduce biodiversity and impair vital ecosystem functions globally, and its impacts worsen over time (Haddad, et al., 2015). As such, any future developments should take into consideration the maintenance of ecological connectivity in the area, which is crucial in sustaining ecosystem functions.

The study area is located along the Bukit Batok Nature Corridor (BBNC), which consists of nature parks, nature ways and park connectors supporting ecological connectivity between areas of rich biodiversity in Western Singapore (NParks, 2024). The BBNC, which connects the BTNR and Tengah Forest Corridor, is part of a series of forest patches such as Tengah Nature Way connecting the Western Catchment, BTNR and CCNR (Figure 2.3). The potential role of the study area as a stepping stone in the Corridor is further discussed in Section 4.7.

Figure 2.3. Map of the BBNC, with location of study area marked by a red star [1]

The forested areas in the Western region of Singapore, where the study site is located, are noticeably fragmented into small patches. Some of the forest fragmentation observed in the current day may be explained by earlier deforestation events in the 1900s brought on by gambier and pepper cultivation and rubber plantations. In recent decades, rapid urbanisation in the Bukit Batok area have made and will continue to cause the Central and Western Catchments to become increasingly ecologically isolated.

It is important to preserve the green corridors that link our remaining forest patches to minimise the impact of habitat fragmentation on declining genetic diversity and shrinking natural populations (Lum & Ngo, 2021). Doing so may give experts and government agencies more time for the conception and implementation of long-term conservation strategies required to bolster genetic flow between forest patches and preserve the biodiversity that remains (Lum & Ngo, 2021). This may be done by strategically protecting small connecting patches of high biodiversity from external pressures through the usage of vegetated buffer zones, such as what is proposed for the study area (Section 4.7).

[1] https://www.facebook.com/nparksbuzz/photos/a.228201063886044/3702442039795245/?type=3

3 EIA 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, forested areas, and other areas of significant biodiversity or with potential trans-boundary impact, are subject to greater scrutiny.

For this study, the methodology deployed to establish the baseline conditions was submitted to URA and relevant Technical Agencies prior to the commencement of the study to confirm the scope.

3.2 EIA Scope

This study was conducted as per the requirements specified during the scoping consultation process with the relevant Technical Agencies.

This EIA shall consider:

- Scale and effect of vegetation removal
- Possibilities of compaction and erosion
- Noise pollution and impacts to air quality
- Impact to the water courses in the area (including risk of water pollution due to surface runoff or overflow from drains/oil interceptors from the potential development works)
- Impacts to ecological connectivity to the BBNC
- Impact to migratory flyways and stopover sites by birds
- Impact on colugo connectivity in the surrounding area
- Impact on species conservation and overall biodiversity in the immediate vicinity of the potential development works
- Specify location and dimensions of Core Sensitive Areas (CSAs), both ecological and hydrological, within and surrounding the study area that should not be affected by developments or activities
- Specify location and dimensions of buffer zone or setbacks, both ecological and hydrological, within and surrounding the study area, as well as the allowable activities and developments

Table 3.1 lists the 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	• Code of Practice on Pollution Control SS593, 2013 • Environmental Protection and Management Act, rev. 2020 • Environmental Public Health Act, rev. 2020
Biodiversity	• Animals and Birds Act, 2020 • Endangered Species (Import and Export) Act, 2020 • Fisheries Act, 2020 • Parks & Trees Act, 2020 • Parks & Trees Regulations, 2006 • Parks & Trees Preservation Order 1998 • Parks & Trees (Composition of Offences) Regulations, 2006 • Parks & Trees (Heritage Road Green Buffers) Order, 2006 • Parks & Trees (Planning Areas) Notifications, 2006 • Wildlife Act, 2020 • CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora, also known as the Washington Convention), 1983 • IUCN Red List of Threatened Species, 2024 • NParks Biodiversity Impact Assessment (BIA) Guidelines, 2024 • Singapore Red Data Book, Third Edition (online), 2024
Surface Water Quality	• Code of Practice on Pollution Control SS593, 2013 • Environmental Protection and Management Act 2020, Part V on water pollution • Environmental Protection and Management Act (Trade Effluent) Regulations, 2008 • Public Utilities Board (PUB) Code of Practice on Surface Water Drainage, 2018 • PUB Guidebook on Erosion and Sediment Control at Construction Sites, 2018 • PUB Handbook on Managing Urban Runoff, 2013 • Sewerage and Drainage Act, rev. 2020 • Sewerage and Drainage (Surface Water Drainage) Regulations, rev. 2007 • Sewerage and Drainage (Trade Effluent) Regulations, rev. 2007
Noise	• Code of Practice for Noise Control on Construction and Demolition Sites SS602, 2014 • Code of Practice on Pollution Control SS593, 2013 • Environmental Protection and Management Act 2020, Part VIII Noise Control • Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008
Air Quality	• Oxygen de of Practice on Pollution Control SS593, 2013 • Environmental Protection and Management Act 2020, Part IV on Air Pollution Control • Environmental Protection and Management (Vehicle Emissions) Regulations, 2008 • Environmental Protection and Management (Prohibition on Use of Open Fires) Order, 2008 • Environmental Protection and Management (Air Impurities) Regulations, 2008 • NEA Singapore Ambient Air Quality Targets
Waste Management	• Code of Practice on Pollution Control SS593, 2013 • Environmental Protection and Management Act 2020, Part VII on Hazardous Substances Control • Environmental Protection and Management (Hazardous Substances) Regulations, 2008 • Environmental Public Health (General Waste Collection) Regulations, 2000 • Environmental Public Health (Toxic Industrial Waste) Regulations, rev. 2000
Vector Control	• Control of Vectors and Pesticides Act, 2020 • Environmental Public Health Act (EPHA), 2020 • NEA Guidelines on Rainwater Collection System and Mosquito Prevention, 2011

3.3 Study Area and Environmental Aspects

The study area denotes the area where development activities are predicted to have impacts on various environmental aspects within the site. Figure 3.1 below shows the extent of the study area. The colugo connectivity study area is also shown below, the detailed report is found in Appendix H.

The study area covers approximately 5.5 ha and is not known to have any streams. The study area is bounded by Old Jurong Road to the north; former GESS site to the west which is intended for future residential developments; and residential developments such as a landed housing estate, Bukit Regency and Verdale toward the east and south.

Notably, the study area is situated along BBNC, which aims to support ecological connectivity between the Central Nature Park Network and Tengah Forest Corridor (NParks, 2024). As such, it sits nearby large nature areas such as BBNP, BTNR and Rifle Range Nature Park (RRNP). BTNR and BBNP are the nearest nature areas located adjacent to the study area.

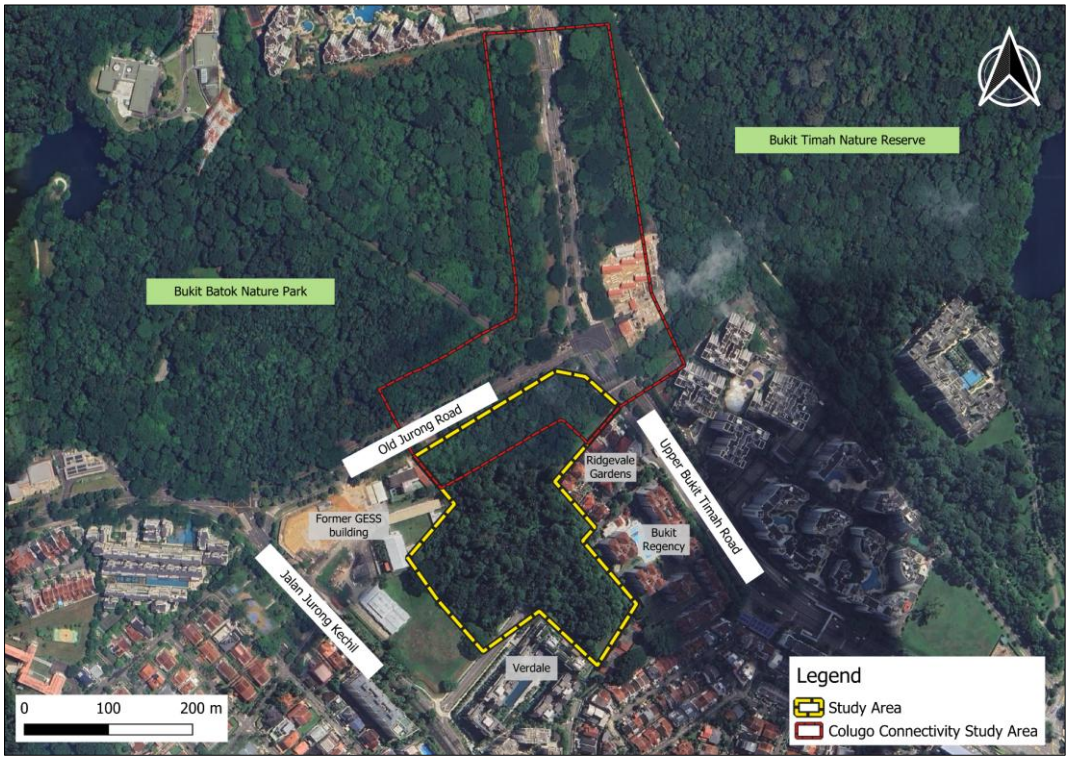


Figure 3.1. Location of study area in the context of the larger area and nature spaces

The environmental aspects that were studied for this project, along with a brief description of each aspect and explanation of its relevance in the study, are presented below. The identified sensitive receptors are listed down in Table 3.2.

Biodiversity

This aspect covers flora and fauna groups inhabiting the project site that may be impacted by future construction and operation of the assumed works. The main groups studied are vegetation on site, birds, mammals, amphibians, reptiles, butterflies, and

odonates. Aquatic surveys were also conducted in a concrete drain along the perimeter of the vegetated area, covering freshwater fish, molluscs, and decapod crustaceans.

Impacts to biodiversity during the implementation of assumed works were assessed, and mitigation measures to address the potential impacts are recommended. These include impacts from physical environmental aspects such as noise, vibration, water quality, and light, which are described below.

Hydrology

This aspect concerns waterbodies within the project site that may be impacted during the construction stage. While no streams were found within the study area, there were concrete drains found directly adjacent to the vegetated patch. Surface water quality analysis, stream characteristics, and flow rate sampling were carried out at the concrete drain(s) to establish the baseline condition. Groundwater sampling was also carried out at points across study area to determine the water table at the site.

Noise and Vibration

Construction activities tend to involve the use of heavy equipment generating noise and vibration. Prolonged high levels of noise and vibration may harm the health of sensitive receptors in surrounding areas. To determine baseline conditions, noise levels were measured where sensitive receptors (e.g., flora, fauna, and residents) are located. Impacts of noise and vibration from construction activities were assessed and recommendations to mitigate the impacts are provided in the Biodiversity Chapter.

Ambient Air Quality

Construction activities are known to release dust and other particulate matters that may harm the health of sensitive receptors (e.g., flora, fauna, and residents) in surrounding areas. Ambient air quality levels were measured at sensitive receptors. The impacts from construction activities were assessed, and recommendations to mitigate the impacts are provided in the Biodiversity Chapter.

Light

Increased artificial light during night-time construction activities could disrupt circadian cycles of animals. Impacts from increased artificial light were qualitatively studied, and mitigation measures were proposed to reduce adverse impacts to the surrounding environment. These are included in the Biodiversity Chapter.

3.4 Identification of Sensitive Receptors

Table 3.2 provides the overview of the identified sensitive environmental receptors that may be affected during the potential works being studied.

Table 3.2. Overview of identified sensitive receptors

Environmental Aspects	Sensitive receptors
Biodiversity	• Native flora and fauna of international conservation significance (i.e., classified as

Environmental Aspects	Sensitive receptors
	critically endangered, endangered, or vulnerable according to IUCN classification system) within project study area • Native flora and fauna of national conservation significance (i.e., classified as critically endangered, endangered, or vulnerable according to Singapore Red Data Book 3 or other relevant local status publications) within project study area • Native flora and fauna endemic to Singapore within project study area • Habitats with high ecological value (i.e., environments that support species of conservation significance)
Surface Water Quality	• Aquatic flora and fauna within project study area
Noise	• Species that are susceptible to noise pollution (e.g., species that require a quiet environment to find prey and species with acute hearing) • People working on the site (e.g., construction workers) • Residents of Ridgevale Gardens, Bukit Regency, and Verdale
Ambient Air Quality	• Flora and fauna living within project study area • People working on the site (e.g., construction workers, consultants) • Residents of Ridgevale Gardens, Bukit Regency, and Verdale
Vibration	• Fauna within project study area • Residents of Ridgevale Gardens, Bukit Regency, and Verdale
Light	• Species that are susceptible to light disturbance (e.g., nocturnal fauna) within project study area

3.5 Impact Assessment Methodology

3.5.1 Identification of Impacts

The potential works being studied involve site clearance, infrastructure works, building works, road construction, and road sidetable works within the project study area. This will involve heavy construction activities such as piling, use of crawler cranes and tower cranes. Some impacts to the sensitive receptors may include reduced connectivity and fauna movement, increased edge effect[2], as well as noise, air, and light pollution during construction and operation phases of the assumed works.

Assessment of the impacts of the assumed works will include:

- Elements of the community, man-made environment, and natural environment likely to be affected by the assumed works (including ecological impacts)
- Habitat loss due to vegetation clearance
- Species disturbance and/or mortality due to vegetation clearance
- Loss in ecological connectivity to other vegetated areas in vicinity
- Roadkill or road injury to fauna attempting to cross the road
- Human-wildlife conflict
- Air pollution, noise, ground-borne vibration, and light disturbances on biodiversity and human receptors
- Disturbances to wildlife considering seasonal migratory variations

[2] i.e., 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.

- Suspended sediment and sedimentation into water bodies
- Water pollution and construction waste management
- Magnitude and likelihood of the potential environmental impacts
- Residual environmental impacts (i.e., after practicable mitigation) and the cumulative effects expected to arise during earthworks and infrastructure works in relation to the sensitive receptors and potential affected uses

3.5.2 Assessment of Impacts

In anticipation of upstream planning processes with an unfinalised development footprint, it is important to engage key stakeholders for their input on multiple development scenarios. In each development scenario, the EIA report shall provide matrices indicating the levels of impact that will be identified before and after implementation of the mitigation measures to allow stakeholders to understand how different designs may affect Rapid Impact Assessment Matrix (RIAM) scores. For the purpose of this impact assessment, it is assumed that all parcels shall be developed and cleared of vegetation.

Based on the impact analysis of construction and post-construction activities of the potential works, suitable mitigation measures are recommended to lower the magnitude of negative impacts on the environment to within acceptable levels as much as practically possible.

Potential impacts were quantified using the RIAM method, a scoring system in which impacts of each construction activity are evaluated against environmental receptors (Pastakia & Barber, 1998; NParks, 2024). The RIAM method attributes values to each condition based on its importance (I), magnitude (M), permanence (P), recoverability (R), and cumulative impact (C).

The parameters of RIAM 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
	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)	Temporary	2
	Permanent	3
Recoverability (R)	Recoverable or controllable through EMMP	2
	Irreversible	3
Cumulative Impact (C)	Non-cumulative / Single	2
	Cumulative / Synergistic	3

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

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

Magnitude	Description
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	Refers 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	Refers to minor positive benefit or change implies that positive changes to baseline conditions are discernible but local. These changes may lead to local and limited reduction of stress to sensitive receptors.
Slight positive benefit or change	Refers to slight positive benefit or change implies that changes in baseline conditions are unlikely to be detectable on-site, and thus are unlikely to cause discernible reduction of stress to sensitive receptors.
No change/status quo	Refers to no change/status quo implies that changes in the baseline conditions are not expected, and unlikely to cause any stress to sensitive receptors.
Slight negative disadvantage or change	Refers to changes in baseline conditions that are unlikely to be detectable in the field, and thus are unlikely to cause discernible stress to sensitive receptors.
Minor negative disadvantage or change	Refers to negative changes to baseline conditions that are discernible 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	Refers 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	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 (ES), where:

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

The ES attained for each condition correlates to a measure of its impact, 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

3.5.3 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 to adopt certain available technology that could address or reduce environmental impacts.

This EIA utilises both concepts for the development of mitigation measures for the assumed works being studied.

4 BIODIVERSITY

Several species of conservation significance reside in the forest habitats along the BBNC. As part of the wildlife corridor between the Tengah Forest Corridor and BTNR, the study area serves as a key stepping stone habitat and allows animal species to cross from one forest patch to another in search of resources.

4.1 Conventions

The main references for flora conservation statuses include a combination of those in the third edition of the Singapore Red Data Book (SRDB3) (NParks, 2024), Flora of Singapore – Checklist and bibliography (Lindsay et al., 2022) and The Checklist of the Total Vascular Plant Flora of Singapore (Chong et al., 2009). For faunal species, local conservation statuses were mainly derived from SRDB3 (NParks, 2024), while global conservation statuses were derived from the IUCN Red List of Threatened Species (IUCN, 2024).

Table 4.1 provides the flora species conservation status definitions according to Lindsay et al. (2022). Table 4.2 provides a consolidated list of global and local fauna statuses from the IUCN Red List (2024) and SRDB3 (2024), respectively. In this report, flora species with local status of Extinct (EX), Presumed Nationally Extinct (NEx), Critically Endangered (CR), Endangered (EN) and Vulnerable (VU) are considered to be of conservation significance, whereas fauna species of conservation significance are of CR, EN, and VU conservation status. Exotic plant species with no local status were categorised as Not Evaluated.

Table 4.1. Local conservation status definitions for flora species in Singapore adapted from Lindsay, et al. **(2022)**

Local Status		**Definition**
Native		Originated or arrived in Singapore without intentional or unintentional involvement of human activities.
	Extinct (EX)	Globally extinct.
	Presumed Nationally Extinct (NEx)	Not recorded in Singapore within the last 30 years. Endemic species that are presumed nationally extinct will consequently also be presumed to be globally extinct.
	Critically Endangered (CR)	Fewer than 50 mature individuals estimated to be in Singapore; or if more than 50 but fewer than 250 mature individuals, with evidence of rapid decline or decline and fragmentation of populations.
	Endangered (EN)	Between 50 and 250 mature individuals estimated to be in Singapore, with no evidence of decline or fragmentation of populations.
	Vulnerable (VU)	Between 250 to 1000 mature individuals estimated in Singapore.
	Least Concern (LC)	More than 1000 mature individuals estimated in Singapore.
	Data Deficient (DD)	Not enough information available to assess the risk of extinction.
Cryptogenic		Uncertain whether presence in Singapore is from natural dispersal or as a result of human activities.
Non-native (=Exotic)		Presence in Singapore is because of intentional or unintentional involvement of human activities.
	Naturalised	Species that have established self-sustaining wild (i.e., non-cultivated) populations such that long-term persistence in Singapore is likely without additional introduction of new individuals or propagules.
	Casual	Species that occur in the wild in Singapore as escapes or relics of cultivation but do not form self-sustaining populations, such that their presence is ephemeral once the original individuals die or are removed without additional introduction of new individuals or propagules. This includes taxa that were formerly considered to be naturalised but have since died out. Those for which we have no record of occurrence in the wild for more than 30 years are still treated as casual but are further highlighted.
	Cultivated Only	Only found in cultivation.
	Not Evaluated (NE)	Not yet assessed for risk of extinction. This includes some species for which there are grounds for rejecting or questioning a previous assessment but for which a new assessment is pending.

Table 4.2. Conservation status for flora & fauna species & respective definitions, adapted from IUCN Red List **(IUCN, 2024)**, SRDB3 **(2024)**.

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 Baseline Survey Methodology

This section of the report describes the existing environmental conditions of the study area. The baseline is developed mainly from primary field data and analysis of secondary desktop surveys. Detailed survey components and their methodologies are presented below. Sensitive environmental receptors include terrestrial flora and fauna.

4.2.1 Habitat Mapping

Habitat maps are to be produced using a combination of recorded data and site observations during flora surveys. Habitat types within the site will be identified during vegetation surveys based on species compositions at canopy level within various areas of the site (Table 4.3). The habitat maps will also include bamboo clusters as they are potential habitats for bamboo bats. There are two known species of bamboo bats in Singapore and they are both locally vulnerable.

Table 4.3. Habitat types found within Singapore and general description of each habitat, modified from NParks' BIA Guidelines **(2024)**

Habitat	Description	Source
Primary forest	Contains an emergent layer that has dipterocarp trees such as *Shorea* and *Dipterocarpus*. Has a continuous layer of tall native trees, a sub-canopy consisting of smaller trees, and an understorey dominated by saplings of big tree species interspersed with other shrubs and treelets.	(Tan et al., 2007)
Native-dominated young secondary forest	Developed on land cleared not long before the 1960s, or on degraded soils and not near other native-dominated forests. Dominated by native pioneer trees such as *Adinandra*, *Macaranga*, *Mallotus* and *Trema*.	(Yee et al., 2016)
Native-dominated old secondary forest	Developed on land cleared much earlier than the 1950s, often on less degraded soil and with higher species richness than early successional native dominated secondary forest. Common species found in the canopy layer include *Alstonia* spp., *Calophyllum* spp., *Campnosperma* spp., *Elaeocarpus* spp., *Garcinia* spp., *Litsea* spp., *Rhodamnia* spp. and *Syzygium* spp. Common understorey plants include *Anisophyllea disticha* and *Agrostistachys borneensis*.	(Yee et al., 2019)
Abandoned Land Forest	Developed from an abandoned kampung/plantation or orchard, usually dominated by fruit trees such as *Durio zibethinus*, *Nephelium lappaceum*, or ornamental plants such as *Spathodea campanulata*, *Aglaonema commutatum*, *Dieffenbachia seguine* and *Heliconia* spp.. Abandoned plantations are usually dominated by *Hevea brasiliensis*.	(Yee et al., 2019)

Habitat	Description	Source
Albizia/Acacia/ Leucaena/Cecropia Dominated Forest	Developed on land recently cleared, plant communities dominated by exotic tree species such as *Acacia auriculiformis*, *Falcataria moluccana*, *Leucaena leucocephala* and *Cecropia pachystachya*.	(NParks, 2024)
Scrubland/Grassland	Exposed areas with very little tree cover, typically dominated by grasses, shrubs and herbs. These can be further split into Grassland (dominated by members of the grass and sedge family), Scrubland dominated by ferns (e.g. *Dicranopteris linearis*), or by herbs and shrubs (e.g. *Mimosa pigra*, *Melastoma malabathricum*, *Piper aduncum*, *Pipterus argenteus*, *Ficus* spp. etc.), often with absent or scattered trees of *Acacia auriculiformis*, *Leucaena leucocephala*, *Mallotus paniculatus*, *Dillenia suffructicosa*, etc.). These subsequently develop into denser open woodland with patches of trees within the scrubland.	(Yee et al., 2011)
Freshwater Swamp Forest	Formed where slow-flowing streams drain into shallow valleys. The swamp is flooded periodically or semi-permanently, resulting in waterlogged soils that are anaerobic and unstable. Dominated by plants with special adaptations such as stilt roots, plank-like buttresses and pneumatophores. Examples include *Xylopia fusca* and *Palaquium xanthochymum*.	(Tan et al., 2007)
Riparian Vegetation	Found along the banks of natural and naturalised streams. Common species on stream banks in secondary forest patches include *Angiopteris evecta*, *Alsophilia latebrosa* and *Dillenia suffruticosa*. Vegetation along native forest streams are more diverse and species such as *Cyrtosperma merkusii*, *Lasia spinosa* and *Hanguana* spp. can be present.	(Yee et al., 2019)
Natural Stream	A well-shaded stream which is shallow, cool, and typically has mildly acidic waters (pH 6–7). Typically flows along natural topographical gradients over sand, clay or mud substrate with accumulations of leaf litter and woody debris.	(Yeo, Wang, & Lim, 2010)
Naturalised Stream	A stream which is warm and typically has less acidic water than natural streams (slightly less than pH 7). Typically modified from pre-existing natural streams and is often linear. Flows through natural earth or open grassy banks, lacking leaf litter and woody debris.	(Yeo, Wang, & Lim, 2010)
Mangrove Forest	A tidal habitat consisting of flora that normally grows above mean sea level in the intertidal zone of marine environments and estuarine margins. Common species include Rhizophora, Bruguiera, Avicennia and Sonneratia trees which have roots	(Ng, Corlett, & Tan, 2011)

Habitat	Description	Source
	that provide structural and respiratory support in the soft anaerobic sediments of the habitat.	
Natural Coastal Vegetation	Found along un-reclaimed coasts where the forest is on sandy or rocky substrate. Dominated by hardy plants which can withstand higher temperatures, strong winds and salt sprays. Common species include *Casuarina equisetifolia*, *Cerbera* spp., and *Barringtonia* spp.	(Tan et al., 2007)
Reclaimed land forest	Forest which develops on land that has been reclaimed. The community of unmanaged / spontaneous vegetation growing on reclaimed land depends on the fill material used.	(NParks, 2024)
Urban Vegetation	Consists of turf, shrubs or trees (often mostly non-native) which are planted by humans. This type of vegetation is typically managed for aesthetic purposes.	(NParks, 2024)

4.2.2 Terrestrial Flora Surveys

Flora surveys utilised a tiered census methodology, in which all woody flora species of girth ≥ 1 m and all native vascular flora of conservation significance of any size were recorded. Other flora species were recorded opportunistically where applicable. All recorded species were compiled in a species inventory list. The flora surveys were conducted within the boundary of the flora survey area, which can be found below in Figure 4.1.

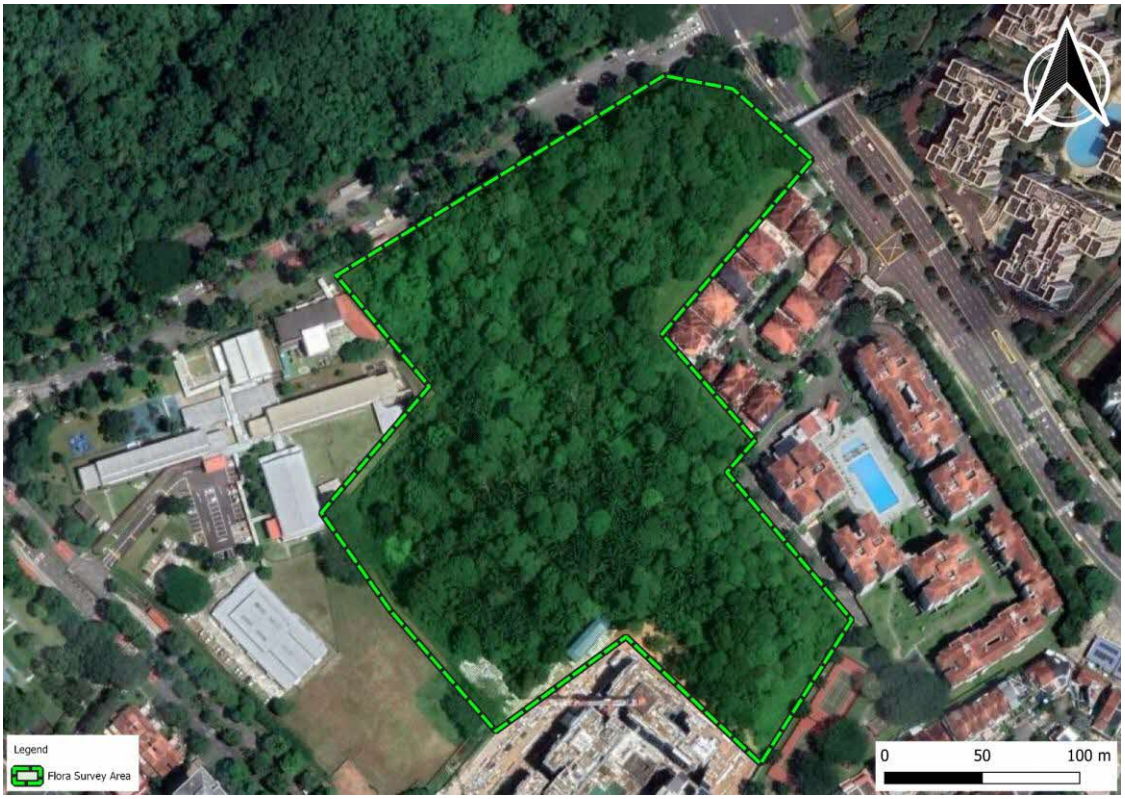


Figure 4.1. Flora survey area

Each two-personnel survey team consisted of at least one flora specialist or International Society of Arboriculture (ISA)-certified Arborist. Where required, plant samples were collected to facilitate species identification. The locations of flora species were recorded using the Garmin GPSMAP 64s unit. The static parameters collected during the flora surveys can be found below in Table 4.4.

Table 4.4. Static parameters collected for the tiered census flora surveys

Static Parameter	Description
Coordinates	In *SVY21 (EPSG:3414)* Coordinate Reference System
Collection date	Date when the tree was geolocated
Tree Identification Number	Unique identification number for every surveyed tree
Flora Species	Scientific and common* names
Growth Form	Tree, shrub, palm, fern, climber/vine, etc.
Girth	Circumference of the tree (m) at 1.0 m height
Height	Height of the tree (m)
Canopy	Canopy width of the tree (m)
Surveyor's remarks	Any remarks about the tree, if applicable
Image^	At least one (1) colour image of every surveyed tree

** = Some flora species within the Southeast Asian region have no common name*

^ = To be provided as supplementary material

Tree Tagging and Mapping

In addition to Global Positioning System (GPS) mapping conducted as part of the flora baseline studies, all large trees (measuring ≥ 1 m girth) will also be temporarily marked using brightly coloured weather-resistant flagging tape with its assigned unique tree identification number written on the tape and included in the topography map.

4.2.3 Terrestrial and Aquatic Fauna Surveys

The terrestrial and aquatic fauna field assessment covered eight (8) fauna groups: birds, mammals (volant and non-volant), herpetofauna (reptiles and amphibians), butterflies, odonates (dragonflies and damselflies), freshwater fish, molluscs and decapod crustaceans. Opportunistic fauna encounters outside their dedicated survey timings were also recorded.

Fauna surveys were conducted mainly through visual encounter surveys, point counts, camera trapping and acoustic surveys for terrestrial fauna, and hand-netting and overnight baited traps for aquatic fauna. The surveys covered abandoned land forest, urban vegetation which includes a drain, scrubland and native-dominated young secondary forest habitats. As many animals (particularly mammals and herpetofauna) are nocturnal, both diurnal and nocturnal surveys were conducted. Table 4.5 summarizes the survey methods and appropriate survey timings for each taxonomic group.

Table 4.5. Survey timings, frequency, and methodology for each fauna taxonomic group.

Taxa	Survey Timings	Number of Surveys	Survey Methodology
Birds	0700 to 1100	1 during non-migratory season; 3 during migratory season	Point count surveys
Mammals (non-volant)	0700 to 1000 2000 to 2300	2	Visual encounter survey; call recognition along transects

Taxa	Survey Timings	Number of Surveys	Survey Methodology
	24 hour(s)	4 cameras, 60 days	Camera traps attached on tree trunks 30 cm above ground level
Mammals (bats)	1900 to 0700	2	Acoustic recording
Herpetofauna (reptiles and amphibians)	0700 to 1000 2000 to 2300	2	Visual encounter survey; call recognition along transects
Butterflies	0900 to 1200	2	Visual encounter survey along transects
Odonates	0900 to 1200	2	Visual encounter survey along transects
Freshwater Fish	1930 – 2300	2	Visual encounter survey; hand-netting; overnight baited traps
Freshwater molluscs	1930 – 2300	2	Visual encounter survey; hand-netting; overnight baited traps
Freshwater decapod crustaceans	1930 – 2300	2	Visual encounter survey; hand-netting; overnight baited traps

A species checklist of taxonomic groups of interest, as well as their conservation status in Singapore were compiled. The locations of encounters with the fauna species of conservation significance were recorded and plotted on a map.

Visual Encounter and Call Recognition Surveys

The terrestrial fauna surveys were conducted by at least two (2) observers walking at a steady pace, along systematic transects illustrated below in Figure 4.2. GPS locations, species name and number of individuals were recorded for every visual or call recognition encounter. Survey timings and frequency can be found in Table 4.5 above.

Figure 4.2. Locations of transects for terrestrial fauna surveys

Point Count Survey

Point count surveys involved identifying birds by sight and sound (within a 50 m radius around each point) for 10 minutes at the point count locations shown in Figure 4.3. Only diurnal point count bird surveys were conducted (see Table 4.5 for the survey timings and frequency).

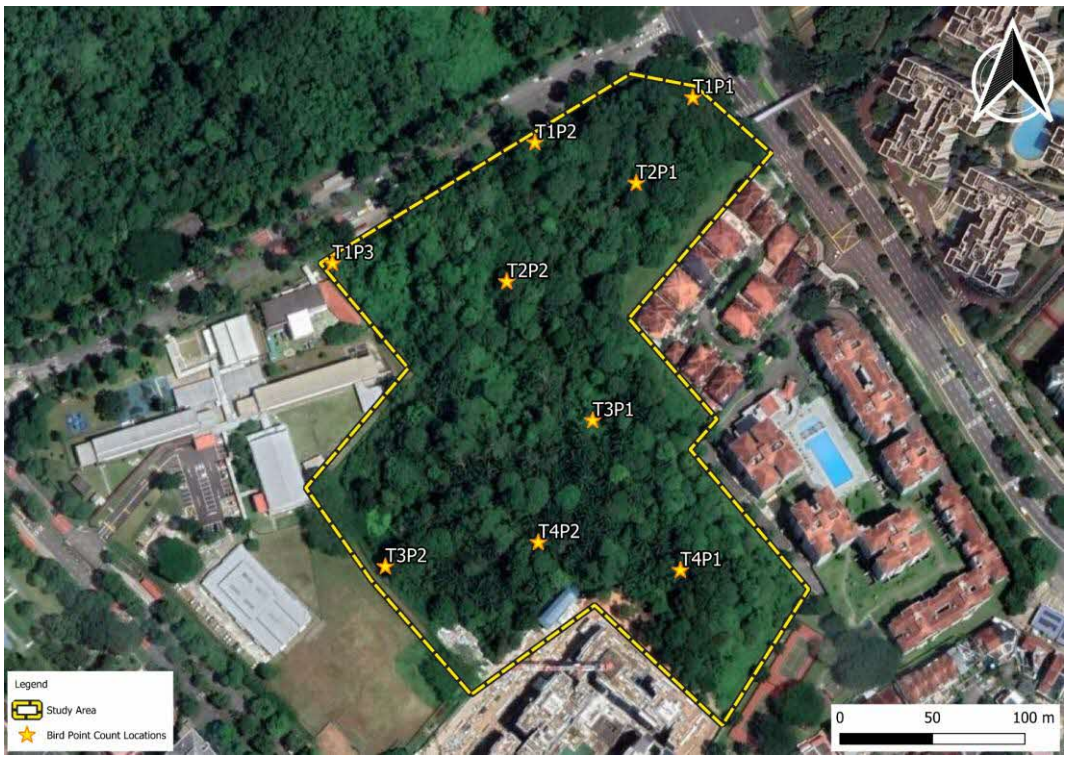


Figure 4.3. Locations of points for terrestrial fauna surveys

Camera Trapping

To supplement the visual encounter surveys, camera trapping was also conducted within the study area. This method is particularly useful for elusive or rare animals that are not often encountered. A total of four (4) camera traps were deployed for a period of 60 to 62 days between 20 August 2024 and 4 November 2024 (Table 4.6).

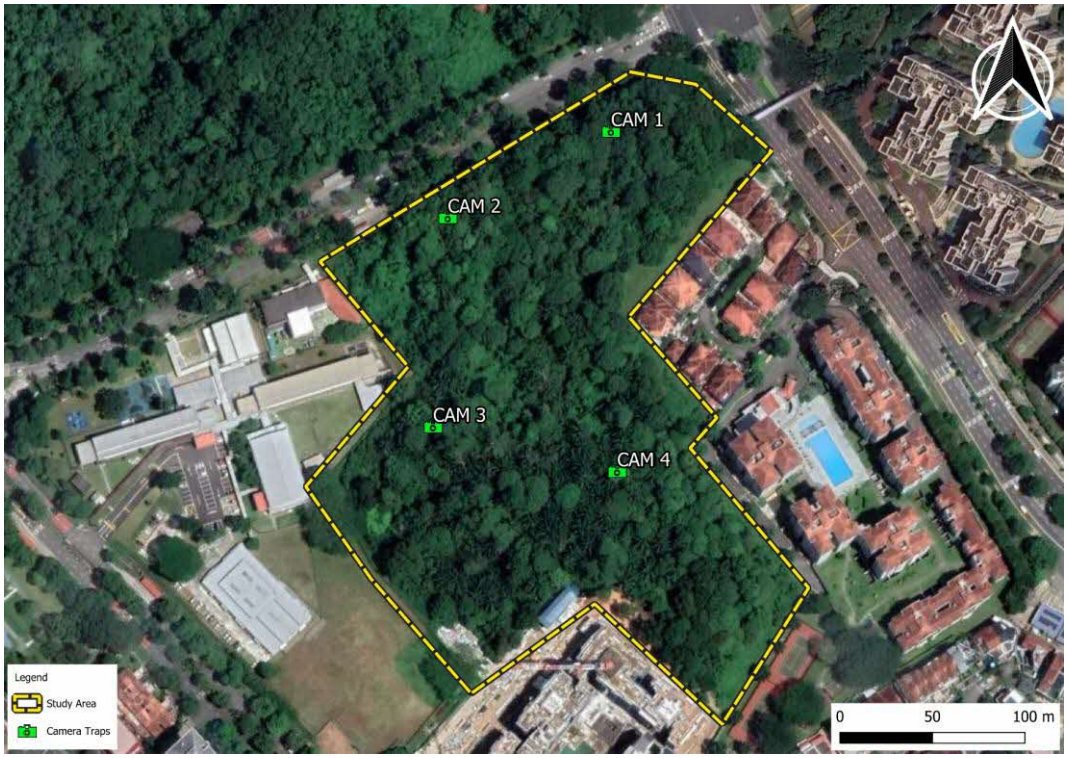


Figure 4.4. Locations of camera traps deployed within the study area

Table 4.6. Coordinates of the camera traps within study area

ID	Latitude (°N)	Longitude (°E)	Dates Deployed
CAM 1	1.348344	103.769835	20 August 2024 – 21 October 2024
CAM 2	1.347924	103.769042	20 August 2024 – 21 October 2024
CAM 3	1.346909	103.76897	5 September 2024 – 4 November 2024
CAM 4	1.346692	103.769865	20 August 2024 – 21 October 2024

The cameras were secured on tree trunks roughly 30 cm above the ground (Figure 4.5). The camera traps were programmed to be continuously active 24 hrs a day, with the camera capturing a sequence of three (3) photos and a 10-second video per trigger. Species captured were identified to the lowest taxonomic level possible. An independent detection was defined as a capture of an individual occurring more than five minutes apart from a previous detection of the same species. The number of independent detections was used to calculate the total number of detections at each camera trap.

Figure 4.5. Example of a camera trap setup in the study area

Acoustic Bat Surveys

Acoustic bat surveys were conducted to survey microchiropteran bats, as echolocation is used by microchiropteran bats to navigate their environment and locate food (Schnitzler et al., 2003). As the echolocation call characteristics of bats (pulses, frequencies, duration, and shape) are somewhat unique to each species, the analysis of calls can be used to identify bats to species (Fenton & Bell, 1981). As megachiropteran bats rely on their vision and do not echolocate, visual encounter surveys were used to detect megachiropteran bats.

Acoustic sampling was conducted using a handheld Echo Meter Touch 2 Pro (Wildlife Acoustics, Inc.) attached to an Android (Android Inc.) mobile device during nocturnal terrestrial surveys. The Echo Meter functions by detecting ultrasonic sounds in real-time and converting them into audible digital signals that can be heard and visualized using the Echo Meter Touch App on the Android mobile device. When sounds resembling a bat call was detected, it was automatically recorded and saved onto the Android mobile device as a 16-bit full spectrum WAV file.

Bat call structure varies based on habitat type (cluttered vs. uncluttered) and foraging mode (gleaning, trawling, aerial) (Schnitzler et al., 2003). Bat call identification is aided by further classifying them into one of six call types based on frequency (frequency-modulated [FM], constant frequency [CF], and quasi-constant frequency [QCF]), and to a lesser degree, habitat use (Denzinger & Schnitzler, 2013; Yoh et al., 2022):

- FM-CF-FM calls used by forest specialists of the family Rhinolophidae.
- CF-FM calls used by forest specialists of the family Hipposideridae.
- QCF Multiharmonic (QCF-MH) calls used by open space foragers of the family Emballonuridae.
- FM Multiharmonic (FM-MH) calls used by forest specialists of the families Megadermatidae and Nycteridae.
- FM Broadband (FM-B) calls used by edge/gap foragers of the family Vespertilionidae.
- FM-QCF calls used by edge/gap foragers of the families Vespertilionidae.

References used to identify the calls of Singapore's bat species include Pottie et al. (2005), Lane et al. (2006) and Baker & Lim (2012). Although the sole published resource regarding bat calls from Singapore is Pottie et al. (2005), the study only reported bat calls for 13 out of Singapore's 26 microchiropteran bats. The bat calls in this study were identified using a call library generated from Pottie et al. (2005) combined with published calls from neighbouring countries (Heller, 1989; Kingston et al., 2009; Hughes et al., 2011). Echolocation signatures for several species in Singapore collated from these references can be found in Table 4.13.

Recorded bat call structures were then analysed using Kaleidoscope Lite Analysis Software (Wildlife Acoustics, Inc.). Key call structure parameters include call shape, frequency (kHz) and duration (ms). Each echolocation recording was identified to species level based on call shape, frequency (minimum, maximum, and peak) and call duration (Pottie et al., 2005). Once these parameters were inspected, the results were compared to echolocation signatures found in Table 4.13.

Aquatic Surveys

Nocturnal aquatic surveys were conducted at two points along the concrete drain within the project area. Visual detection, hand netting and overnight baited traps were used, focusing on freshwater fishes, molluscs and decapod crustaceans. Hand netting was conducted at two 10 m transects for 10 minutes each. Baited traps were deployed and left on site for at least 12 hours before retrieval. A portion of each trap was left above water to reduce the risk of drowning of air-breathing species.

All aquatic fauna caught by hand netting or baited traps were sorted, photographed and identified to species or family level where possible, before being released. The survey locations are indicated in Figure 4.6.

Figure 4.6. Location of aquatic transects

4.3 Habitat Mapping Results

The study area can be divided into five habitat types: native-dominated young secondary forest (NDYSF), abandoned land forest, urban vegetation, scrubland and urban area (road reserve) based on the species composition at canopy level. Among the abandoned land forest, we identified a few patches where the understorey consists predominantly of late-successional forest species that are associated with native-dominated old secondary forests (NDOSF) habitat type. Such understorey patches are highlighted in the map for their ecological importance as they show strong forest ecological succession potential. The habitat map, summary of habitat areas, and representative photos of habitats can be found below in Figure 4.7, Table 4.7, and Figure 4.8 respectively.

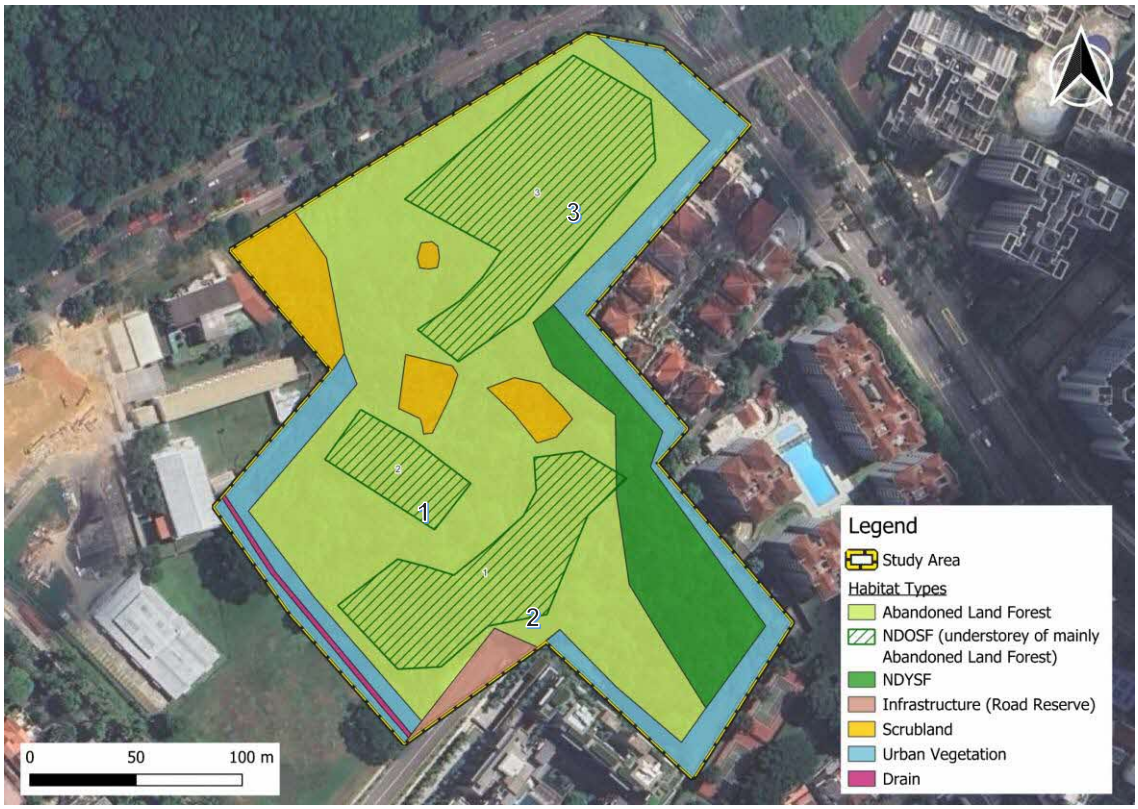


Figure 4.7. Habitat map

Table 4.7. Areas and percentage of each habitat type found within the study area

Habitat Type	Area (ha)	Percentage
Abandoned Land Forest	3.76	68.36%
Native-dominated Old Secondary Forest (NDOSF) – understorey of mainly Abandoned Land Forest*	1.52	-
Urban Vegetation (including drain)	0.82	14.91%
Scrubland	0.32	5.82%
Native-dominated Young Secondary Forest (NDYSF)	0.53	9.64%
Urban Area (Road Reserve)	0.07	1.27%
Total	**5.5**	**100.00%**

**Note: NDOSF represents significant understorey species occurring as a subset within Abandoned Land Forest and is therefore excluded from the total hectarage and percentage tabulation of overall habitat types.*

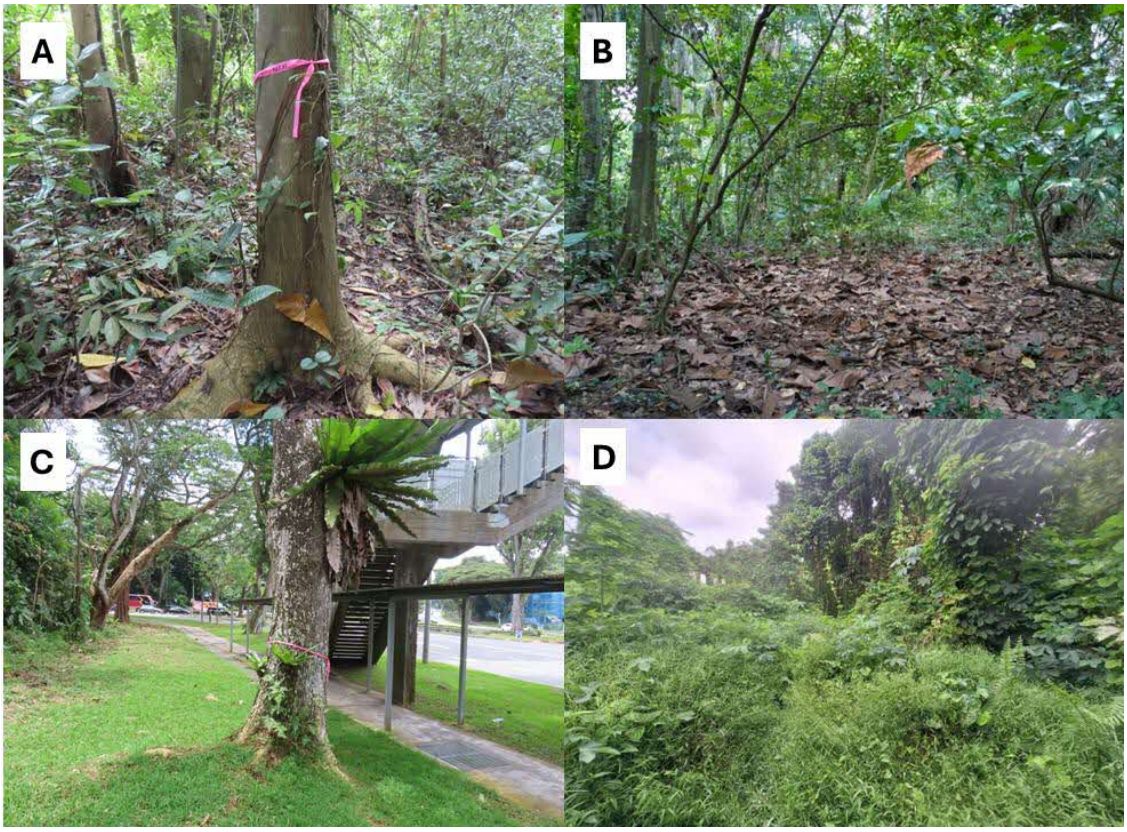


Figure 4.8. Representative photos of habitat types in the study area. **A:** Native-dominated young secondary forest; **B:** Abandoned land forest; **C:** Urban vegetation; **D:** Scrubland.

Throughout the study area, extensive regeneration of native tree species was observed. Some of the more commonly observed species in the study area include common ivy palm (*Arthrophyllum jackianum*), crescent tree (*Aporosa benthamiana*), blue laurel (*Litsea umbellata*), bayam badak (*Strombosia javanica*), green coffee *(Canthiumera robusta)* and indonesian bayleaf (*Syzygium polyanthum*). There were also late-successional species observed in the undergrowth such as silver back tree (*Rhodamnia cinerea*), *Calophyllum tetrapterum*, *Syzygium pycnanthum*, beaked kandis (*Garcinia nigrolineata*), *Dacryodes* cf. *costata,* dedali paya (*Xanthophyllum vitellinum*) and *Horsfieldia* cf. *punctatifolia*, occurring mostly in the understorey of abandoned land forests. Climbers such as native *Erycibe tomentosa*, non-native *Syngonium angustatum* and *Epipremnum aureum* are generally common in the understorey. In some scrubland and abandoned land forest understorey, zanzibar yam (*Dioscorea sansibarensis*) were observed to grow in large clusters.

A patch of NDYSF can be found in the north-eastern region of the study area. It is generally characterised by the presence of common native species such as common red-stem fig (*Ficus variegata*), simpoh air (*Dillenia suffruticosa*) and sea apple (*Syzygium grande*), with some sparse undergrowth consisting of native species such as *Erycibe tomentosa*, fishtail palm (*Caryota mitis*), false curry (*Clausena excavata*) and wild cinnamon (*Cinnamomum iners*).

In general, the northern region of the abandoned land forest was dominated by rubber (*Hevea brasiliensis*), and the centre and southern region of the abandoned land forest

habitats were largely dominated by oil palm (*Elaeis guineensis*) in the canopy. Many fruit trees species were observed interspersed among rubber and oil palm, such as breadfruit (*Artocarpus altilis*), durian (*Durio zibethinus*) and rambutan (*Nephelium lappaceum*). Ornamental plants such as African tulip (*Spathodea campanulata*), Chinese evergreen (*Aglaonema commutatum*) and dumbcane (*Dieffenbachia seguine*) were also common in areas of abandoned land forest habitat. These flora species observed suggest that those areas were developed from abandoned kampung/plantations or orchards, which aligns with the historical land use recorded for study area (Figure 2.1).

At some parts of the abandoned land forest, native seedlings and saplings of late successional species were recorded occurring at exceptionally high density in the understorey (Figure 4.9). Three such patches were identified, with the following estimated areas: 0.18 ha (patch 1), 0.53 ha (patch 2) and 0.81 ha (patch 3) (Figure 4.7), adding up to 1.52 ha which comprises 27.6% of study area. This indicates significant native regeneration at almost 30% of the study area, with potential to transition from abandoned land forest into NDOSF in future under forest succession processes. Interestingly, compared to areas dominated by oil palms or other fruit trees, areas dominated by breadfruit in the canopy have relatively few seedlings and saplings observed in the undergrowth. The fallen leaves of breadfruit tend to persist on site and the leaf litter thickens as the fallen leaves accumulate, which may have reduced the surface area for seeds to land on and germinate in the soil, hindering the native regeneration process.

Figure 4.9. Native regeneration suggesting potential to transition into NDOSF

There were a few patches of scrubland habitats in the middle and the north-western regions of the study area. They are characterised by herbs and shrubs such as common sendudok (*Melastoma malabathricum*), spiked pepper (*Piper aduncum*), grasses such as lalang (*Imperata cylindrica*), and ferns such as resam (*Dicranopteris linearis*). There were also many climbers/creepers such as bearded smilax (*Smilax setosa*) and zanzibar yam (*Dioscorea sansibarensis*).

Urban vegetation was mostly characterised by cow grass (*Axonopus compressus*) and

cultivated rain trees (*Samanea saman*) at the edges of the vegetated patch. A small part of the study area in the south includes a portion of De Souza Avenue, which was characterised as urban area (road reserve).

4.4 Flora Baseline Survey Results

4.4.1 Flora Baseline Survey Results

The terrestrial flora baseline survey recorded a total of 205 flora identified to species level. Of these, 136 (66.3%) species are native, 64 (31.2%) are non-native, and five (5) (2.4%) are uncertain in origin. A summary of local conservation status of these species can be found below in Table 4.8. The species list and representative flora images are provided in **Appendix A** and **Appendix B**, respectively. The full flora inventory containing all the static parameters (Table 4.4) and photos for each flora entry were provided as additional attachments.

Table 4.8. Distribution of flora species found in the study area based on local conservation status

Origin	Local Status	Number of Species	Percentage of Species
Native		**136**	**66.3%**
	Least Concern	72	35.1%
	Vulnerable	26	12.7%
	Endangered	16	7.8%
	Critically Endangered	20	9.8%
	Data Deficient	2	1.0%
Non-native		**64**	**31.2%**
	Casual	22	10.7%
	Cultivated Only	10	4.9%
	Excluded	1	0.5%
	Excluded (Cultivated Only)	2	1.0%
	Naturalised	29	14.1%
Uncertain		**5**	**2.4%**
	Cryptogenic	5	2.4%
Total Number of Species		205	100%

62 of all 205 species (30.2%) found within the study area were identified to be of conservation significance, 54 of which were assessed to be at least partially of native regeneration (Table 4.9) as these species are typically not cultivated.

Table 4.9. Flora species of local conservation significance encountered within the study area and likely source of stock. Flora species classified under "Either of Native Regeneration or Cultivated Stock" can either be of native germplasm or from germplasm of cultivated stock

S/N	Scientific Name	Common Name	National Status
Likely a result of Native Regeneration			
1	*Alangium griffithii*		Endangered
2	*Aporosa benthamiana*	Crescent tree	Vulnerable
3	*Aporosa* cf. *nervosa*		Endangered
4	*Archidendron* cf. *jiringa*	Jering	Vulnerable

5	*Beilschmiedia madang*		Vulnerable
6	*Bhesa robusta*	Red-flowered malayan spindle tree, Biku-biku	Vulnerable
7	*Calophyllum tetrapterum*		Vulnerable
8	*Canthiumera robusta*	Green coffee	Endangered
9	*Chassalia curviflora*		Vulnerable
10	*Cissus repens*	Malayan wild vine, Carik merah	Vulnerable
11	*Cnestis palala*		Vulnerable
12	*Cryptocarya* cf. *nitens*		Critically Endangered
13	*Dacryodes* cf. *costata*		Endangered
14	*Erythropalum scandens*	Kulim akar	Vulnerable
15	*Ficus caulocarpa*	Stem-fruited fig	Endangered
16	*Ficus* cf. *glandulifera*	Gaping fig	Endangered
17	*Ficus vasculosa*	White fig, Ara nasi	Vulnerable
18	*Garcinia nigrolineata*	Beaked kandis, Kandis hutan	Critically Endangered
19	*Gardenia subcarinata*		Critically Endangered
20	*Glochidion* cf. *singaporense*		Critically Endangered
21	*Glochidion lutescens*		Critically Endangered
22	cf. *Glochidion zeylanicum var. zeylanicum*		Vulnerable
23	*Goniophlebium percussum*		Vulnerable
24	*Gynochthodes rigida*		Vulnerable
25	*Horsfieldia* cf. *polyspherula*	Horsfield Tree	Vulnerable
26	*Horsfieldia* cf. *punctatifolia*		Endangered
27	*Horsfieldia* cf. *sparsa*	Penarahan gajah, Samak pulut	Endangered
28	*Litsea umbellata*	Blue laurel, Medang	Vulnerable
29	*Macaranga griffithiana*	Mahang bulan, Mahang tutup	Vulnerable
30	*Madhuca sericea*		Critically Endangered
31	*Maranthes corymbosa*	Merbatu, Sea beam	Vulnerable
32	*Melicope* cf. *glabra*		Endangered
33	*Melicope* cf. *lunu-ankenda*		Endangered
34	*Memecylon paniculatum*		Critically Endangered
35	*Morinda elliptica*		Endangered
36	*Palaquium microphyllum*		Critically Endangered
37	*Palaquium obovatum*		Vulnerable
38	*Pellacalyx axillaris*	Abu-abu air, Bebuloh	Vulnerable
39	*Pternandra coerulescens*	Cursed shade, Sial menahun	Vulnerable
40	*Strombosia javanica*	Bayam badak, Dali-dali	Vulnerable
41	*Syzygium* cf. *pycnanthum*	Wild rose apple, Kelat jambu	Critically Endangered
42	*Tetracera* cf. *fagifolia*		Critically Endangered
43	*Tinospora krispura*		Endangered
44	*Tristellateia australasiae*	Maiden's jealousy, Galphimia vine	Endangered
45	*Uncaria cordata*	Gambir-gambir hutan	Endangered
46	*Xanthophyllum ellipticum*	Crenate-leaved xanthophyllum	Critically Endangered
47	*Xanthophyllum eurhynchum*	Warty fruited xanthophyllum	Vulnerable

48	*Xanthophyllum vitellinum*	Dedali paya, Big-budded xanthophyllum	Vulnerable
49	*Xylopia malayana*	Kayu tapis, Krai	Vulnerable
Likely of Cultivated Stock			
1	*Baccaurea motleyana*	Rambai, Common rambai	Critically Endangered
2	*Barringtonia racemosa*	Common putat, Fish-killer tree	Critically Endangered
3	*Cerbera odollam*	Pong pong, Pong-pong	Vulnerable
4	*Gnetum gnemon*	Belinjau, Meninjau	Critically Endangered
5	*Memecylon ovatum*	Delek air, Bayan	Endangered
6	*Palaquium gutta*	Gutta percha, Getah merah	Critically Endangered
7	*Peltophorum pterocarpum*	Yellow flame, Jemerlang laut	Critically Endangered
8	*Syzygium myrtifolium*	Kelat oil, Kelat paya	Critically Endangered
Either of Native Regeneration or Cultivated Stock			
1	*Breynia androgyna*	Cekur manis, Chekur manis	Vulnerable
2	*Cayratia mollissima*		Endangered
3	*Sterculia cordata*	Kelumpang, Kembang	Critically Endangered
4	*Sterculia parviflora*	Common sterculia, Kelumpang burong	Critically Endangered
5	*Suregada glomerulata*	Limau-limau, Penawar puteh	Critically Endangered

In general, the most commonly encountered native species include trees such as common red-stem fig (*Ficus variegata*), wild cinnamon (*Cinnamomum iners*) and sea apple (*Syzygium grande*), and climbers such as *Erycibe tomentosa* and *Tetracera indica*. Many of the flora species of conservation significance found in this baseline survey corresponded to previous records in nearby forest patches. For instance, cursed shade (*Ptenandra coerulescens*), beaked kandis (*Garcinia nigrolineata*), biku-biku (*Bhesa robusta*), kayu tapis (*Xylopia malayana*), dedali paya (*Xanthophyllum vitellinum*), warty fruited xanthophyllum (*Xanthophyllum* eurhynchum), bayam badak (*Strombosia javanica*), blue laurel (*Litsea umbellata*), *Beilschmiedia madang*, *Alangium griffithii*, horsfield tree (*Horsfieldia* cf. *polyspherula*), *Horsfieldia* cf. *punctatifolia*, *and Cnestis palala* were previously found in Bukit Timah Nature Reserve (Turner & Chua, 2011; Ho, et al., 2019). Crenate-leaved xanthophyllum (*Xanthophyllum ellipticum*), mahang *bulan* (*Macaranga griffithiana*), wild rose apple (*Syzygium* cf. *pycnanthum*), *Goniophlebium percussum* and *Palaquium obovatum* were previously found in both Bukit Timah Nature Reserve and Bukit Batok Nature Park (Ho, et al., 2019; Neo, et al., 2013).

As mentioned in Section 4.2.1, most of the flora of conservation significance observed in this survey were seedlings or saplings occurring at understorey of abandoned land forest habitats with no corresponding mature parent plants in the study area. This suggests seed dispersal via fauna or wind and thus genetic exchange into and from the nearby forest patches. Notable findings include *Palaquium microphyllum*, which was last observed to have fruited in recent years with two seedlings recorded in Nee Soon Swamp Forest (Chan, et al., 2022), *Dacryodes* cf. *costata* which was almost exclusively found at BTNR and Chestnut area, *Cryptocarya* cf. *nitens* which was found in mostly BTNR and Mandai, and *Gardenia subcarinata* which was mostly found in BTNR with one recent record at MacRitchie (Singapore Herbarium Online, 2024). It is likely that the seedlings observed in this survey originate from relatively recent seed dispersal from BTNR.

Some species observed had not been recorded in BTNR before, and their presence may potentially indicate a new locality, such as *Canthiumera robusta*, *Glochidion lutescens*, *Madhuca sericea* and *Memecylon paniculatum* which were previously mainly recorded in places such as MacRitchie, Mandai and/or Nee Soon (Singapore Herbarium Online, 2024). *Ficus caulocarpa* was also recorded in the site, in which the known localities on mainland Singapore are relatively far from BTNR, such as Tengah North (Jacobs, 2021), Bukit Brown (Jong, 2022) and Changi (Singapore Herbarium Online, 2024). Interestingly, the young plants of *Ficus caulocarpa* were mainly observed growing on oil palms, with varying degrees of strangling observed. *Palaquium gutta* and *Memecylon ovatum* were observed to be planted in rows with stakings at the edge of NDYSF, suggesting past tree planting events in the study area.

Photos of four (4) of these conservation significant species can be found in Figure 4.10 and the spatial distribution of species of conservation significance, likely a result of native regeneration, separated into Critically Endangered, Endangered and Vulnerable local status, can be found in Figure 4.11, Figure 4.12 and Figure 4.13, respectively.

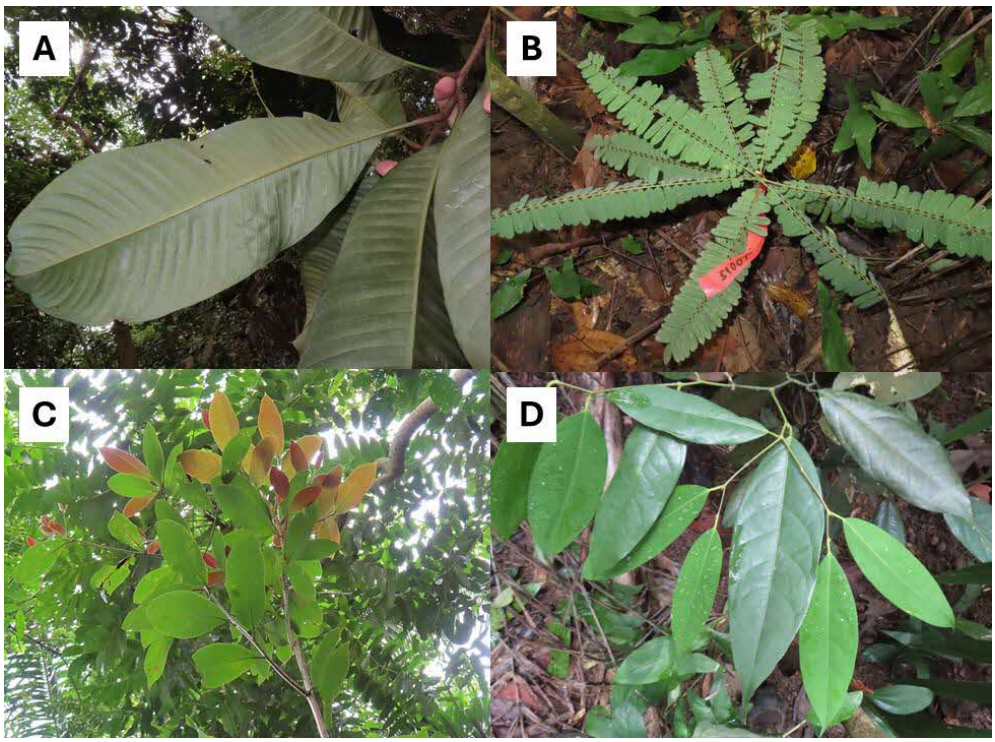


Figure 4.10. Flora species of conservation significance. **A:** *Madhuca sericea*; **B:** *Cnestis palala*; **C:** *Litsea umbellata*; **D:** *Xanthophyllum vitellinum*

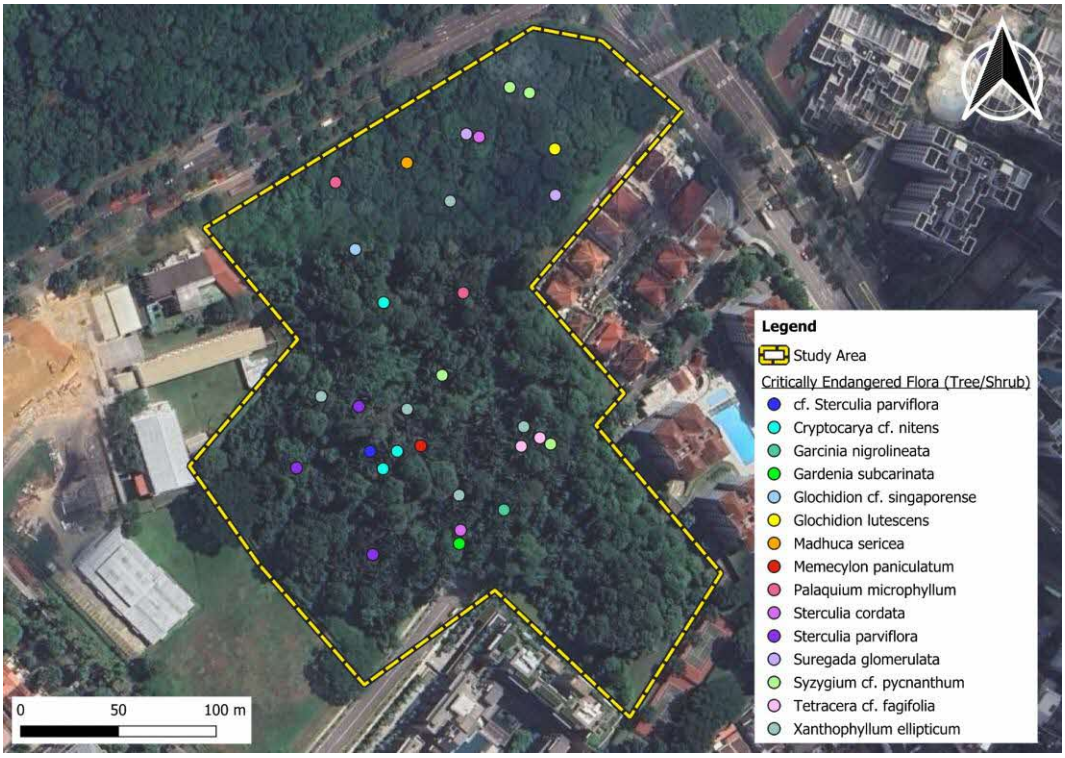


Figure 4.11. Spatial distribution of flora species of CR conservation status likely of native regeneration

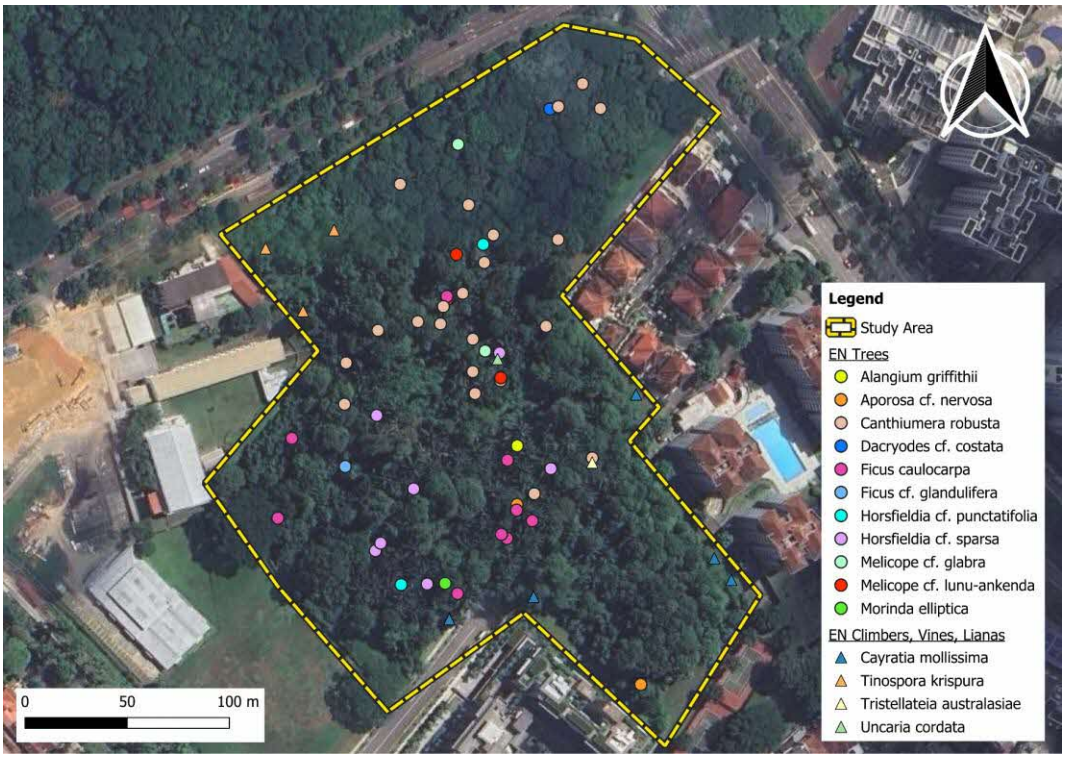


Figure 4.12. Spatial distribution of flora species of EN conservation status likely of native regeneration further catergorised by trees and climbers, vines and liana

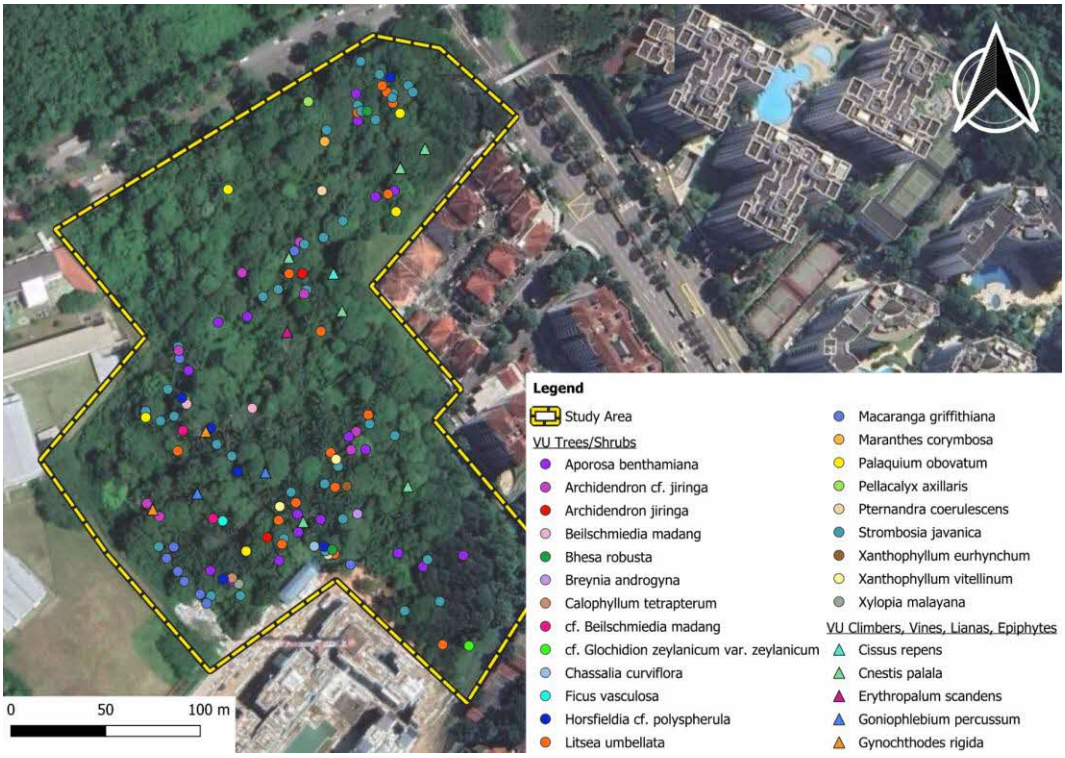


Figure 4.13. Spatial distribution of flora species of VU conservation status likely of native regeneration further categorised by trees/shrubs and climbers, vines, lianas, epiphytes

There were 12 keystone flora species, with a total of 133 individuals. All *Ficus* sp. were considered to be keystone species. Their spatial distribution is shown below (Figure 4.14).

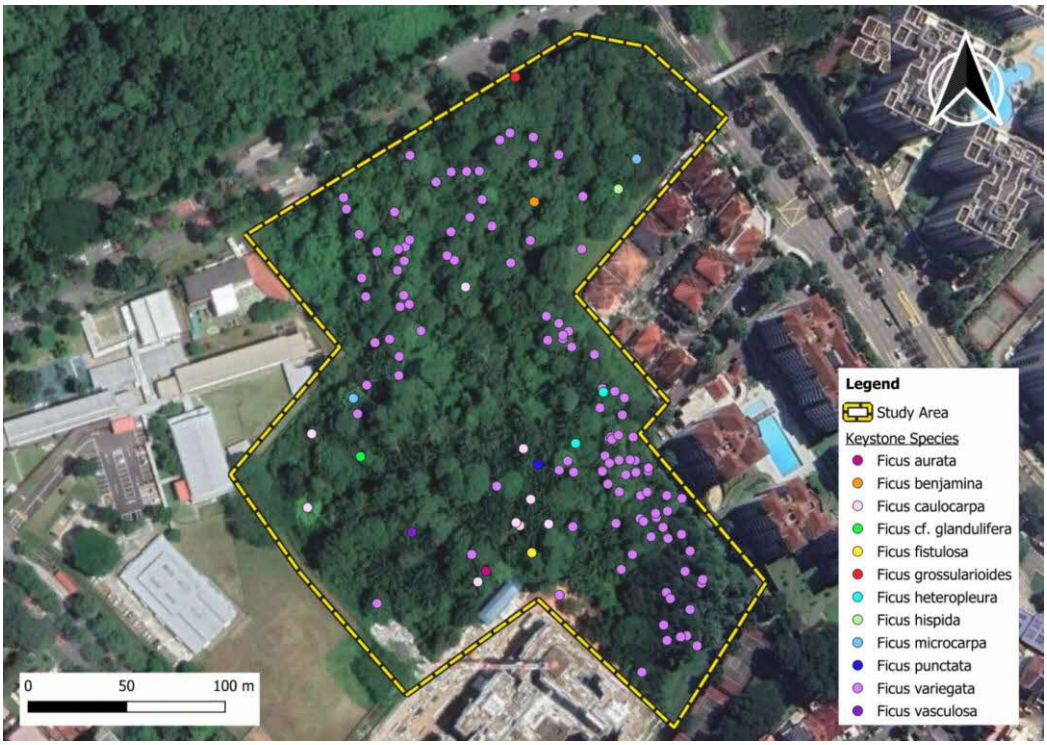


Figure 4.14. Spatial distribution of keystone flora species

4.4.2 Large Trees

A total of 596 large trees (≥ 1 m girth) consisting of 43 species were recorded during this terrestrial flora baseline study, the vast majority of which are common or exotic. The most common species within the study area are oil palm (*Elaeis guineensis*), common red-stem fig (*Ficus variegata*), breadfruit (*Artocarpus* altilis), durian (*Durio zibethinus*), African tulip (*Spathodea campanulata*) and rambutan (*Nephelium lappaceum*). There were only a few large trees of local conservation significance such as *Melicope* cf. *lunu-ankenda,* stem-fruited fig (*Ficus caulocarpa*), blue laurel (*Litsea umbellata*) and gaping fig (*Ficus* cf. *glandulifera*). The spatial distribution of large trees categorised by their local conservation status can be found in Figure 4.15.

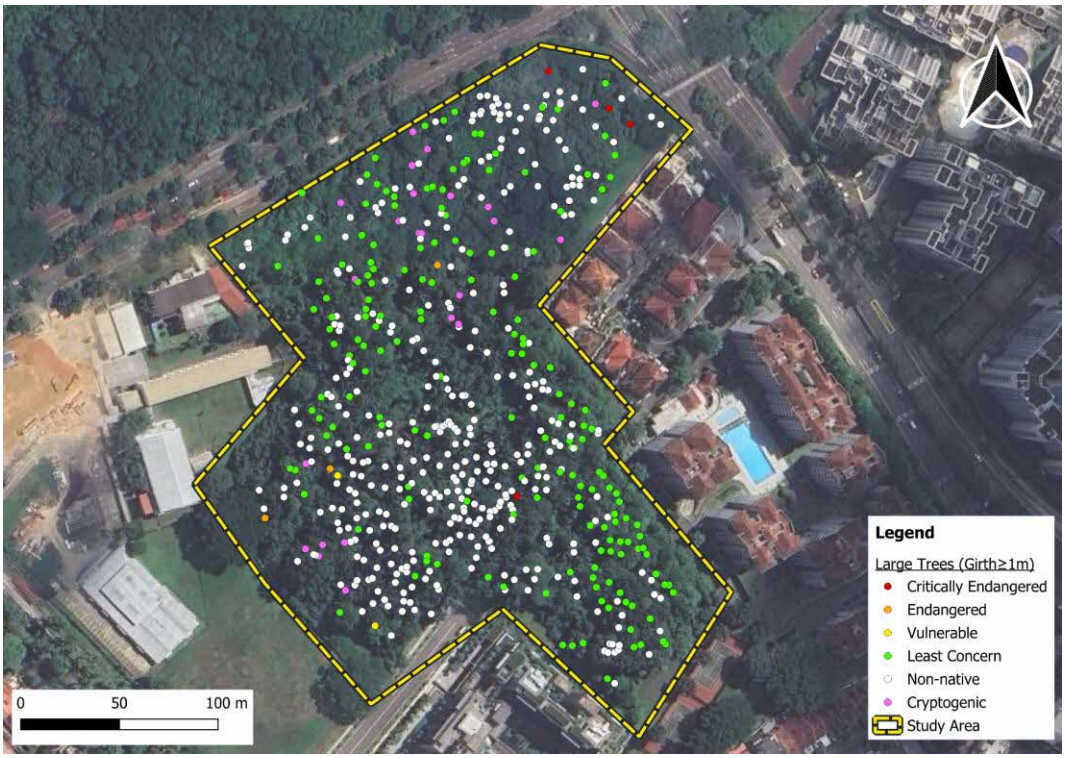


Figure 4.15. Spatial distribution of large trees according to local conservation status.

4.5 Fauna Baseline Survey Results

The study found a total of 113 species of fauna, comprising six (6) species of local conservation significance. The complete list of fauna sightings and photographs of observed animals can be found in **Appendix C** and **Appendix D** respectively, which is summarised in Table 4.10.

Table 4.10. Number of species recorded and species of local conservation significance per fauna group

Fauna Group		Total number of recorded species	Species of Local Conservation Significance		
			VU	EN	CR
Birds		54	4	1	-
Mammals	Non-volant mammals	10	-	-	1
	Bats	5	-	-	-
Reptiles		8	-	-	-
Amphibians		3	-	-	-
Butterflies		25	-	-	-
Odonates		7	-	-	-
Molluscs		1	-	-	-
TOTAL		**113**	**4**	**1**	**1**

4.5.1 Birds

Of the 429 species of birds known to occur in Singapore (Bird Society of Singapore, 2024), 54 species were recorded in the current surveys, of which five (5) are locally threatened (NParks, 2024) (Table 4.11). Although the Javan myna (*Acridotheres javanicus*) is globally vulnerable (IUCN, 2024), it is not of local conservation value as it is non-native to Singapore.

Table 4.11. List of all bird species of local and global conservation significance found in the study area

No.	Family	Species name	Common Name	Local Status	Global Status
1	Accipitridae	*Nisaetus cirrhatus*	Changeable Hawk-eagle	VU	LC
2	Corvidae	*Corvus macrorhynchos*	Large-billed Crow	VU	LC
3	Muscicapidae	*Copsychus saularis*	Oriental Magpie-robin	VU	LC
4	Pycnonotidae	*Pycnonotus zeylanicus*	Straw-headed Bulbul	EN	CR
5	Zosteropidae	*Zosterops simplex*	Swinhoe's White-eye	VU	LC
6	Psittacidae	*Psittacula longicauda*	Long-tailed Parakeet	NT	VU
7	Sturnidae	*Acridotheres javanicus*	Javan Myna	-	VU

Bird species recorded in the study area are generally typical of secondary forests and parkland, including a variety of bulbuls, doves, sunbirds, woodpeckers and parakeets. Several uncommon resident species that are largely forest-associated include the orange-bellied flowerpecker (*Dicaeum trigonostigma*), rufous-tailed tailorbird (*Orthotomus sericeus*), common emerald dove (*Chalcophaps indica*), and little spiderhunter (*Arachnothera longirostra*), which tend to be found in the central forests of Singapore, in the CCNR and BTNR, and their adjacent parks, such as BBNP (Yong,

Lim, & Lee, 2017). Given the study area's proximity to these areas, the finding of these uncommon forest birds is unsurprising. Two (2) migratory bird species – the Asian brown flycatcher (*Muscicapa dauurica*) (Figure 4.16) and an unidentified leaf warbler (*Phylloscopus sp.*) – were also recorded.

Figure 4.16. Asian brown flycatcher (*Muscicapa dauurica*)

The locally vulnerable changeable hawk-eagle (*Nisaetus cirrhatus*) is one of three species of raptors recorded in this study, the other two being the Brahminy kite (*Haliastur indus*) and the Sunda scops owl (*Otus lempiji*) (Figure 4.17). The changeable hawk-eagle is dependent on tall trees such as albizia (*Falcataria falcata*), found in small numbers in the study area, for nesting. While it used to be considered rare in Singapore, population numbers appear to be increasing in recent years (Yong, Lim, & Lee, 2017). The Sunda scops owl is the sole nocturnal bird species recorded in this study and is the also most common owl species in Singapore (Yong, Lim, & Lee, 2017).

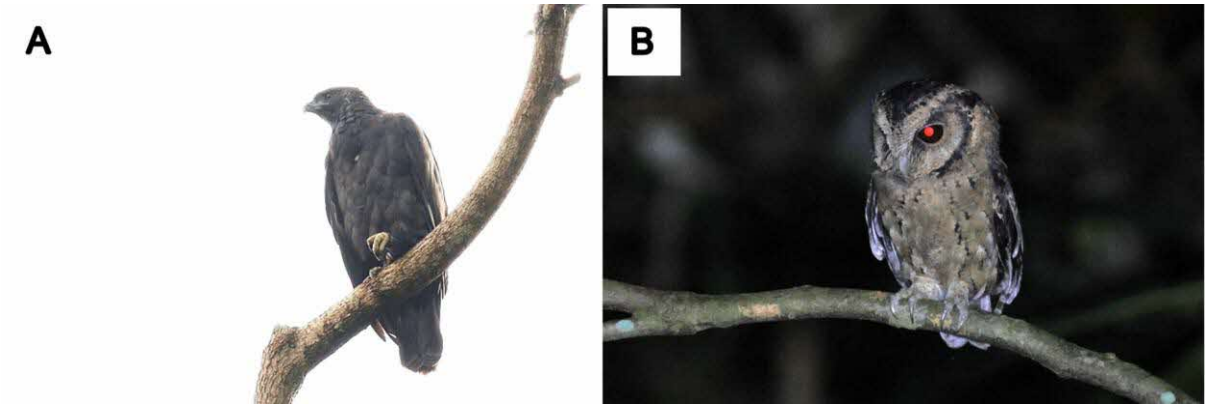


Figure 4.17. Raptors recorded in the study area. **A**: Changeable hawk-eagle (*Nisaetus cirrhatus*); **B**: Sunda scops owl (*Otus lempiji*)

The only native species of crow in Singapore, the locally vulnerable large-billed crow (*Corvus macrorhynchos*) is less common than the introduced house crow (*Corvus splendens*), likely due to its lower adaptability to urban environments (Bird Society of Singapore, n.d.). Other locally threatened species include the vulnerable oriental magpie-robin (*Copsychus saularis*) and Swinhoe's White-eye, which are common birds in the pet trade (Yong, Lim, & Lee, 2017).

The globally critically endangered straw-headed bulbul (*Pycnonotus zeylanicus*) (Figure 4.18) is a particularly noteworthy species as there are only an estimated 573 individuals in Singapore (Chiok et al., 2020). With declining numbers in South-East Asia, the Singapore population makes up 22.9%-57.3% of its global population, making Singapore an important stronghold for this species (Chiok et al., 2019; Chiok et al., 2020). Though much of Singapore's population occurs in protected areas such as Pulau Ubin and BTNR, straw-headed bulbuls (*Pycnonotus zeylanicus*) are also frequently encountered in degraded scrubland and secondary forests that lie outside of protected areas (Yong et al., 2018), similar to those within the study area.

Figure 4.18. Straw-headed bulbul (*Pycnonotus zeylanicus*)

4.5.2 Mammals

There are currently 76 known species of terrestrial mammals extant in Singapore (NParks, 2024). A total of ten (10) non-volant mammal species and five (5) bat species were encountered during the current surveys, of which one (1) is locally and globally critically endangered, and one (1) is globally endangered (Table 4.12).

Table 4.12. List of all mammal species of local and global conservation significance found in the study area

No.	Family	Species name	Common Name	Local Status	Global Status
1	Manidae	*Manis javanica*	Sunda Pangolin	CR	CR
2	Cercopithecidae	*Macaca fascicularis*	Long-tailed Macaque	LC	EN

The critically endangered Sunda pangolin (*Manis javanica*) was recorded in the study area via camera trapping at 0440 hrs (Figure 4.19). This finding is not surprising given the known presence of pangolins around the study area (see Section 2.3). While no burrows were detected during the current surveys, and the study area is smaller than its reported home range of 6.97 ha (Lim & Ng, 2008), the study area possibly serves as a foraging ground for the Sunda pangolin. As habitat generalists, pangolins are not averse to crossing roads; as such, roadkill is the greatest threat to pangolins in Singapore (Challenger et al., 2019; Nursamsi et al., 2023). In Singapore, pangolin rescue and

roadkill incidents are largely concentrated in the central and western regions, near forested nature reserves and water catchment areas, where the study area is located (Aziz et al., 2024). In August 2025, a dead pangolin was also observed by a member of public on the centre divider along Old Jurong Road (Low, 2025). As such, the Sunda pangolin possibly traverses the adjacent Old Jurong Road and Upper Bukit Timah Road to move from nearby BBNP and BTNR into the study area.

Figure 4.19. Sunda pangolin (*Manis javanica*) recorded via camera trapping

A notable mammal also found in the study area is the locally near-threatened Malayan colugo (*Galeopterus variegatus*), a nocturnal and arboreal species that is usually found clinging onto tree trunks or gliding between trees (NParks, 2024). The Malayan colugo occurs mainly in CCNR, BTNR and BBNP (NParks, 2024), and has been regularly observed along roads and forests surrounding the study area (see Section 2.3). During the current surveys, the Malayan colugo was observed on trees on the centre divider along Old Jurong Road at night, and further south within the study area (along transect T4) both in the day and night (Figure 4.20). These findings suggest that this species is not only actively crossing between BBNP and the study area to feed at night but also uses the study area as a diurnal resting site. Given that the Malayan colugo is known to exhibit a preference for forest habitats with high percentages of canopy cover (above 95%) (Lim, Giam, Byrnes, & Clements, 2013), the study area is likely a suitable habitat for the colugo to persist in.

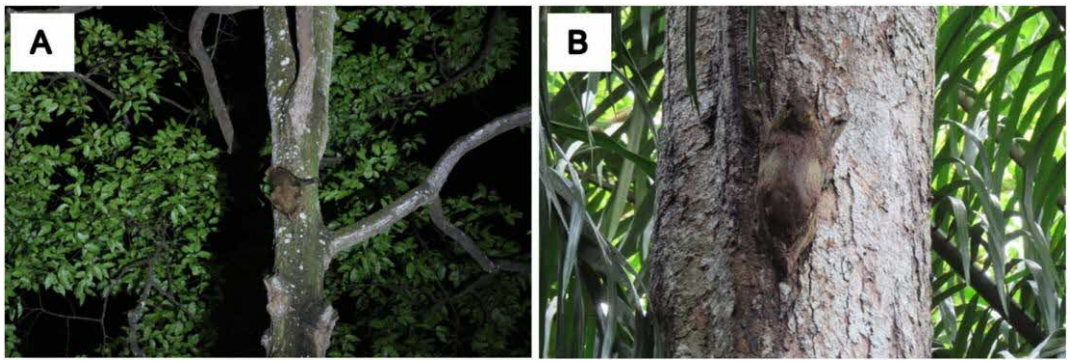


Figure 4.20. Malayan colugo (*Galeopterus variegatus*). **A**: On tree on centre divider at night; **B**: On tree along transect T4 in the day

Another nocturnal mammal found in the study area is the common palm civet (*Paradoxurus musangus*), an omnivore which can be found in a variety of habitats in Singapore, including urban areas (NParks, 2023). While considered common in Singapore, the slender squirrel (*Sundasciurus tenuis*) (Figure 4.21) is also of note as it is known to be restricted to the CCNR, BTNR, BBNP and Singapore Botanic Gardens (NParks, 2024).

Figure 4.21. Mammals found in the study area. **A**: Common palm civet (*Paradoxurus musangus*); **B**: Slender squirrel (*Sundasciurus tenuis*) (indicated in red circle)

The call structure and spectrograms for the four (4) microchiropteran bat species recorded during acoustic sampling are presented in Table 4.13, and Figure 4.22 to Figure 4.25.

Table 4.13. Call structure summary of bat species recorded during acoustic sampling.

Species name	Frequency (kHz)		Peak Frequency (kHz)	Call duration (ms)	Source
	Maximum	Minimum			
Myotis muricola	79.9 ± 1.02	53.7 ± 0.48	57.2 ± 0.01	4.98 ± 0.07	(Pottie et al., 2005)
Pipistrellus stenopterus	56.0±1.81, 42.8±2.01	32.9±0.28, 28.0±0.40	37.8 ± 0.38	9.70 ± 0.21	(Kingston et al., 2003)
Scotophilus kuhlii	84.9 ± 2.25	36.6 ± 0.46	43.3 ± 0.16	4.01 ± 0.03	(Pottie et al., 2005)
Taphozous melanopogon	28.7 ± 1.24	25.2 ± 0.82	27.9 ± 0.56	10.43 ± 0.06	(Pottie et al., 2005)

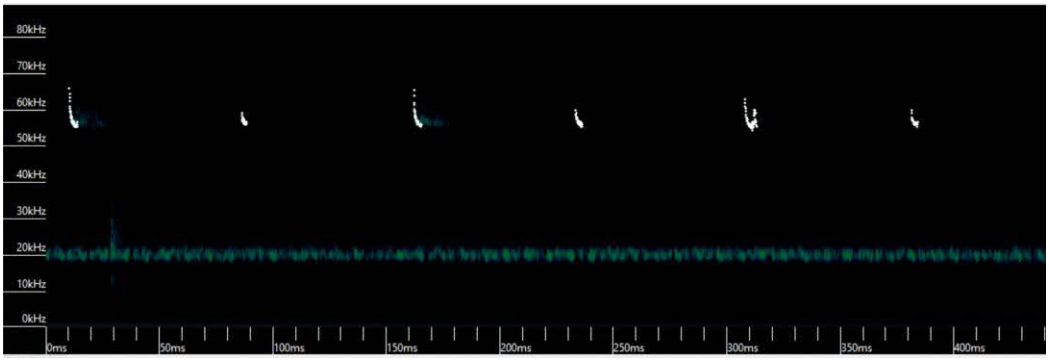


Figure 4.22. Spectrogram showing the acoustic call characteristics of *Myotis muricola*

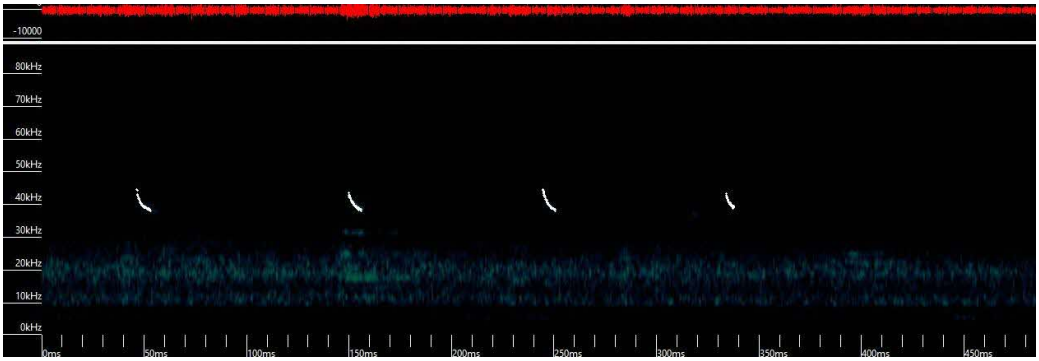


Figure 4.23. Spectrogram showing the acoustic call characteristics of *Pipistrellus stenopterus*

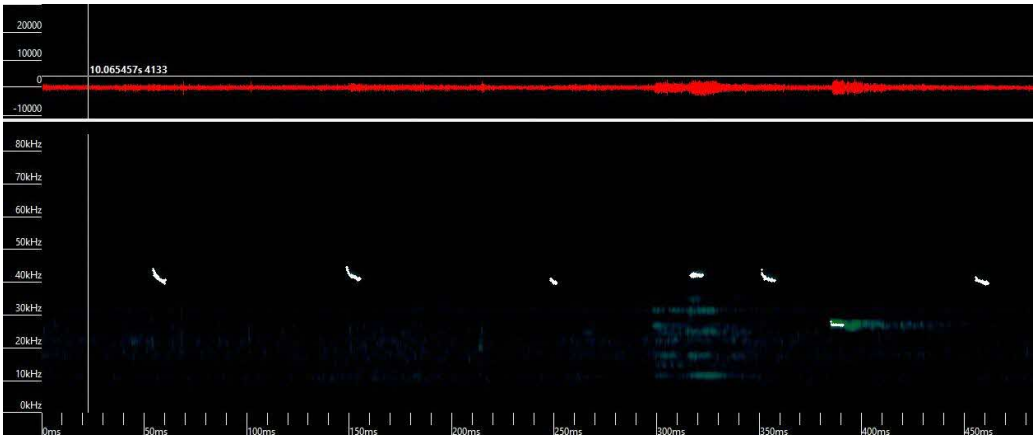


Figure 4.24. Spectrogram showing the acoustic call characteristics of *Scotophilus kuhlii*

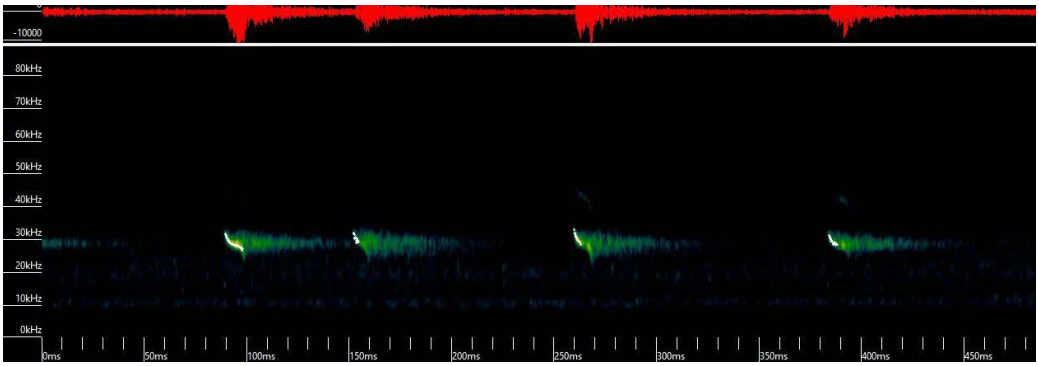


Figure 4.25. Spectrogram showing the acoustic call characteristics of *Taphozous melanopogon*

All four (4) bat species recorded are habitat generalists, adapted to foraging in open environments such as around artificial streetlights and tree crowns in suburban to urban areas (McKenzie & Bullen, 2019; Tzi et al., 2010; Zhu et al., 2012). The study area is characterised by various habitat types which include abandoned land forests and urban vegetation, which have sources of artificial lights including streetlights on the roads and lights from the nearby housing estates. The site is likely used by bat species adapted to both urban and forest environments. Apart from the lesser dog-faced fruit bat (*Cynopterus brachyotis*) which belongs to the megachiroptera suborder, all the remaining bats recorded during this study are from the microchiroptera suborder.

Unlike microchiropteran bats, the lesser dog-faced fruit bat (*Cynopterus brachyotis*)

utilises its keen sense of sight and smell to forage instead of using echolocation, which is why it was not detected by calls and excluded from the acoustic sampling findings above. This species is also the only frugivorous bat recorded. Due to its ability to retain viable seeds for more than 12 hrs, this species is an important long-distance seed disperser (Shilton et al., 1999). This highlights the ecological importance of the study area for seed dispersal, helping to improve genetic exchange and long-term population viability of forests.

4.5.3 Reptiles

A total of eight (8) species comprising seven (7) lizards and one (1) snake were recorded during the present surveys, out of the 135 species of reptiles recorded in Singapore (Figueroa et al., 2023). One (1) non-native species, the changeable lizard (*Calotes versicolor*), was recorded. The remaining six (6) native species recorded are common and widely distributed in Singapore, and are not locally or globally threatened (Figueroa et al., 2023) except for the clouded monitor lizard (*Varanus nebulosus*) (Figure 4.26) which has a global near threatened status. One (1) unidentified species of monitor lizard was recorded.

The current surveys recorded both the native green crested lizard (*Bronchocela cristatella*) (Figure 4.26) and non-native changeable lizard (*Calotes versicolor*) (Figure 4.26). Diong et al. (1994) and Figueroa (2023) assessed that the once-ubiquitous green crested lizard (*Bronchocela cristatella*) has been outcompeted and displaced mostly into forested habitats by the changeable lizard (*Calotes versicolor*). The latter species was introduced as recently as the 1980s and has rapidly proliferated to become one of the most abundant reptiles in Singapore (Lim & Chou, 1990; Figueroa et al., 2023). Ginal et al. (2022) reported that changeable lizards (*Calotes versicolor*) had likely spread globally as stowaways on maritime routes and suggested that Singapore's position as a global trans-shipment hub may have further facilitated their dispersal to yet-uncolonised regions.

The painted bronzeback (*Dendrelaphis pictus*) (Figure 4.26) was the only snake recorded. Considered to be the nation's most prevalent snake (Figueroa et al., 2023), the painted bronzeback (*Dendrelaphis pictus*) is regularly found in disturbed vegetated habitats like those found in the study area.

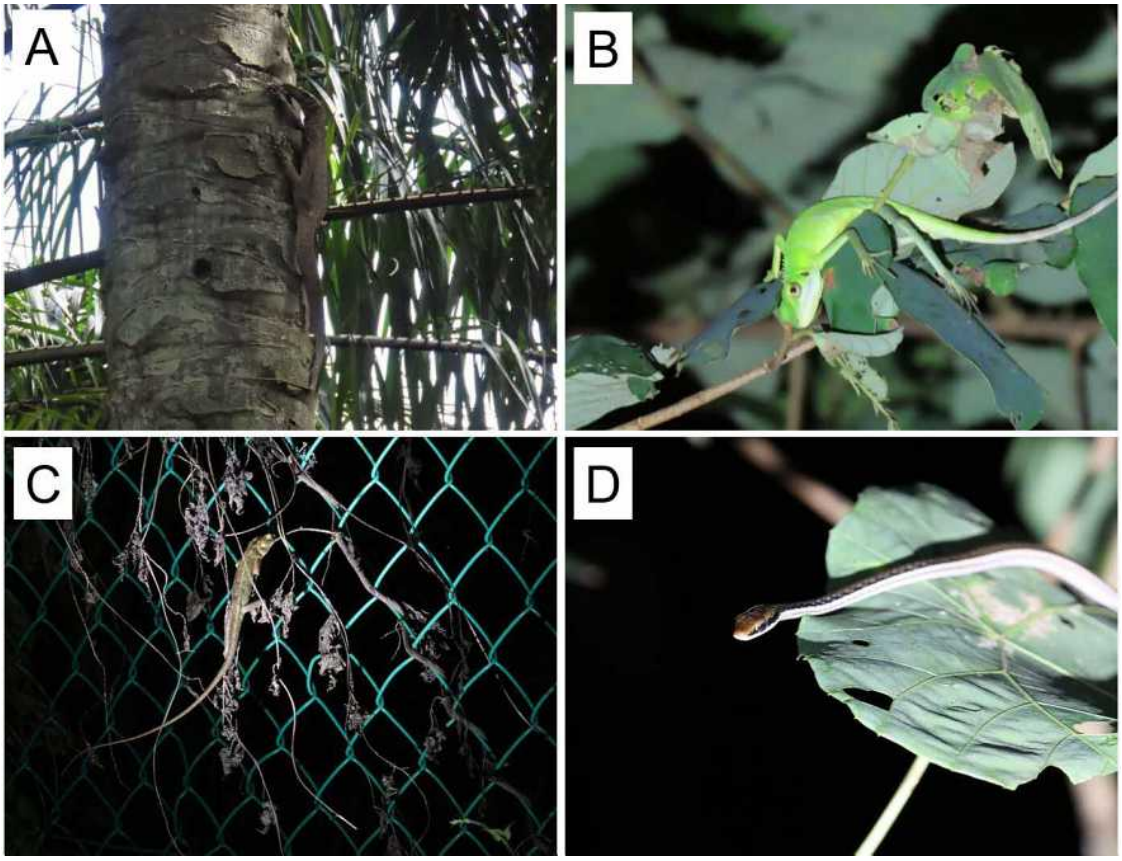


Figure 4.26. Reptiles recorded in study area. **A:** Clouded monitor lizard (*Varanus nebulosus*); **B**: Green crested lizard (*Bronchocela cristatella*); **C**: Changeable lizard (*Calotes versicolor*); **D**: Painted bronzeback (*Dendrelaphis pictus*).

4.5.4 Amphibians

Thirty-one (31) species of amphibians comprising two (2) caecilians and 29 frogs are currently known from Singapore (Figueroa et al., 2023). The present surveys in the study area reported one (1) toad species, two (2) frog species and one (1) dark-sided chorus frog (*Microhyla* cf. *heymonsi*) tadpole. Two (2) of the species, the four-lined tree frog (*Polypedates leucomystax*) (Figure 4.27) and the dark-sided chorus frog (*Microhyla* cf. *heymonsi*), are native. The Asian toad (*Duttaphrynus bengalensis*) is non-native and has established populations in Singapore (Figueroa et al., 2023) (Figure 4.27). All three (3) toad and frog species found in the present surveys are regarded as human commensals, commonly found in urban habitats and disturbed areas (Figueroa et al., 2023). They are one of the most common frogs and toads in Singapore and have also been reported in the adjacent Bukit Timah Nature Reserve (Teo & Thomas, 2019). None of the species recorded were listed as locally or globally threatened.

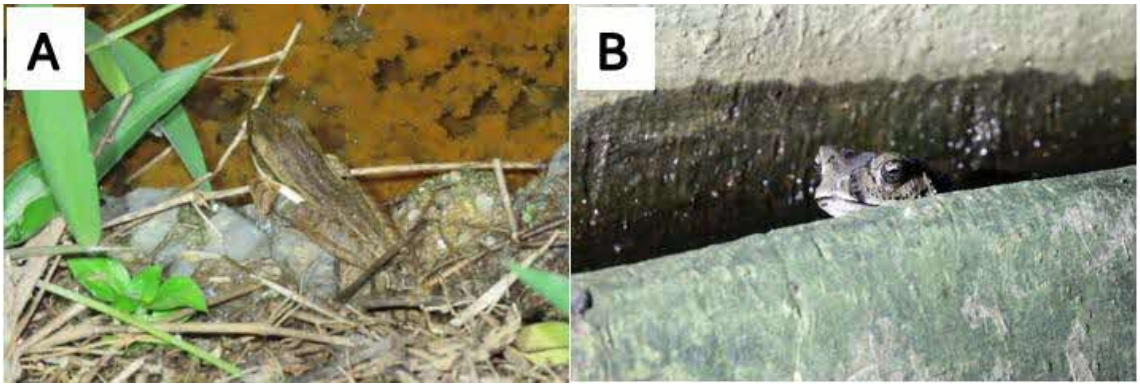


Figure 4.27. Amphibians recorded in study area. **A:** Four-lined tree frog (*Polypedates leucomystax*); **B**: Asian toad (*Duttaphrynus bengalensis*).

Larval forms of the four-lined tree frog (*Polypedates leucomystax*) and dark-sided chorus frog (*Microhyla* cf. *heymonsi*) (Figure 4.28) were encountered in the drain along transect T5. It is not uncommon to find four-lined tree frog tadpoles in man-made structures such as the drain in the present surveys; and mating pairs and foam nests have also been observed in urban habitats near a freshwater source (e.g., drums, containers, side of a concrete pond) (Chan & Goh, 2010; Chin, 2024). They have been observed to lay their eggs in a protective foam nest, attached to objects suspended above the water surface (Chan & Goh, 2010; Chin, 2024). The mating pair, while in amplexus, would kick their hind limbs into the nest to form more foam (Pearlindah et al., 2012; Chin, 2024). The eggs and sperm will be released into the foam nest, and when the tadpoles hatch, they will fall into the water body below.

Figure 4.28. Larval form of dark-sided chorus frog (*Microhyla* cf. *heymonsi*) found in the drain along T5

Amphibian species richness is largely dependent on the degree of habitat structural complexity, types of waterbodies present and degree of human disturbance (Bateman & Merritt, 2022; Decena et al., 2020; Bickford et al., 2010). Anthropogenic modification of habitats has been shown to reduce the diversity of amphibians globally (Cordier et al., 2021; Hamer & McDonnell, 2008), as well as in Singapore (Bickford et al., 2010). The low amphibian species richness recorded corresponds with the current absence of

permanent freshwater bodies and suggests that the habitats present may be unsuitable to support species with more stringent habitat requirements.

4.5.5 Butterflies

There are 367 butterfly species are currently extant in Singapore (NParks, 2024). A total of 25 butterfly species were recorded in the study area during the baseline surveys, the majority of which are native to Singapore. While all the butterfly species observed are listed as least concern locally, some of them are forest-associated species such as the branded imperial (*Eooxylides tharis distanti*) (Figure 4.29) and rustic (*Cupha erymanthis lotis*).

Figure 4.29. Branded imperial (*Eooxylides tharis distanti*)

The branded imperial (*Eooxylides tharis distanti*) is a forest-dependent species and is one of five imperial butterfly species found in Singapore (Khew, 2019). Of the five imperials, the branded imperial is the most common species, often observed in the shaded understorey of Singapore's forests (Khew, 2019; ButterflyCircle, 2014). The presence of this species has been recorded in other forested areas such as the CCNR, BTNR, and Southern Ridges (Tan, 2010). The larvae of the branded imperial is known to feed on a common forest edge climber, the *Smilax setosa* (Khew, 2019; ButterflyCircle, 2014; Lindsay, et al., 2022), which was recorded during the baseline surveys at this site.

Another notable species is the rustic (*Cupha erymanthis lotis*) which is typically observed in forested areas such as the Central Catchment Nature Reserve (Tan H. , 2009; ButterflyCircle, 2024). Outside of forested areas, the rustic may occasionally be observed close to where the host plants of its larvae, *Flacourtia rukam* and *Flacourtia inermis*, are present (Khew, 2013).

4.5.6 Odonates

There are 136 odonate species are recorded in Singapore, of which 126 are currently extant (Ngiam & Ng, 2022; NParks, 2024). A total of seven (7) dragonfly species were recorded in the study area during the baseline surveys, all of which are listed as least concern locally (Ngiam & Ng, 2022; NParks, 2024). All seven (7) species are widespread

and common in Singapore and inhabit disturbed habitats with suitable waterbodies for breeding, such as urban areas, grassland or parkland (Ngiam & Davison, 2011; Ngiam & Ng, 2022).

Most of the dragonfly observations were recorded at transect T5, along a concrete drain at the perimeter of the vegetated area. Within the vegetated patch, where there are no existing streams, there were only a handful of individuals recorded. This is expected because dragonflies typically require a suitable waterbody, such as the water in the drain, to lay their eggs (Ngiam & Ng, 2022).

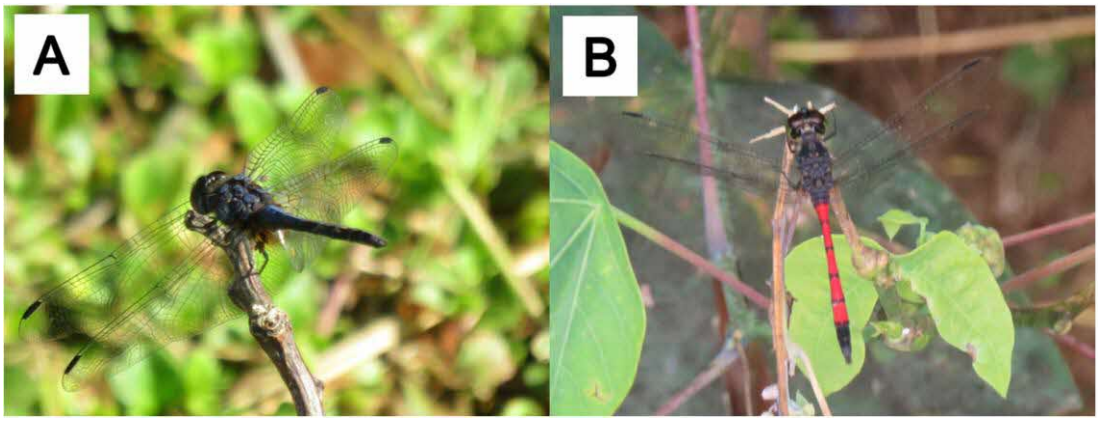


Figure 4.30. Dragonflies observed along the drain. **A**: Indigo dropwing *(Trithemis festiva*); **B**: Grenadier (*Agrionoptera insignis*)

4.5.7 Aquatic Fauna

The two aquatic transects, located along a stretch of concrete drain, were observed to have sections of stagnant water at survey time. Only one mollusc species was detected in the area, with no fish or decapod crustaceans recorded.

Hand netting and baited traps combined caught a total of 16 acute bladder snails (*Physella acuta*). This globally invasive freshwater snail has been recorded in Singapore since the 1980s and is suspected to have been introduced via the aquarium trade (Ng, Tan, & Yeo, 2015). Native to the Americas, *Physella acuta* thrives in man-made water bodies (such as the concrete drain surveyed) and is suggested to competitively displace native mollusc species at high densities (Cieplok & Spyra, 2020).

Figure 4.31. Acute bladder snail (*Physella acuta*) found during aquatic survey

Larvae from the Chironomidae family were found during the aquatic survey. A common, pollution-tolerant group, chironomids serve as an important food source for other invertebrates, birds and amphibians where they occur (Armitage, Cranston, & Pinder, 1995). An oligochaete was also found during hand-netting. As detritivores, oligochaetes promote nutrient cycling through the ingestion of sediments (Thorp & Covich, 2001).

A water scorpion (*Laccotrephes* sp.) specimen was recorded. *Laccotrephes* is native to Singapore and inhabits small, stagnant bodies of water amid submerged leaf litter (Polhemus & Polhemus, 2013). As poor swimmers, they prefer to ambush prey like tadpoles, small fish and other invertebrates (Mogali, Shanbhag, & Saidapur, 2022). The water scorpion may be feeding on the other organisms found in the same drain.

Figure 4.32. Organisms found during aquatic surveys. **A**: Water scorpion (*Laccotrephes* sp.); **B**: Flatworms; **C**: Oligochaete; **D:** Larval dipteran; **E**: Larval chironomid; **F**: Dark-sided chorus frog (*Microhyla* cf. *heymonsi*) tadpole

4.5.8 Camera Trapping

The four (4) camera traps deployed yielded a total of 312 independent detections which comprise 18 identified fauna species (Table 4.14).

Table 4.14. Number of detections for each species per camera trap

S/N	Species	CAM 1	CAM 2	CAM 3	CAM 4
1	Asian Glossy Starling	0	0	0	10
2	Asian House Shrew	2	0	0	0
3	Common Flameback	0	2	0	0
4	Common Malayan Treeshrew	57	32	0	0
5	Common Palm Civet	3	0	0	0
6	Feral Cat	0	1	4	3
7	Laced Woodpecker	0	1	0	0
8	Long-tailed Macaque	0	4	10	0
9	Malayan Water Monitor	5	0	0	0
10	Oriental Magpie-robin	0	0	1	0
11	Plantain Squirrel	23	19	2	8
12	Red Junglefowl	11	7	40	2
13	Rufous Woodpecker	0	0	0	1
14	Slender Squirrel	0	2	0	0
15	Spotted Dove	0	0	13	2
16	Sunda Pangolin	1	0	0	0
17	Sunda Scops Owl	0	0	0	1
18	White-crested Laughingthrush	5	1	0	1
-	Unidentified Bat	0	0	8	6
-	Unidentified Bird	0	0	2	5
-	Unidentified Rat	16	6	1	0
-	Unidentified Small Mammal	9	38	0	0
-	Unidentified	1	4	2	0
Total Number of Independent Detections		133	117	83	39
Total Number of Identified Species		8	9	6	8

Small mammals such as the common Malayan treeshrew (*Tupaia glis*) and plantain squirrel (*Callosciurus notatus*), and the ground-dwelling red junglefowl (*Gallus gallus*) generally dominated the detections, making up more than half of the total number of detections. Several species – the common palm civet (*Paradoxurus musangus*), feral cat (*Felis catus*), Malayan water monitor (*Varanus salvator*), rufous woodpecker (*Micropternus brachyurus*) and Sunda pangolin (*Manis javanica*) – were recorded only via camera trapping in this study (Figure 4.33).

Figure 4.33. Fauna recorded in camera trap images. **A**: Malayan water monitor (*Varanus salvator*); **B**: Rufous woodpecker (*Micropternus brachyurus*) (indicated in red circle)

The most notable finding from camera trapping was the sole record of a Sunda pangolin (*Manis javanica*) in this study (Figure 4.34). The individual was captured at CAM 1, located at the northern boundary of the site, facing Old Jurong Road. This finding is not surprising as the Sunda pangolin is known to inhabit nearby forests in BBNP and BTNR, and has also been recorded along nearby roads, as detailed in Section 2.3. While there is no direct footage of this individual crossing the road, it is plausible that it had crossed over from the adjacent BBNP or BTNR via Old Jurong Road or Upper Bukit Timah Road, given the proximity of its recorded location to the road, and the lack of records elsewhere in this study.

Figure 4.34. Sunda pangolin (*Manis javanica*) recorded in CAM 1

4.6 Discussion of Biodiversity Findings

In general, the combined flora and fauna findings of the study area suggested high ecological value. While the canopy of the site is mostly typical of abandoned land forest, the understorey species composition shows multiple shade-tolerant native tree species across most of the understorey, with some clusters achieving such high density that the habitat is indicative of NDOSF, which is the same habitat type as CCNR and therefore of national importance. Compared to manicured landscapes, remnants of natural vegetation are more important in supporting wildlife diversity and mitigating biodiversity decline (Chong, et al., 2014; Hahs, et al., 2009). As such, the study area has high future ecological value since it is already undergoing active ecological succession without any human assistance, and it is expected to be replaced by NDOSF habitat within several decades.

On top of habitat type, the presence of multiple late-successional forest species in the understorey also suggests the study area is an important destination site for seed dispersal from BTNR and BBNP, as many of these species were also recorded to occur at both sites (Turner & Chua, 2011; Ho, et al., 2019). Given that many of the forest species produce fleshy fruits that are dispersed by fauna, their presence as understorey seedlings also suggests high levels of fauna activity in the study area, which is supported by the fauna survey findings. The presence of many mature figs mainly in the NDYSF such as the common red-stem fig (*Ficus variegata*) is also of ecological significance, as *Ficus* species are widely considered to be keystone species in tropical Southeast Asia owing to their provision of a steady supply of ripe syconia year-round (Lok, et al., 2013). Besides mature figs, multiple flora species observed in the study area are fauna-attracting, such as the bandicoot berry (*Leea indica*), star fruit (*Averrhoa carambola*), turn-in-the-wind (*Mallotus paniculatus*), pink lime-berry (*Clausena excavata*) and common lantana (*Lantana camara*).

Indeed, many frugivorous birds, such as doves, bulbuls and starlings, and mammals,

such as the common palm civet (*Paradoxurus musangus*) and lesser dog-faced fruit bat (*Cynopterus brachyotis*), were recorded in the study area. Many birds were also observed flying across Old Jurong Road and Upper Bukit Timah Road to and from BBNP and BTNR respectively. A comparison of fauna species lists from the current study, previous EIAs conducted along the BBNC (NParks, pers. comm., October 2024) and checklists of fauna species in BTNR (Teo & Thomas, 2019) revealed that all terrestrial fauna species recorded in this study were previously recorded in nearby areas, suggesting strong existing connectivity between the study area and forests in BTNR and BBNP.

Despite being separated by Old Jurong Road and Upper Bukit Timah Road, existing records of non-volant mammals such as the Sunda pangolin (*Manis javanica*) along these roads suggests that they are not averse to crossing roads. The presence of trees on the centre divider may also serve as a stepping-stone to shorten gap-crossing distance for fauna, especially for the Malayan colugo (*Galeopterus variegatus*), which was observed gliding towards the study area from trees on the centre divider on Old Jurong Road (refer to Appendix H for detailed Colugo Connectivity Study Report). While the study area is relatively small in size compared to the surrounding forests of BBNP and BTNR, and may not itself support populations of these mammals, it likely serves as an important foraging ground or even sink habitat for dispersing fauna when source habitats have reached carrying capacity. Therefore, any impact on the study area needs to be considered in the context of its ecological connectivity with surrounding sites.

The presence of fauna species of local and global conservation significance, such as the Sunda pangolin (*Manis javanica*) and straw-headed bulbul (*Pycnonotus zeylanicus*), as well as other forest-dependent non-volant mammals, such as the Malayan colugo (*Galeopterus variegatus*), slender squirrel (*Sundasciurus tenuis*), and common treeshrew (*Tupaia glis*), in the study area confirms the observation that many of the surviving native bird and mammal species of Singapore are able to adapt to secondary vegetation (Corlett, 1992). With existing nature reserves making up only 4.6% of Singapore's land area (Corlett, 1992; Yee et al., 2011), this highlights the conservation value of vegetated patches and secondary forests outside of protected nature reserves and parks.

Combining floristic and faunistic findings, the NDYSF and the NDOSF understorey mainly within the abandoned land forest (Figure 4.35) should be prioritised for conservation as far as possible. Given the highly diverse species composition, strong ecological connectivity and future ecological value, this location may not just be beneficial, but necessary in the greater ecological connectivity in the western region of Singapore.

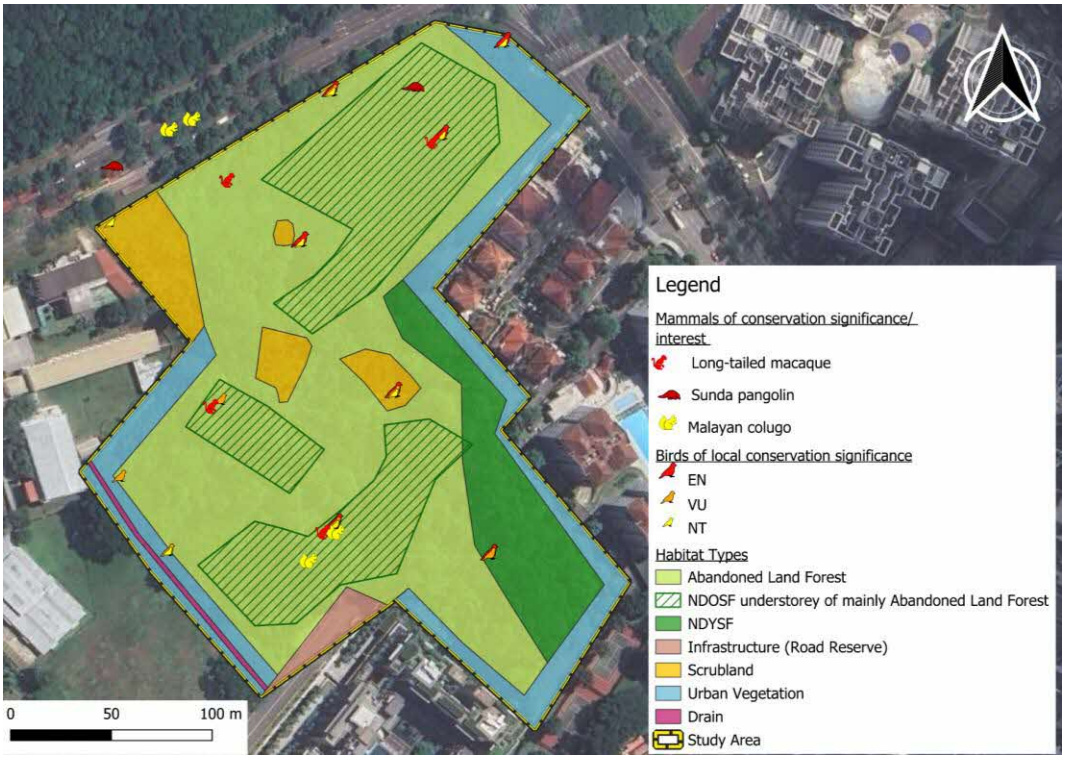


Figure 4.35. Locally threatened fauna species found in the study area overlaid on habitat map

4.7 Core Sensitive Areas

The study area lies in the eastern part of the BBNC, a series of nature parks, nature ways and park connectors (NParks, 2024) (Figure 4.36) linking forest patches west of the CCNR (Figure 2.3). In the immediate vicinity of the study area lies BTNR to the east and BBNP to the north-west. Hence, Core Sensitive Areas (CSAs) with buffer zones are identified in the study area, which can potentially serve as an important stepping stone habitat in the eastern section of the BBNC.

Figure 4.36. Map of the BBNC, with location of study area marked by a red star [3]

As mentioned in the previous section, the NDYSF and the abandoned land forest with NDOSF understorey (Figure 4.35) should be prioritised for conservation as far as possible in view of their biodiversity and ecological significance. As such, all NDYSF and abandoned land forest with NDOSF understorey are identified as CSAs, and other adjoining vegetation with sightings of fauna of conservation significance (Figure 4.35), flora of conservation significance (Figure 4.11, Figure 4.12, Figure 4.13) and/or bamboo clusters are identified as buffer zones (Figure 4.37). Bamboo clusters are potential habitats for bamboo bats. There are two known species in Singapore and they are both locally vulnerable and are known to be present near the study area (NParks, pers. comm., October 2024). Buffer zones also aid in ensuring contiguity between the CSAs, especially for smaller CSA patches. Care was taken such that areas with invasive Zanzibar yam occurrences are excluded from considerations of CSA and buffer zones, as they spread very fast and uncontrollably which will smother the native flora. The identified CSAs consists of three zones – Zones A, B and C of 1.08 ha, 0.81 ha and 0.18 ha respectively, adding up to 2.07 ha. The buffer zones, on the other hand, consist of adjoining vegetations of Zone A of 0.31 ha and adjoining vegetations of Zone B of 0.38 ha, and the buffer zone joining both Zone A and Zone C of 0.35 ha, adding up to 1.04 ha. Overall, the CSAs and buffer zones add up to 3.11 ha, which is roughly 53% of the study area.

[3] https://www.facebook.com/nparksbuzz/photos/a.228201063886044/3702442039795245/?type=3

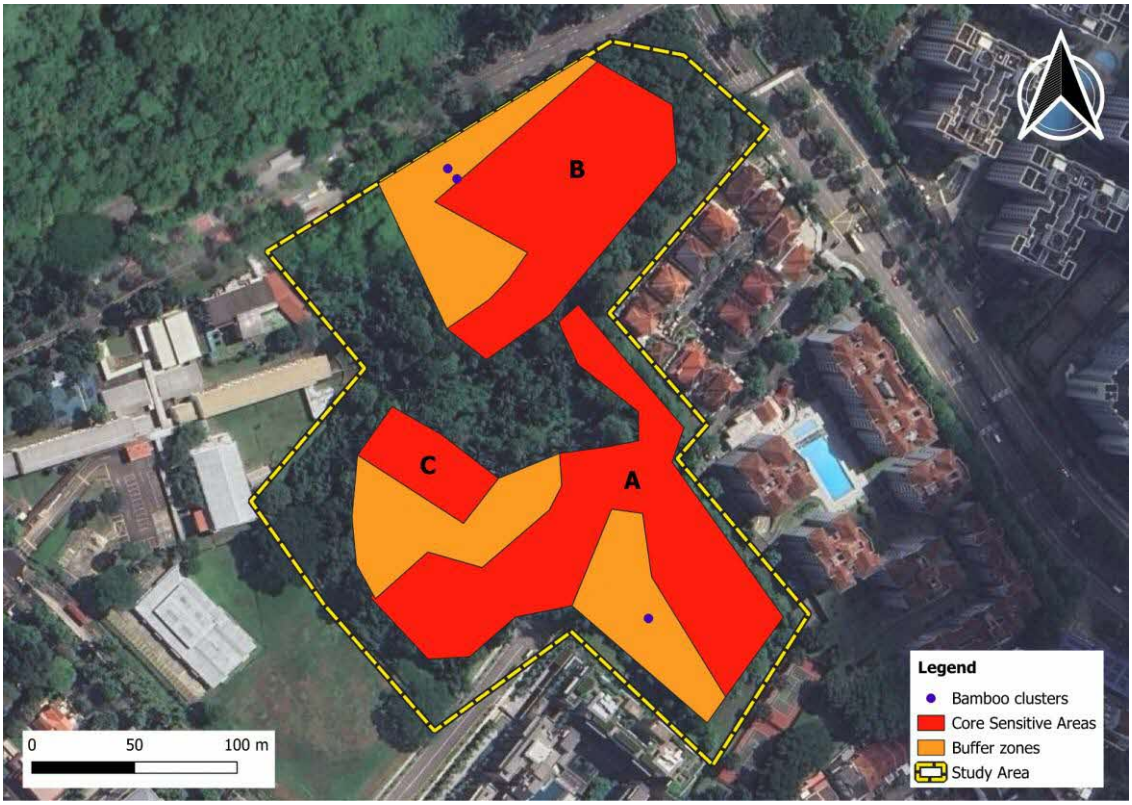


Figure 4.37. Identified CSA and Buffer Zones in the study area

5 HYDROLOGY AND WATER QUALITY

This section describes the relevant legislations and standards for water quality that are applicable to the project, as well as the methodology and results for the baseline hydrological conditions and surface water quality in the study area.

5.1 Relevant Environmental Legislation, Guidelines and Standards

Environmental legislation in Singapore concerning the management and/or protection of surface water quality, which are used as guiding documents throughout various project development stages (i.e., pre-construction, construction, and post-construction), are presented below:

Sewerage and Drainage Act 1999, (Revised 2020)

- Act to provide for and regulate the construction, maintenance, improvement, operation and use of sewerage and land drainage systems, to regulate the discharge of sewage and trade effluent and for matters connected therewith. This act is under the jurisdiction of PUB.

Sewerage and Drainage (Surface Water Drainage) Regulations 1999, (Revised 2007)

- Provides details on the measures and considerations to be implemented to protect the stormwater drainage system. This regulation is under the jurisdiction of PUB.

Sewerage and Drainage (Trade Effluent) Regulations 1999, (Revised 2007)

- Provides details on the measures and considerations to be implemented to regulate trade effluent discharge into the public sewerage system. This regulation is under the jurisdiction of PUB.

Environmental Protection and Management (Trade Effluent) Regulations 1999, (Revised 2008)

- Discusses details on the measures and considerations to be implemented to regulate trade effluent discharge into public watercourse. This regulation is under the jurisdiction of NEA.

PUB Code of Practice on Surface Water Drainage (Seventh Edition, 2018)

- Discusses guidelines on appropriate measures to be implemented for the protection of the stormwater drainage system and the management of surface water drainage (e.g., development and implementation of an ECM Plan). This code is under the jurisdiction of PUB.

PUB Handbook on Managing Urban Runoff (First Edition, 2013)

- Outlines information on stormwater management strategies, resources for designing stormwater drainage systems, source solutions to on-site stormwater management, and receptor solutions to protect developments from flood risks. This document is published by PUB.

PUB Guidebook on Erosion and Sediment Control at Construction Sites (2018)

- Provides best practices on keeping waterways free of muddy water, industry

standards on effective ECM, and guidelines on ECM provisions on construction sites. This document is published by PUB.

PUB Circular on Preventing Muddy Water from the Construction Site (2015)

- Stipulates that all new construction sites with site area of 0.2 ha and above, sites with problematic ECM, and sites within sensitive areas are required to implement closed-circuit television (CCTV) including a Silt Imagery Detection System (SIDS) at the public drain to monitor the surface run-off discharge from the site. This circular is published by and under the jurisdiction of PUB.

For the purpose of the current study, the water quality findings were compared against the threshold values stipulated under the National Environment Agency (NEA) *Allowable Limits for Trade Effluent Discharge to Watercourse or Controlled Watercourse*.

5.2 Catchment Profile

The project study area is located within the catchment area of Pandan Reservoir which was created by damming the mouth of Sungei Pandan in 1974. In Figure 5.1, the Pandan Reservoir catchment area is shaded in red, and the approximate location of the project site is demarcated by the yellow box. There are no natural streams found within the project site.

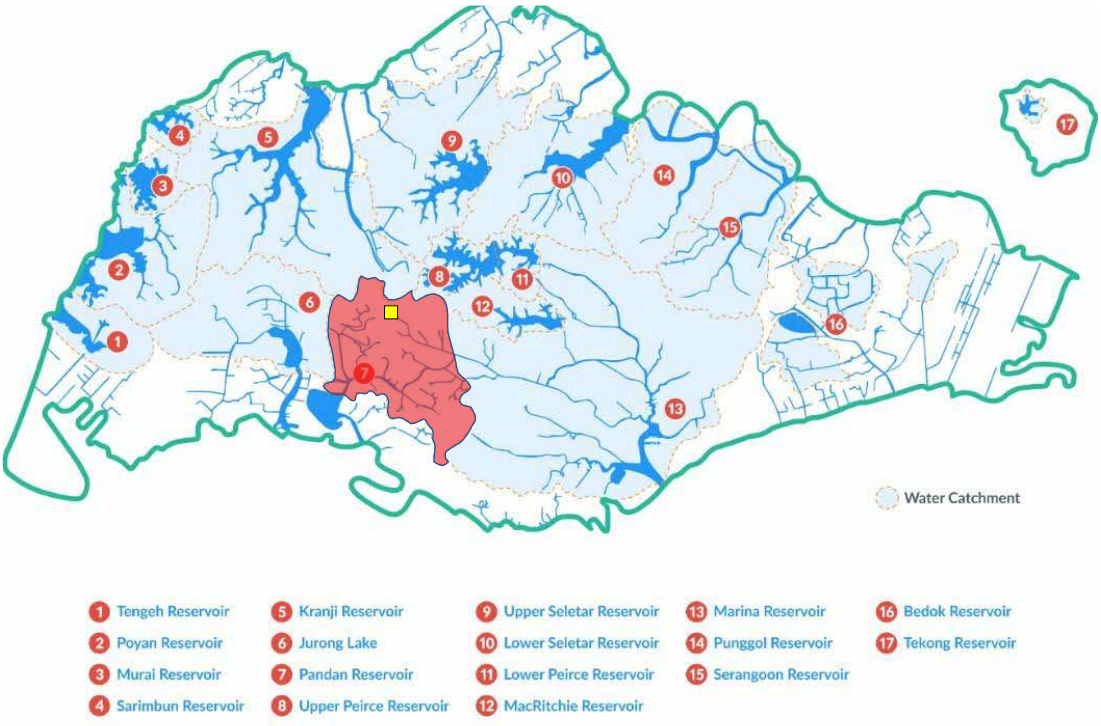


Figure 5.1. Catchment areas of Singapore **(PUB, 2023)**

The reservoir's main body covers an area of approximately 176 ha. Pandan Reservoir is the largest service reservoir in Singapore providing non-potable water to the surrounding industrial areas. It is in the Western Region and is the only elevated reservoir in Singapore. The flow of the Ulu Pandan Canal was in the past reversed such

that water now drains toward Pandan Reservoir instead of towards the Alexandra and Singapore Rivers.

5.3 Annual Rainfall

Meteorological Service Singapore (MSS) publishes historical daily records of weather conditions in Singapore such as rainfall and wind speed (MSS, 2024). As the Clementi rain gauge is the closest rain gauge to the project site, the daily rainfall data at this location was extracted. The approximate location of the project site is demarcated by the yellow box in Figure 5.2. The total amount of daily rainfall in each month was combined to tabulate the monthly rainfall.

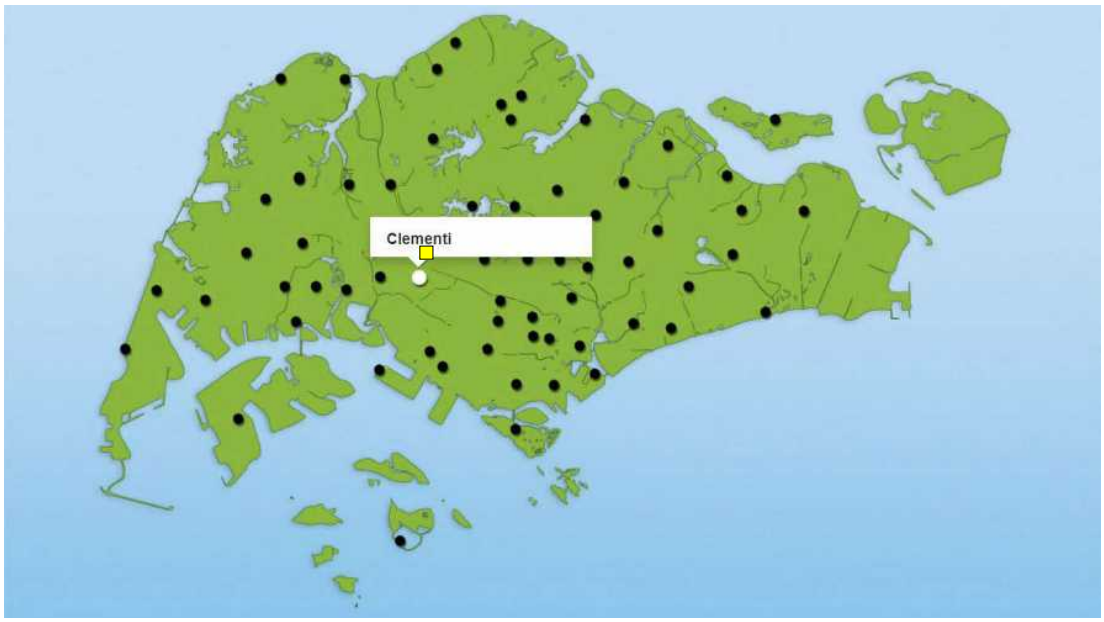


Figure 5.2. Rain gauge locations across Singapore **(MSS, 2024)**

Monthly rainfall over the last ten years at the project study area is shown in Figure 5.3, adapted from historical records at the Clementi weather station that represents the site (MSS, 2024).

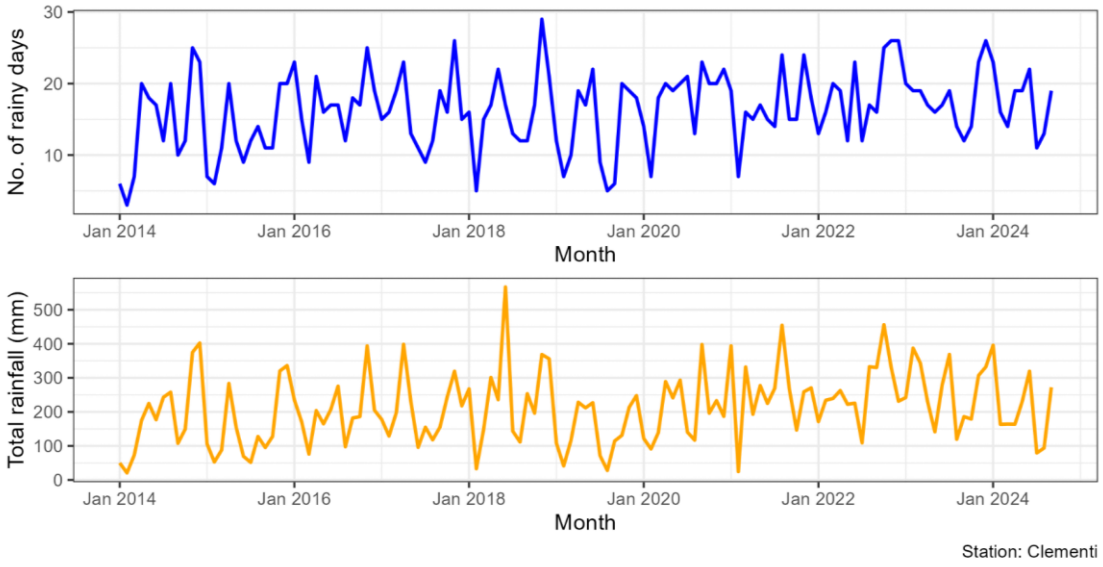


Figure 5.3. Annual monthly rainfall at the Clementi rain gauge station through 2014–2024 **(MSS, 2024)**

5.4 Stream Characterisation

5.4.1 Stream Characterisation Approach

While there are no natural streams within the vegetated area, there is a concrete drain running parallel to one edge. It was noted that there was water flowing during periods of heavy rainfall. Two points were selected along the drain for stream characterisation survey which were spaced approximately 95 m apart. The stream characterisation survey covered details such as substrate type, riparian vegetation composition, wetted width and depth, and the flow velocity of the stream as explained below.

Figure 5.4. Location map of stream characterisation survey points

Wetted Depth and Width

The depths and widths of the stream channel were measured using a scale ruler as well as a metric transect tape depending on site conditions.

Canopy Cover

To measure the canopy cover at each measuring point, a photograph of the canopy was taken parallel to the ground at eye-level. The photographs were then processed through the Canopeo application (Canopeo, n.d.) to generate a percentage of canopy cover. The percentage value derived is an estimate of the total area covered by vegetation in the entire frame of the taken canopy photo.

Substrate Type

The soil substrate on the banks of the stream and in the waterbody were determined using visual assessment as well as the "texture by feel" method (Thein, 1979). The "texture by feel" method involves picking up roughly 25 g of moistened soil and shaping it into a ball, which is then squeezed between the thumb and index finger upwards beyond the fingers and allowed to break from its own weight. The length of the resultant ribbon is measured to determine the soil substrate. Following that, a pinch of the soil was wet and rubbed to determine the soil texture and composition. Table 5.1 shows the soil substrate types that can be determined based on soil textures and ribbon length.

Table 5.1. Classification of substrate types **(Thein, 1979)**

Ribbon Length	Soil Texture	Soil Substrate
No ribbon	NA	Loamy sand
2.5 cm or less	Gritty	Sandy loam
	Smooth	Silt loam
	Neither gritty nor smooth	Loam
2.5 to 5 cm	Gritty	Sandy clay loam
	Smooth	Silty clay loam
	Neither gritty nor smooth	Clay loam
More than 5 cm	Gritty	Sandy clay
	Smooth	Silty Clay
	Neither gritty nor smooth	Clay

Subsequently, sandy substrates were further categorised visually according to their estimated particle size in Table 5.2 using the "texture by feel" method as well as by placing a sample of the soil on and spreading it across a scale card.

Table 5.2. Classification of sand particle sizes **(Wentworth, 1922)**

Sand Particle Type	Particle Size
Fine sand	≤ 0.5 mm
Coarse sand	> 0.5 mm and ≤ 2 mm

Fine gravel	≤ 4 mm
Coarse gravel	> 4 mm and ≤ 32 mm
Cobble	≤ 256 mm

Figure 5.5. Example of stream characterisation in progress

Riparian Vegetation and Associated Fauna

The species of plants that are immediately next to, within or overhead each measuring point were identified by an ISA-certified Arborist. Fauna species that were observed at each point were also reported.

Flow velocity

To measure the flow velocity of the stream, the float method was employed with the use of a ping pong ball as a float, a metric transect tape to set the travel distance, and a stopwatch to measure the duration of travel. To begin the measurement, the transect tape is laid down parallel to the stream flow, and the start and end points determined. When the float enters the start point of the stretch, the stopwatch starts timing. When the float passes the end point of the stretch, the stopwatch stops timing. The resulting duration is recorded. Each measurement is taken three (3) times and then averaged out to obtain a more accurate approximate time taken for the float to cover the predetermined stretch.

To calculate the flow velocity using the recorded data, the formula below was used:

$$Flow\ Velocity = \frac{Distance}{Time}\ x\ Friction\ Correction$$

Friction correction refers to the numerical factors used to factor in the difference in flow due to the channel surfaces, where 0.9 is used for smooth surfaces (e.g., drains, canals, and sandy bottoms) and 0.85 is used for rough surface rock bottoms. Since the top of a stream typically flows faster than the bottom due to friction against the stream bed, applying friction correction evens out the flow velocity (Harrelson et al., 1994). The unit used for flow velocity is meter per second (m/s).

5.4.2 Stream Characterisation Results

Stream characterisation was conducted on 2 and 24 September 2024 for dry and wet weather conditions respectively. Generally, it was observed that there is a low flow rate in the drain surveyed. It is likely that the main source of flow is from rainwater. During dry weather conditions, the drain was observed to have little to no flow. During wet weather conditions, while one survey point had slightly more flow, the other point still had insufficient flow for a flow rate to be measured.

Table 5.3 summarises the results of the average flow velocities.

Figure 5.6. Pictures of the drain at SC1 (left) and SC2 (right) after a wet weather event

Table 5.3. Results of stream characterisation survey

Point ID	Stream Photographs	Ave. Wetted Width & Depth (m)	Ave. Flow Velocity (m/s)	Soil Substrate	Riparian Vegetation	Associated Fauna
SC1	Overview:  Cross-Section:  Canopy: 38% 	<u>Dry weather</u> Width: 0.29 m Depth: 0.02 m <u>Wet weather</u> Width: 0.35 m Depth: 0.04 m	<u>Dry weather</u> Stagnant/ Insufficient flow <u>Wet weather</u> Stagnant/ Insufficient flow	<u>Stream</u> Loam, well sorted, fine sand <u>Bank</u> Concrete	*Coleus monostachyus, Legazpia polygonoides, Melothria pendula*	Acute bladder snail, common parasol, spine-tufted skimmer
SC2	Overview: 	<u>Dry weather</u> Width: 0.25 m Depth: 0.01 m	<u>Dry weather</u> Stagnant/ Insufficient flow	<u>Stream</u> Gritty, moderately sorted, medium sand	*Peperomia pellucida, Pilea microphylla*	Four-lined tree frog, acute bladder snail, blue dasher, indigo

Point ID	Stream Photographs	Ave. Wetted Width & Depth (m)	Ave. Flow Velocity (m/s)	Soil Substrate	Riparian Vegetation	Associated Fauna
	Cross-Section:  Canopy: 13% 	<u>Wet weather</u> Width: 0.53 m Depth:0.15 m	<u>Wet weather</u> 0.044 m/s	<u>Bank</u> Concrete		dropwing, wandering glider

5.5 Groundwater Levels

5.5.1 Baseline Methodology

Five boreholes (BHs) were installed to measure baseline groundwater levels. The locations of the boreholes are spaced apart across the site. Their locations are provided in Figure 5.7 and Table 5.4. Pictures of the groundwater wells are presented in Figure 5.8.

Figure 5.7. Locations of groundwater sampling points

Table 5.4. Coordinates of groundwater sampling points

ID	Latitude	Longitude
BH1	1.3458713	103.7691241
BH2	1.3462387	103.7706144
BH3	1.3469736	103.7695653
BH4	1.3483901	103.7704167
BH5	1.3478810	103.7687478

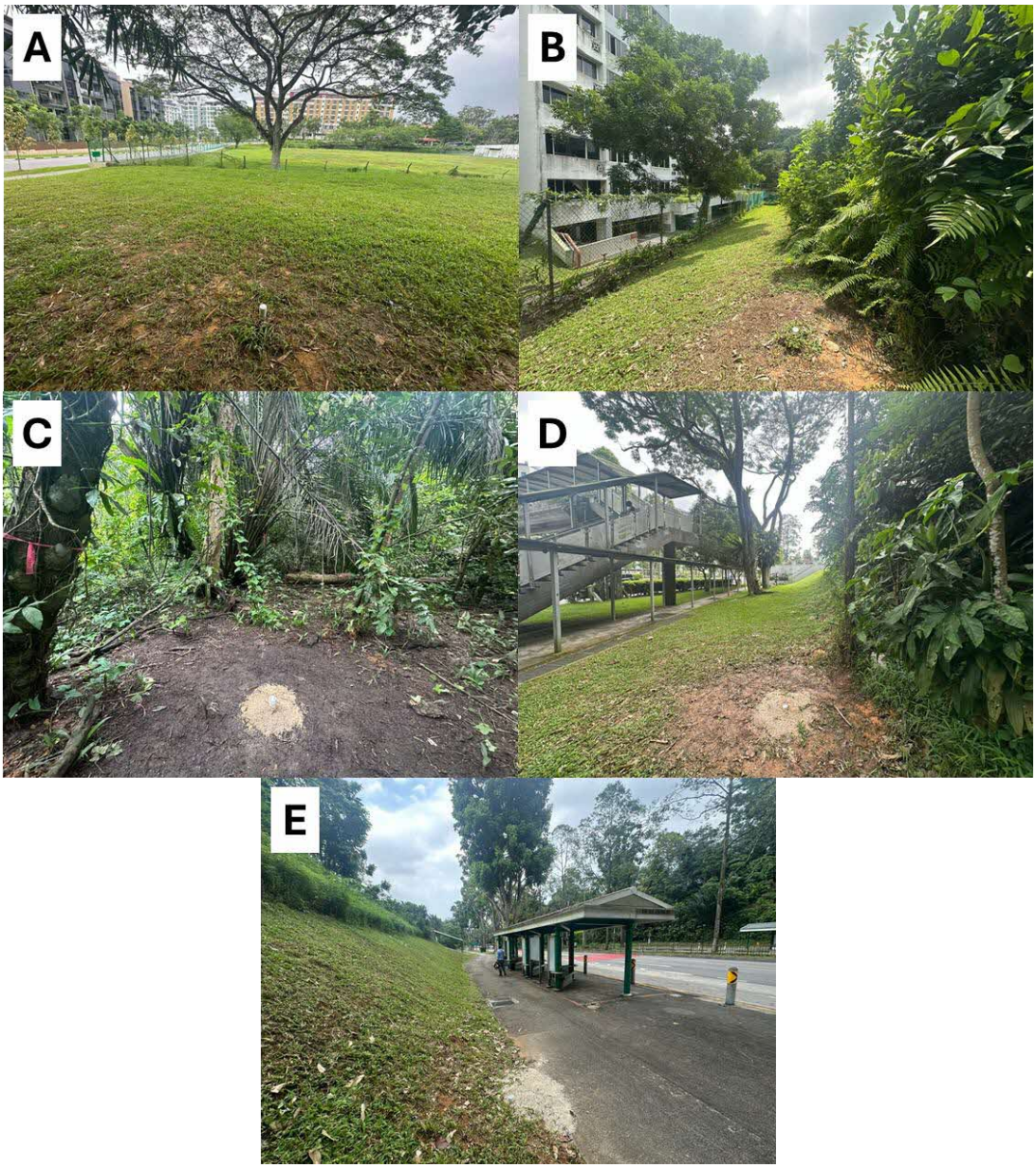


Figure 5.8. Pictures of the five boreholes installed in the project site. **A:** BH1; **B:** BH2; **C:** BH3; **D:** BH4; **E:** BH5.

Groundwater levels were measured relative to the top of the borehole, near the ground elevation. The uncertainty of measurement is approximately 0.005 m. An example of a groundwater survey being done is shown in Figure 5.9.

Figure 5.9. Example of groundwater level survey being conducted

5.5.2 Groundwater Survey Results

Groundwater levels were measured on 13 November 2024. The groundwater levels are shown in Table 5.5 below.

Table 5.5. Groundwater levels measured at the boreholes

ID	Water level below ground level (m)
BH1	1.715
BH2	1.540
BH3	3.000
BH4	0.200
BH5	0.790

The water level at BH3 is notably deeper than at other boreholes. It was noted that BH3 is located at a higher elevation (i.e., at the top of a hill), which may explain the deeper measurement of groundwater.

At all other boreholes, the groundwater levels are observed to be shallow (less than 2 m below ground level).

5.6 Surface Water Quality

5.6.1 Baseline Methodology

Baseline surface water quality assessment was conducted at four (4) sampling points

(i.e., WQ1 to WQ4) during two (2) dry weather conditions (i.e., 6 Sep 2024 and 13 Sep 2024) and one (1) wet weather condition (i.e., 23 Sep 2024). The site map showing the indicative locations of the surface water quality locations, along with the GPS coordinates of each location, are shown in Figure 5.10 and Table 5.6 respectively.

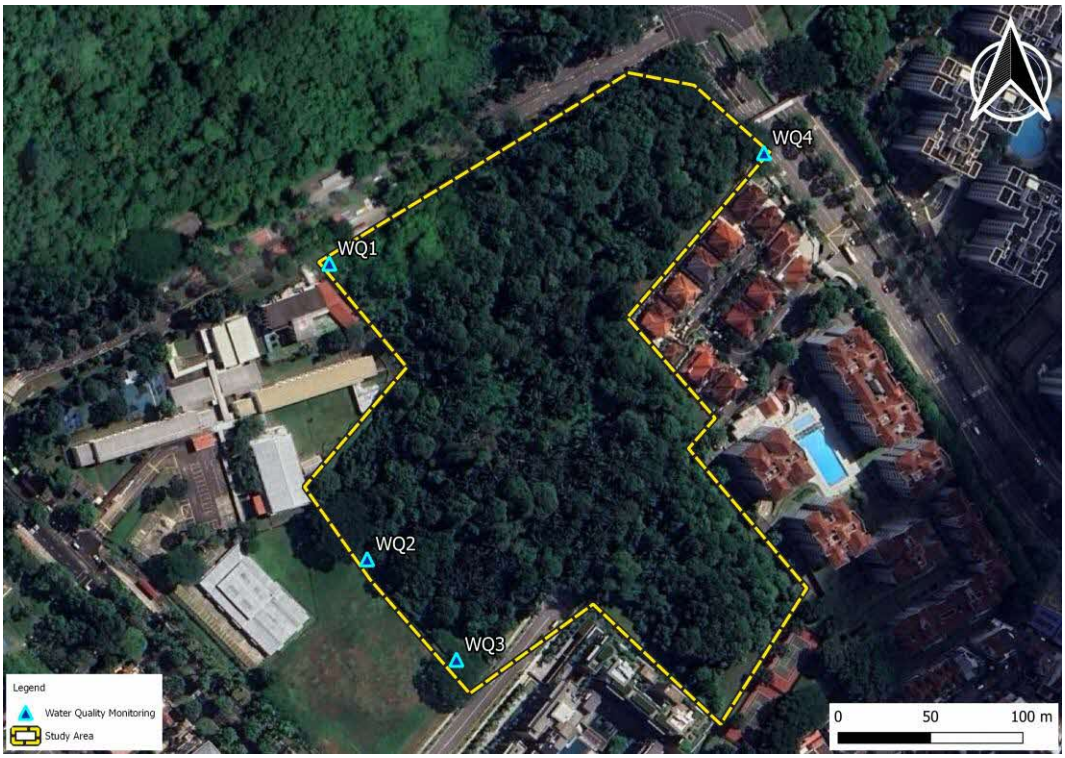


Figure 5.10. Location of surface water quality sampling points in study area

Table 5.6. GPS coordinates of surface water quality sampling locations

Station ID	Latitude	Longitude
WQ1	1.347703	103.768472
WQ2	1.346265	103.768656
WQ3	1.345776	103.769090
WQ4	1.348241	103.770587

In-situ Measurements

In-situ measurements were taken at each sampling location using an accredited method stated in Table 5.7. Measured parameters include pH, temperature, turbidity, salinity, and dissolved oxygen. The results of the measurements were then compared against threshold limits based on those set by NEA (2023b), where applicable.

Table 5.7. *In-situ* surface water quality parameters

Test Parameter	Unit	Threshold Limit [4]	Test Method
pH	-	6 – 9	Accredited Method MLS-SOP-ES-004
Salinity	ppt	-	

[4] NEA's Allowable Limits for Trade Effluent Discharge to Watercourse guideline

Temperature	°C	45	
Turbidity	NTU	-	
Dissolved Oxygen	mg/L	-	

Ex-situ Laboratory Analysis

In addition to *in-situ* measurements, collected water samples were sent to a SAC-SINGLAS-accredited laboratory for analysis. The test methods used are stated in Table 5.8. The test methods follow the American Public Health Association (APHA) which describes standard methods for the examination of water and wastewater (APHA, 2017).The laboratory results were then compared against allowable limits set by NEA (2023b). *Enterococcus* values, which are not regulated by Singapore standards, were compared with the Australian Guidelines for Urban Stormwater Management (2000).

Table 5.8. *Ex-situ* surface water quality parameters tested in the laboratory

Test Parameter	Unit	Threshold Limit	Test Method
(Threshold limit referenced to NEA's allowable limits unless otherwise stated)			
Total Phosphorus	mg/L	-	APHA 4500-P (J)
Total Nitrogen	mg/L	-	APHA 4500-P (J)
Total Organic Carbon (TOC)	mg/L	-	APHA 5310 B
Nitrate (NO3 as N)	mg/L	-	APHA 4500-NO3 (I)
Ammoniacal Nitrogen	mg/L	-	APHA 4500-NH3 (H)
Orthophosphate (PO4-P)	mg/L	5	APHA 4500-P (G)
Total Dissolved Solids (TDS)	mg/L	-	APHA 2540 C
Total Suspended Solids (TSS)	mg/L	50	APHA 2540 D
*Lead (Pb)	mg/L	0.1	APHA 3125 B
*Zinc (Zn)	mg/L	1	APHA 3125 B
*Mercury (Hg)	mg/L	0.05	APHA 3120 B
Free Chlorine	mg/L	1	Lovibond Test Kit (DPD) Rev 1.0
Enterococcus	CFU/100mL	40,000 [5]/ 200,000 [6]	APHA 9230 C
Biological Oxygen Demand (BOD5)	mg/L	50	APHA 5210 B

**Where 2 or more of the metals specified in the table are present, the total concentration of the metals shall not be more than 1 mg/L.*

5.6.2 Surface Water Quality Results and Discussion

In-situ Measurements

It was noted that sampling point WQ2 did not have sufficient water for sampling on both dry weather sampling trips (6 and 13 September 2024); and WQ4 did not have sufficient

[5] Values for dry weather sample in Australian Guideline for Urban Stormwater Management (2000)

[6] Values for wet weather sample in Australian Guideline for Urban Stormwater Management (2000)

water for sampling on all three sampling trips. As such, there are no results presented on these sampling trips. Figure 5.11 below shows the locations of the four water quality sampling points. The pictures of WQ2 and WQ4 show dry conditions with insufficient water for sampling.

Figure 5.11. Photographs showing the locations of water quality sampling points

Where water sampling was possible, the *in-situ* water quality measurements are presented in Table 5.9. The laboratory reports are provided in **Appendix E**.

Table 5.9. Results of surface water quality parameters tested *in-situ*

Test Parameter	Unit	Threshold	Dry weather (6 Sep 2024)		Dry weather (13 Sep 2024)		Wet weather (23 Sep 2024)		
			WQ1	WQ3	WQ1	WQ3	WQ1	WQ2	WQ3
pH	-	6 – 9	**5.36**	6.08	6.76	**5.61**	6.14	6.1	**5.5**
Salinity	ppt	-	0.11	0.06	0.12	0.03	0.06	0.02	0.03
Temperature	°C	45	30.9	33.1	30.8	33.2	28.4	27.7	28.1
Turbidity	NTU	-	47.8	136	67	7.31	38.8	27.1	38.6
Dissolved Oxygen	mg/L	-	4.55	1.45	4.74	7.94	5.88	6.38	5.22

Overall, the *in-situ* surface water quality readings did not show any exceedances across

all sampling points, except for pH levels at WQ1 on 6 September 2024 with pH of 5.36; and at WQ3 on 13 and 23 September 2024, with pH of 5.61 and 5.5 respectively. For the other sampling points, the pH values ranged from 6.08 to 6.76, which are within the threshold limits for watercourses (NEA, 2023b). Salinity ranged from 0.02 to 0.12 ppt, with the highest level recorded at WQ1 at 0.11 and 0.12 ppt under dry weather conditions, and 0.06 ppt under wet weather conditions. The baseline temperatures measured were relatively stable with little fluctuation, ranging from 30.8 to 33.2 °C in dry weather conditions and 27.7 to 28.4 °C in wet weather conditions.

The baseline turbidity readings ranged from 7.31 to 136 NTU, with the highest turbidity readings measured at WQ3 (136 NTU) during dry weather conditions. Turbidity readings at WQ3 are observed to be inconsistent, given that the sampling trips were conducted approximately two weeks apart. The high turbidity level on 6 September may be attributed to the turbidity accumulating through the previous week of dry weather. From 31 August to 6 September, five of seven days had 0.0 mm of daily rainfall reported at the nearest rain gauge (MSS, 2024). In comparison to the week of 7 to 13 September before another dry weather sampling, only one of seven days had 0.0 mm of daily rainfall. The relatively drier weather prior to 6 September may have facilitated an accumulation of foliage and leaf packs, which are reported to produce coarse particulate organic matter over time (Nakajima et al., 2006).

As for dissolved oxygen, the measured concentrations ranged from 1.45 to 7.94 mg/L. Dissolved oxygen concentration was observed to be the lowest at WQ3 on 6 September, at 1.45 mg/L. Similar to turbidity readings, this might be attributed to the dry weather leading to accumulation of leaf litter at WQ3. Decomposition of dead organic matter requires uptake of oxygen, which can in turn lead to a decrease in dissolved oxygen concentration (Zhang, et al., 2024; Mnaya et al., 2006).

Ex-situ Laboratory Analysis

The results of the *ex-situ* laboratory analysis are shown in Table 5.10. The full results are provided in **Appendix E**.

Table 5.10. Results of the surface water quality parameters analysed *ex-situ*

Test Parameter	Unit	Threshold	Dry weather (6 Sep 2024)		Dry weather (13 Sep 2024)		Wet weather (23 Sep 2024)		
			WQ1	WQ3	WQ1	WQ3	WQ1	WQ2	WQ3
Total Phosphorus	mg/L	-	0.4	0.21	0.58	0.055	0.37	0.17	0.16
Total Nitrogen	mg/L	-	<0.01	2.63	3.56	0.45	1.77	1.28	0.96
Total Organic Carbon (TOC)	mg/L	-	500	14.9	30	<1	8.11	4.89	3.27
Nitrate (NO_3 as N)	mg/L	-	<0.07	<0.07	<0.07	0.33	<0.015	0.55	0.55
Ammoniacal Nitrogen	mg/L	-	<0.01	<0.01	0.14	<0.01	0.099	0.12	0.086
Orthophosphate (PO_4-P)	mg/L	5	0.17	0.038	0.21	0.036	0.045	0.036	0.03
Total Dissolved Solids (TDS)	mg/L	-	165	74	164	41	78	30	38
Total Suspended Solids (TSS)	mg/L	50	**103**	**302**	28.6	42.6	20.4	15	23.2
*Lead (Pb)	mg/L	0.1	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
*Zinc (Zn)	mg/L	1	0.07	0.0061	0.038	0.023	0.11	0.08	0.003
*Mercury (Hg)	mg/L	0.05	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Free Chlorine	mg/L	1	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Enterococcus	CFU/100mL	40,000 [7]/ 200,000 [8]	100	100	2,700	<1	1,600	1,100	1,000
Biological Oxygen Demand (BOD5)	mg/L	50	**1,168**	27.7	**108**	<2	32	<2	<2

[7] Values for dry weather sample in Australian Guideline for Urban Stormwater Management (2000)

[8] Values for wet weather sample in Australian Guideline for Urban Stormwater Management (2000)

Total suspended solids (TSS) recorded on 6 September 2024 exceeded the threshold value set by NEA (50 mg/L) at both WQ1 (103 mg/L) and WQ3 (302 mg/L). For the other sampling trips, TSS ranged from 15 to 42.6 mg/L across all sampling points, and are within the threshold limit of 50 mg/L. Total dissolved solids (TDS) ranged from 30 to 165 mg/L, with WQ1 having the greatest TDS levels (165 mg/L) under dry weather conditions.

Biological oxygen demand (BOD5) recorded at WQ1 exceeded NEA's maximum allowable limits for uncontrolled watercourses (50 mg/L) on 6 September 2024 (1168 mg/L) and 13 September 2024 (108 mg/L) under dry weather conditions. For the other sampling trips, BOD was recorded with values ranging from less than 2 mg/L to 32 mg/L across all sampling points, which are within NEA's maximum allowable limits for uncontrolled watercourses (50 mg/L).

Total organic carbon (TOC) measurements for all samples collected ranged from <1 to 500 mg/L, with WQ1 achieving the highest concentration (500 mg/L) under dry weather conditions.

For nutrient parameters, nitrate (NO_3 as N) had a recorded range of <0.015 (below Limit of Reporting) to 0.55 mg/L, with WQ3 and WQ4 having the highest nitrate concentration under wet weather conditions. In turn, total nitrogen (TN) had a recorded range of <0.01 (below Limit of Reporting) to 3.56 mg/L, with WQ1 having the highest TN values under dry weather conditions. Ammoniacal nitrogen concentrations ranged from <0.01 (below Limit of Reporting) to 0.14 mg/L. Orthophosphate (PO_4-P) ranged from 0.03 to 0.21 mg/L and total phosphorus (TP) ranged from 0.055 to 0.58 mg/L.

For heavy metals, lead (Pb), Zinc (Zn), and Mercury (Hg), reported values across all three sampling points were within NEA's maximum allowable limits for uncontrolled watercourses (0.1 mg/L, 1 mg/L, and 0.05 mg/L respectively). For lead (Pb) and Mercury (Hg), values reported were less than the Limit of Reporting (0.02 mg/L and 0.0002 mg/L respectively). Zinc (Zn) had a recorded range of 0.003 to 0.11 mg/L, with the highest record reported at WQ1 in wet weather conditions.

Enterococcus counts were found highest in WQ1 (i.e., dry weather = 2,700 CFU/ 100 mL; wet weather = 1,600 CFU/ 100 mL). Nonetheless, these values are lower than the threshold level of 40,000 CFU/ 100 mL (ARMCANZ, 2000).

6 NOISE AND AIR QUALITY

6.1 Noise Quality

6.1.1 Relevant Environmental Legislation, Guidelines and Standards

The Environmental Protection and Management (EPM) (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, measured in equivalent continuous sound level (Leq). The permissible levels are listed in Table 6.1 below.

Table 6.1. Maximum permissible noise levels from construction site (source: SSO)

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

No Work Rule on Sundays and Public Holidays

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

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

b) Construction Work Commenced on or after 1st September 2011
- No work is allowed from 10 pm on Saturday/eve of Public Holiday to 7 am on the following Monday/day after the Public Holiday

Correction Factor for Baseline Background Noise Exceeding the Regulations

In certain areas, the baseline background noise levels may already exceed permissible noise levels outlined in Table 6.1. As such, the maximum permissible noise levels during the assumed work activities will be adjusted according to a correction factor. The value of this factor is subject to the difference between the background noise level and

permissible noise level, as shown in Table 6.2 below. This correction factor is added to the higher of the two noise levels to produce a new permissible value during the assumed work activities.

Table 6.2. Value of correction factor accounting for baseline noise level exceedance

Difference between Permissible and Baseline Background Noise Levels (dB(A))	Correction Factor to be Added to the Higher of the Two Noise Levels (dB(A))
< 2	3
2 ≤ difference < 4	2
4 ≤ difference < 10	1
≥ 10	0

The EPM (Control of Noise at Construction Sites) Regulations 2008 focuses on managing noise impacts on humans, rather than animals including birds, which have different hearing ranges.

The project area is home to various animal species (see Section 4) that may be sensitive to noise. Some of these species, particularly nocturnal species, rely on their hearing for movement, communication, and foraging, causing them to be particularly vulnerable to increased noise levels. Continuous noise such as traffic-generated noise disrupts animals' ability to detect crucial sounds, while intermittent and impulsive noise generated from piling, honking from vehicles, machinery and shouting is often perceived as a threat (Francis & Barber, 2013). This will lead to animal behavior alteration, hinder foraging and increase the risk of predation, ultimately affecting their survival.

Therefore, adherence to the EPM (Control of Noise at Construction Sites) Regulations 2008 during construction may not sufficiently protect wildlife from noise impacts. The effects of noise on fauna are poorly understood since both stimuli and responses can vary.

6.1.2 Baseline Methodology

Noise can cause annoyance by disrupting communication, interfering with leisure activities and disturbing sleep of receptors involved. Its effects can differ for each individual, influenced by factors such as the specific activity they are engaged in and the duration they are exposed to the noise.

The criteria used to identify Noise Sensitive Receptors (NSRs) are based on the EPM (Control of Noise at Construction Sites) Regulations 2008, as outlined below:

(a) Hospitals, schools, institutions of higher learning, homes for aged sick, etc.
(b) Residential buildings located less than 150 m from the construction site
(c) Buildings other than those in (a) and (b) above

Table 6.3. List of identified NSRs

Type	Description	Approximate Distance*
Workers	People working on the site (e.g., construction workers, consultants)	Within study area
Flora and Fauna	Flora and fauna living within project study area	Within study area

Type	Description	Approximate Distance*
Residential building	Residential buildings of Bukit Regency	10 m from study area
Residential building	Residential buildings of Upper Bukit Timah View	10 m from study area
Residential building	Residential buildings of Verdale	10 m from study area

*Approximate distance from the nearest project work area

6.1.3 Baseline Field Survey

Baseline ambient noise quality assessment was conducted at three (3) locations, with each location surveyed for the duration of a week (24 hours × 7 days). Figure 6.1 shows photographs of on-site monitoring instrument setup, while the deployed location and monitoring period for the instrument is shown in Figure 6.2 and Table 6.4 below.

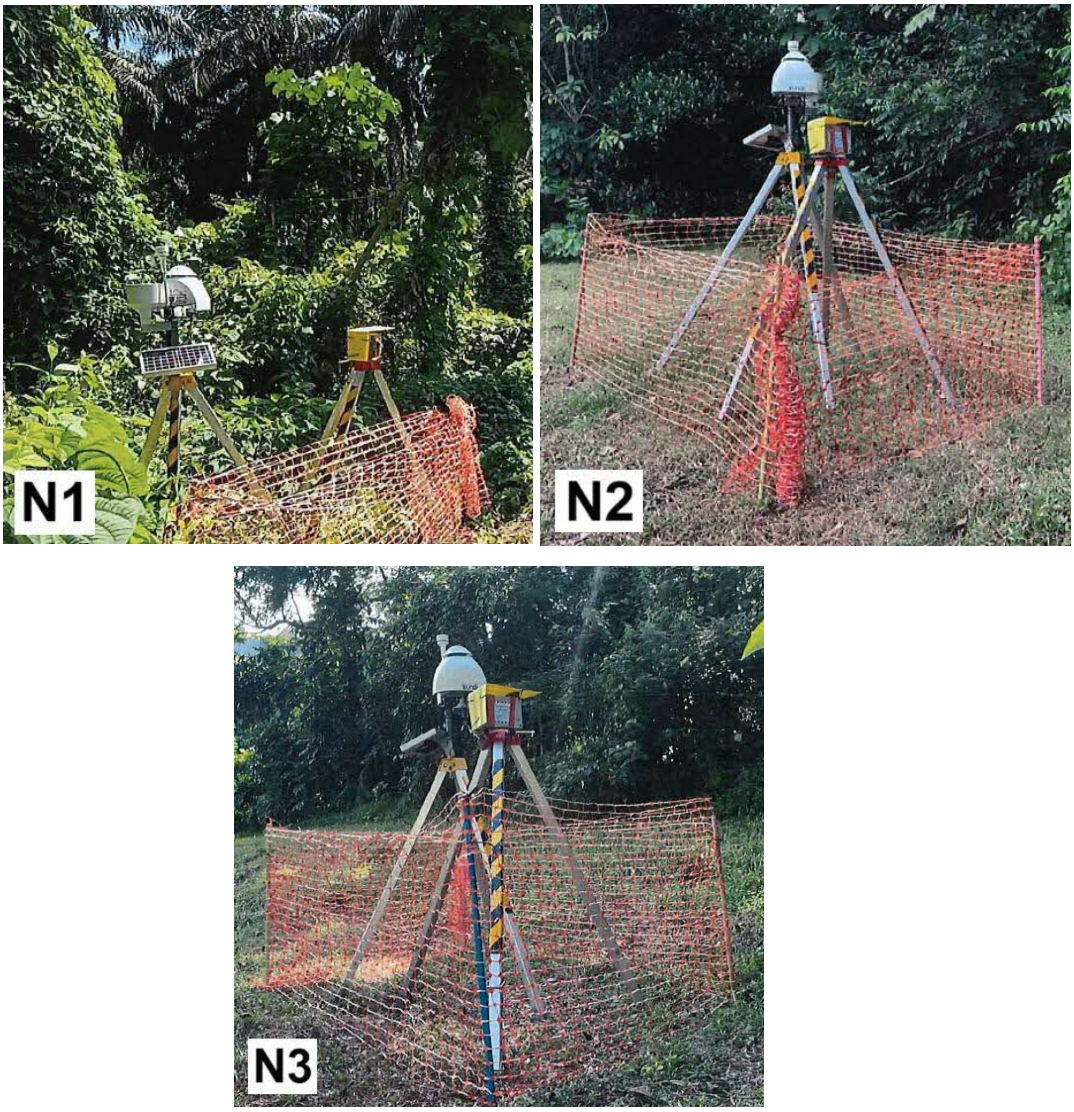


Figure 6.1. Photos of the on-site noise monitoring instrument

Figure 6.2. Deployment location of the noise monitoring instruments in study area

Table 6.4. Noise monitoring instrument deployed location and monitoring period

Station ID	Location Coordinates		Monitoring Period		Noise Limit Type	Description of Location
	Latitude	Longitude	Start	End		
N1	1.346972	103.769694	29/09/2024 00:00	05/10/2024 23:59	(b)	Middle of vegetated area south-west of Upper Bukit Timah View
N2	1.347583	103.769917	21/09/2024 00:00	27/09/2024 23:59	(b)	Open grass patch behind 32 Upper Bukit Timah View
N3	1.345944	103.770639	13/09/2024 00:00	19/09/2024 23:59	(b)	Beside tennis court north of Yuk Tong Ave

*Approximate distance from the nearest project work area

Type 1 sound level meter Svantek Model SVAN971 was installed and housed in an environmental enclosure with solar panels during field deployment. Calibration of the sound level meter was done before and after deployment at each location.

Data was logged every 1 second at slow response at A weighting over the frequency of 10 Hz to 20 kHz. The 1 second data was then used to calculate 5 min, 1-hour and 12-hour equivalent readings.

The applicable noise limits follow the EPM (Control of Noise at Construction Sites) Regulations 2008 which prescribes the maximum noise levels permissible at

construction sites for different periods and types of premises affected. The permissible levels are listed in Table 6.1 above.

6.1.4 Noise Quality Results and Discussion

Table 6.5 and Figure 6.3 show the baseline noise level monitored by Station N1; results show most of the monitoring period still within noise limit of type (b). However, a few spikes over the limit were being noted indicating exceedances to the noise limit.

Table 6.5. Summary of the baseline Leq 5 mins noise monitoring results at station N1

Date	Monitoring Period	Monitored Noise Level (dBA)			Type (b) Noise Limit Leq 5mins (dB(A))
		Min. Leq 5 mins	Median Leq 5 mins	Max. Leq 5 mins	
Sun, 29/9/2024	7am - 7pm	42.0	46.3	67.8	75
	7pm - 7am	37.9	45.7	**66.0**	55
Mon, 30/9/2024	7am - 7pm	44.8	50.3	75.5	90
	7pm - 10pm	48.7	57.6	62.7	70
	10pm - 7am	39.0	49.4	**58.9**	55
Tue, 1/10/2024	7am - 7pm	44.1	50.4	64.6	90
	7pm - 10pm	45.1	53.6	59.7	70
	10pm - 7am	39.7	41.8	55.0	55
Wed, 2/10/2024	7am - 7pm	43.4	47.8	66.3	90
	7pm - 10pm	42.4	44.5	61.5	70
	10pm - 7am	37.8	41.5	52.8	55
Thu, 3/10/2024	7am - 7pm	41.9	47.3	52.3	90
	7pm - 10pm	40.9	42.2	47.3	70
	10pm - 7am	37.9	40.7	53.4	55
Fri, 4/10/2024	7am - 7pm	43.7	49.3	68.2	90
	7pm - 10pm	49.0	59.5	72.0	70
	10pm - 7am	42.7	52.4	**74.9**	55
Sat, 5/10/2024	7am - 7pm	41.9	47.9	61.4	90
	7pm - 10pm	41.4	52.7	59.2	70
	10pm - 12MN	46.9	49.9	53.7	55

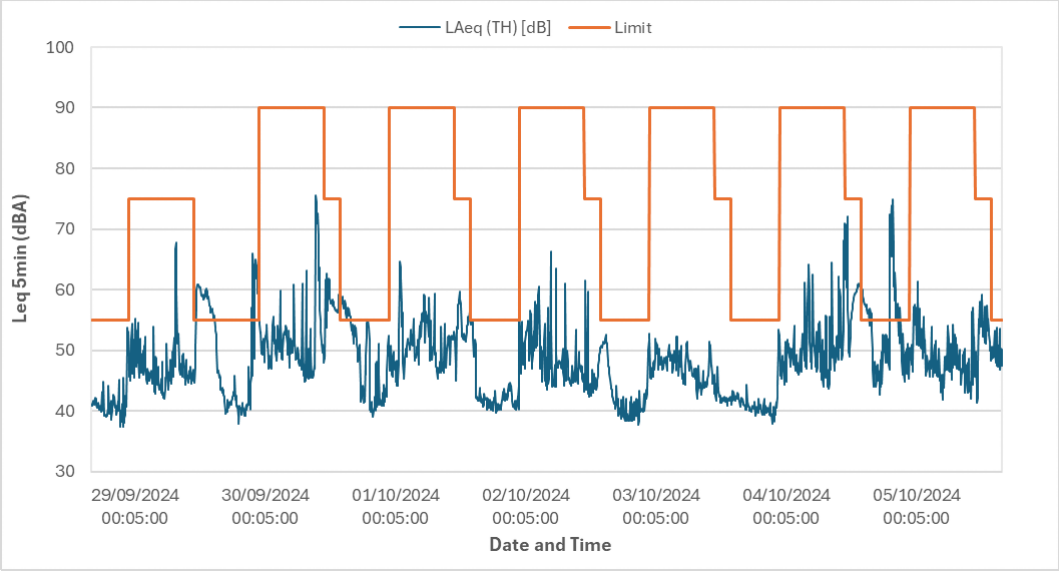


Figure 6.3. Baseline Leq 5 mins monitoring results at Station N1 over one-week period

Table 6.6 and Figure 6.4 show the baseline noise level monitored by Station N2; results show most of the daytime monitoring period still within noise limit of type (b). However, during night-time, exceedances over the noise limit were recorded.

Table 6.6. Summary of the baseline Leq 5 mins noise monitoring results at station N2

Date	Monitoring Period	Monitored Noise Level (dBA)			Type (b) Noise Limit Leq 5mins (dB(A))
		Min. Leq 5mins	Median Leq 5mins	Max. Leq 5mins	
Sat, 21/9/2024	7am - 7pm	50.2	52.8	58.7	90
	7pm - 10pm	51.5	64.2	**72.1**	70
	10pm - 7am	48.1	51.2	**60.1**	55
Sun, 22/9/2024	7am - 7pm	49.8	51.5	60.0	75
	7pm - 7am	47.5	50.7	**57.0**	55
Mon, 23/9/2024	7am - 7pm	49.7	54.0	73.2	90
	7pm - 10pm	51.1	65.4	71.5	70
	10pm - 7am	47.1	51.3	**55.1**	55
Tue, 24/9/2024	7am - 7pm	50.4	54.6	71.1	90
	7pm - 10pm	50.7	53.0	64.1	70
	10pm - 7am	48.9	51.6	**57.3**	55
Wed, 25/9/2024	7am - 7pm	51.2	53.7	74.3	90
	7pm - 10pm	51.4	55.6	73.3	70
	10pm - 7am	48.1	50.4	55.0	55
Thu, 26/9/2024	7am - 7pm	44.6	53.5	65.4	90
	7pm - 10pm	46.9	51.2	57.6	70
	10pm - 7am	47.7	53.6	**69.4**	55
Fri, 27/9/2024	7am - 7pm	46.2	54.0	73.4	90
	7pm - 10pm	47.0	50.3	55.7	70
	10pm - 12MN	48.9	51.8	**56.5**	55

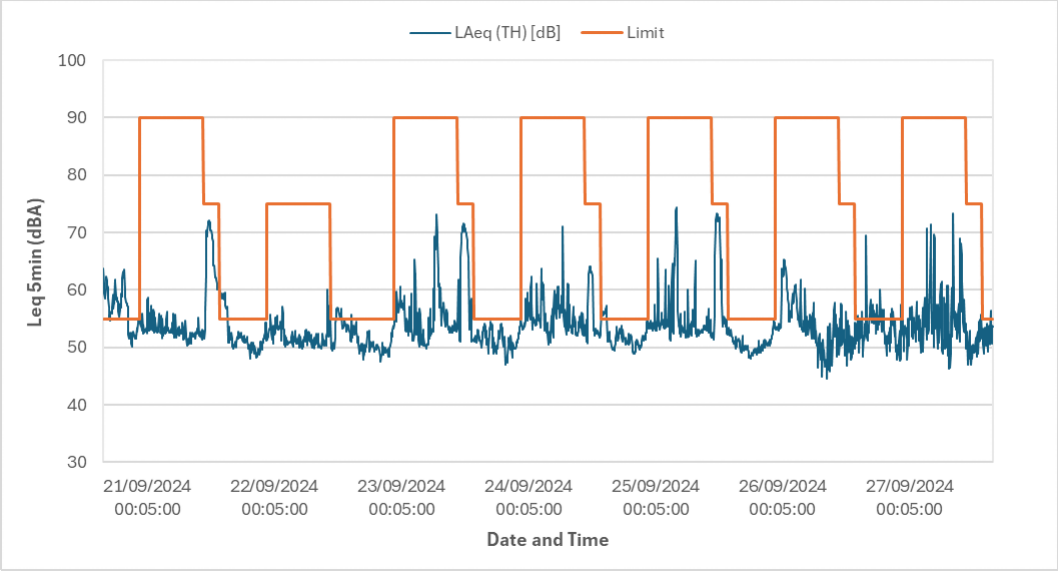


Figure 6.4. Baseline Leq 5 mins monitoring results at Station N2 over one-week period

Table 6.7 and Figure 6.5 show the baseline noise level monitored by Station N3; results show that most of the monitoring period does not exceed the noise limit except for a few incidences represented by spikes in the graph.

Table 6.7. Summary of the baseline Leq 5 mins noise monitoring results at station N3

Date	Monitoring Period	Monitored Noise Level (dBA)			Type (b) Noise Limit Leq 5mins (dB(A))
		Min. Leq 5mins	Median Leq 5mins	Max. Leq 5mins	
Fri, 13/9/2024	7am - 7pm	43.8	48.2	61.0	90
	7pm - 10pm	42.5	45.2	47.7	70
	10pm - 7am	44.4	47.4	**72.0**	55
Sat, 14/9/2024	7am - 7pm	43.2	47.5	56.5	90
	7pm - 10pm	41.8	51.9	56.8	70
	10pm - 7am	42.6	47.0	50.6	55
Sun, 15/9/2024	7am - 7pm	42.2	48.1	68.7	75
	7pm - 7am	44.0	47.5	**56.2**	55
Mon, 16/9/2024	7am - 7pm	43.3	48.5	67.5	90
	7pm - 10pm	42.3	46.2	62.1	70
	10pm - 7am	44.1	46.9	49.3	55
Tue, 17/9/2024	7am - 7pm	44.0	49.8	63.2	90
	7pm - 10pm	44.6	50.1	68.9	70
	10pm - 7am	43.0	46.6	**57.0**	55
Wed, 18/9/2024	7am - 7pm	44.0	48.4	62.1	90
	7pm - 10pm	44.4	50.7	66.7	70
	10pm - 7am	41.2	45.4	50.6	55
Thu, 19/9/2024	7am - 7pm	40.2	47.4	59.5	90
	7pm - 10pm	43.6	45.9	51.8	70
	10pm - 12MN	44.0	46.6	48.9	55

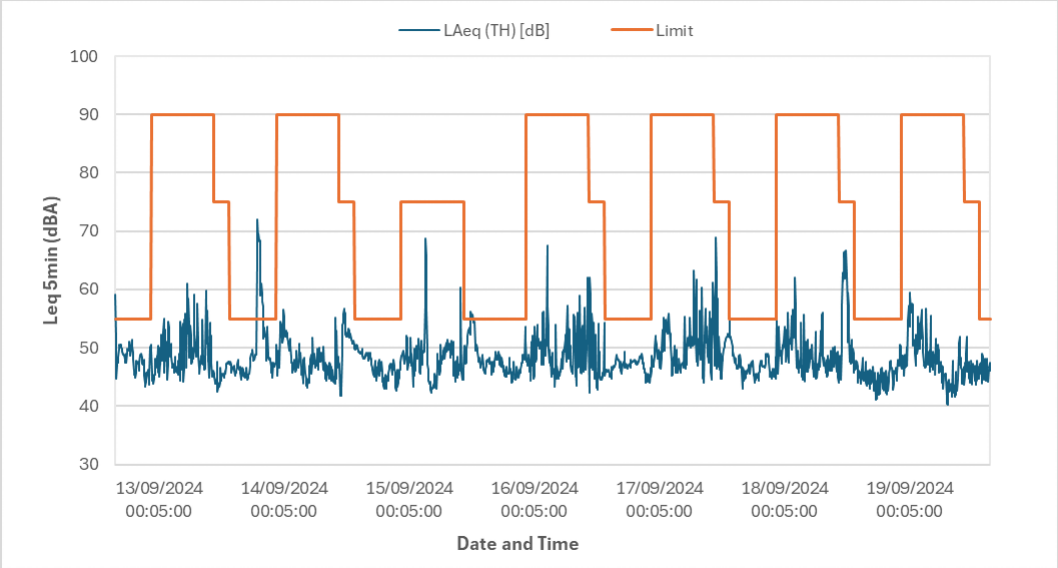


Figure 6.5. Baseline Leq 5 mins monitoring results at Station N3 over one-week period

6.2 Air Quality

6.2.1 Relevant Environmental Legislation, Guidelines and Standards

The Singapore ambient air quality targets are provided in Table 6.8.

Table 6.8. Applicable Singapore Ambient Air Quality Targets **(NEA, 2023a)**.

Pollutant	Long Term Targets
Particulate Matter (PM_{10})	24-hour mean: 50 µg/m^3 (WHO Final)
Particulate Matter ($PM_{2.5}$)	24-hour mean: 25µg/m^3 (WHO Final)
Sulphur Dioxide (SO_2)	24-hour mean: 20 µg/m^3 (WHO Final)
Carbon Monoxide (CO)	1-hour mean: 30 mg/m^3 (WHO Final); 8-hour mean: 10 mg/m^3
Nitrogen Dioxide (NO_2)	1-hour mean: 200 µg/m^3 (WHO Final)
Ozone (O_3)	8-hour mean: 100 µg/m^3 (WHO Final)

6.2.2 Baseline Methodology

In Singapore, air quality is one of the critical public health issues. Poor air quality can lead to a range of health problems including respiratory diseases, cardiovascular issues, and decreased overall well-being. The identification of Air Sensitive Receptors (ASRs) is crucial for assessing potential health impacts and ensuring that measures are in place to mitigate any adverse effects on vulnerable populations, particularly in densely populated areas.

The ASRs potentially affected by the assumed works are shown in Table 6.9, through a combination of desktop study and visual surveys at the study areas.

Table 6.9. List of identified ASRs

Type	Description	Approximate Distance*
Workers	People working on the site (e.g., construction workers, consultants)	Within Study Area

Flora and Fauna	Flora and fauna living within project study area	Within Study Area
Residential building	Residential buildings of Bukit Regency	10 m from Study Area
Residential building	Residential buildings of Upper Bukit Timah View	10 m from Study Area
Residential building	Residential buildings of Verdale	10 m from Study Area

*Approximate distance from the nearest project work area

6.2.3 Baseline Field Survey

Baseline ambient air quality assessment was conducted at three (3) locations, with each location surveyed for the duration of a week (24 hours × 7 days). Six (6) parameters were monitored, namely Particulate Matter (PM) with diameters of less than 10 and 2.5 microns (PM_{10} and $PM_{2.5}$ respectively), Sulphur Dioxide (SO_2), Carbon Monoxide (CO), Nitrogen Dioxide (NO_2), and Ozone (O_3). The Kunak AIR Pro was used for the monitoring. Onboard Optical Particle Counter (OPC) was used to monitor PM_{10} and $PM_{2.5}$, while individual electrochemical sensors were installed alongside to measure SO_2, CO, NO_2, and O_3. The instrument is powered by solar energy and holds UKAS M-CERTS certification. The baseline data were recorded at 10-minute intervals for PM_{10} and $PM_{2.5}$ and 5-minute intervals for SO_2, CO, NO_2, and O_3. The averages were then calculated and compared with respective values in the Singapore Ambient Air Quality Targets (NEA, 2023b).

The deployed locations and monitoring period for the instrument is shown in Figure 6.6 and Table 6.10 below.

Figure 6.6. Deployment locations of ambient air quality monitoring instruments in study area

Table 6.10. Locations and monitoring periods of ambient air quality monitoring

Station ID	Location Coordinates		Monitoring Period		Noise Limit Type	Description of Location
	Latitude	Longitude	Start	End		
A1	1.346972	103.769694	29/09/2024 00:00	05/10/2024 23:59	(b)	Middle of vegetated area south-west of Upper Bukit Timah View
A2	1.347583	103.769917	21/09/2024 00:00	27/09/2024 23:59	(b)	Open grass patch behind 32 Upper Bukit Timah View
A3	1.345944	103.770639	13/09/2024 00:00	19/09/2024 23:59	(b)	Beside tennis court north of Yuk Tong Ave

6.2.4 Air Quality Results and Discussion

The baseline air quality monitoring results generally complied with Singapore Ambient Air Quality Targets (NEA, 2023a).

Table 6.11, Table 6.12, and Table 6.13 show the baseline ambient air quality level monitored by Station A1. From the results obtained, there was no exceedance recorded during the stipulated monitoring period.

Table 6.11. 24-hour average of PM_{10}, $PM_{2.5}$, and SO_2 levels at Station A1

Monitoring Period	24-hour PM_{10} average ($\mu g/m^3$)	24-hour $PM_{2.5}$ average ($\mu g/m^3$)	24-hour SO_2 average ($\mu g/m^3$)
Sun, 29/9/2024	18.9	8.6	< 8
Mon, 30/9/2024	28.4	10.6	< 8
Tue, 1/10/2024	15.2	5.3	28.1
Wed, 2/10/2024	14.3	6.0	15.8
Thu, 3/10/2024	14.3	6.1	< 8
Fri, 4/10/2024	20.5	11.7	16.3
Sat, 5/10/2024	16.0	7.3	< 8
2020 Target ($\mu g/m^3$)	**50.00**	**37.50**	**50.00**
Long Term Target ($\mu g/m^3$)	**50.00**	**25.00**	**20.00**

Table 6.12. 8-hour and maximum daily hourly average of CO level at Station A1

Monitoring Period	Duration	8-hour CO average (mg/m^3)	Max. hourly CO average (mg/m^3)
Sun, 29/9/2024	00:00–08:00	0.24	0.53
	08:00–16:00	0.25	
	16:00–00:00	0.39	
Mon, 30/9/2024	00:00–08:00	0.24	0.54
	08:00–16:00	0.30	
	16:00–00:00	0.37	

Tue, 1/10/2024	00:00–08:00	0.34	0.69
	08:00–16:00	0.37	
	16:00–00:00	0.43	
Wed, 2/10/2024	00:00–08:00	0.39	0.52
	08:00–16:00	0.29	
	16:00–00:00	0.32	
Thu, 3/10/2024	00:00–08:00	0.26	0.59
	08:00–16:00	0.27	
	16:00–00:00	0.41	
Fri, 4/10/2024	00:00–08:00	0.53	0.59
	08:00–16:00	0.35	
	16:00–00:00	0.33	
Sat, 5/10/2024	00:00–08:00	0.38	0.44
	08:00–16:00	0.26	
	16:00–23:00	0.26	
2020 Target (mg/m^3)		**10**	**30**

Table 6.13. 8-hour average of O_3 and maximum daily hourly average of NO_2 at Station A1

Monitoring Period	Duration	8-hour O_3 average (µg/m^3)	Max. hourly NO_2 average (µg/m^3)
Sun, 29/9/2024	00:00–08:00	2.38	4.7
	08:00–16:00	18.87	
	16:00–00:00	10.93	
Mon, 30/9/2024	00:00–08:00	0.71	11.3
	08:00–16:00	30.62	
	16:00–00:00	16.54	
Tue, 1/10/2024	00:00–08:00	0.48	6.9
	08:00–16:00	15.99	
	16:00–00:00	14.62	
Wed, 2/10/2024	00:00–08:00	0.05	< 4
	08:00–16:00	10.57	
	16:00–00:00	5.87	
Thu, 3/10/2024	00:00–08:00	0.15	30.9
	08:00–16:00	8.25	
	16:00–00:00	20.03	
Fri, 4/10/2024	00:00–08:00	5.13	22.9
	08:00–16:00	32.95	
	16:00–00:00	6.02	
Sat, 5/10/2024	00:00–08:00	0.90	< 4
	08:00–16:00	29.21	
	16:00–23:00	13.04	
2020 Target (µg/m^3)		**100**	**200**

Table 6.14, Table 6.15, & Table 6.16 show the baseline ambient air quality level monitored by Station A2. From the results obtained, there was no exceedance recorded during the stipulated monitoring period.

Table 6.14. 24-hour average of PM_{10}, $PM_{2.5}$, and SO_2 levels at Station A2

Monitoring Period	24-hour PM_{10} average ($\mu g/m^3$)	24-hour $PM_{2.5}$ average ($\mu g/m^3$)	24-hour SO_2 average ($\mu g/m^3$)
Sat, 21/9/2024	21.1	9.3	< 8
Sun, 22/9/2024	23.4	12.1	< 8
Mon, 23/9/2024	27.1	13.7	< 8
Tue, 24/9/2024	32.5	15.7	23.8
Wed, 25/9/2024	26.1	13.3	19.2
Thu, 26/9/2024	15.7	5.7	< 8
Fri, 27/9/2024	17.7	7.3	13.8
2020 Target ($\mu g/m^3$)	**50**	**37.5**	**50**
Long Term Target ($\mu g/m^3$)	**50**	**25**	**20**

Table 6.15. 8-hour and maximum daily hourly average of CO level at Station A2

Monitoring Period	Duration	8-hour CO average (mg/m^3)	Max. hourly CO average (mg/m^3)
Sun, 29/9/2024	00:00–08:00	0.23	0.69
	08:00–16:00	0.32	
	16:00–00:00	0.46	
Mon, 30/9/2024	00:00–08:00	0.43	0.6
	08:00–16:00	0.28	
	16:00–00:00	0.36	
Tue, 1/10/2024	00:00–08:00	0.30	0.56
	08:00–16:00	0.32	
	16:00–00:00	0.38	
Wed, 2/10/2024	00:00–08:00	0.50	0.83
	08:00–16:00	0.34	
	16:00–00:00	0.57	
Thu, 3/10/2024	00:00–08:00	0.53	0.9
	08:00–16:00	0.33	
	16:00–00:00	0.41	
Fri, 4/10/2024	00:00–08:00	0.21	0.58
	08:00–16:00	0.17	
	16:00–00:00	0.37	
Sat, 5/10/2024	00:00–08:00	0.46	0.8
	08:00–16:00	0.37	
	16:00–23:00	0.28	
2020 Target (mg/m^3)		**10**	**30**

Table 6.16. 8-hour average of O_3 and maximum daily hourly average of NO_2 at Station A2

Monitoring Period	Duration	8-hour O_3 average ($\mu g/m^3$)	Max. hourly NO_2 average ($\mu g/m^3$)
Sun, 29/9/2024	00:00–08:00	7.03	15.7
	08:00–16:00	27.04	

	16:00–00:00	23.38	
Mon, 30/9/2024	00:00–08:00	6.08	28.5
	08:00–16:00	59.47	
	16:00–00:00	36.77	
Tue, 1/10/2024	00:00–08:00	20.69	21.4
	08:00–16:00	44.37	
	16:00–00:00	15.73	
Wed, 2/10/2024	00:00–08:00	2.82	27.8
	08:00–16:00	30.84	
	16:00–00:00	20.80	
Thu, 3/10/2024	00:00–08:00	6.36	22.5
	08:00–16:00	23.88	
	16:00–00:00	21.41	
Fri, 4/10/2024	00:00–08:00	5.08	4.7
	08:00–16:00	16.23	
	16:00–00:00	12.02	
Sat, 5/10/2024	00:00–08:00	0.56	6.7
	08:00–16:00	30.53	
	16:00–23:00	21.20	
2020 Target (μg/m^3)		**100**	**200**

Table 6.17, Table 6.18, & Table 6.19 show the baseline ambient air quality level monitored by Station A3. From the results obtained, there was no exceedance recorded during the stipulated monitoring period.

Table 6.17. 24-hour average of PM_{10}, $PM_{2.5}$, and SO_2 levels at Station A3

Monitoring Period	24-hour PM_{10} average (μg/m^3)	24-hour $PM_{2.5}$ average (μg/m^3)	24-hour SO_2 average (μg/m^3)
Fri, 13/9/2024	22.4	10	< 8
Sat, 14/9/2024	18.3	7.4	< 8
Sun, 15/9/2024	22.5	10.9	< 8
Mon, 16/9/2024	24.7	12.3	< 8
Tue, 17/9/2024	20	8.2	< 8
Wed, 18/9/2024	14.7	4.5	< 8
Thu, 19/9/2024	25.4	12.4	< 8
2020 Target (μg/m^3)	**50**	**37.5**	**50**
Long Term Target (μg/m^3)	**50**	**25**	**20**

Table 6.18. 8-hour and maximum daily hourly average of CO level at Station A3

Monitoring Period	Duration	8-hour CO average (mg/m^3)	Max. hourly CO average (mg/m^3)
Fri, 13/9/2024	00:00–08:00	0.26	0.45
	08:00–16:00	0.24	
	16:00–00:00	0.29	

Sat, 14/9/2024	00:00–08:00	0.25	0.57
	08:00–16:00	0.19	
	16:00–00:00	0.37	
Sun, 15/9/2024	00:00–08:00	0.45	0.58
	08:00–16:00	0.27	
	16:00–00:00	0.27	
Mon, 16/9/2024	00:00–08:00	0.35	0.63
	08:00–16:00	0.27	
	16:00–00:00	0.24	
Tue, 17/9/2024	00:00–08:00	0.24	0.32
	08:00–16:00	0.28	
	16:00–00:00	0.21	
Wed, 18/9/2024	00:00–08:00	0.16	0.36
	08:00–16:00	0.23	
	16:00–00:00	0.29	
Thu, 19/9/2024	00:00–08:00	0.38	0.71
	08:00–16:00	0.35	
	16:00–23:00	0.29	
2020 Target (mg/m^3)		**10**	**30**

Table 6.19. 8-hour average of O_3 and maximum daily hourly average of NO_2 at Station A3

Monitoring Period	Duration	8-hour O_3 average (µg/m^3)	Max. hourly NO_2 average (µg/m^3)
Fri, 13/9/2024	00:00–08:00	1.46	15.3
	08:00–16:00	41.70	
	16:00–00:00	36.79	
Sat, 14/9/2024	00:00–08:00	7.39	17.5
	08:00–16:00	41.39	
	16:00–00:00	34.53	
Sun, 15/9/2024	00:00–08:00	5.62	12.5
	08:00–16:00	31.94	
	16:00–00:00	29.77	
Mon, 16/9/2024	00:00–08:00	6.79	8.7
	08:00–16:00	44.79	
	16:00–00:00	47.11	
Tue, 17/9/2024	00:00–08:00	30.74	12.2
	08:00–16:00	49.96	
	16:00–00:00	15.39	
Wed, 18/9/2024	00:00–08:00	3.13	13.2
	08:00–16:00	30.32	
	16:00–00:00	29.65	
Thu, 19/9/2024	00:00–08:00	6.35	10.5
	08:00–16:00	47.36	
	16:00–23:00	62.66	
2020 Target (µg/m^3)		**100**	**200**

7 IMPACT ASSESSMENT

7.1 Assumed Development Works

The study area is characterised by gentle to steep slopes with up to 18 m level difference across the sites (Figure 7.1). The study area is largely zoned for residential use in URA's 2019 Master Plan, with one reserve site. For the purpose of this study, the study area is assumed to be fully developed for residential use within the next 15 years. The assumed works include vegetation clearance, earthworks, piling works, building works, infrastructure works, road construction, road sidetable works, etc.

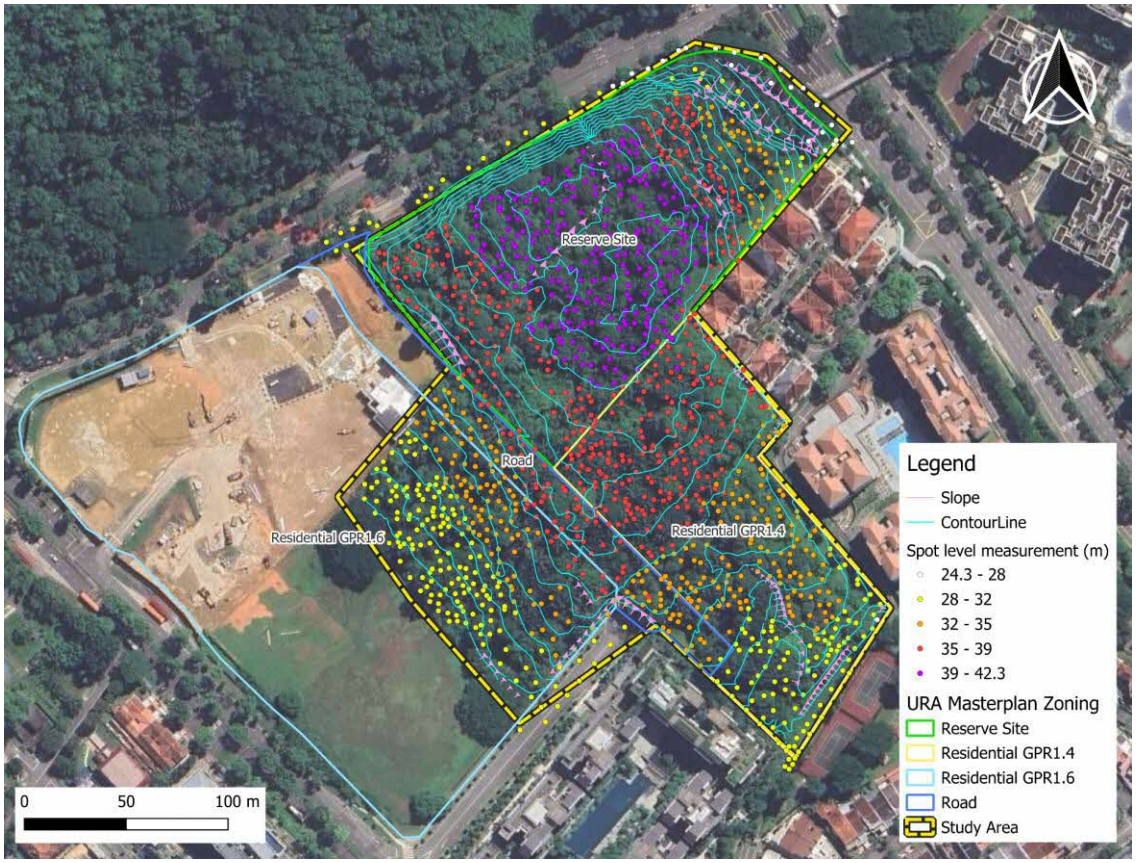


Figure 7.1. Spot measurement level, slopes and contour map within study area, overlaid with the URA Master Plan

As part of development plans, there are planned transport infrastructure improvements which are required to serve future developments, including the extension of De Souza Ave linking Old Jurong Road with a new junction and slip roads.

The mitigation measures provided in Section 7.5 are general guidelines that need to be refined and developed further in downstream processes once the development footprint is finalised.

7.2 Identification of Sources of Potential Impacts

The pre-construction, construction, and post-construction phases of a development project often have impacts on the natural environment. The main activity that affects

biodiversity sensitive receptors is vegetation clearance. Vegetation clearance contributes to loss of habitat, loss of breeding and foraging ground for fauna, and disturbance to both flora and fauna species. Sources of impacts during the different phases of a project are identified as the following:

Pre-construction / Construction Phase

- Vegetation clearance and habitat disturbance due to construction of road and residential buildings (permanent)
- Vegetation clearance for vehicular access, storage of equipment, setting up of temporary hoarding, and other forms of working space (temporary)
- Heavy construction activities such as earthworks and piling (temporary)
- Chemical use such as for vector control (temporary)
- Use of heavy machinery for activities such as pipe jacking and piling (temporary)
- Use of construction lights for night works and pedestrian access (temporary)
- Earth Control Measures (ECM) discharge into waterbodies (temporary)
- Surface runoff and accidental spillage of chemicals into waterbodies (temporary)

Operation Phase

- Residential development (permanent)
- Landscaping (permanent)

7.3 Identification of Potential Impacts

This section summarises the potential impacts affecting biodiversity sensitive receptors that may take place during the pre-construction, construction, and operation phases as a result of development in the study area.

Pre-construction / Construction Phase

During pre-construction and construction stages, vegetation clearance and tree felling will be conducted in the study area, followed by other construction activities such as earthworks and piling. These works will result in direct impacts to flora, fauna and habitats present within the study area (Table 7.1).

Table 7.1. Potential impacts to sensitive receptors due to various construction works

Source of Impact	Potential Impact	Sensitive Receptor Affected		
		Flora	Fauna	Habitat
Vegetation clearance for vehicular access, storage of equipment, setting up of temporary hoarding, and other forms of working space	Habitat loss	√	√	√
	Loss in ecological connectivity	√	√	√
	Species mortality or injury	√	√	
	Change in species composition	√		
	Roadkill or road injury to		√	

Vegetation clearance and habitat disturbance due to construction of road and residential buildings	fauna attempting to cross the road			
	Human-wildlife conflict		√	
	Edge effects			√
	Disruption and reversal of forest succession process			√
Heavy construction activities such as earthworks and piling	Changes in soil and topography	√		
Chemical use such as for vector control	Air pollution	√	√	
Use of heavy machinery for activities such as pipe jacking and piling	Noise and ground-borne vibration disturbance		√	
Use of construction lights for night works and pedestrian access	Light disturbance	√	√	
Earth Control Measures (ECM) discharge into waterbodies Surface runoff and accidental spillage of chemicals into waterbodies	Water pollution		√	

Habitat Loss

Vegetation clearance and tree felling will be carried out on site as part of earthworks. Assuming full clearance, a loss of 0.53 ha of NDYSF and a loss of 1.51 ha of abandoned land forests with strong native regeneration of old secondary forest species (NDOSF) is expected. These habitat types are of high importance as they have many native flora species which support many native fauna species, including six fauna species of conservation significance. Not only will there be a direct loss of habitats for these fauna species, but there will also be a reduction of foraging area, food sources, roosting, breeding and nesting sites, and other resources needed for the continued survival of a species. Moreover, these habitats are showing signs of natural forest succession, clearing them will disrupt this process. For flora sensitive receptor, they are unable to move and relocate to other vegetated patches nearby, so habitat loss is a permanent, irreversible and cumulative impact and therefore the impact of habitat loss on flora is assessed to be major negative. Given the presence of several fauna species of conservation significance such as the locally critically endangered Sunda pangolin (*Manis javanica*), the impact on habitat loss on fauna is assessed to be major negative.

When evaluating the impact of habitat loss on habitat sensitive receptor, the importance score was assigned based on joint consideration of the spatial relationship and

uniqueness of the habitat compared to surroundings. The study area is spatially connected to similar habitats nearby and the loss of this habitat in terms of spatial connectivity and uniqueness of habitat are considered of local importance, and thus the impact of habitat loss on habitat is assessed to be moderate negative.

Loss in Ecological Connectivity

The study area is located along the BBNC, which aims to provide ecological connectivity between the Tengah Forest Corridor and Central Nature Park Network. As the study area serves as a stepping stone between the BTNR and forest patches in Western Singapore, the loss of habitats may affect the overall ecological connectivity of the BBNC. The clearance of the study area will affect habitat connectivity by increasing isolation between extant vegetated patches across spatial extent. The vegetation clearance will also reduce the population of mature and fertile plant individuals or groups that can provide seed sources to be dispersed along BBNC, reducing the connectivity between flora germplasm sources. The loss of spatial habitat connectivity and native flora germplasm connectivity is important to areas immediately outside the study area, and the magnitude of this impact is likely major negative, and thus the impact of loss of ecological connectivity for both habitat and flora sensitive receptors are assessed as moderate negative.

According to a recently published EIA of parks within the BBNC, Old Jurong Road and Upper Bukit Timah Road were identified to have gaps in terrestrial connectivity, while Upper Bukit Timah Road was also identified to have gaps in arboreal connectivity (Ramboll Pte Ltd, 2025). Given that BBNP and the study area are the only two substantial linkages between BTNR and the rest of the BBNC, and the poor existing connectivity in the area, the further loss in ecological connectivity for fauna may be damaging, especially for non-volant fauna such as the Sunda pangolin (*Manis javanica*). Hence, the impact on volant fauna and non-volant fauna are assessed to be slight negative and moderate negative respectively. The impact of loss in ecological connectivity for the Malayan colugo (*Galeopterus variegatus*) is assessed to be moderate negative due to the 75.9% decrease in feasible glide paths involving trees in the study area (refer to Appendix H for detailed Colugo Connectivity Study).

Species Mortality or Injury

Vegetation clearance and tree felling as part of the earthworks leads to a direct loss of flora species. Assuming the study area is fully cleared, a loss of 62 flora species of conservation significance is expected. There will be a loss of the entire flora population in the study area which is a permanent, irreversible and cumulative impact. Although there is a significant number of conservation significant species, they are largely young plants and most of the mature trees are non-native or of least concern status. Therefore, the impact on flora is assessed to be moderate negative.

During vegetation clearance, fauna species responses may differ according to their mobility. For volant fauna such as birds, they are likely to fly to nearby vegetated patches in BBNP or BTNR; as such, the magnitude of impact to volant fauna is likely to be minor negative. However, it is to be noted that forest-dependent bird species, such as the pin-striped tit-babbler (*Mixornis gularis*) recorded in the study area, have a much lower tolerance to gaps and may be unable to readily disperse (Robertson & Radford, 2009).

Nesting birds and their young are also especially susceptible to mortality or injury during vegetation clearance as they may not leave their nests easily.

Given that the study area is isolated and nearby vegetated patches are separated by Old Jurong Road and Upper Bukit Timah Road, negative impacts to non-volant fauna is likely to be major, should no mitigation measures be put in place. Being unable to fly nor have a place to escape to, there is likely to be a high risk of mortality or injury for these species during vegetation clearance. Moreover, there are several non-volant fauna species of interest in the study area, such as the critically endangered Sunda pangolin (*Manis javanica*) and the Malayan colugo (*Galeopterus variegatus*).

Additionally, given the proximity of the study area to surrounding nature areas, during construction works, animals may continue to enter the site. Particularly, highly mobile reptiles and amphibians, such as the Malayan water monitor (*Varanus salvator*), may become entrapped and killed when navigating through the worksite, especially by getting stuck in ECM blankets or falling into pits. Therefore, the impact is assessed to be slight negative for volant fauna and major negative for non-volant fauna.

Change in Species Composition

Full vegetation clearance will result in a direct loss of at least 205 flora species. Among these, at least 136 are native species—constituting 66.3% of those recorded in the baseline survey—of which 62 are considered to be of conservation significance. Within the construction site, due to the presence of waterlogged soil, there is also likely to be spontaneous growth of sun-loving and waterlogging-tolerant species, such as sedges, non-native herbs like *Spermacoce* sp. and *Ludwigia* sp., and trees such as *Mimosa pigra* and *Neptunia plena*, leading to an increase of non-native species. If there are retained vegetated patches, the increased light and decreased humidity due to the vegetation clearance in vicinity may cause remaining shade-tolerant late-successional forest species to decline while sun- and drought-tolerant species such as native pioneer species or non-native species to increase. Given the drastic loss of native flora species in which many are late-successional forest species during vegetation clearance, the anticipated spontaneous growth of non-native species within construction site, and the anticipated species composition change in retained vegetation, the impact of changes in species composition on flora is assessed to be major negative.

Roadkill or Road Injury to Fauna Attempting to Cross the Road

The study area is bounded by three roads – Old Jurong Road, Upper Bukit Timah Road and De Souza Ave. Upper Bukit Timah Road is a major six-lane road with high traffic volume. While Old Jurong Road and De Souza Ave currently see lower traffic volume, during the construction phase, it is likely to increase from construction vehicles accessing the site. Although roadkill is less of a concern for volant fauna due to their ability to fly, majority of non-volant fauna species recorded in the study area are identified as likely to cross roads and are susceptible to collision with vehicles.

Past records around the study area from ACRES and the Herptile Roadkill Project show that several reptile, amphibian and mammal species, such as the equatorial spitting cobra (*Naja sumatrana*), Malayan water monitor (*Varanus salvator*), four-lined tree frog (*Polypedates leucomystax*) and long-tailed macaque (*Macaca fascicularis*) have been

recorded as roadkill along the roads bounding the study area and nearby Jln Jurong Kechil (ACRES, pers. comm., October 2024; Herpetology Society of Singapore, n.d.). As mentioned in Section 2.3, there have also been several past records of the Sunda pangolin (*Manis javanica*) on or beside nearby roads, as well as injured pangolins, likely due to road accidents.

With the presence of species of conservation significance already traversing roads to cross between fragmented habitats, development works further reducing available habitat for fauna, and increased in traffic in the area, roadkill incidents are likely to increase further. Hence, the impact of roadkill for non-volant fauna is assessed to be moderate negative.

Human-Wildlife Conflict

The study area currently contains at least 11 species perceived to be nuisances/ of threat to humans, including snakes, monitor lizards, bats, rats, the common palm civet (*Paradoxurus musangus*) and the long-tailed macaque (*Macaca fascicularis*). As residential development encroaches into animals' habitat, these species may not be able to find alternative habitats and may return to the site during the construction phase, resulting in human-wildlife conflict. During site clearance, workers may also face injury due to attack by wildlife such as the Eurasian wild boar (*Sus scrofa*), which although was not recorded in the current surveys, is known to be present in the area.

The long-tailed macaque (*Macaca fascicularis*) has long been recognised as a conflict species, particularly in the Bukit Timah area (Yeo & Neo, 2010), and there have been at least 18 reported cases of macaques entering residential, retail and school premises surrounding the study area handled by ACRES between 2015 to 2024 (ACRES, pers. comm., October 2024). Given their established presence in the area and the presence of food on construction sites, long-tailed macaques are highly likely to enter the site, leading to interactions with construction personnel which may result in human-wildlife conflict. Despite the high magnitude of impact, it is only important to the local condition, and as such the predicted impact of human-wildlife conflict is assessed to be minor negative.

Edge Effects

Edge effects are commonly observed when vegetation clearance creates new forest edges. These new edges are then exposed to abiotic and biotic changes such as increased light intensity and temperature, noise, increased soil nutrient content, and changes in air and soil moisture levels. Should there be nightworks within the area, artificial lighting may also cause species disturbance. Alteration of natural cycles of light and dark by artificial light sources can negatively impact the ecosystem if not managed properly. Some fauna species, particularly nocturnal species which rely on their hearing for movement, communication, and foraging, are vulnerable to increased night-time noise levels. 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 in the areas adjacent to the assumed development due to edge effects may also occur. Assuming full clearance, there will be no forest edges remaining, hence, the impact scoring for edge effect in this case will not be applicable since edge effects will only be assessed in scenarios where new forest edges are created.

Disruption and Reversal of Forest Succession Process

Vegetation clearance may disrupt the naturally occurring process of forest succession, which is a slow process for most forests in Singapore due factors such as the lack of native late-successional species seedling recruitment, persistence of early successional species and dominance of exotic species (Tan, Chan, Loo, & Tan, 2023). In the study area, a significant area of abandoned land forests with strong native regeneration consisting of multiple native late-successional seedling species had been identified (areas indicated as NDOSF understorey on the habitat map). These areas show strong potential to undergo natural ecological succession to transition into NDOSF in the next few decades, which is unusual amongst Singapore's remaining forests and clearing the study area will result in a permanent and irrecoverable impact in terms of disrupting the forest succession process. Therefore, the impact of disruption and reversal of forest ecological succession on habitat is assessed to be moderate negative.

Changes in Soil and Topography

The interaction between vegetation cover and soil and topography is multifaceted. For example, vegetation clearance will increase soil erosion as there is a loss of plant roots which hold the soil together, and in the event where there is remaining vegetation, such soil erosion will in return affect remaining vegetation by further exposing the roots of remaining vegetation which decrease the water and nutrient intake. The final platform level of development will determine if tree retention will be feasible as trees are sensitive to drought or waterlogging when their ground level is distinctly different from their surroundings. In the event where trees are retained within development site, heavy machinery and trampling from construction personnel may lead to compaction of soil, which reduces the availability of air for root tissues leading to physiological stress. For this study, the direct impact of changes in soil and topography on flora is expected to be of physiological nature and assessed to be minor negative because while changes in soil and topography are assessed to cause major negative impacts to flora sensitive receptors, the importance score is low since the impact is important to local condition without affecting areas nearby.

Air Pollution

Particulate Matter (PM) from construction activities may have negative effects on any retained or nearby flora. Dust deposited on the surface of leaves have been found to reduce plant growth (Prabhat, 2016). The plants may also absorb and accumulate fine PM which may affect growth in the long term and disrupt physiological processes such as photosynthesis and transpiration (Prabhat, 2016). However, these negative effects of air pollution on plants are relatively understudied, and air pollution is expected to be a temporary impact as it should be minimal once construction stops. The extent of the air pollution will also depend on weather conditions. For example, if there is more rain, it will wash away the dust deposited on the flora, or if there is more wind, the dust can travel further and deposit on flora surrounding the site. Therefore, the impact on flora is assessed to be slight negative.

PM is also associated with respiratory diseases in fauna, affecting lung function and morbidity (Losacco & Perillo, 2018). Additionally, vector control activities such as thermal fogging can also lead to air pollution, and can have severe effects on non-target

invertebrates, causing mortality (Abeyasuriya et al., 2017). Due to the potential for air pollution to be far-reaching and have a continuous effect on nearby fauna, the impact on fauna is assessed to be moderate negative.

Noise and Ground-Borne Vibration Disturbance

Although the effects of noise and vibration on fauna are poorly understood since both stimuli and responses can vary, these impacts are more likely for nocturnal species such as bats and frogs as they rely on their sense of hearing for movement, communication, and foraging. 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 are often perceived as threats (Francis & Barber, 2013). This can alter the species behaviour and impair their ability to forage and avoid predation, leading to decreased survivability.

As the study area is in close proximity to BBNP and BTNR, noise impacts are likely to be felt by fauna in these areas as well. Several nocturnal fauna are present in and around the study area, such as bats, amphibians, the Sunda pangolin (*Manis javanica*), Malayan colugo (*Galeopterus variegatus*), common palm civet (*Paradoxurus musangus*) and Sunda scops owl (*Otus lempiji*). As such, the impact is assessed to be moderate negative.

Light Disturbance

Artificial lighting is typically used to illuminate the project site and surrounding pedestrian access paths, particularly if night works are conducted. Increased artificial light during the night disrupts the circadian rhythms of animals and distorts the day-night cycle of plants. Impacts of artificial lighting on flora species are understudied but varied depending on species, with effects ranging from decreased flora diversity and increased defense response (Zhou, Nakamura, Song, & Katabuchi, 2023; Cao, Zhang, & Ma, 2024). However, light disturbance is expected to be quite localised. Hence, the impact to flora is assessed to be slight negative in both the construction and operation phase.

Impacts on fauna include increased predation pressure by diurnal carnivores on nocturnal animals, exhaustion of insects being attracted to artificial light, foraging disruption of birds, and the alteration of breeding and sleeping cycles. Moreover, artificial night lights have been shown to have an impact on migratory birds, a large proportion of which migrate at night. In general, the risk of bird collisions increases with increased light emissions (Ogden, 2002). Fruit bats play the ecological role of seed dispersers and pollinators, and reduced foraging activities in artificially illuminated areas may result in the loss of pollinating and seed-dispersal services they provide (Lewanzik & Voigt, 2014). These examples of altered foraging, reproduction, migration, and communication behaviour are all a result of disorientation due to the altered light environment. The cumulative effects of such behavioural changes induced by artificial night lighting can have the potential to disrupt key ecosystem functions (Longcore & Rich, 2004).

Given the presence of several light-sensitive fauna species, including bats, birds, nocturnal mammals and a likely significant increase in amount of light from baseline condition, the impact of light disturbance on fauna is assessed to be moderate negative.

Water Pollution

There are several potential sources of water pollution that can affect aquatic fauna species. For example, surface runoff into watercourses can cause elevated TSS, while spillage of chemicals such as fuel and lubricants used in machinery can lead to metal contamination. However, as there are no natural streams within the study area, and only concretised drains surrounding the study area, there were no aquatic fauna species of conservation significance recorded. As such, the impact of water pollution is assessed to be slight negative.

Operation Phase

The main impacts from the potential works being studied are likely to be felt during the construction phase. However, during the operation phase, it is assumed that the study area largely will be zoned for residential use. An increase in human activities will likely lead to an increase in noise levels, light levels, and potential human-wildlife conflict (Table 7.2).

Table 7.2 Potential impacts to sensitive receptors during the operation phase

Source of Impact	Potential Impact	Sensitive Receptor Affected		
		Flora	Fauna	Habitat
Residential development	Light disturbance	√	√	
	Change in species composition		√	
Increased human activity	Human-wildlife conflict		√	
	Noise disturbance		√	
Landscaping	Habitat enhancement			√

Light Disturbance

During the operation phase, the high-rise residential blocks and pedestrian access paths in and around the residential development will result in far higher light levels than before. This increase in light levels will affect surrounding nature areas, where light-sensitive fauna species are known to occur. However, the impact is largely localised along the forest edges and therefore assessed to be slight negative.

Change in Species Composition

The conversion of a forested habitat to an urban environment will lead to a loss of forest-dependent species and an increase in human commensal species, such as the Javan myna (*Acridotheres javanicus*) and house crow (*Corvus splendens*). These human commensals will likely outcompete species that are less adapted to urban environments, causing them to move to other forested areas. Given that it is assumed that none of the forest-dependent species will remain with total clearance of the study area, the impact is likely major negative.

Human-Wildlife Conflict

The presence of forested areas such as BBNP directly adjacent to residential buildings will result in wildlife being in closer proximity to the residents. Given the established

presence of conflict species such as the long-tailed macaque (*Macaca fascicularis*) in the area and their penchant for entering residential developments, human-wildlife conflict is likely and important to the local condition even during the operation phase, resulting in a minor negative impact.

Noise Disturbance

The increase in human activity and vehicular traffic in the area during all times of the day may disturb both diurnal and nocturnal fauna. However, as there are existing residential developments and traffic noise in the area, the increase in noise is likely to be minimal, leading to a slight negative impact.

Habitat Enhancement

Planting of salvaged plants or other fauna-attracting native plants as part of the landscaping will lead to a slight positive impact.

Overall Impact

Based on the assessment above, some of the potential impacts on the site's biodiversity are deemed to be permanent in nature while the others are short-term and reversible. One impact that stands out for this study area is the disruption and reversal of the forest succession process. When a vegetated area that is undergoing robust succession processes is cleared, there will be a loss of conservation potential over and above its current habitat value (Tan, Feng, & Hwang, 2016). Appropriate measures are to be taken to minimise these impacts.

7.4 Evaluation of Impacts

Table 7.3, Table 7.4 and Table 7.5 summarise the impacts listed in Section 7.3 evaluated using the RIAM method with their corresponding Environmental Scores (ESes). Assuming all of the study area is to be cleared, the ES is evaluated to be in the range of slight negative to major negative during pre-construction and construction stage, and major negative to slight positive during operation phase.

Table 7.3 RIAM scoring on predicted impacts to flora

Phase	Impact Component	Predicted Impacts Without Mitigation						
		I	M	P	R	C	ES	ES Impact
Pre-Construction and Construction	Habitat loss	4	-4	3	3	3	-144	Major Negative
	Species mortality due to vegetation clearance	3	-4	3	3	3	-108	Moderate Negative
	Loss in ecological connectivity	3	-4	3	3	3	-108	Moderate Negative
	Change in species composition	4	-4	3	3	3	-144	Major Negative
	Changes in soil and topography	2	-4	3	3	3	-72	Minor Negative
	Air pollution	2	-2	2	2	3	-28	Slight Negative
	Light disturbance	2	-2	2	2	3	-28	Slight Negative
Operation	Light disturbance	2	-2	3	2	3	-32	Slight Negative

Table 7.4 RIAM scoring on predicted impacts to fauna

Phase	Impact Component		Predicted Impacts Without Mitigation						
			I	M	P	R	C	ES	ES Impact
Pre-Construction / Construction	Habitat loss		4	-4	3	3	3	-144	Major Negative
	Loss in ecological connectivity	Volant fauna	3	-1	3	3	3	-27	Slight Negative
		Non-volant fauna	4	-3	3	3	3	-108	Moderate Negative
		Malayan colugo	3	-4	3	3	3	-108	Moderate Negative
	Species mortality or injury	Volant fauna	3	-2	2	3	3	-48	Minor Negative
		Non-volant fauna	4	-4	2	3	3	-128	Major Negative
	Roadkill or road injury to fauna attempting to cross the road	Volant fauna	3	-1	2	3	3	-24	Slight Negative
		Non-volant fauna	4	-3	2	3	3	-96	Moderate Negative
	Human-wildlife conflict		2	-4	2	2	3	-56	Minor Negative
	Air pollution		4	-2	2	2	3	-56	Minor Negative
	Noise and ground-borne vibration disturbance		4	-4	2	2	3	-112	Moderate Negative
	Light disturbance		4	-4	2	2	3	-112	Moderate Negative
	Water pollution		1	-2	2	2	3	-14	Slight Negative
Operation	Light disturbance		4	-2	3	2	3	-64	Minor Negative
	Change in species composition		4	-4	3	3	3	-144	Major Negative
	Human-Wildlife Conflict		2	-3	3	2	3	-48	Minor Negative
	Noise disturbance		4	-2	3	2	3	-64	Minor Negative

Table 7.5 RIAM scoring on predicted impacts to habitat

Phase	Impact Component	Predicted Impacts Without Mitigation						
		I	M	P	R	C	ES	ES Impact
Pre-Construction and Construction	Habitat loss	3	-4	3	3	3	-108	Moderate Negative
	Loss in ecological connectivity	3	-3	3	3	3	-81	Moderate Negative
	Disruption and reversal of forest succession process	3	-4	3	3	3	-108	Moderate Negative
	Edge effect	N.A.						
Operation	Habitat enhancement planting	1	1	3	3	3	9	Slight Positive

7.5 Mitigation Measures

Mitigation measures are to be implemented wherever significant negative impacts are predicted, to reduce the impacts on the environment. Key mitigation measures are discussed below, while a full list of mitigation measures for each impact type is found in

Section 7.6. The mitigation measures below serve as general guidelines that will be refined and further developed in downstream processes after incorporating inputs from relevant stakeholders.

7.5.1 General Mitigation Measures

Pre-construction / Construction Phase

Site Hoarding

The full working area should be hoarded, with hoardings embedded at a depth of 300 mm to prevent animals from digging under the hoarding. The Contractor should engage an Arborist to ensure that the hoarding does not damage any major tree roots (of trees both inside and outside the hoarding). Hoarding should be monitored regularly to ensure that no animals may enter the site either through gaps or by digging under the hoarding. In the event of any wildlife encounter, the Contractor should follow the wildlife response and rescue plan that will be elaborated on in the EMMP.

Having a hoarding along the work site, as well as directional clearance of trees in the direction away from Old Jurong Road, could help to prevent animals from running onto the road, hence avoiding fauna mortality from roadkill.

Management of Human–Wildlife Encounters

As described above, mortality from roadkill can be avoided by installing hoarding around the worksite to prevent animals from running onto the road. To prevent other wild animals from scavenging on construction site, areas for food consumption, storage, and waste disposal should be demarcated and maintained. There should also be no consumption of food and drink within vegetated areas. The presence of snakes, long-tailed macaques, and bees may pose a threat to human health and safety. Prior to the commencement of works, beehives should be relocated out of the construction site to reduce the risk of such encounters. Monkey-proof bins can also be utilised in the site to discourage macaques from returning to site.

NParks' advisory on how to keep macaques at bay are provided on their website (https://www.nparks.gov.sg/avs/animals/wildlife-in-singapore/macaques).

Construction personnel should also be briefed on what to do should they encounter specific wild animals. In the event of wildlife encounters, the Wildlife Response and Rescue Protocol, which is elaborated upon in the EMMP document, should be followed.

Plant Salvaging and Planting of Native Species

To remedy the adverse impact to biodiversity, it is recommended to salvage saplings and small individuals of plants of conservation value within the understorey patch that will be affected by development works. We recommend transplanting as many flora species of local conservation significance that likely spawned from natural regeneration (Table 4.9) as possible. Additionally, some more common native plants may also be targeted for translocation, including the Indonesian bayleaf (*Syzygium polyanthum*), sea apple (*Syzygium grande*) and bat's laurel (*Prunus polystachya*).

Salvaged native species can be incorporated as far as reasonably practical as a nature-

based component for replanting requirements such as for reinstatement, slope stabilising, or fauna connectivity purposes. Compared to the conventional method of planting solely ornamental trees in residential estates with planting stocks ordered from local or overseas nurseries, using native plants salvaged in-situ at least partially for reinstatement works brings ecological and biodiversity benefits, as this demonstrates an effort to preserve and disperse native flora germplasm rather than introducing foreign species which might deter conservation of native flora germplasm. This will help to mitigate biodiversity loss and conserve a certain degree of biodiversity. Should there be additional flora saplings of conservation significance, these could also be used to enhance areas in vicinity such as BBNP, BTNR and the Rail Corridor.

Flora Management Plan

The detailed plant salvaging and tree protection guidelines will be provided in the EMMP document, including the requirements of personnel qualification, specifications of nursery, transplanting, tree assessment, tree felling and so on. A summary of the flora management plan is provided below.

Prior to any site clearance, NParks shall be consulted for plant salvaging work matters.

In general, all trees within any retained areas (subject to further discussions to agencies) shall be preserved, and large trees outside any retained areas that are of conservation significance status such as *Ficus* cf. *glandulifera*, *Ficus caulocarpa*, *Litsea umbellata*, *Melicope* cf. *lunu-ankenda* are recommended to be retained or transplanted subject to availability of detailed development footprint with final platform level and consultation with technical agencies. For trees identified for retention, a tree assessment report recording tree information such as site and tree photos, species, height, girth, crown spread, tree health, form, structure, site observations and assessment for the trees affected by the assumed development footprint is to be prepared. The report should also include mitigation measures to reduce construction impact on trees. This tree assessment report will then serve as a record of pre-development tree condition and is to be utilised when performing monthly monitoring for retained trees. Such trees should also be demarcated by Tree Protection Zones (TPZs) determined by an ISA-certified Arborist. TPZs should be installed prior to construction stage, and monthly monitoring should be conducted by the Arborist to maintain records of tree health and TPZ integrity. If the tree needs to be pruned due to machinery access, the pruning will need to be carried out by landscape contractors with relevant qualifications under supervision of the Arborist.

Any slope levelling work that may be required should also consider any flora immediately upslope of the planned work area, especially trees, as their root zones would likely be affected by any excavation works that are carried out. Any waste material should also be disposed of properly, as the leaching of contaminants into the soil or wastewater could result in negative impacts.

Tree Felling Protocol

The contractor will need to engage landscape operating contractors listed on NParks' Landscape Company Register (LCR) list, and the workers conducting the tree felling works must possess Workforce Skills Qualifications (WSQ) certificates (Level 2) in

chainsaw operation and maintenance and tree pruning. During tree felling operation works, the Contractor shall exercise all necessary precaution to ensure safety of workers and road users.

Pre-felling Fauna Inspections

Mortality of fauna species should be avoided. There are recorded species of conservation interest that are non-volant, such as the Sunda pangolin (*Manis javanica*) and Malayan colugo (*Galeopterus variegatus*), which roost or rest in the daytime on trees; hence, measures should be put in place to decrease species mortality. Prior to any tree felling, the project site should be inspected for nests, tree holes, burrows and day roosts on the same day as tree felling by an ecologist or wildlife specialist. If any active nesting activity is observed, young birds should be allowed to fledge prior to tree felling. If necessary, other species (e.g., mammals) should be translocated prior to tree felling.

Directional Clearance

TPZs are to be set up for all retained trees before any tree felling activity commences. In situations where a tree to be felled falls within the TPZ of a retained tree, an Arborist should be present to monitor the tree removal. If the retained tree is likely to be affected during the felling, the Arborist can provide recommendations on the spot.

The details of the directional tree felling plan will be proposed when the development design is available. Commencement of tree felling works are also to avoid the peak breeding period of many birds (between the months of February and July). Moreover, the equipment used to crush the tree trunks should be well-maintained and in good working condition to prevent buildup of dead wood on site.

Minimising Fauna Entrapment

All ECM blankets used throughout the site should be made of biodegradable material with no plastic mesh netting. These blankets should minimise the likelihood of entrapment of fauna such as snakes and monitor lizards. ECM blankets and pits should be inspected daily to identify and rescue any entrapped fauna.

Restricted Work Timings for Heavy Construction

Due to the sensitive nature of forest animals, particularly nocturnal animals, heavy construction works (including tree clearance, piling, and pipejacking) are to be limited to daylight hours (8 am – 6 pm). Should there be a need for construction activities to continue at night due to work exigencies, approval from authorities should be obtained. If nightworks are required, a detailed Light Management Plan (LMP) should be developed in consultation with NParks prior to the start of nightworks to mitigate light impacts.

If light nightworks are to be conducted, construction lights should be shielded, and facing downwards and away from vegetated areas, which will eliminate light falling outside the area intended to be lit (known as light spill). Examples of ideal shielded lighting can be seen in Figure 7.2. All artificial lights should be turned off outside working hours unless required for safety and security reasons.

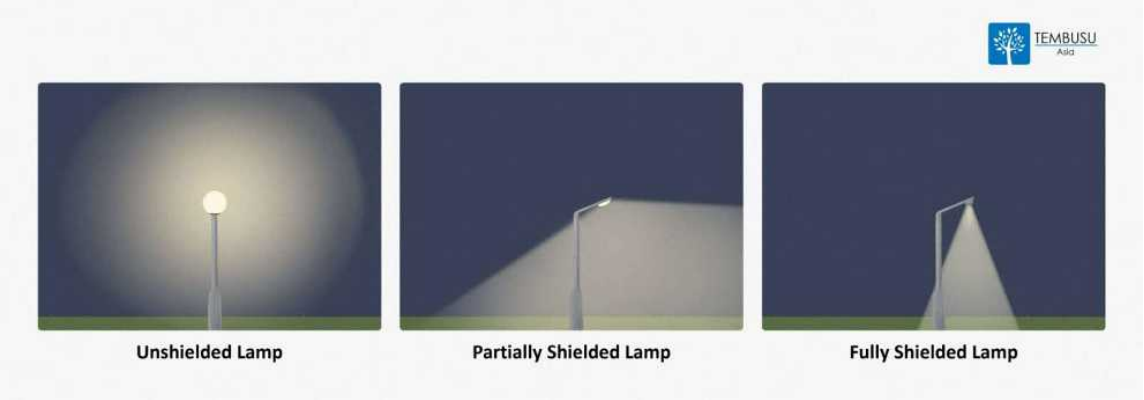


Figure 7.2. Example of ideal light shielding

The LMP should minimally include the following aspects:

- Objectives of LMP
- Purposes and categories of artificial lighting required
- Spatial layout of lighting utilised in project site
- Designs of lighting utilised – including height and shielding design
- Specifications of lighting utilised – lighting temperature, spectrum, and brightness
- Additional measures in place if white or non-shielded lighting is required
- Implementation of monitoring plan
- Schedule of night works

Noise Management

Noise barriers (STC20) of 6m to 12m height shall be maintained along the construction boundary to reduce noise impacts to fauna. The exact hoarding heights might be subject to change and shall follow the final EMMP document developed prior to the construction stage.

Additionally, the following recommendations should be implemented during pre-construction and construction phase:

- Schedule heavy construction works within daylight hours (8 am – 6 pm) if possible
- Use acoustic enclosures for noise-generating equipment such as rig engines, compressors, generators, drilling tools, etc
- Install portable noise barriers around drilling rigs
- Install a silencer at the exhaust pipe of the engines throughout drilling operations
- Stagger pilling activities (e.g., sheet piles, bored piles, and RC piles) where possible to minimise cumulative impact
- Avoid piling where possible (e.g., install concrete footing instead of pilling)
- Deploy quieter equipment and vehicles where possible
- Use a silent piler for sheet piling work where possible
- Use hydraulic and electric tools in place of pneumatic equipment such as concrete breakers where possible
- Implement any means of reducing the sound levels for any exhaust systems in

bulldozers, dump trucks and excavators

- Ensure all noise and acoustic barriers are able to reduce at least 10dB(A) from source noise levels
- Remind construction personnel on noise-reduction behaviours (e.g., reducing the drop height of materials) during daily toolbox meetings
- Care shall be taken when loading or unloading vehicles, dismantling, or moving materials to reduce impact noise
- Start-up plant and vehicles sequentially instead of simultaneously
- Ensure all machinery used are well-maintained
- Shut down vehicles and machinery when not in use
- For vehicles and machinery known to emit high levels of noise in one direction, orientate the noise away from forested areas

Air Pollution Management

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

- Install hoarding at project boundary to minimise dust generation by attenuating wind forces
- Avoid stockpiles of soil and dusty materials within project site
- If stockpiles are unavoidable, place stockpiles as far as possible from sensitive receptors
- Provide additional dust screen at project boundary near sensitive receptors where necessary
- Ensure all stockpiles of dusty material or soil are properly stored, covered entirely with impervious sheeting, or dampened with water
- Ensure soil stockpiles are kept below 0.6 times of the nearest hoarding height
- Stabilise/cover all stockpiled materials for longer than one month by turfing, erosion blanketing or other methods
- Use of regular watering to reduce dust emissions from exposed site surfaces and roads, particularly during dry weather at open areas
- Avoid works that cause soil disturbance during dry and/or windy conditions
- Backfill or reinstate excavations as soon as practicable after completion of the construction work
- No open burning of construction and other wastes at the worksite as this is an offence under the Environmental Pollution Control regulation
- Enclose excavated materials with impervious sheeting during transportation
- Impose speed limits for vehicle on-site to prevent dust being stirred up by vehicle movement
- Wear personal protective equipment (PPE) such as masks during periods of severe air pollution and/or dust exposure on site

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

- Provide vehicle washing facilities before the construction site exit
- Pave the area between construction site exit and the vehicle washing facilities
- Maintain road surface in the construction site to be damp (e.g., using sprinkler)
- Proper maintenance of construction vehicles and fuel burning equipment

- Shut down vehicles and machinery when not in use to minimise exhaust emissions
- No thermal fogging is to be conducted in close proximity to forested areas

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

Operation Phase

The impacts from the operation phase of the assumed works are related mostly to an increase in human presence in the area, leading to increased levels of noise and light, and potential human-wildlife conflict. The following general mitigation measures are proposed to mitigate some of these impacts.

Implementation of Wildlife-safe Designs

Certain mitigation measures could improve the safety of fauna species in the vicinity of the study area, while lowering potential human-wildlife encounters leading to conflict.

For bird strikes, bird-safe windows should be incorporated into building design to reduce the incidence of bird strikes. Relevant measures for this development include:

- Reducing the amount of glass surfaces, particularly on high levels.
- Increasing the visibility of glass through the addition of structural components such as columns or sunshades.
- Using non-mirrored glass or treat glass to increase visibility.
- Including decals or stickers to increase the visibility of glass.

Details of such guidelines are further elaborated upon on NParks' website (https://www.nparks.gov.sg/docs/default-source/resources/2024/bird-safety-guidelines-jun2024.pdf).

The installation of designated eating areas in common spaces and monkey-proof bins could ensure that monkeys do not become habituated to human food.

Develop Biodiversity Awareness among Residents and Visitors

Programmes to familiarise residents should be developed to cultivate an awareness of wildlife in the area and what to do should wildlife be encountered. This could take the form of signages or citizen science activities which could be open to the residents. By developing an understanding of the natural world among people, this could help to reduce negative wildlife encounters.

7.5.2 Proposed Retained Area

As vegetation clearance is the main source of impacts in the current study, a Proposed Retained Area (PRA) is recommended to mitigate some of the potential impacts from development. This retention is aimed at the avoidance of impacts, which sits at the top of the mitigation hierarchy, as opposed to the minimisation of impacts which Section 7.5.1 is geared towards. Among the identified CSAs, the northern portion of the study area (i.e. the Reserve Site parcel) is prioritised for retention as colugos and pangolins

have been observed and recorded using this vegetated area for faunal connectivity and also due to its proximity to BBNP and BTNR (Figure 7.3). Furthermore, there are plans to enhance connectivity within the BBNC through the development of an eco-pedestrian bridge (Ramboll Pte Ltd, 2025).

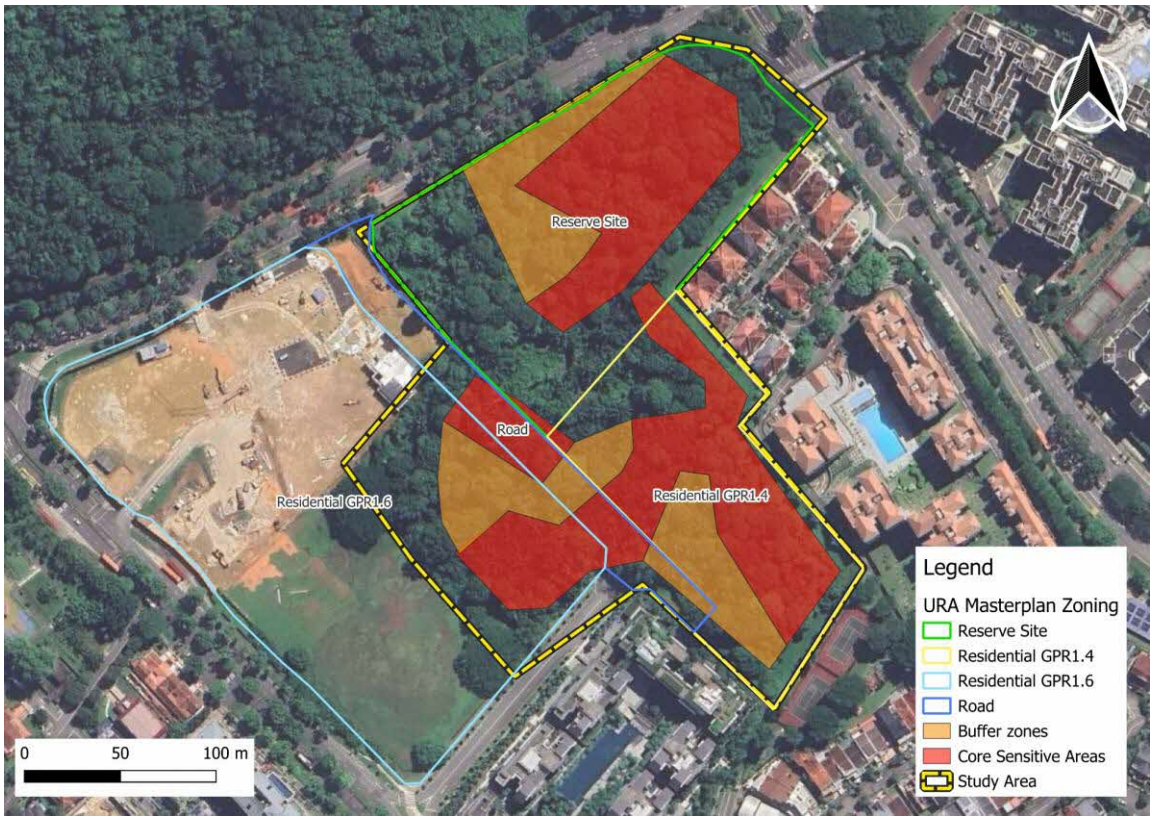


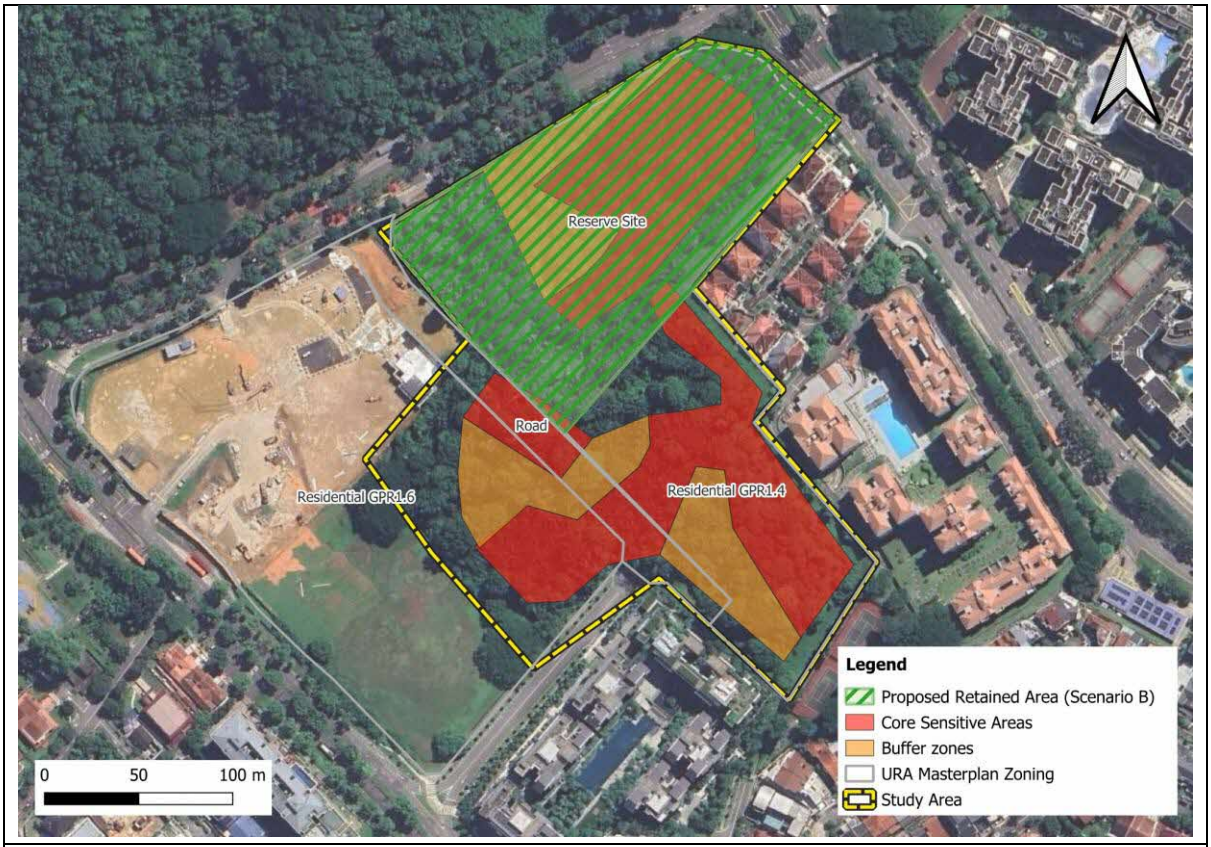
Figure 7.3. CSA and buffer zones overlaid with the URA Master Plan

For the purposes of this Final Report, one scenario assuming the study area is fully cleared (Scenario A), and one PRA scenario (Scenario B) is proposed and compared (Table 7.6). To reconcile the irregular outline of the CSAs and development considerations, the PRA scenario was developed in consultation with agencies, considering site constraints, ecological connectivity, existing land use planning and the viability of the existing vegetation. These resulted in a regularised PRA boundary containing varying extents of CSAs.

Assuming no modifications are made to the existing slope along Old Jurong Road, only one (1) tree along the centre divider and two (2) trees located at the western corner of the study area—along the road linking Old Jurong Road and De Souza Avenue—are anticipated to be affected. All trees within the PRA across the study area will be retained.

As detailed in Table 7.6, Scenario B retains 44.0% of the study area including the full extent of the CSA at the Reserve parcel.

Table 7.6. PRA Scenario B



Proposed Retained Area = 2.40 ha (44.0% of study area)

- 40.8% (0.85 ha) of Core Sensitive Area retained
- Maintains 94.0% (1546 out of 1645 in study area) of feasible glide paths for colugos as all trees (except three affected by road works) adjacent to Upper Bukit Timah Road and Old Jurong Road are retained
- Retention of 240 large trees, of which 86 are native
- Retention of 35 native flora species of conservation significance, including unusual findings such as critically endangered *Palaquium microphyllum* and *Glochidion singaporense*
- 33% (44) of trees that are identified as keystone flora species (*Ficus* sp.) are retained, ensuring some supply of food for fauna species

Additional mitigation measures in relation to the PRA are proposed below.

Habitat Enhancement

In order to reduce the impacts of edge effects on the PRA, its edges should be planted with hedge plants and other forest plants. This can be done utilising salvaged native common species from the land clearance stage. The planting palette for the edge should include native species of various plant forms (e.g., tree, shrub, herbaceous plants) to mimic the structure of a healthy vegetated area. The abandoned land forest area of the PRA can also be enhanced by removing the existing non-native young plants such as rubber and planting more native flora such as the salvaged plants from the non-retained areas.

Noise and Light Management

As with the pre-construction/ construction phases, light spill should be minimised as far as possible using shielded lighting (Figure 7.2) and directed downwards and away from vegetated areas. Other measures to be implemented include:

- Adjust the number and intensity of lights abutting the PRA to minimum levels required for safety and security
- Use motion-activated lighting in areas less frequently visited

For noise, residents are to be advised to avoid noisy recreational activities during the quiet hours between 10:30 pm and 7:00 am. Enforcement should also be carried out for noise nuisances in common spaces such as entertainment and F&B outlets; and amenities such as playgrounds, pavilions, void decks, basketball, and badminton courts after 10.30 pm.

7.6 Residual Impacts

Assuming the mitigation measures in Section 7.5 are fully implemented, the residual impacts (predicted impacts with mitigation) are evaluated for the two different scenarios.

7.6.1 Scenario A

Residual impacts are assessed for flora, fauna and habitat sensitive receptors in Table 7.7, Table 7.8 and Table 7.9 respectively, assuming full clearance of the study area and all general mitigation measures listed in Section 7.5.1 and below are fully implemented.

Table 7.7. Comparison of RIAM scoring on predicted impacts to flora without and with mitigation for Scenario A

Phase	Impact Component	Predicted Impacts Without Mitigation							Mitigation measures	Predicted Impacts With Mitigation						
		I	M	P	R	C	ES	ES Impact		I	M	P	R	C	ES	ES Impact
Pre-Construction and Construction	Habitat loss	4	-4	3	3	3	-144	Major Negative	-	4	-4	3	3	3	-144	Major Negative
	Loss in ecological connectivity	3	-4	3	3	3	-108	Moderate Negative	• Retention of selected large trees within the construction site (assuming retention of up to 10 trees)	3	-4	3	3	3	-108	Moderate Negative
	Species mortality or injury	3	-4	3	3	3	-108	Moderate Negative	• Plant salvaging	3	-3	3	3	3	-81	Moderate Negative
	Change in species composition	4	-4	3	3	3	-144	Major Negative	• Landscaping along streetscape and within the new development	4	-4	3	3	3	-144	Major Negative
	Changes in soil and topography	2	-4	3	3	3	-72	Minor Negative	• Implement Earth Control Measures (ECM) Plan approved by PUB • Utilise ECM blankets made of non-plastic, 100% biodegradable material	2	-4	3	3	3	-72	Minor Negative
	Air pollution	2	-2	2	2	3	-28	Slight Negative	• Implement dust suppression plan • Install hoarding at project boundary • Place stockpiles of dusty material as far away as possible from sensitive receptors • Ensure all stockpiles are properly stored, covered entirely with impervious sheeting, or regularly dampened with water • Regularly water exposed surfaces/roads • Avoid works that cause soil disturbance during dry and/or windy conditions	2	-1	2	2	3	-14	Slight Negative

Phase	Impact Component	Predicted Impacts Without Mitigation							Mitigation measures	Predicted Impacts With Mitigation						
		I	M	P	R	C	ES	ES Impact		I	M	P	R	C	ES	ES Impact
									• Backfill or reinstate excavations as soon as practicable • Enclose excavated materials with impervious sheeting during transportation • Provide vehicle washing facilities before the construction site exit • Proper maintenance of construction vehicles and fuel burning equipment • Shut down vehicles and machinery when not in use							
	Light disturbance	2	-2	2	2	3	-28	Slight Negative	• Avoid night works where possible (i.e., limit construction activities to 8 am – 6 pm) • If nightworks are necessary, develop and implement the Light Management Plan approved by NParks • Use construction lights that are shielded, and directed downwards and away from vegetated areas • Turn off all unnecessary lights outside working hours	2	-1	2	2	3	-14	Slight Negative
Operation	Light disturbance	2	-2	3	2	3	-32	Slight Negative	• Use shielded lights that are directed downwards and away from vegetated areas • Adjust the number and intensity of lights abutting forests to minimum levels required for safety and security • Use motion-activated lighting in areas less frequently visited	2	-1	3	2	3	-16	Slight Negative

Table 7.8. Comparison of RIAM scoring on predicted impacts to fauna without and with mitigation for Scenario A

Phase	Impact Component		Predicted Impacts Without Mitigation							Mitigation measures	Predicted Impacts With Mitigation						
			I	M	P	R	C	ES	ES Impact		I	M	P	R	C	ES	ES Impact
Pre-Construction / Construction	Habitat loss		4	-4	3	3	3	-144	Major Negative	-	4	-4	3	3	3	-144	Major Negative
	Loss in ecological connectivity	Volant fauna	3	-1	3	3	3	-27	Slight Negative	• Sparsely planted landscaping can be implemented along the edges of Old Jurong Road and Upper Bukit Timah Road • Landscaping can incorporate bird- and butterfly-attracting shrubs, including species that naturally occur in the study area	3	-1	3	3	3	-27	Slight Negative
		Non-volant fauna	4	-3	3	3	3	-108	Moderate Negative		4	-2	3	3	3	-72	Minor Negative
		Malayan colugo	3	-4	3	3	3	-108	Moderate Negative	-	3	-4	3	3	3	-108	Moderate Negative
	Species mortality or injury	Volant fauna	3	-2	2	3	3	-48	Minor Negative	• Phased/directional clearance of vegetation • Active translocation of wildlife • Visual inspections of trees and holes for nesting birds and animals prior to felling	3	-1	2	3	3	-24	Slight Negative
		Non-volant fauna	4	-4	2	3	3	-128	Major Negative		4	-3	2	3	3	-96	Moderate Negative
	Roadkill or road injury to fauna attempting to cross the road	Volant fauna	3	-1	2	3	3	-24	Slight Negative	• Hoarding of project area prior to vegetation clearance and works • Phased/directional clearance of vegetation • Wildlife shepherding/translocation	3	-1	2	3	3	-24	Slight Negative
		Non-volant fauna	4	-3	2	3	3	-96	Moderate Negative		4	-1	2	3	3	-32	Slight Negative
	Human-wildlife conflict		2	-4	2	2	3	-56	Minor Negative	• Designated eating areas for construction personnel • Monkey-proof bins • Biodiversity awareness training for construction personnel • Wildlife Response and Rescue Protocol • Wildlife incidence reporting framework	2	-2	2	2	3	-28	Slight Negative

Phase	Impact Component	Predicted Impacts Without Mitigation							Mitigation measures	Predicted Impacts With Mitigation						
		I	M	P	R	C	ES	ES Impact		I	M	P	R	C	ES	ES Impact
	Air pollution	4	-2	2	2	3	-56	Minor Negative	• No thermal fogging is to be conducted in close proximity to forested areas • Implement dust suppression plan Install hoarding at project boundary Place stockpiles of dusty material as far away as possible from sensitive receptors • Ensure all stockpiles are properly stored, covered entirely with impervious sheeting, or regularly dampened with water • Regularly water exposed surfaces/roads • Avoid works that cause soil disturbance during dry and/or windy conditions • Backfill or reinstate excavations as soon as practicable • Enclose excavated materials with impervious sheeting during transportation • Provide vehicle washing facilities before the construction site exit • Proper maintenance of construction vehicles and fuel burning equipment • Shut down vehicles and machinery when not in use	4	-1	2	2	3	-28	Slight Negative

Phase	Impact Component	Predicted Impacts Without Mitigation							Mitigation measures	Predicted Impacts With Mitigation						
		I	M	P	R	C	ES	ES Impact		I	M	P	R	C	ES	ES Impact
	Noise and ground-borne vibration disturbance	4	-4	2	2	3	-112	Moderate Negative	• Install 6 m to 12 m-high noise barriers around the work site • No heavy nightworks (i.e., limit heavy construction activities to 8 am – 6 pm) • Conduct continuous noise and vibration level monitoring throughout the construction phase • Maintain construction noise levels within NEA's acceptable limits • Stagger excavation, earth-moving, and pilling activities • Use equipment or methods which generate lower noise and vibration levels (e.g., silent piler, static compactor, hydraulic tools) • Use equipment or methods which reduce noise and vibration levels (e.g., isolators, acoustic enclosures, noise panels, exhaust silencers) • Ensure all machinery used and access roads are well-maintained • Control the speed of vehicle movement within the worksite to 10 km/hour • Route heavily loaded trucks away from the sensitive receptors as far away as possible • Remind construction personnel on noise-reduction behaviours daily • Shut down vehicles and machinery when not in use	4	-2	2	2	3	-56	Minor Negative
	Light disturbance	4	-4	2	2	3	-112	Moderate Negative	• Avoid night works where possible (i.e., limit construction activities to 8 am – 6 pm) • If nightworks are necessary, develop and implement the Light Management Plan approved by NParks • Use construction lights that are shielded, and directed downwards and away from vegetated areas • Turn off all unnecessary lights outside working hours	4	-2	2	2	3	-56	Minor Negative

Phase	Impact Component	Predicted Impacts Without Mitigation							Mitigation measures	Predicted Impacts With Mitigation						
		I	M	P	R	C	ES	ES Impact		I	M	P	R	C	ES	ES Impact
	Water pollution	1	-2	2	2	3	-14	Slight Negative	• Implement Earth Control Measures (ECM) Plan approved by PUB • Ensure only treated water is discharged from site • Utilise ECM blankets made of non-plastic, 100% biodegradable material • Foreign material should be removed from site by a licensed waste collector, not be illegally disposed at the water bodies • Excess loose soil and rock to be contained prior to the commencement of the works • To ensure that slurry is contained within the working area and does not enter any watercourses or surface water drains • Micropile storage tanks for slurry should have secondary containment • Vehicle fuelling and major maintenance to be minimised within the project area • Diesel/ fuel tanks are to be located away from any watercourses or surface water drains • To ensure that diesel has stopped leaking from the hose before removing it • To ensure that the inside of the hose is cleared after refuelling • Appropriate concrete wash bays should be provided and should not be performed in or near any waterbody • Emergency spill kits should be provided by contractor on site in the event of any chemical spillage • Emergency response team should also be trained in the use of these spill kits	1	-1	2	2	3	-7	Slight Negative
Operation	Light disturbance	4	-2	3	2	3	-64	Minor Negative	• Use shielded lights that are directed downwards and away from vegetated areas • Adjust the number and intensity of lights abutting forests to minimum levels required for safety and security • Use motion-activated lighting in areas less frequently visited	4	-1	3	2	3	-32	Slight Negative

Phase	Impact Component	Predicted Impacts Without Mitigation							Mitigation measures	Predicted Impacts With Mitigation						
		I	M	P	R	C	ES	ES Impact		I	M	P	R	C	ES	ES Impact
	Change in species composition	4	-4	3	3	3	-144	Major Negative	-	4	-4	3	3	3	-144	Major Negative
	Human-Wildlife Conflict	2	-3	3	2	3	-48	Minor Negative	• Wildlife-proof refuge centre and bins • Educational signages on wildlife	2	-2	3	2	3	-32	Slight Negative
	Noise disturbance	4	-2	3	2	3	-64	Minor Negative	• Enforcement actions to deter noise nuisances from residents at common spaces and amenities after 10:30 pm • Implement speed limits near forested areas where necessary	4	-1	3	2	3	-32	Slight Negative

Table 7.9. Comparison of RIAM scoring on predicted impacts to habitat without and with mitigation for Scenario A

Phase	Impact Component	Predicted Impacts Without Mitigation							Mitigation measures	Predicted Impacts With Mitigation						
		I	M	P	R	C	ES	ES Impact		I	M	P	R	C	ES	ES Impact
Pre-Construction and Construction	Habitat loss	3	-4	3	3	3	-108	Moderate Negative	-	3	-4	3	3	3	-108	Moderate Negative
	Loss in ecological connectivity	3	-3	3	3	3	-81	Moderate Negative	-	3	-3	3	3	3	-81	Moderate Negative
	Edge effects	N.A.														
	Disruption and reversal of forest succession process	3	-4	3	3	3	-108	Moderate Negative	-	3	-4	3	3	3	-108	Moderate Negative
Operation	Edge effects	N.A.														
	Habitat enhancement	1	1	3	3	3	9	Slight Positive	-	1	1	3	3	3	9	Slight Positive

7.6.2 Scenario B

Residual impacts are assessed for flora, fauna and habitat sensitive receptors in Table 7.10, Table 7.11 and Table 7.12 respectively, assuming all trees within a Proposed Retained Area (PRA) are retained, and all general mitigation measures listed in Section 7.5.1 and below are fully implemented.

Table 7.10. Comparison of RIAM scoring on predicted impacts to flora without and with mitigation for Scenario B

Phase	Impact Component	Predicted Impacts Without Mitigation							Mitigation measures	Predicted Impacts With Mitigation (Scenario B)						
		I	M	P	R	C	ES	ES Impact		I	M	P	R	C	ES	ES Impact
Pre-Construction and Construction	Habitat loss	4	-4	3	3	3	-144	Major Negative	• Retention of PRA with NDOSF and NDYSF	4	-2	3	3	3	-72	Minor Negative
	Loss in ecological connectivity	3	-4	3	3	3	-108	Moderate Negative	• Retain conservation significant large trees • Planting of native flora species • Retention of PRA	3	-2	3	3	3	-54	Minor Negative
	Species mortality or injury	3	-4	3	3	3	-108	Moderate Negative	• Retain conservation significant large trees • Plant salvaging • Retention of PRA	3	-2	3	3	3	-54	Minor Negative
	Change in species composition	4	-4	3	3	3	-144	Major Negative	• Plant salvaging and planting of native flora species • Retention of PRA	4	-2	3	3	3	-72	Minor Negative
	Changes in soil and topography	2	-4	3	3	3	-72	Minor Negative	• Avoid having retained trees at lower elevation to prevent waterlogging in such areas • Implement Earth Control Measures (ECM) Plan approved by PUB • Utilise ECM blankets made of non-plastic, 100% biodegradable material • Excess loose soil and rock to be contained prior to the commencement of the works	2	-3	3	3	3	-54	Minor Negative
	Air pollution	2	-2	2	2	3	-28	Slight Negative	• Implement dust suppression plan • Install hoarding at project boundary • Place stockpiles of dusty material as far away as possible from sensitive receptors	2	-1	2	2	3	-14	Slight Negative

Phase	Impact Component	Predicted Impacts Without Mitigation							Mitigation measures	Predicted Impacts With Mitigation (Scenario B)						
		I	M	P	R	C	ES	ES Impact		I	M	P	R	C	ES	ES Impact
									• Ensure all stockpiles are properly stored, covered entirely with impervious sheeting, or regularly dampened with water • Regularly water exposed surfaces/roads • Avoid works that cause soil disturbance during dry and/or windy conditions • Backfill or reinstate excavations as soon as practicable • Enclose excavated materials with impervious sheeting during transportation • Provide vehicle washing facilities before the construction site exit • Proper maintenance of construction vehicles and fuel burning equipment • Shut down vehicles and machinery when not in use							
	Light disturbance	2	-2	2	2	3	-28	Slight Negative	• Avoid night works where possible (i.e., limit construction activities to 8 am – 6 pm) • If nightworks are necessary, develop and implement the Light Management Plan approved by NParks • Use construction lights that are shielded, and directed downwards and away from vegetated areas and the PRA • Turn off all unnecessary lights outside working hours • Hoarding of at least 6m height with additional 0.5-1m flap angling towards forest edge of the PRA	2	-1	2	2	3	-14	Slight Negative
Operation	Light disturbance	2	-2	3	2	3	-32	Slight Negative	• Use shielded lights that are directed downwards and away from PRA • Adjust the number and intensity of lights abutting the forest to minimum levels required for safety and security	2	-1	3	2	3	-16	Slight Negative

Phase	Impact Component	Predicted Impacts Without Mitigation							Mitigation measures	Predicted Impacts With Mitigation (Scenario B)						
		I	M	P	R	C	ES	ES Impact		I	M	P	R	C	ES	ES Impact
									• Use motion-activated lighting in areas less frequently visited • Buffer planting with hedges along the boundary of the PRA							

Table 7.11. Comparison of RIAM scoring on predicted impacts to fauna without and with mitigation for Scenario B

Phase	Impact Component		Predicted Impacts Without Mitigation							Mitigation measures	Predicted Impacts With Mitigation (Scenario B)						
			I	M	P	R	C	ES	ES Impact		I	M	P	R	C	ES	ES Impact
Pre-Construction / Construction	Habitat loss		4	-4	3	3	3	-144	Major Negative	Retention of PRA	4	-3	3	3	3	-108	Moderate Negative
	Loss in ecological connectivity to other vegetated areas in vicinity	Volant fauna	3	-1	3	3	3	-27	Slight Negative	• Sparsely planted landscaping can be implemented along the edges of Old Jurong Road and Upper Bukit Timah Road • Landscaping can incorporate bird- and butterfly-attracting shrubs, including species that naturally occur in the study area • Retention of PRA	3	-1	3	3	3	-27	Slight Negative
		Non-volant fauna	4	-3	3	3	3	-108	Moderate Negative		4	-1	3	3	3	-36	Slight Negative
		Malayan colugo	3	-4	3	3	3	-108	Moderate Negative	Retention of PRA	3	-1	3	3	3	-27	Slight Negative
	Species mortality or injury	Volant fauna	3	-2	2	3	3	-48	Minor Negative	• Phased/directional clearance of vegetation • Active translocation of wildlife • Visual inspections of trees and holes for nesting birds and animals prior to felling	3	-1	2	3	3	-24	Slight Negative
		Non-volant fauna	4	-4	2	3	3	-128	Major Negative		4	-1	2	3	3	-32	Slight Negative
	Roadkill or road injury to fauna attempting to cross the road	Volant fauna	3	-1	2	3	3	-24	Slight Negative	• Hoarding of project area prior to vegetation clearance and works • Phased/directional clearance of vegetation • Wildlife shepherding/translocation	3	-1	2	3	3	-24	Slight Negative
		Non-volant fauna	4	-3	2	3	3	-96	Moderate Negative		4	-1	2	3	3	-32	Slight Negative

Phase	Impact Component	Predicted Impacts Without Mitigation							Mitigation measures	Predicted Impacts With Mitigation (Scenario B)						
		I	M	P	R	C	ES	ES Impact		I	M	P	R	C	ES	ES Impact
	Human-wildlife conflict	2	-4	2	2	3	-56	Minor Negative	• Designated eating areas for construction personnel • Monkey-proof bins • Biodiversity awareness training for construction personnel • Wildlife Response and Rescue Protocol • Wildlife incidence reporting framework	2	-3	2	2	3	-42	Minor Negative
	Air pollution	4	-2	2	2	3	-56	Minor Negative	• No thermal fogging is to be conducted in close proximity to forested areas • Implement dust suppression plan • Install hoarding at project boundary • Place stockpiles of dusty material as far away as possible from sensitive receptors • Ensure all stockpiles are properly stored, covered entirely with impervious sheeting, or regularly dampened with water • Regularly water exposed surfaces/roads • Avoid works that cause soil disturbance during dry and/or windy conditions • Backfill or reinstate excavations as soon as practicable • Enclose excavated materials with impervious sheeting during transportation • Provide vehicle washing facilities before the construction site exit • Proper maintenance of construction vehicles and fuel burning equipment • Shut down vehicles and machinery when not in use	4	-1	2	2	3	-28	Slight Negative

Phase	Impact Component	Predicted Impacts Without Mitigation							Mitigation measures	Predicted Impacts With Mitigation (Scenario B)						
		I	M	P	R	C	ES	ES Impact		I	M	P	R	C	ES	ES Impact
	Noise and ground-borne vibration disturbance	4	-4	2	2	3	-112	Moderate Negative	• Install 6 m to 12 m-high noise barriers around the work site • No heavy nightworks (i.e., limit heavy construction activities to 8 am – 6 pm) • Conduct continuous noise and vibration level monitoring throughout the construction phase • Maintain construction noise levels within NEA's acceptable limits • Stagger excavation, earth-moving, and pilling activities • Use equipment or methods which generate lower noise and vibration levels (e.g., silent piler, static compactor, hydraulic tools) • Use equipment or methods which reduce noise and vibration levels (e.g., isolators, acoustic enclosures, noise panels, exhaust silencers) • Ensure all machinery used and access roads are well-maintained • Control the speed of vehicle movement within the worksite to 10 km/hour • Route heavily loaded trucks away from the sensitive receptors as far away as possible • Remind construction personnel on noise-reduction behaviours daily • Shut down vehicles and machinery when not in use	4	-2	2	2	3	-56	Minor Negative
	Light disturbance	4	-4	2	2	3	-112	Moderate Negative	• Avoid night works where possible (i.e., limit construction activities to 8 am – 6 pm) • If nightworks are necessary, develop and implement the Light Management Plan approved by NParks • Use construction lights that are shielded, and directed downwards and away from vegetated areas • Turn off all unnecessary lights outside working hours	4	-2	2	2	3	-56	Minor Negative

Phase	Impact Component	Predicted Impacts Without Mitigation							Mitigation measures	Predicted Impacts With Mitigation (Scenario B)						
		I	M	P	R	C	ES	ES Impact		I	M	P	R	C	ES	ES Impact
	Water pollution	1	-2	2	2	3	-14	Slight Negative	• Implement Earth Control Measures (ECM) Plan approved by PUB • Ensure only treated water is discharged from site • Utilise ECM blankets made of non-plastic, 100% biodegradable material • Foreign material should be removed from site by a licensed waste collector, not be illegally disposed at the water bodies • Excess loose soil and rock to be contained prior to the commencement of the works • To ensure that slurry is contained within the working area and does not enter any watercourses or surface water drains • Micropile storage tanks for slurry should have secondary containment • Vehicle fuelling and major maintenance to be minimised within the project area • Diesel/ fuel tanks are to be located away from any watercourses or surface water drains • To ensure that diesel has stopped leaking from the hose before removing it • To ensure that the inside of the hose is cleared after refuelling • Appropriate concrete wash bays should be provided and should not be performed in or near any waterbody • Emergency spill kits should be provided by contractor on site in the event of any chemical spillages. Emergency response team should also be trained in the use of these spill kits	1	-1	2	2	3	-7	Slight Negative

Phase	Impact Component	Predicted Impacts Without Mitigation							Mitigation measures	Predicted Impacts With Mitigation (Scenario B)						
		I	M	P	R	C	ES	ES Impact		I	M	P	R	C	ES	ES Impact
Operation	Light disturbance	4	-2	3	2	3	-64	Minor Negative	• Use shielded lights that are directed downwards and away from vegetated areas • Adjust the number and intensity of lights abutting forests to minimum levels required for safety and security • Use motion-activated lighting in areas less frequently visited	4	-1	3	2	3	-32	Slight Negative
	Change in species composition	4	-4	3	3	3	-144	Major Negative	• Retention of PRA	4	-2	3	3	3	-72	Minor Negative
	Human-Wildlife Conflict	2	-3	3	2	3	-48	Minor Negative	• Wildlife-proof refuge centre and bins • Educational signages on wildlife	2	-3	3	2	3	-48	Minor Negative
	Noise disturbance	4	-2	3	2	3	-64	Minor Negative	• Enforcement actions to deter noise nuisances from residents at common spaces and amenities after 10:30 pm • Implement speed limits near forested areas where necessary	4	-1	3	2	3	-32	Slight Negative

Table 7.12. Comparison of RIAM scoring on predicted impacts to habitat without and with mitigation for Scenario B

Phase	Impact Component	Predicted Impacts Without Mitigation							Mitigation measures	Predicted Impacts With Mitigation (Scenario B)						
		I	M	P	R	C	ES	ES Impact		I	M	P	R	C	ES	ES Impact
Pre-Construction and Construction	Habitat loss	3	-4	3	3	3	-108	Moderate Negative	• Retention of part of NDYSF and part of the area with strong NDOSF regeneration in the PRA	3	-2	3	3	3	-54	Minor Negative
	Loss in ecological connectivity	3	-3	3	3	3	-81	Moderate Negative	• Retention of PRA • Propose implementation of animal crossings to improve ecological connectivity	3	-2	3	3	3	-54	Minor Negative
	Edge effects (on Proposed Retained Area (PRA))	N.A.							• Hoarding of at least 4m along the PRA boundary • The hoarding may include a flap angling inwards to the forest to limit the amount of light reaching the understorey of forest edge to deter invasive weed growth • No encroachment in PRA • Flora monitoring	2	-1	3	2	3	-16	Slight Negative

Phase	Impact Component	Predicted Impacts Without Mitigation							Mitigation measures	Predicted Impacts With Mitigation (Scenario B)						
		I	M	P	R	C	ES	ES Impact		I	M	P	R	C	ES	ES Impact
	Disruption and reversal of forest succession process	3	-4	3	3	3	-108	Moderate Negative	• Plant salvaging • Planting of native species • Retention of PRA • Transplanting of salvaged plants to the PRA	3	-2	3	3	3	-54	Minor Negative
Operation	Edge effects (on Proposed Retained Area (PRA))	N.A							• Maintain buffer distance between PRA and development footprint • Buffer planting along PRA boundary • Adjust design of development to reduce anthropogenic activities nearby to PRA	2	-1	3	2	3	-16	Slight Negative
	Habitat enhancement	1	1	3	3	3	9	Slight Positive	-	1	1	3	3	3	9	Slight Positive

7.7 Cumulative Impacts

The assumed residential development and road works in the study area are expected to take place concurrently with the proposed development of former Bukit Timah Fire Station and an eco-pedestrian bridge across Upper Bukit Timah Road, as well as enhancement works at BBNP, Bukit Batok Town Park and proposed Bukit Batok Hillside Nature Park, as part of the BBNC (Ramboll Pte Ltd, 2025). Furthermore, there are ongoing construction works at The Sen, a condominium development bounded by Old Jurong Road and Jln Jurong Kechil, directly adjacent to the study area. Among these developments, BBNP, eco-pedestrian bridge, Old Bukit Timah Fire Station and The Sen are located within 300m of the study area and will be considered for cumulative impacts to sensitive receptors.

7.7.1 Construction Phase

While detailed construction activities are unavailable for the eco-pedestrian bridge and Old Bukit Timah Fire Station, enhancement works at BBNP are expected to entail refurbishment of a carpark, toilet and existing trails, including slope stabilisation works with micro piling and soil nails (Ramboll Pte Ltd, 2025). Works at The Sen for residential development are likely to entail demolition works, earthworks, piling, substructure and superstructure works. Altogether, these works are likely to mainly affect flora and fauna sensitive receptors and could potentially result in increased (i) roadkill or road injury to fauna attempting to cross the road, (ii) air pollution and (iii) noise and ground-borne vibration disturbance.

Roadkill or Road Injury to Fauna Attempting to Cross the Road

The development works in BBNP are expected to have a small loss in habitat for fauna species (Ramboll Pte Ltd, 2025). Despite the small construction footprint, should the works take place concurrently with that of the study area, fauna species can be expected to face disturbance and be driven out of construction areas. Considering both the study area and BBNP border Old Jurong Road and Upper Bukit Timah Road, there is a possibility that disturbed fauna may venture onto roads and be unable to get to undisturbed vegetated areas. With the increase in traffic from construction vehicles in both construction areas, impacts of roadkill to non-volant fauna may increase further. However, with mitigation measures proposed in Section 7.5 and 7.6, and for the BBNP project, such as road calming measures (Ramboll Pte Ltd, 2025), the overall residual cumulative impact to fauna is expected to remain as slight negative.

Air Pollution

Dust is expected to be generated from minor demolition works in BBNP, as well as slope forming and stabilisation activities resulting in exposed earth surfaces (Ramboll Pte Ltd, 2025). Demolition and earthworks at The Sen will also likely result in dust emissions. Given the proximity of the study area to BBNP and The Sen, it is possible that these air emissions will reach flora and fauna sensitive receptors in the study area. However, given mitigation measures such as the implementation of a dust suppression plan, the overall residual cumulative impact to flora and fauna will likely remain as slight negative and minor negative respectively.

Noise and Ground-Borne Vibration Disturbance

During the construction phase of The Sen, noise and vibration will be generated by demolition of the existing buildings, earthworks, foundation works, and general construction activities, including the operation of machinery and vehicle movements. Furthermore, given that noise was assessed to have high impact intensity and minor to moderate significance to ecological receptors from works in BBNP (Ramboll Pte Ltd, 2025), the combined noise disturbance could further stress sensitive fauna species in the study area. Individually, construction activities are expected to result in temporary, localised increases in noise levels. However, when considered cumulatively with other concurrent developments, construction noise may occur over extended periods, resulting in a prolonged elevation of ambient noise levels. Without mitigation, cumulative construction noise impacts may increase from moderate negative to major negative in the short to medium term. Mitigation measures such as noise barriers and acoustic enclosures will likely be able to reduce the residual impact to moderate to minor negative.

7.7.2 Operation Phase

Given that the scale of works at BBNP are relatively minor and the area is already open to park visitors, there are unlikely to be significant impacts above baseline levels during the operation phase. The residential development at The Sen is also taking place on urban land-use; thus, any increases in human disturbance due to light and noise is likely to be slight. Residual operational noise impacts are generally expected to be slight negative and largely consistent with residential and recreational land-use expectations.

The operation of the eco-pedestrian bridge along Upper Bukit Timah Road, however, may potentially mitigate losses in ecological connectivity from proposed developments in the study area by providing a safe crossing for non-volant fauna between BBNP to BTNR.

7.8 Summary of Impact Assessment

A summary and comparison of the impacts without mitigation and with mitigation for the two scenarios are shown in Table 7.13, Table 7.14 and Table 7.15.

Table 7.13. Comparison of predicted impacts to flora without and with mitigation for the two scenarios

Phase	Impact Component	Predicted Impacts Without Mitigation		Predicted Impacts With Mitigation			
				Scenario A		Scenario B	
		ES	ES Impact	ES	ES Impact	ES	ES Impact
Pre-Construction and Construction	Habitat loss	-144	Major Negative	-144	Major Negative	-72	Minor Negative
	Loss in ecological connectivity	-108	Moderate Negative	-108	Moderate Negative	-54	Minor Negative
	Species mortality or injury	-108	Moderate Negative	-81	Moderate Negative	-54	Minor Negative
	Change in species composition	-144	Major Negative	-144	Major Negative	-72	Minor Negative
	Changes in soil and topography	-72	Minor Negative	-72	Minor Negative	-54	Minor Negative
	Air pollution	-28	Slight Negative	-14	Slight Negative	-14	Slight Negative
	Light disturbance	-28	Slight Negative	-14	Slight Negative	-14	Slight Negative
Operation	Light disturbance	-32	Slight Negative	-16	Slight Negative	-16	Slight Negative

Table 7.14. Comparison of predicted impacts to fauna without and with mitigation for the two scenarios

Phase	Impact Component		Predicted Impacts Without Mitigation		Predicted Impacts With Mitigation			
					Scenario A		Scenario B	
			ES	ES Impact	ES	ES Impact	ES	ES Impact
Pre-Construction / Construction	Habitat loss		-144	Major Negative	-144	Major Negative	-108	Moderate Negative
	Loss in ecological connectivity	Volant fauna	-27	Slight Negative	-27	Slight Negative	-27	Slight Negative
		Non-volant fauna	-108	Moderate Negative	-72	Minor Negative	-36	Slight Negative
		Malayan colugo	-108	Moderate Negative	-108	Moderate Negative	-27	Slight Negative
	Species mortality or injury	Volant fauna	-48	Minor Negative	-24	Slight Negative	-24	Slight Negative
		Non-volant fauna	-128	Major Negative	-96	Moderate Negative	-32	Slight Negative
	Roadkill or road injury to fauna attempting to cross the road	Volant fauna	-24	Slight Negative	-24	Slight Negative	-24	Slight Negative
		Non-volant fauna	-96	Moderate Negative	-32	Slight Negative	-32	Slight Negative
	Human-wildlife conflict		-56	Minor Negative	-28	Slight Negative	-42	Minor Negative

	Air pollution	-56	Minor Negative	-28	Slight Negative	-28	Slight Negative
	Noise and ground-borne vibration disturbance	-112	Moderate Negative	-56	Minor Negative	-56	Minor Negative
	Light disturbance	-112	Moderate Negative	-56	Minor Negative	-56	Minor Negative
	Water pollution	-14	Slight Negative	-7	Slight Negative	-7	Slight Negative
Operation	Light disturbance	-64	Minor Negative	-32	Slight Negative	-32	Slight Negative
	Change in species composition	-144	Major Negative	-144	Major Negative	-72	Minor Negative
	Human-Wildlife Conflict	-48	Minor Negative	-32	Slight Negative	-48	Minor Negative
	Noise disturbance	-64	Minor Negative	-32	Slight Negative	-32	Slight Negative

Table 7.15. Comparison of predicted impacts to habitat without and with mitigation for the two scenarios

Phase	**Impact Component**	**Predicted Impacts Without Mitigation**		**Predicted Impacts With Mitigation**			
				Scenario A		**Scenario B**	
		ES	**ES Impact**	**ES**	**ES Impact**	**ES**	**ES Impact**
Pre-Construction and Construction	Habitat loss	-108	Moderate Negative	-108	Moderate Negative	-54	Minor Negative
	Loss in ecological connectivity	-81	Moderate Negative	-81	Moderate Negative	-54	Minor Negative
	Edge effects	N.A.				-16	Slight Negative
	Disruption and reversal of forest succession process	-108	Moderate Negative	-108	Moderate Negative	-54	Minor Negative
Operation	Edge effects	N.A.				-16	Slight Negative
	Habitat enhancement	9	Slight Positive	9	Slight Positive	9	Slight Positive

8 ENVIRONMENTAL MONITORING AND MANAGEMENT PLAN

8.1 Overview

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 the project implementation of a typical development project 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 the assumed development works to minimal and acceptable levels during the construction.

The EMMP framework presented in this chapter is an outcome from the EIA process. This EMMP framework consolidates the mitigation and monitoring strategy required for the assumed works for a typical development project, and the appointed Contractor shall adhere to this strategy, develop it further and implement throughout during the construction phase.

8.2 Construction EMMP

Before the construction works start, the appointed Contractor and Environmental Consultant will establish a detailed Construction EMMP (CEMMP) based on this EMMP framework, which is to be implemented and monitored during the construction phase. The Contractor shall be responsible for submitting and obtaining approval for CEMMP from NParks and other relevant Technical Agencies before commencement of works.

The CEMMP is to include the identified mitigation measures of this EIA and shall address the methodologies of the construction works prior to their commencement. Additionally, Fauna and Flora Management Plans recommended in this chapter need to be incorporated in the CEMMP with involvement of flora and fauna specialists from the EMMP team to finetune 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 the surrounding vegetated area.

The CEMMP shall include environmental monitoring, which comprises of compliance inspections for prescribed mitigation measures and ambient environmental data collection, 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 are maintained.

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 report should report on successful or failed follow-up actions until a problem has been effectively mitigated.

Table 8.7 provides the overview of recommended EMMP measures for this project which is to be incorporated into the CEMMP by the Contractor. The environmental monitoring locations are to be finalised by the EMMP team during CEMMP formulation in consultation with relevant stakeholders.

8.3 EMMP Team

The Contractors shall be responsible for implementing all the environmental requirements specified in this EIA report including CEMMP conditions as well as requirements mandated by the applicable regulations and relevant authorities. It is recommended that to implement the CEMMP, an EMMP team with the necessary qualifications and experience shall be available throughout the construction period to support the Contractor. The EMMP team should include but not be limited to the following:

Table 8.1. Roles and Responsibilities of EMMP Team Members

Role Name	Qualification	Responsibilities
Environmental Manager/ Environment Control Officer (ECO)	Valid registration with the National Environment Agency (NEA) and demonstrated previous work experience in developments of similar size or complexity.	To act as CEMMP in-charge and lead the implementation and reporting requirements of CEMMP during construction phase. Responsible for managing all environmental issues arising from the construction work which includes monitoring and ensuring the implementation and management of change of the CEMMP, the environmental performance of the project, investigation of incidents, inspections of site and implementations of corrective/ preventive measures. To coordinate with other EMMP team members for advice on specific issues related to CEMMP implementation. To prepare monthly environmental performance monitoring reports.
Contractor's Qualified Erosion Control Professional (QECP)	Valid registration with the Institution of Engineers Singapore (IES)	Responsible to prepare, submit and obtain approval for Earth Control Measures (ECM) Plan from PUB prior to Contractors start work. To ensure that the Contractors implement the ECM in compliance with the ECM Plan and conduct periodic monitoring of ECM Plan.
Arborist/ Flora Specialist	Certified Arborist (CA) with an International Society of Arboriculture (ISA) certification with 8 years' experience.	To prepare project site-specific flora management plan as part of CEMMP, utilising the EMMP framework recommended in the EIA and assist the Contractor in obtaining authority approval. To review the flora that will be affected, and to provide monitoring and advice to the Contractor on matters related to tree protection. To visit the site fortnightly to oversee the implementation of flora management plan and provide monthly reports. To advise and implement specific measures in the case of tree pruning prior to clearance, tree injury, and construction activities affecting tree roots. To provide checks on Tree Protection Zone (TPZ). To

Role Name	Qualification	Responsibilities
		assist in reporting requirements of CEMMP during construction phase. To liaise with NParks on addressing any comments/ requirements related to flora implementation measures.
Ecologist / Wildlife Specialist	Experience in wildlife in Singapore and/or the region	To prepare project site-specific fauna management plan as part of CEMMP, utilising the EMMP framework recommended in the EIA and assist the Contractor in obtaining authority approval. To conduct pre-clearance wildlife inspections and prepare wildlife management protocols as necessary during site clearance stage. To provide advice and inspection related to wildlife throughout the construction duration and to identify, rescue & manage any trapped and/or injured wildlife at project site. To visit the site fortnightly to oversee the implementation of fauna management plan and to provide biodiversity awareness training to site personnel. To assist in reporting requirements of CEMMP during construction phase. To liaise with NParks on addressing any comments/ requirements related to wildlife implementation measures.

8.4 Environmental Objectives

Environmental Objectives for the project are recommended below. Contractors are required to adhere to the Environmental Objectives during the entire construction stage.

- Minimise removal of conservation-significant flora species at or adjacent to worksite.
- Maximise harvesting of saplings and transplantation of conservation-significant flora species that will be affected.
- Prevent risk of fauna injury related to construction such as from fauna re-entry to worksite.
- Prevent human-wildlife conflicts at or near to worksite.
- Ensure the health of retained, translocated, and planted flora.
- Ensure noise impacts comply with adjusted Maximum Permissible Noise Limits.
- Ensure water quality impacts comply with PUB and NEA allowable limits for trade effluent quality.
- Ensure no transmission of vector borne diseases.
- Ensure no indiscriminate / illegal disposal of waste.
- Ensure no spillage / leakage of hazardous material.

8.5 Training requirements

The site personnel involved in implementation of CEMMP shall be adequately trained. Assessments of training needs shall be conducted regularly and should also include any sub-contractors concerned. The contractors shall ensure that trainings are conducted before the starting the construction work and at regular intervals for site personnel during the construction phase. The recommended training programme is provided in Table 8.2.

Table 8.2. Training programme for site personnel

Training Schedule	Training Topics	Conducted By	Target Audience	Frequency
Prior to commencement of activities on site	CEMMP Requirements Biodiversity & Environmental Awareness	EMMP Consultant	Environmental Manager/ ECO/ Project Manager / Construction Manager/ Construction Engineers/ Site Supervisors/ Sub-contractors	Once
Refresher training	Biodiversity & Environmental Awareness Briefing	EMMP Consultant	Site Personnel including Sub-contractors	Monthly during construction phase
Toolbox meetings	Briefing to include reminders on wildlife encounters and environmental protection	CEMMP In-charge/ ECO	Construction Workers including Sub-contractors	Daily

8.6 Environmental Emergency Response Procedure

The regular and continual environmental monitoring may result in observations of failed or inadequate mitigation measures. Also, a public complaint/ observation may be received. Examples of environmental emergencies are described below.

- Incident related to human-wildlife conflict
- Discovery of wildlife within construction site
- Incident of injury to wildlife due to work activity
- Damage to retained/ translocated flora
- Earth control measures (i.e., silt fence, cut-off drain, treatment) are ineffective
- Discharge of ECM does not meet regulatory limits
- Illegal water discharge from construction site
- Noise levels from construction activities exceed maximum permissible limits
- Dust event due to dry weather conditions and high winds
- Release of hazardous materials to land and watercourse
- Illegal disposal of waste into vegetated area
- Community complaint relating to pollution

In the event that a failure is discovered, that failure must be reported to the CEMMP In-charge/ Project Manager within the shortest possible time. The CEMMP In-charge/ Project Manager will be responsible for ensuring adequate follow-up activities. This may include:

- Consultation with the EMMP specialists/ QECP/ VCO/ PRO.
- Arranging an immediate appropriate response on guidance of EMMP Specialists/ QECP/ VCO as necessary.

- Reporting and consultation with the relevant authorities (i.e., NEA, NParks, PUB) as required.

The emergency response flowchart in handling environmental emergencies is presented in Figure 8.1. 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 is taken immediately to reduce impacts to acceptable levels.

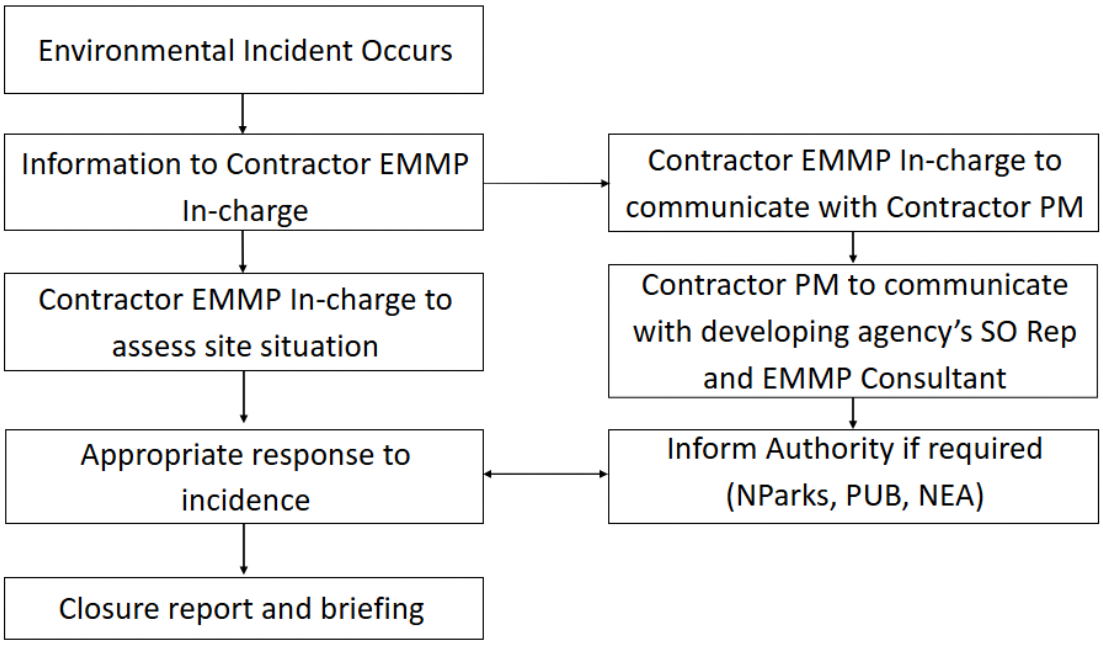


Figure 8.1. Environmental Incidence Reporting Flowchart

8.7 EMMP Reporting and Documentation

Site Environmental Control Report by Environmental Control Officer

As per the Code of Practice for Environmental Control Officers for Construction Sites, the ECO shall prepare the Site Environmental Control Programme before work commences at the worksite. Further, the ECO shall submit the Site Environmental Control Report (SECR) to the Project Manager covering assessment of the environmental efforts carried out and review of the effectiveness of these measures.

The ECO shall inspect the construction activities regularly and routinely to ensure that the appropriate environmental protection and pollution control mitigation measures are properly implemented in a timely manner based on the CEMMP's recommendations. The ECO shall record all observations and actions taken to report them in the SECR. This SECR should form part of the CEMMP monthly performance report described in next section.

Monthly Environmental Performance Report

A monthly Environmental Performance Report is to be prepared by the EMMP Team with assistance from the ECO for each phase of works, and to be submitted to the SO, project management team, NParks, and other relevant authorities. The Performance Report is to include the description of the project activities being carried out at site during the month and status of implementation of the CEMMP including information on environmental incidence if any. Table 8.3 provides the monthly environmental performance reporting framework.

Table 8.3. Monthly Environmental Performance Report Framework

Sr. No.	Item	Description
1.	Project Status	Update on project activities within study area
2.	CEMMP Implementation Status	Daily observations and actions taken, ECO report, ECM performance checklist, Ecologists' observations and recommendations, physical monitoring results (noise, air, surface water quality, ECM discharge) and assessment, vector control report, waste disposal record
3.	Environmental Awareness Training	Record of periodic biodiversity awareness training/ toolbox briefings
4.	Environmental Incident	Environmental incident report and corrective actions, public feedback & response
5.	Authority Inspection & Findings	Record of authority inspection visits (i.e., NParks, NEA, PUB) and corrective actions

Environmental Close-Off Report

A final environmental close-off report should be prepared for each phase after construction work is completed to confirm that no residual impacts are observed.

8.8 Wildlife Management Plan

Given the importance of this location as part of the BBNC, it is necessary to minimise impacts to fauna species on the site. The development of a proper Wildlife Response and Rescue Plan will help to reduce impacts to fauna, while also reducing the risk of human-wildlife conflict, which may pose a human health and safety issue if not managed.

Wildlife management should commence prior to construction works. This is to ensure that animals within the site are safely moved outside the working boundaries, either by passive shepherding or active relocation. A Wildlife Rescue and Response Plan should then be put in place for the duration of the construction period for animals that may get trapped or injured within the construction site.

All construction personnel are to be sufficiently trained on biodiversity issues on the site and how to respond to sightings of fauna.

Additionally, the Contractor shall engage an NParks Certified Animal Management

Specialist that can be mobilised immediately when the Consultant's CEMMP Specialist (Fauna)/ Ecologist recommends the relocation of fauna species at any stage during the project. The Animal Management Specialist must be a third-party contractor that has been given approval from the Director-General of Wildlife Management to conduct specific activities that are restricted by the Wildlife Act.

8.8.1 Biodiversity and Environmental Awareness Training

Prior to any construction activities, all construction personnel are to attend a biodiversity and environmental awareness training by the EMMP consultant. This training should impart important information on the ecological importance of the site, and the importance of minimising impacts to the natural environment. Also, they should be trained on the common fauna species they may encounter, and what to do should they have any wildlife encounters.

After the initial training, refresher trainings and toolbox briefings are to be conducted as specified in Section 8.5.

8.8.2 Wildlife Management during Clearance

Wildlife management during tree clearance is a requirement for the project site. Directional clearance will allow for the passive shepherding of mobile fauna species, while active relocation of animals found within the project will be required for other non-volant species due to the study area's isolation from other forested areas. This is done in order to:

- Minimise the risk of road hazards and kills from the terrestrial fauna that are displaced from the project site onto adjacent roads.
- Minimise the risk of human-wildlife conflict from animals remaining within the project boundaries
- Encourage wildlife movement into designated vegetated areas (e.g., PRA)
- Ensure safe translocation of non-volant animals to outside the construction area

Site clearance is to be conducted in the following steps:

- Setting up of TPZs for trees prior to the start of any works, which are to be maintained;
- Permanent hoarding along proposed working boundary starting along Old Jurong Road, Upper Bukit Timah Road, De Souza Ave, neighbouring residences and internal PRA boundary to prevent entry of fauna species into construction area and prevent animals from running onto the road;
- Inspection of trees and tree holes for arboreal fauna in phases, and relocation by qualified agencies and/or specialists;
- Felling of trees within each phase in one direction.

The general principles of phased site clearance can be found in Section 8.8.5.

8.8.3 Target Species

A list of target fauna species has been developed based on the findings of the EIA. Besides species encountered during the baseline surveys, other probable species that

exist on the site were also included. This list was developed with the following considerations:

- probable presence of species in the study area prior to construction;
- risks to species from being in close proximity to construction activities;
- practicality of relocating species from the construction site;
- conservation significance of species; and
- risk of road kills, road hazards, and/or human-wildlife conflict arising from uncontrolled species displacement from the study area.

The target species in the list in Table 8.4 have been categorized into two groups depending on their habits, and thus the approach required for wildlife shepherding. Fauna species in the first category are in general highly mobile species in which a passive approach is recommended, while fauna species in the second category are less mobile and would require a more active approach to shepherding.

Table 8.4. List of identified target species

Category	Species	Active Hours
Passive Shepherding	Long-tailed macaque	Diurnal
	Common palm civet	Nocturnal
Capture-and-Release	Sunda pangolin	Nocturnal
	Malayan colugo	Nocturnal
	Clouded monitor	Diurnal
	Equatorial spitting cobra	Diurnal
	Reticulated python	Nocturnal
	Other snake species	Diurnal and nocturnal

For wild boars found at or around the site at any time during the project, NParks is to be informed as soon as possible at nparks_wildlife_management@nparks.gov.sg for advice and subsequent action. An approved wild boar removal contractor must also be engaged to trap and remove said animals, the process of which may take about 4–8 weeks.

As a feral cat was observed on site during the baseline surveys, a trapping programme is to be implemented prior to the start of the construction activities. The programme is to adhere to following protocol shown in the flowchart below.

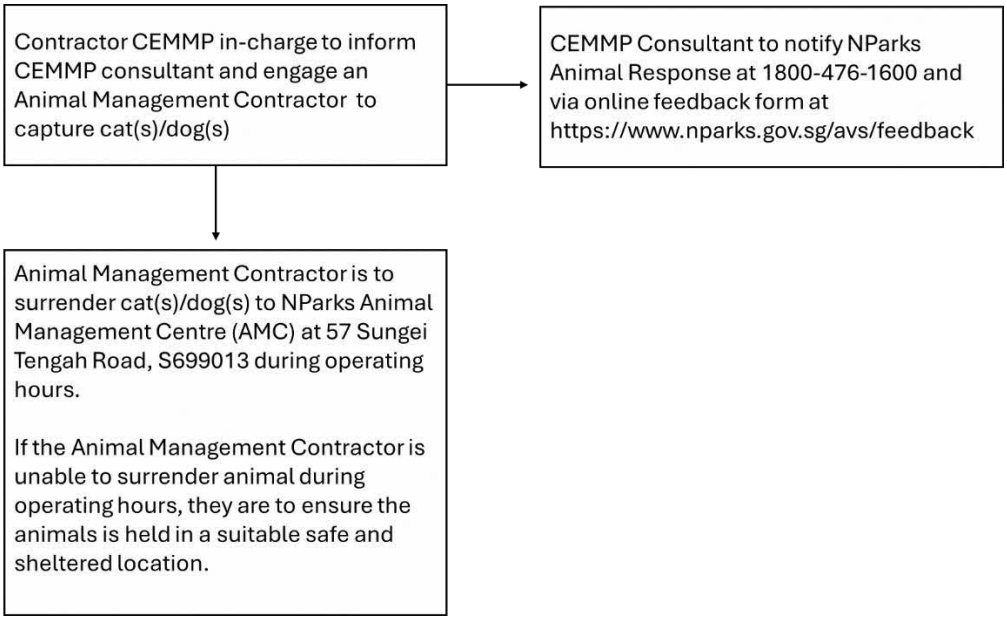


Figure 8.2. Trapping Programme Flowchart

8.8.4 Methodology and Approach

Phased tree clearance should only be conducted during scheduled daylight hours (8am to 6pm). It may include a combination of the following activities:

- Installation of hoarding along project boundaries, which would help to guide target terrestrial fauna in the intended direction of movement and act as a barrier to prevent wildlife displacement onto adjacent roads;
- Installation of temporary hoarding along width of cleared areas to prevent wildlife from re-entering the cleared areas;
- Systematic pattern of tree clearance on site in order to encourage wildlife to move in the intended direction of movement towards adjacent refuge habitats, and;
- Careful survey to check for the presence of target fauna species and any active nests or dens.

The area is to be divided into phases and clearly demarcated on site. Prior to tree-felling within a phase, undergrowth clearance is to be carried out with a fallow period of three days observed afterwards. Tree felling should only take place after the three-day fallow period.

Prior to any tree felling, the site is to be inspected by an ecologist to ensure that no target fauna and active nests or dens remain. Cleared areas should be hoarded up to prevent target terrestrial fauna from returning to the site. The wildlife inspection prior to tree felling will check for any entrapped animals within the phase. This inspection will be valid for 7 days only, during which the trapped animals must be translocated away from the site and clearance must be conducted. If more than 7 days have passed and site clearance is not yet complete, the inspection should be carried out again.

In the event that any target fauna listed in Table 8.4 are encountered during this process, the following actions, which have been developed with the consideration of reducing

stress to fauna while ensuring the effectiveness of the exercise, shall be taken:

i) Passive Shepherding: These are highly mobile species such as birds, squirrels, and bats where passive shepherding is likely to be effective. When species in this category are encountered, personnel should allow the animal to move on its own accord. If necessary, personnel may talk loudly or make some noise by clapping their hands together to encourage the animal to move. If any individual fauna is injured or trapped, the EMMP team is to call NParks' Animal Response Centre or ACRES for the appropriate removal of the animal.

ii) Capture-and-Release: Species in this group are less mobile and/or venomous, and a passive shepherding approach is deemed to be ineffective and/or unsafe. A capture-and-release approach will be needed to ensure safe relocation of these fauna from the site prior to construction. In the event that these species are encountered, NParks' Animal Response Centre or ACRES should be called immediately for the next course of action. Capture-and-release of animals encountered should be conducted by an NParks-licensed animal management company, with the relevant Letter of Approval.

Should the team encounter a visibly injured animal, NParks' Animal Response Centre or ACRES should be called immediately for the next course of action.

No attempt should be made by the EMMP team, workers, or other unqualified personnel at any point to handle animals on site. Handling animals without appropriate certification is illegal under the Wildlife Act.

For trees that are subject to removal, it is necessary to check for the presence of fauna species before each individual tree is felled.

The ecologist shall inspect the tree for the presence of fauna, including birds, bats, arboreal mammals, and arboreal herpetofauna. The ecologist should do the following:

- Check the crown of the tree for bird nests
- Check along the trunk from the bottom up for holes in which animals could be nesting
- Scan the trunk and all the branches for animals using the tree
- Scan the ground for potential nests, eggs, or burrows

Photographs of all nests, tree holes, and burrows should be taken for recording purposes. In the event that the presence of birds, bats, arboreal mammals or herpetofauna is found on the tree, tree felling or transplanting must be postponed until the animal has left the tree on its own accord.

Tree felling or transplanting should not occur during prime breeding season for birds in Singapore, between the months of mid-March to July if possible. In the event that this period is unavoidable for tree-felling, the frequency of pre-felling fauna inspections shall be increased as needed. Outside these months, if active nests are detected on the tree, nests shall be left undisturbed until the young birds have fledged. Inactive nests should

be removed to minimise the possibility of a new nesting attempt. Tree felling or transplanting shall occur only when no active nests are present on the tree.

Once tree felling is completed, the tree should be inspected again for any animals that were not detected earlier. Should an animal be detected after felling, NParks Animal Response Centre or ACRES should be contacted immediately, especially since the animal might be injured.

Through the undertaking of this general approach, a register shall be maintained to record:

- the activities that were carried out,
- the species, numbers, GPS locations, dates, timings, and actions taken (if any) for each target fauna that was identified, and
- the description, GPS location, and actions taken (if any) for each burrow, inhabited tree hole and nest that was identified.

Bee Hives and Wasp/Hornet Nest

The presence of hornet and wasp nests within the study area may result in human-wildlife conflict during the construction phase. Prior to the commencement of works, the hornet and wasp nests should be removed. Bee hives are to be relocated out of the construction site to reduce the risk of injury.

8.8.5 Spatial Visualisation of Directional Clearance

Phased directional clearance is recommended to be conducted in at least two phases to allow better management of any non-volant species found on site. Permanent hoarding is to be erected first along all boundaries except those abutting the PRA to control the movement of wildlife. The direction of the clearance and tree felling should then be towards the PRA (Figure 8.3).

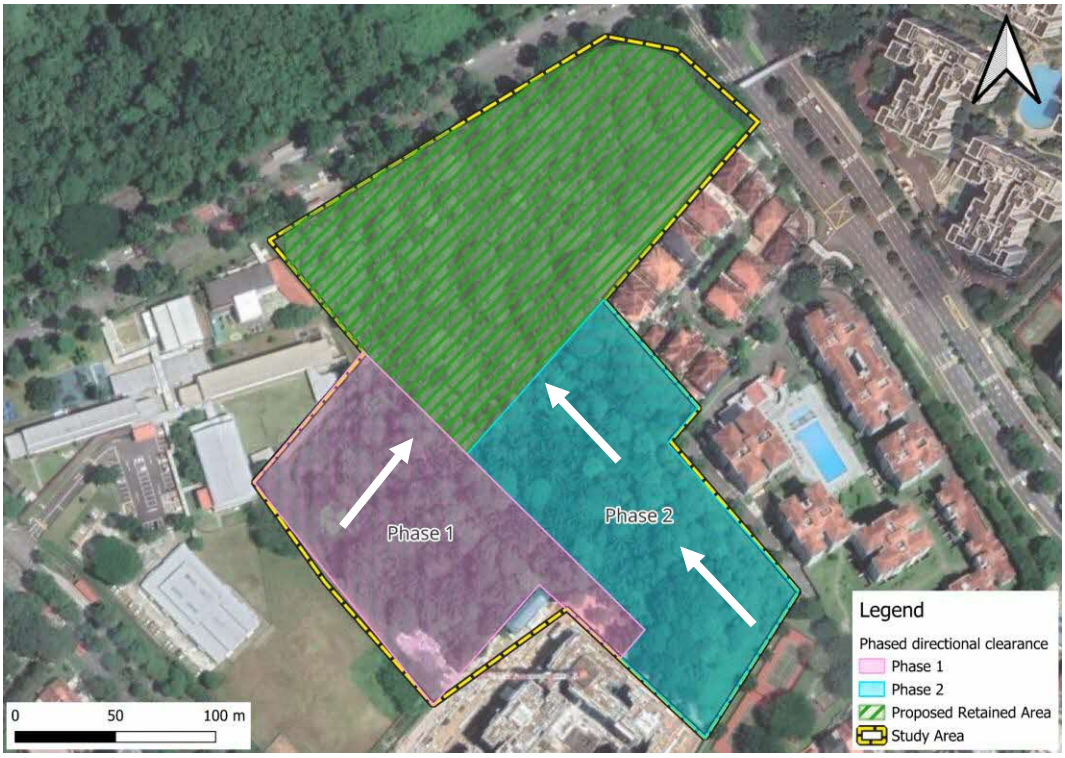


Figure 8.3 Visualisation of phased directional clearance

Within each phase, should clearance not be able to be completed within the same day, the phase should be divided into smaller zones for clearance. Temporary hoarding should be erected between zones to prevent fauna re-entry into cleared areas. Once the entire phase is cleared, permanent hoarding is to be erected along all boundaries. These activities should take place during daylight hours only (i.e., 8am to 6pm) and a minimum of one rest day (i.e., Sunday) per week should be provided to reduce disturbance to wildlife.

The site clearance plan shall be finalised prior to actual clearance works once the Contractor is on board to include a more detailed clearance regime. TPZs are to be set up before any works (including the installation of hoarding) to ensure there is no damage to the trees. Prior to vegetation clearance, permanent hoarding is to be installed around the study area. The hoarding should have no gaps and be embedded 300 mm into the ground to prevent fauna from digging under the hoarding. An example of permanent hoarding is illustrated in Figure 8.4 below.

Figure 8.4. Example of the permanent hoarding

8.8.6 Wildlife Response and Rescue Protocol

Even upon the completion of wildlife shepherding works, it is highly probable that animals might be able to enter the site and get trapped, particularly burrowing or climbing animals. Whenever fauna is encountered within the working areas, all construction activities should be stopped immediately, and the Wildlife Response and Rescue Plan should be followed (Table 8.5). Workers are to notify their supervisor, who will in turn contact the designated ecologist. The ecologist will then decide the next appropriate course of action.

All documentations of wildlife are to be captured in photographs, and a Wildlife Incident Form provided in Appendix I is to be filled.

Table 8.5. Wildlife response and rescue plan

Location	**Within the project site**					**Outside project site**
Timeframe	During working hours					Any time
Animal type	Highly mobile animals (e.g., wild boar, common palm civet and long-tailed macaque)		Non-large animals			Any
			Venomous / poisonous (e.g., king cobra, black spitting cobra)		Non-venomous / non-poisonous (e.g., Malayan water monitor)	
Animal condition	Alive / Moving / Resting	Dead	Alive / Moving / Resting	Dead	Any	–
Risk To human	High	Low	High	Low	Low	–
Response	a. Stop work on work site b. Report to PM c. PM to report to CEMMP In-charge d. CEMMP In-charge to inform EMMP Specialist (Fauna), who will advise on contacting NParks/ the appointed	a. Barricade affected area b. Report to PM c. PM to report to CEMMP In-charge d. CEMMP In-charge to inform EMMP Specialist (Fauna). e. If required,	a. Stop work at affected area; if possible, barricade affected area b. Report to PM c. PM to report to CEMMP In-charge d. CEMMP In-charge to inform EMMP Specialist (Fauna), who will advise on	a. Barricade affected area b. Report to PM c. PM to report to CEMMP In-charge d. CEMMP In-charge to inform EMMP Specialist (Fauna). e. If required, Contractor to assist with	a. Stop work at affected area; if possible, barricade affected area b. Report to PM c. PM to report to CEMMP In-charge d. CEMMP In-charge to inform EMMP Specialist (Fauna), who will advise on	Notify NParks Animal Response Centre/ ACRES hotline if necessary

Location	Within the project site					Outside project site
	Animal Management Specialist for next steps if necessary	Contractor to assist with transporting of the Wild Animal to Disposal Location	contacting NParks/ the appointed Animal Management Specialist for next steps if necessary	transporting of Wild Animal to Disposal Location	contacting NParks/ the appointed Animal Management Specialist for next steps if necessary	
Remarks	• No attempts shall be made by Contractors to handle the animal • Contractor to take photograph of the animal if possible • Contractors shall allow the animal to leave the site without harassment / handling • If animal is trapped, notify NParks Animal Response Centre or the appointed Animal Management Specialist hotline • For wild boar found at or around the site, NParks is to be informed as soon as possible for advice and subsequent	• Contractor to take photograph of the animal	• No attempts shall be made by Contractors to handle the animal • Contractor to take photograph of the animal if possible • Contractors shall allow the animal to leave the site without harassment / handling • If animal is trapped, notify NParks Animal Response Centre or the appointed Animal Management Specialist hotline	• Contractor to take photograph of the animal	• No attempts shall be made by contractors to handle the animal • Contractor to take photographs of the animal if possible • Contractors shall allow the animal to leave the site without harassment / handling • If animal is trapped, notify NParks Animal Response Centre or the appointed Animal Management Specialist hotline	• Contractor is encouraged to report • Reports could be from Public and/or Contractor's Staff • If required, CEMMP In-charge to contact PM for assistance of transferring Wildlife Animal Carcass to Disposal Location

Location	Within the project site					Outside project site
	action. An approved wild boar removal contractor must also be engaged to trap and remove the animal					

8.9 Flora Management Plan

The following Flora Management Plan lays out the details on salvaging plants, how to carry out tree protection works, the required components of tree assessments and monthly monitoring, etc. The tree protection and assessment duties should come under an ISA Certified Arborist.

Within the areas to be cleared, trees to be retained will be identified and confirmed during pre-construction phase. Protection of retained trees should be done though the establishment of appropriate TPZs. Additionally, permanent hoarding is to be set up around the adjacent areas of the project site to prevent unnecessary vegetation damage particularly along the PRA.

8.9.1 Salvaging Native Plants

The site has large populations of saplings of late-successional secondary forest species that may be suitable for transplanting, including saplings or young plants of *Aporosa benthamiana, Beilschmiedia madang, Canthiumera robusta, Chassalia curvilora, Cryptocarya cf. nitens, Gardenia subcarinate, Horsfieldia cf. sparsa, Memecylon paniculatum, Palaquium microphyllum, Strombosia javanica, Xanthophyllum ellipticum, Xanthophyllum vitellinum*. Some climbers are of conservation interest and may be transplanted too, including *Cnestis palala*, *Erythropalum scandens*, *Gynochthodes rigida*, *Tetracera* cf. *fagifolia*, *Tinospora krispura* and *Uncaria cordata*. The Contractor will liaise with NParks so that they are informed at least eight weeks prior to vegetation clearance to facilitate plant salvaging, if required. These salvaged plants will be housed and maintained in NParks-approved locations.

It is important that all individuals involved in the salvaging works are qualified persons to conduct the required works (i.e., relevant experience and professional expertise in the landscaping industry). Preferably, they shall have good local flora (trees, shrubs) identification skills as well as hands on experience in the operational aspects such as transplanting techniques and nursery management knowledge to ensure a higher success rate in the transplanting process.

8.9.2 Assessment and Monitoring of Trees to be Protected

A tree inventory for all existing trees had been prepared during baseline survey period as part of this EIA study. The final list of retained trees is subject to future development footprint, final platform level and consultation with technical agencies. Once the list of retained trees has been selected, the steps below are to be implemented.

Before any construction activity begins (including both planned and ad-hoc site clearance), the Arborist shall assess the trees listed in the arborist assessment matrix, record any new large trees with unique tree id number, and prepare an arborist assessment report for retained trees. For the retained trees, the Arborist shall produce tree assessment report recording tree information such as site condition, tree photos, species, height, girth, crown spread, tree health, form, structure. The Arborist will then provide recommended mitigation measures to mitigate these impacts. This tree assessment report will then serve as a record as the pre-development tree condition,

and the Arborist will have to refer to this report as benchmark when performing monthly monitoring for trees. For trees to be removed, the Arborist shall assist the developer in compiling a tree table for further consultation with NParks Greenery and Development Planning (GDP) branch and other necessary departments when required.

For retained trees on site, mitigation actions such as crown cleaning to remove damaged and dead branches, as well as applying appropriate pest and disease control should be the first line of measures. Tree Support Systems such as Tree Guying and Root Anchoring may be considered if the tree is deemed to be susceptible to wind throw. Furthermore, active regular monitoring of defects such cavity with wounded wood development by the Arborist will also be useful in early detection of hazardous trees.

8.9.3 Tree Protection Zones (TPZ)

It is possible to retain large and significant trees within construction footprint with a thorough and carefully thought-out pre-construction planning such as rerouting underground pipelines, altering footpath direction and repositing hardscape infrastructures etc. pavilion to avoid a native / mature tree within or at the border of such site. However, if these measures or plans proved to be impossible to put into place and works near / around a large, retained tree is unavoidable, a minimal TPZ needs to be demarcated to protect individual trees, so as to minimise the impacts of construction activities (including root cuts, mechanical trunk damage, branches breakage, damage due to soil compaction, etc.) on the tree. NParks (2018) has included some guidelines on TPZs in their Guidelines on Greenery Provision and Tree Conservation for Developments.

Trees identified for retention onsite or at the boundaries of the construction footprint of the working area and boundary of the PRA should be demarcated by Tree Protection Zones (TPZs) determined by an ISA-certified Arborist. TPZ size varies depending on tree size (Table 8.6). In general, the remaining space should be sufficient for implementation of design and required infrastructures. In the event the Contractor require extra spacing during the construction period for necessary works, the adjacent areas should be surveyed for native species / trees to be retained and possibly salvaged to an interim nursery before any clearance. If any materials spill into TPZ, the spillage should be cleaned up immediately and the Arborist must be informed. The Contractor is also required to notify the Arborist immediately if retained trees are observed to have been damaged. If the tree suffers from substantial damage and are in a state of irreversible deterioration as determined by the Arborist, the Contractor should replace the tree of the same species at a minimum girth size of 0.2m subject to further consultation with NParks.

Table 8.6. TPZ size required for different girth range

Girth	Recommended TPZ (radius)
<0.5m	1 m
>0.5m but less than 1m	2 m
>1m but less than 1.5m	3 m

Girth	Recommended TPZ (radius)
>1.5m but less than 2m	4 m
>2m	5 m
Fig trees and Trees with Critically Endangered status	Prescribed individually by Arborist on a case-by-case basis
Mangrove Trees	2m away from visible pencil, conical, or prop roots

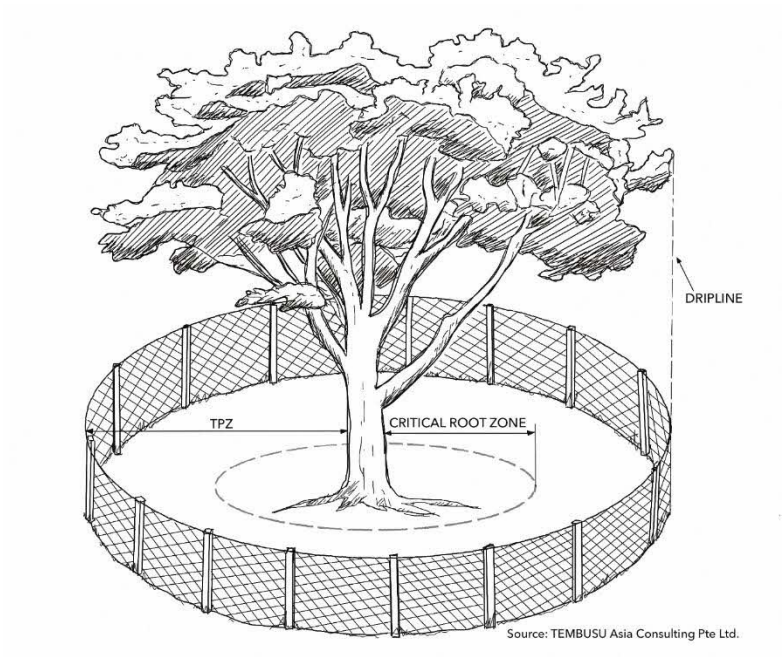


Figure 8.5. Tree Protection Zone Diagram

The following specifies guidelines for construction activities within and outside the TPZ, extracted from NParks (2018).

Inside TPZ

- There must be no excavation, raising or lowering of soil level, compaction or any form of construction activities including temporary works within the hoarded area.
- Dumping of debris, excavated materials and/or storage of construction materials and equipment are not allowed within the TPZ.
- The demolition of drains, structures within the TPZ should be carried out manually and backfilled with Approved Soil Mixture (ASM) immediately.
- Trees are to be watered regularly if rainfall is inadequate.
- Trees are to be fertilised if soil tests or deficiency symptoms indicate they are nutrient stressed.

Outside TPZ

- If major roots are encountered during excavation, the applicant may like to seek

advice from a Certified Arborist, as cutting of major roots may affect the stability of the tree. Where possible, alternative proposals should be explored to avoid the need to cut the roots.

- In cases where the trees are managed by NParks (e.g., trees within the park connector planting verge), or are required by NParks to be conserved (e.g., trees with girth >1.0m within TCA or vacant land), approval from NParks must be obtained before the major root can be cut. If approval is granted by NParks to cut the roots, this must be done with a clean cut using a chainsaw.
- All building debris and chemical waste should not be burned or buried within green verges on the site.

8.9.4 Tree Felling Within Vegetated Areas

Before felling trees, the Arborist must ensure native saplings have already been tagged, identified, and transplanted into on-site nursery. The Arborist must also survey, identify, and confirm the trees to be protected in the surrounding area and establish a tree felling protection distance based on site condition and tree crown spread.

The trees to be felled shall be inspected for any fauna as per guidelines provided in wildlife management plan (Section 8.8). Such trees will be marked with red & white tape and no tree felling operation shall be carried out within 5 m from the said tree until further instruction.

Prior to the any tree felling, URA's land clearance process circular must be followed. This includes but is not limited to consulting all relevant agencies in upstream planning and detailed design stage, and tagging trees on site such as labelling each tree with laminated or weather protected A4 sheet to indicate if the tree is to be retained or translocated. This minimises the risk of felling any trees that were supposed to be retained.

During tree felling operation works, the Contractor shall exercise all necessary precaution to ensure safety of workers and road users. Before commencing tree felling works, the supervisor, banksman, and foreman shall scout the area a final time to ensure that the tree felling protection zone is clear of human activities, while fauna specialist will inspect the tree felling protection zone if the site is free of wildlife activities. Once the areas are cleared, the banksman should signal the excavator operator to commence work for trees felling. The excavator operator should first clear off the shrubs and small trees (<5 m height) to create a clear line of sight for the whole area and to keep away blind spot areas which are blocked by small trees or tall shrubs. The excavator operator shall operate cautiously and fell all small trees and shrubs in a controlled manner, aware of the location of the locations of other trees to be protected.

When opening is completed, the excavator operator should clear off small trees and shrubs along the path into the site to mark the area that they are supposed to work within. When the paths are cleared, the operator should then move inward to fell trees within the area. If the operator faces a tree with height between 5 and 7 m, they should clear off shrubs in the surrounding area so that the foreman can move closer to the tree. The recommended tree cutting method should be the notch cut (Figure 8.6). The

foreman shall determine the direction of falling and ensure the tree does not land on any property, cause injury, or damage nearby Trees to be Protected. To avoid trees leaning to an unintended direction when performing a third cut, the excavator should assist to prevent fall back and guide the tree to fall into the intended direction. Once the tree has been felled, the tree cutter shall cut the tree trunk into shorter lengths for easier loading during clearing of the debris from site.

If the tree has a height greater than 7 m, the tree height has to be reduced by using a lorry crane to perform crown reduction first. Before the lorry crane can enter the site, the Contractor has to prepare proper access for the lorry crane to enter the site and access the tree location. The Contractor must ensure that the access ground is firm enough to allow the lorry crane to deploy its outrigger. When the access is ready, the Contractor will then mobilize the lorry crane to enter the site to reduce tree height to 7 m in order to adopt the notch cut method for trees less than 7 m in height.

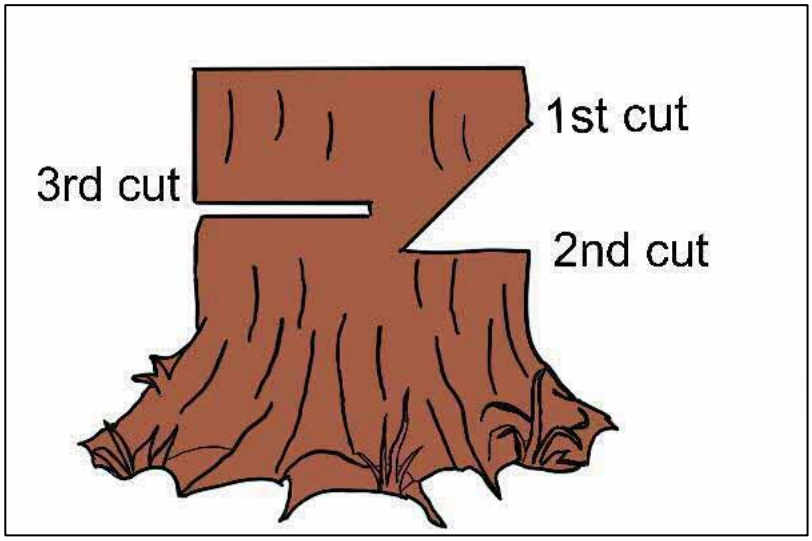


Figure 8.6. Illustration of a notch cut

8.9.5 Flora monitoring at vegetation edges

For the existing vegetated patches to be retained in the PRA, engineering solutions can be provided to limit the amount of light entering the newly created forest edges to deter growth of invasive species at forest understorey, including but not limited to minimum 2 m height hoarding with additional panel at the top of hoarding angled towards the vegetated area.

The Contractor will also need to engage a flora specialist to conduct monthly flora monitoring along vegetation edges of retained vegetated patch during the whole construction period. Some of the key monitoring parameters include:

- Identify any vegetation disturbance that are of natural causes (e.g. tree failure)
- Identify any vegetation disturbance that might be of manmade causes (e.g. machinery damage, soil erosion due to excavation)
- Along the edges of retained vegetated patches, regular weeding shall be conducted with help of the Contractor's workers to remove clusters of *Miconia crenata*, *Miconia dependens* and saplings of exotic species such as *Acacia*

auriculiformis, *Cecropia pachystachya*, *Falcataria falcata* and *Leucaena leucocephala* to minimise disturbance to edge of vegetation

8.10 Lighting Management Plan (LMP)

In the event that night works are required, a Lighting Management Plan (LMP) shall be developed as part of the CEMMP.

The LMP should minimally include the following aspects:

- Objectives of LMP
- Purposes and categories of artificial lighting required
- Spatial layout of lighting utilised in project site
- Designs of lighting utilised – including height and shielding design
- Specifications of lighting utilised – lighting temperature, spectrum, and brightness
- Additional measures in place if white or non-shielded lighting is required
- Implementation of monitoring plan
- Schedule of night works

8.11 Biodiversity Monitoring Requirements

Specific monitoring requirements for biodiversity are detailed in this section. The other monitoring requirements for physical parameters are presented in Table 8.7.

8.11.1 Fauna Monitoring

There should be regular checks to ensure that the mitigation measures for fauna protection are in place and effective in the mitigation of impacts. Sensitive biodiversity should also be monitored to ensure that their presence has not been adversely affected by the works. The following section outlines visual site inspection recommendations.

Visual Site Inspection

Monthly inspections of hoarding surrounding the worksite:

- There should be no clearance of vegetation outside the hoarding boundary. Additionally, the hoarding should be implemented with no gaps between to ensure that animals are not able to enter the site. Specifications for hoarding should also follow directives from NParks.

Monthly inspection of habitats:

- Visual inspections of sensitive habitats should also be made, especially the PRA (if applicable). There should be no visible impacts to the PRA (if applicable), including but not limited to loss of vegetation, siltation, visibly increased erosion, presence of chemicals, etc.

8.11.2 Flora Monitoring

Due to the presence of plant species of conservation significance within and around the project site, there should be mitigation measures conducted during pre-construction stage to reduce plant mortality, and regular checks during construction stage to ensure

that the implementation of mitigation measures for flora and arboriculture protection are in place for retained areas and retained trees, and to ensure such measures are effective in the mitigation of impacts. The following section outlines monitoring recommendations for flora protection. For the monitoring of flora, the flora specialist and arborist should have access to the documents listed in Section 9.2.

Monitoring of Retained Trees

During the construction period, all retained trees will need to be protected from the side effects of major work activities. For such retained trees, it is recommended for the Certified Arborist to conduct monthly Level 2 visual tree assessment (VTA) and to ensure that the retained trees are not gravely affected by ongoing construction activities. During the assessment, he/she will need to do a basic ground level assessment of every individual tree with general hand tools and produce an arborist report thereafter. The arborist report will document photo(s) of the specific tree and include information such as the general appearance, abnormalities and/or defects observed due to the construction activities, and follow-up recommendations to be taken (e.g., pruning/felling). The arborist report should generally cover 2 main components: (i) Overall tree health and (ii) TPZ condition with the criteria listed in the table below.

Table 8.7. Parameters to take note during monthly tree inspections.

Tree Health	TPZ Condition
• Foliage colour (Normal, Chlorotic, Necrotic) • Foliage density (Normal, Sparse, Dense) • Leaf size (Normal, Small) • Vigour (Good, Average, Poor) • Lean (Self corrected, Unnatural) • Diebacks and Dead branches (%) • Cracks • Cavities / Conks / Fungi • Roots collar buried / not visible • Pest / Disease Infestation • Damaged / Cut roots • Root plate lifting • Site Changes (None, Grade change, Site Clearing) • Soil Condition (Limited volume, Saturated, Compacted, Pavement over roots) • Wind Exposure (Protected, Partial, Full, Funnelling)	• TPZ barriers installed/good condition • Evidence of illegal encroachment • Evidence of damage to tree • Evidence of toxic splash • Evidence of illegal compaction • Evidence of materials storage • Evidence of machinery, equipment and vehicle storage

It is critical for the Certified Arborist to be proactive in his / her inspection checks to manage the trees well, thus preventing the trees from consequential death and / or failure (i.e., snapping, uprooting). Shall any tree incident occur on site (e.g. Tree damage caused by construction works, tree failure occur on site), the arborist will have to attend

urgent site meeting and ad-hoc arborist assessment as and when required. The Certified Arborist should also recommend routine maintenance such as deadwooding and formative pruning to be done periodically to keep the trees structurally safe and sound.

Flora Monitoring for Retained Area

Monthly checks should be conducted by qualified persons (i.e., Flora specialist and / or Certified Arborist) to ensure that all the mitigation measures are implemented and effective in the protection any retained vegetated areas during the construction phase. Flora inspections shall be conducted at areas within 15m buffer from the worksite boundary and/or at edges of retained areas.

The general criteria that the Flora Specialist can use to monitor the plants' condition during his / her periodic checks are presented in the table below.

Table 8.8. Parameters to take note during for flora monitoring

Signs of site disturbance
Soil erosion
Occurrence of invasive species previously not found on site (such invasive species include *Falcataria falcata*, *Leucaena leucocephala*, *Miconia crenata*, *Miconia dependens*, *Spathodea campanulata*, *Dioscorea sansibarensis*, *Mucuna pruriens*)
Waterlogging
Signs of mechanical excavation near forest edges

The Flora Specialist will need to pay attention to occurrence of new invasive species and remove such species as early as possible to prevent spreading of such species across disturbed forest edges. Regular weeding at forest edge can prevent the growth of undesirable tree species and prevent the development of Albizia/Leucaena-dominated secondary forests at edges of retained areas, and to allow native species to establish at the understorey level with less competition from species such as *Miconia crenata*.

8.12 Environmental Monitoring Plan

Table 8.7 provides an overview of the recommended environmental monitoring plan and EMMP measures for this project which is to be incorporated into the CEMMP by the Contractor. The environmental monitoring locations are to be finalised by EMMP team during CEMMP formulation in consultation with relevant stakeholders.

Table 8.7. Recommended Environmental Monitoring Plan for construction phase

Monitoring Category	Impact	Monitoring Parameters	Monitoring Method	Location	Standards / Criteria	Time / Duration / Frequency	Reporting	Implementation
Biodiversity Monitoring • Avoid clearance of vegetation outside working boundaries • Avoid human-wildlife conflict	On-site Visual and Compliance Monitoring							
	Habitat loss	• Implement hoarding around worksite boundary • Implement hoarding around PRA • No construction activity within the PRA • No encroachment into the PRA by construction personnel	• Visual monitoring • Compliance check	• Entire project site • PRA boundary	• Proper installation of hoarding • Absence of construction works in PRA (if applicable) • Absence of vegetation clearance outside working boundaries	Fortnightly during construction phase	Monthly Environmental Performance Report	• Contractor PM • Contractor ECO / CEMMP In-charge • Ecologist • Arborist
	Species mortality or injury	• Implement hoarding around project boundary • Minimise felling trees and clearing vegetation during the peak bird breeding season (March to July) • Pre-felling fauna inspection should be conducted before felling any trees or removing any vegetation • Phased directional clearing to	• Visual monitoring • Compliance check	Entire project site	• Proper TPZ installation • Retention of tree health • Absence of mechanical damage on trees • Absence of nesting birds • Absence of	• Prior to vegetation clearance (for wildlife translocation and fauna inspection) • Monthly during construction phase	Monthly Environmental Performance Report	• Contractor PM • Contractor ECO / CEMMP In-charge • Ecologist • Arborist

Monitoring Category	Impact	Monitoring Parameters	Monitoring Method	Location	Standards / Criteria	Time / Duration / Frequency	Reporting	Implementation
		be adopted during vegetation clearance • Active translocation of target fauna species • Use only fully biodegradable erosion control blankets (ECB) to avoid trapping fossorial fauna such as snakes • Check ECBs for entrapped fauna on a daily basis .			entrapped fauna	• Daily for fauna entrapment		
	Human-wildlife conflict	• Ensure good housekeeping controls such as provision of wildlife-proof bins and eating areas • Execute Wildlife Response and Rescue Plan when fauna is found on-site • Train site personnel on biodiversity awareness and actions to take when encountering wildlife	• Visual monitoring • Compliance check	Entire project site (near vegetated area)	No injuries due to wild animals	• Continuous • As and when required for Wildlife Response and Rescue Plan	• Monthly Environmental Performance Report • As and when a wildlife incident occurs	• Contractor PM • Contractor ECO / CEMMP In-charge • Ecologist
	Light and noise disturbance	• Implementation of LMP • Installation of 6m to 12m noise barrier around the site and boundary of PRA	• Visual monitoring • Compliance check	PRA	• Implementation of LMP developed with consultation with NParks • Proper installation of noise barriers around PRA boundary	• During nightworks • Continuous	Monthly Environmental Performance Report	• Contractor PM • Contractor ECO / CEMMP In-charge

Monitoring Category	Impact	Monitoring Parameters	Monitoring Method	Location	Standards / Criteria	Time / Duration / Frequency	Reporting	Implementation
Surface Water Quality Monitoring • Minimisation of impact to receiving watercourse due to contaminated site run-off • Minimisation of impact to receiving watercourse due to erosion of topsoil	<u>On-site Visual and Compliance Monitoring</u>							
	Water pollution	• Verify implementation of ECM Plan • Perimeter cut-off drains, perimeter silt fence, silt traps, sedimentation basin and silt treatment system	• Visual monitoring • Compliance check • ECM checklist	Construction area with earthworks	ECM Plan designed by a Qualified Erosion Control Professional (QECP)	Daily compliance monitoring during entire construction phase	Monthly Environmental Performance Report	• Contractor PM • Contractor ECO / CEMMP In-charge • QECP
	<u>On-site Water Quality Monitoring</u>							
	Water pollution	Total Suspended Solids (TSS)	Implementation of TSS monitor and CCTV including a Silty Imagery Detection System (SIDS)	• Final ECM discharge points	• Less than 30 mg/L for TSS • Sewerage and Drainage (Surface Water Drainage) Regulation 2007	Real-time continuous monitoring during entire construction phase	• TSS report • Monthly Environmental Performance Report	• Contractor PM • Contractor ECO / CEMMP In-charge
		• All parameters identified in EPM (Trade Effluent) Regulations for Controlled Watercourse	In-situ and ex-situ monitoring	• At every discharge outlet	EPM (Trade Effluent) Regulations for Controlled Watercourse	Monthly during construction phase	Monthly Environmental Performance Report	• Contractor PM • Contractor ECO / CEMMP In-charge
Noise Monitoring • Minimisation of biodiversity disturbance due to construction noise • Minimisation of	<u>On-site Visual and Compliance Monitoring</u>							
	Noise disturbance	• Noise barriers around construction work areas (along Old Jurong Road, Upper Bukit Timah Road, De Souza Ave, neighbouring residences and internal PRA boundary (if applicable))	• Visual monitoring • Compliance check	Entire project site	Environmental Protection and Management (Control of Noise at Construction Sites) 2008	Monthly during entire construction phase	Monthly Environmental Performance Report	• Contractor PM • Contractor ECO / CEMMP In-charge

Monitoring Category	Impact	Monitoring Parameters	Monitoring Method	Location	Standards / Criteria	Time / Duration / Frequency	Reporting	Implementation
nuisances to humans due to construction noise		• Utilization of quieter equipment and vehicles with low noise levels • PPE use by construction personnel at all times while on the construction site						
	<u>On-site Noise Monitoring</u>							
	Noise disturbance	• Leq 12 hrs • Leq 1 hr • Leq 5 mins	Sound level meter	3 locations	Environmental Protection and Management (Control of Noise at Construction Sites) 2008	• Continuous (24x7) boundary noise monitoring • During entire construction phase	Monthly Environmental Performance Report	• Contractor PM • Contractor ECO / CEMMP In-charge
Air Quality Monitoring • Minimisation of human health & biodiversity impacts due to dust pollution • Minimisation of human health impacts due to exhaust emissions	<u>On-site Visual and Compliance Monitoring</u>							
	Air pollution	• Implementation of dust suppression plan • Watering to reduce dust emissions from exposed areas • Washing bay • Implementation of vehicular speed limit • Covered stockpiles • Use of PPE (face mask) by construction personnel • Maintenance frequency of vehicles and machinery	• Visual monitoring • Compliance check	All construction areas	• Approved dust suppression plan • No visible exhaust plume, dark smoke etc.	During entire construction phase	Monthly Environmental Performance Report	• Contractor PM • Contractor ECO / CEMMP In-charge

9 CONCLUSION

The current report provides an overview of the results of the biodiversity and environmental baseline surveys, conducted from August to November 2024. The information collected during this round of surveys adds to the substantial existing reservoir of knowledge about the Bukit Timah and Bukit Batok area, including BTNR and BBNP. The biodiversity findings re-emphasise the importance of the study area in maintaining ecological connectivity in the western region of Singapore, given its location along the BBNC, which aims to support ecological connectivity between the Central Nature Park Network and Tengah Forest Corridor. This information will be valuable for development planning and environmental management to ensure any environmental impacts arising from future developments are minimised.

From the results of the baseline surveys, an assessment of impacts on biodiversity sensitive receptors was conducted. A summary of the unmitigated and residual impacts of the assessed environmental aspects for both the pre-construction/ construction phase and operation phase, as well as the key mitigation measures to be implemented, are shown in Table 9.1 and Table 9.2 respectively.

Table 9.1. Summary of impact assessment

Sensitive Receptor	**Predicted Impacts Without Mitigation**		**Predicted Impacts With Mitigation**			
			Scenario A		**Scenario B**	
	ES	**ES Impact**	**ES**	**ES Impact**	**ES**	**ES Impact**
Pre-Construction/ Construction Phase						
Flora	-28 to -144	Slight Negative to Major Negative	-14 to -144	Slight Negative to Major Negative	-14 to -72	Slight Negative to Minor Negative
Fauna	-14 to -144	Slight Negative to Major Negative	-7 to -144	Slight Negative to Major Negative	-7 to -108	Slight Negative to Moderate Negative
Habitat	-81 to -108	Moderate Negative	-81 to -108	Moderate Negative	-16 to -54	Slight Negative to Minor Negative
Operation Phase						
Flora	-32	Slight Negative	-16	Slight Negative	-16	Slight Negative
Fauna	-48 to -144	Minor Negative to Major Negative	-32 to -144	Slight Negative to Major Negative	-32 to -72	Slight Negative to Minor Negative
Habitat	9	Slight Positive	9	Slight Positive	9 to -16	Slight Positive to Slight Negative

Table 9.2. Summary of key mitigation measures to be implemented

Phase	**Key mitigation measures**
Pre-Construction/ Construction	• Retention of as much of the Proposed Retained Area (PRA) as practicable • Phased/ directional clearance of vegetation • Wildlife shepherding/ active translocation of wildlife • Visual inspections of trees and holes for nesting birds and animals prior to felling

	• As far as practicable, avoid the commencement of tree felling during the peak bird breeding period (March to July) • Physically tag trees to be retained, felled, and transplanted on site • Establish Tree Protection Zones (TPZ) for trees to be retained • Identify plants to be salvaged/transplanted • Monitor tree and vegetation health regularly • Install hoarding around the work site • Conduct daily checks of ECM blankets and pits • Ensure ECM blankets are made of biodegradable material with no plastic mesh netting • Conduct biodiversity awareness trainings for workers • Implement dust suppression plan • Install 6m to 12m noise barrier along boundary of the site during construction • Implement Light Management Plan (LMP) if night works are necessary • Implement PUB-approved ECM Plan • Emergency spill kits to be present to handle any chemical spillages
Operation	• Use shielded lights that are directed downwards and away from the PRA • Adjust the number and intensity of lights abutting the forest to minimum levels required for safety and security • Use motion-activated lighting in areas less frequently visited • Buffer planting with hedges along the boundary of the PRA • Planting of native, fauna-attracting species as part of the landscaping • Wildlife-proof refuge centre and bins • Educational signages on wildlife

REFERENCES

Abeyasuriya, K. T., Nugapola, N. N., Perera, M. D., Karunaratne, W. I., & Karunaratne, S. P. (2017). Effect of dengue mosquito control insecticide thermal fogging on non-target insects. *International Journal of Tropical Insect Science, 37*(1), 11-18.

Agriculture and Resource Management Council of Australia and New Zealand. (2000). Australian Guidelines for Urban Stormwater Management. Canberra, Australian Capital Territory, Australia. Retrieved from https://www.waterquality.gov.au/sites/default/files/documents/australian-guidelines-urbanstormwater.pdf

American Public Health Association. (2017). *Standard methods for the examination of water and wastewater* (23rd ed.). Washington, DC: American Public Health Association.

Armitage, P., Cranston, P., & Pinder, L. (Eds.). (1995). *The Chironomidae: Biology and ecology of non-biting midges.* London: Springer Dordrecht. doi:https://doi.org/10.1007/978-94-011-0715-0

Aziz, M. K., O'Dempsey, A., Ng, B. C., Balakrishnan, K. V., Luz, S., Yeong, C., . . . Chua, M. A. (2024). Georeferencing Sunda pangolin Manis javanica records in Singapore. *Oryx*, 1-4.

Baker, N., & Lim, K. (2012). *Wild Animals of Singapore: A Photographic Guide to Mammals, Reptiles, Amphibians and Freshwater Fishes* (2nd ed.). Draco Pub and Distribution, Singapore.

Bateman, H., & Merritt, D. (February, 2022). Complex riparian habitats predict reptile and amphibian diversity. *Global Ecology and Conservation, 22*(3). doi:10.1016/j.gecco.2020.e00957

Begum, S. (2 November, 2023). 10-year-old jungle bridge over BKE proves a lifeline for pangolins, mousedeer and other wildlife. Singapore. Retrieved from https://www.straitstimes.com/singapore/from-pangolins-to-mousedeer-10-year-old-jungle-bridge-over-bke-proves-a-lifeline-for-wildlife

Bickford, D., Ng, T., Lan, Q., Kudavidanage, E., & Bradshaw, C. (2010). Forest Fragment and Breeding Habitat Characteristics Explain Frog Diversity and Abundance in Singapore. *Biotropica, 42*(1), 119-125.

Bird Society of Singapore. (2024). *Singapore Bird Checklist, version 2024-1.* Retrieved 5 July, 2024, from Birds of Singapore: https://singaporebirds.com/downloads/

Bird Society of Singapore. (n.d.). *Large-billed Crow*. Retrieved 9 November, 2024, from Birds of Singapore by Bird Society of Singapore: https://singaporebirds.com/species/large-billed-crow/

Boeadi, & Steinmetz, R. (2008). *Galeopterus variegatus*. Retrieved from The IUCN Red List of Threatened Species 2008: e.T41502A10479343: https://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T41502A10479343.en

ButterflyCircle. (11 February, 2014). *Butterflies Galore! : Branded Imperial*. Retrieved 23 October, 2024, from Butterflies of Singapore: https://butterflycircle.blogspot.com/2014/02/butterflies-galore-branded-imperial.html

ButterflyCircle. (2024). *Cupha erymanthis lotis*. Retrieved 23 October, 2024, from Butterfly Circle Checklist: https://www.butterflycircle.com/checklist/index.php?/showbutterfly/62

Canopeo. (n.d.). *Canopeo App*. Retrieved 11 October, 2024, from How To Use: https://canopeoapp.com/#/login

Cao, Y., Zhang, S., & Ma, K.-M. (2024). Artificial light at night decreases leaf herbivory in typical urban areas. *Frontiers in Plant Science*, 01-09.

Challenger, D., Willcox, D., Panjang, E., Lim, N., Nash, H., Heinrich, S., & Chong, J. (2019). *Manis Javanica*. Retrieved from The IUCN Red List of Threatened Species 2019: e.T12763A123584856: https://dx.doi.org/10.2305/IUCN.UK.2019-3.RLTS.T12763A123584856.en

Chan, P., Lam, W., Ting, Y., Phang, A., Chong, R., Rahman, N., & Chong, K. (2022). Towards a field guide to the trees of the Nee Soon Swamp Forest (VIII): Sapotaceae. *Nature in Singapore*, 129-158.

Chan, S., & Goh, C. (2010). Frogs of Sungei Buloh Wetland Reserve (Amphibia: Anura). *Nature in Singapore, 3*, 103–116.

Chin, Y. (2024). Biodiversity Record: Apparent sexual rivalry in four-lined tree frogs. *Nature in Singapore, 17*, e2024039.

Chiok, W. X., Miller, A. E., Pang, S. E., Eaton, J. A., Rao, M., & Rheindt, F. (2019). Regional and local extirpation of a formerly common Sundaic passerine, the Straw-headed Bulbul Pycnonotus zeylanicus. *Forktail*, 3-11.

Chiok, W. X., Ng, E. Y., Tang, Q., Lee, J. G., & Rheindt, F. (2020). A distance sampling survey of the Critically Endangered Straw-headed Bulbul Pycnonotus zeylanicus in Singapore. *Bird Conservation International*, 1-13.

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

Chong, K., Teo, S., Kurukulasuriya, B., Chung, Y., Rajathurai, S., & Tan, H. (2014). Not all green is as good: Different effects of the natural and cultivated components of urban vegetation on bird and butterfly diversity. *Biological Conservation*, 299-309.

Cieplok, A., & Spyra, A. (2020). The roles of spatial and environmental variables in the appearance of a globally invasive Physa acuta in water bodies created due to human activity. *Science of the Total Environment, 744*, 140928. doi:https://doi.org/10.1016/j.scitotenv.2020.140928

Clevenger, A. P., Chruszcz, B., & Gunson, K. (2001). Drainage culverts as habitat linkages and factors affecting passage by mammals. *Journal of applied ecology, 38*(6), 1340-1349.

Cordier, J. M., Aguilar, R., Lescano, J. N., & Leynaud, G. C. (January, 2021). A global assessment of amphibian and reptile responses to land-use changes. *Biological Conservation, 253*(80). doi:10.1016/j.biocon.2020.108863

Corlett, R. T. (July, 1992). The Ecological Transformation of Singapore, 1819-1990. *Journal of Biogeography*, 411-420.

Decena, S., Avorque, C., Decena, I., Asis, P., & Pacle, B. (2020). Impact of habitat alteration on amphibian diversity and species composition in a lowland tropical rainforest in Northeastern Leyte, Philippines. *Scientific Reports, 10*. doi:10.1038/s41598-020-67512-6

Denzinger, A., & Schnitzler, H. (2013). Bat guilds, a concept to classify the highly diverse foraging and echolocation behaviors of microchiropteran bats. *Frontiers in Physiology, 4*(164), 1-15.

Department of Geography, National University of Singapore. (2024). *Historical Maps of Singapore*. Retrieved 31 May, 2024, from Historical Maps of Singapore - NUS Libraries - Digitised by Department of Geography, National University of Singapore: https://libmaps.nus.edu.sg/

Diong, C., Chou, L., & Lim, K. (1994). Calotes versicolor, the changeable lizard. *Nature*

Malaysiana, 19(2), 46–54.
Fenton, M., & Bell, G. (1981). Recognition of species of insectivorous bats by their echolocation calls. *Journal of Mammalogy, 62*, 233–243.
Figueroa, A., Low, M., & Lim, K. (2023). Singapore's herpetofauna: updated and annotated checklist, conservation, and distribution. *Zootaxa, 5287*(1), 1–378.
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.
Franklin, A. B., Noon, B. R., & George, T. L. (2002). What is habitat fragmentation? *Studies in Avian Biology, 25*, 20-29.
GESS. (n.d.). *About us: Travel through time*. Retrieved from https://www.gess.edu.sg/en/about/travel-through-time
Ginal, P., Tan, W., & Rödder, D. (August, 2022). Invasive risk assessment and expansion of the realized niche of the. *Frontiers of Biogeography, 14*(3).
Goh, S. G., & Tang, Z. (2023). Biodiversity Record: Roadkill of Sunda colugo along Jalan Jurong Kechil. *Nature in Singapore, 16*, e2023067. doi: 10.26107/NIS-2023-0067
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
Haddad, N. M., Brudvig, L. A., Jean, C., Davies, K. F., Gonzalez, A., Holt, R. D., . . . Townshend, J. R. (2015). Habitat fragmentation and its lasting impact on Earth's ecosystems. *Science Advances, 1*(2), e1500052. doi:10.1126/sciadv.1500052
Hahs, A., McDonnell, M., McCarthy, M., Vesk, P., Corlett, R., Norton, B., . . . Williams, N. (2009). A global synthesis of plant extinction rates in urban areas. *Ecology Letters*, 1165-1173.
Hamer, A. J., & McDonnell, M. J. (July, 2008). Amphibian ecology and conservation in the urbanising world: A review. *Biological Conservation, 141*.
Harrelson, C. C., Rawlins, C. L., & Potyondy, J. P. (1994). *Stream Channel Reference Sites: An Illustrated Guide to Field Technique.* United States: United States Department of Agriculture: Forest Service.
Heller K.G. (1989). Echolocation of Malaysian bats. Zeitschrift für Säugetierkunde, 54, 1–8.
Herpetology Society of Singapore. (n.d.). *Herptile Roadkill Project*. Retrieved from Herpetology Society of Singapore: https://herpsocsg.com/herp-roadkills-sg/
Ho, B. C., K., L. H., Ibrahim, B., Yeo, R. S., Athen, P., Leong, P. K., . . . Middleton, D. J. (2019). The plant diversity in Bukit Timah Nature Reserve, Singapore. *Gardens' Bulletin Singapore*, 41-134.
Hughes A.C., S. C. (2011). Using echolocation calls to identify Thai bat species: Vespertilionidae, Emballonuridae, Nycteridae and Megadermatidae. Acta Chiropterologica, 13 (2), 447–455.
International Union for Conservation of Nature and Natural Resources (IUCN). (2024). *The IUCN Red List of Threatened Species*. Retrieved 15 February, 2024, from http://www.iucnredlist.org
Jackson, J. C. (July, 1965). Chinese Agricultural Pioneering in Singapore and Johore 1800-1917. *Journal of the Malaysian Branch of the Royal Asiatic Society*, 77-105.
Jacobs. (3 November, 2021). *Tengah North EIA Report*. Retrieved from Housing Development Board: https://www.hdb.gov.sg/-/media/doc/RPG/Tengah-North-EIS-Report.ashx
Jong, Y. (2022). A checklist of the vascular plant flora of Bukit Brown and Lau Sua, and

suggestions for improving reporting practices in Biodiversity Impact Assessments. *NATURE IN SINGAPORE Supplement 1*, 172-189.

Khew, S. K. (29 June, 2013). *Butterfly of the Month - June 2013*. Retrieved 23 October, 2024, from Butterflies of Singapore: https://butterflycircle.blogspot.com/2013/06/butterfly-of-month-june-2013.html

Khew, S. K. (17 November, 2019). *Flight of the Imperials*. Retrieved 23 October, 2024, from Butterflies of Singapore: https://butterflycircle.blogspot.com/2019/11/

Kingston , T., Lim, B., & Zubaid, A. (2009). *Bats of Krau Wildlife Reserve.* Penerbit Universit Kebangsaan Malaysia.

Kingston, T., Jones, G., Akbar, Z., & Kunz, T. (2003). Alternation of echolocation calls in 5 species of aerial-feeding insectivorous bats from Malaysia. *Journal of Mammalogy, 84*(1), 205-215.

Lane, D., Kingston, T., & Lee, B.-H. (2006). Dramatic decline in bat species richness in Singapore, with implications for Southeast Asia. *Biological Conservation, 131*, 584–593.

Legislation Division of the Attorney-General's Chambers. (n.d.). *Singapore Statutes Online*. Retrieved June, 2021, from Singapore Statutes Online: https://sso.agc.gov.sg/

Lewanzik, D., & Voigt, C. C. (10 April, 2014). Artificial light puts ecosystem services of frugivorous bats at risk. *Journal of Applied Ecology, 51*(2), 388-394. doi:https://doi.org/10.1111/1365-2664.12206

Lim, K., & Chou, L. (1990). The herpetofauna of Singapore. In N. U. Singapore, & L. &. Chou (Ed.), *Essays in Zoology: Papers commemorating the 40th anniversary of the Department of Zoology, National University of Singapore* (pp. 49-59). Singapore.

Lim, N. T., & Ng, P. K. (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.

Lim, N. T., Giam, X., Byrnes, G., & Clements, G. R. (2013). Occurrence of the Sunda colugo (Galeopterus variegatus) in the tropical forests of Singapore: A Bayesian approach. *Mammalian Biology, 78*, 63-67.

Lindsay, S., Middleton, D., Ho, B., Chong, K., Turner, I., Ibrahim, A., . . . Er, K. (2022). Flora of Singapore: Checklist and bibliography. *Gardens' Bulletin Singapore, 74*(Suppl. 1), 3-860. doi:10.26492/gbs74(suppl.1).2022-01

Lok, A. F., Ang, W. F., Ng, B. Y., Leong, T. M., Yeo, C. K., & Tan, H. T. (2013). *Native fig species as a keystone resource for the Singapore urban environment.* Singapore: Raffles Museum of Biodiversity Research.

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

Losacco, C., & Perillo, A. (2018). Particulate matter air pollution and respiratory impact on humans and animals. *Environmental Science and Pollution Research, 25*(34), 33901-33910.

Low, T. W. (4 August, 2025). *Singapore Wildlife Sightings*. Retrieved from Facebook: https://www.facebook.com/groups/179531089457/permalink/10163716636394458/?mibextid=rS40aB7S9Ucbxw6v

Lum, S., & Ngo, K. (2021). Lessons in ecology and conservation from a tropical forest fragment in Singapore. *Biological Conservation*, 254. Retrieved from https://dx.doi.org/10.1016/j.biocon.2020.108847

Lum, S., & Sharp, I. (Eds.). (1996). *A view from the summit: The story of Bukit Timah Nature Reserve.* Singapore: Nanyang Technological University and the National University of

Singapore.
McKenzie, N. L., & Bullen, R. D. (2019). What can echolocation recordings reveal about the foraging ecology of Saccolaimus saccolaimus (Emballonuridae) in north-western Australia? *Australian Journal of Zoology, 66*(6), 326-334. doi:https://doi.org/10.1071/ZO19012
Meteorological Service Singapore (MSS). (2024). *Historical Daily Records*. Retrieved 11 October, 2024, from http://www.weather.gov.sg/climate-historical-daily/
Ministry of Education. (n.d.). *Bukit Timah Primary School*. Retrieved from MOE Heritage Centre: https://moehc.moe.edu.sg/school-histories/bukit-timah-pri/
Mnaya, B., Mwangomo, E., & Wolanski, E. (2006). The influence of wetlands, decaying organic matter, and stirring by wildlife on the dissolved oxygen concentration in eutrophicated water holes in the Seronera River, Serengeti National Park, Tanzania. *Wetlands Ecology and Management, 14*, 421-425.
Mogali, S. M., Shanbhag, B. A., & Saidapur, S. K. (2022). Predatory influence of dragonfly larvae and water scorpions on eggs and tadpoles of Indosylvirana temporalis (Anura: Ranidae). *Phyllomedusa, 21*(1), 51-57. doi:http://dx.doi.org/10.11606/issn.2316-9079.v21i1p51-57
Nakajima, T., Asaeda, T., Fujino, T., & Nanda, A. (2006). Coarse particulate organic matter distribution in the pools and riffles of a second-order stream. *Hydrobiologia, 559*, 275-283.
NEA. (2023a). *Air Quality*. Retrieved from Our Services: https://www.nea.gov.sg/our-services/pollution-control/air-pollution/air-quality
NEA. (7 June, 2023b). *Water Quality*. Retrieved from Allowable Limits for Trade Effluent Discharge to Watercourse or Controlled Watercourse: https://www.nea.gov.sg/our-services/pollution-control/water-quality/allowable-limits-for-trade-effluent-discharge-to-watercourse-or-controlled-watercourse#:~:text=2%20Where%20two%20or%20more,if%20discharged%20into%20controlled%20watercourse.
Neo, L., Yee, A. T., Chong, K. Y., Kee, C. Y., Lim, R. C., Ng, W. Q., . . . Tan, H. T. (13 November, 2013). The Vascular Plant Flora of Bukit Batok, Singapore. *Nature in Singapore, 6*, 265–287.
Ng, P. K., Corlett, R. T., & Tan, H. T. (2011). *Singapore Biodiversity. An Encyclopedia of the Natural Environment and Sustainable Development.* Singapore: Editions Didier Millet.
Ng, T. H., Tan, S. K., & Yeo, D. C. (2015). Clarifying the identity of the long-established, globally-invasive Physa acuta Draparnaud, 1805 (Gastropoda: Physidae) in Singapore. *BioInvasions Records, 4*(3), 189-194. doi:http://dx.doi.org/10.3391/bir.2015.4.3.06
Ngiam, R., & Davison, G. (2011). A checklist of dragonflies in Singapore parks (Odonata: Anisoptera, Zygoptera). *Nature in Singapore, 4*, 349–353.
Ngiam, R., & Ng, M. (2022). *A Photographic Field Guide to the Dragonflies and Damselflies of Singapore.* Oxford: John Beaufoy Publishing.
NParks. (30 August, 2023). *Paradoxurus musangus*. Retrieved from Flora & Fauna Web: https://www.nparks.gov.sg/florafaunaweb/fauna/4/7/477
NParks. (2024). *About our parks, nature reserves and park connectors*. Retrieved from National Parks Board: https://beta.nparks.gov.sg/visit/when-visiting-parks/about-parks-nature-reserves-pcns/nature-corridors-ways
NParks. (2024). *About our parks, nature reserves and park connectors*. Retrieved 9 July, 2024, from National Parks Board: https://beta.nparks.gov.sg/visit/when-visiting-

parks/about-parks-nature-reserves-pcns/nature-corridors-ways
NParks. (2024). *About our parks, nature reserves and park connectors*. Retrieved from NParks.gov.sg: https://beta.nparks.gov.sg/visit/when-visiting-parks/about-parks-nature-reserves-pcns/nature-corridors-ways
NParks. (2024). *Biodiversity Impact Assessment (BIA) Guidelines.* National Parks Board, Singapore.
NParks. (2024). *Biodiversity Impact Assessment (BIA) Guidelines.* National Parks Board, Singapore.
NParks. (29 Jaunary, 2024). *Galeopterus variegatus*. Retrieved from Flora & Fauna Web: https://www.nparks.gov.sg/florafaunaweb/fauna/4/7/478
NParks. (17 January, 2024). *Species List (Red Data Book List)*. Retrieved 6 February, 2024, from National Parks Board: https://www.nparks.gov.sg/biodiversity/wildlife-in-singapore/species-list
NParks. (18 January, 2024). *Tupaia glis (Diard, 1820)*. Retrieved from Flora & Fauna Web: https://www.nparks.gov.sg/florafaunaweb/fauna/5/6/561
NParks. (2024). *Visit Rail Corridor*. Retrieved from Our Rail Corridor: https://railcorridor.nparks.gov.sg/visit-rail-corridor/
NParks. (n.d.). *Biodiversity & Greenery*. Retrieved from Our Rail Corridor: https://railcorridor.nparks.gov.sg/biodiversity/
NParks. (n.d.). *History of Bukit Timah Nature Reserve*. Retrieved from https://beta.nparks.gov.sg/visit/parks/bukit-timah-nature-reserve/special-features/history
NParks. (n.d.). *Pangolins*. Retrieved from Animal Advisories: https://www.nparks.gov.sg/gardens-parks-and-nature/dos-and-donts/animal-advisories/pangolins
Nursamsi, I., Amir, Z., Decoeur, H., Moore, J. H., & Luskin, M. S. (2023). Sunda pangolins show inconsistent responses to disturbances across multiple scales. *Wildlife Letters, 1*, 59-70.
Ogden, L. J. (2002). Summary Repor y Report on the Bir t on the Bird Friendly Building Pr riendly Building Program: Effect of Light Reduction on Collision of Migratory Birds. *Special Report for the Fatal Light Awareness Program (FLAP)* , 2 - 16 .
Pastakia, C., & Barber, J. R. (1998). The Rapid Impact Assessment Matrix (RIAM) for EIA. *Environmental Impact Assessment Review*, 461-482.
Pearlindah, Kusumawati, E., Wulandari, D. R., & Listyorini, D. (2012). Embryo development of tree frog Polypedates leucomystax at Campus of State University of Malang. *Journal of Tropical Life Science, 2*(3), 99–102.
Polhemus, D., & Polhemus, J. T. (2013). Guide to the aquatic Heteroptera of Singapore and Peninsular Malaysia. X. infraorder Nepomorpha-famlies Belostomatidae and Nepidae. *The Raffles Bulletin of Zoology, 61*(1), 25-45. Retrieved from https://www.researchgate.net/publication/288272284_Guide_to_the_aquatic_Heteroptera_of_Singapore_and_Peninsular_Malaysia_X_infraorder_Nepomorpha-famlies_Belostomatidae_and_Nepidae
Pottie, S., Lane, D., Kingston, T., & Lee, B.-H. (2005). The microchiropteran bat fauna of Singapore. *Acta Chiropterologica, 7*(2), 237-247.
Prabhat, K. R. (2016). Impacts of particulate matter pollution on plants: Implications for environmental biomonitoring. *Ecotoxicology and Environmental Safety, 129*, 120-136. doi:https://doi.org/10.1016/j.ecoenv.2016.03.012
PUB. (25 January, 2023). *Water from Local Catchment*. Retrieved 21 July, 2023, from

https://www.pub.gov.sg/watersupply/fournationaltaps/localcatchmentwater

Ramboll Pte Ltd. (2025). *Biodiversity and Environmental Studies for BBNP, BBTP and BBHNP - Biodiversity and Environmental Impact Assessment Report.* Singapore.

Robertson, O. J., & Radford, J. Q. (2009). Gap-crossing decisions of forest birds in a fragmented landscape. *Austral Ecology, 34*(4), 435-446.

Schnitzler, H.-U., Moss, C., & Denzinger, A. (2003). From spatial orientation to food acquisition in echolocating bats. *TRENDS in Ecology and Evolution, 18*(8), 386-394.

Shilton, L. A., Altringham, J. D., Compton, S. G., & Whittaker, R. J. (1999). Old World fruit bats can be long-distance seed dispersers through extended retention of viable seeds in the gut. *Proceedings of the Royal Society B: Biological Sciences, 266*(1416), 219. doi:https://doi.org/10.1098/rspb.1999.0625

Singapore Herbarium Online. (11 July, 2024). Retrieved from https://herbaria.plants.ox.ac.uk/bol/sing

Survey Department, Singapore. (1885). Map Of The Island Of Singapore And Its Dependencies. (S.-G. O.-G. Prepared and published by J. Von Cuylenburg, Compiler) National Archives of Singapore. Retrieved 31 May, 2024, from https://www.nas.gov.sg/archivesonline/maps_building_plans/record-details/fba0dd42-115c-11e3-83d5-0050568939ad

Tan, H. (26 September, 2009). *Life History of the Rustic*. Retrieved 23 October, 2024, from Butterflies of Singapore: https://butterflycircle.blogspot.com/2009/09/life-history-of-rustic.html

Tan, H. (19 June, 2010). *Life History of the Branded Imperial*. Retrieved 23 October, 2024, from Butterflies of Singapore: https://butterflycircle.blogspot.com/2010/06/life-history-of-branded-imperial.html

Tan, H. T., Chou, L. M., Yeo, D. C., & Ng, P. K. (2007). *The Natural Heritage of Singapore (2nd edition).* Singapore: Prentice Hall/Pearson Education South Asia Pte Ltd.

Tan, P. Y., Feng, Y., & Hwang, Y. H. (2016). Deforestation in a tropical compact city (Part A): understanding its socio-ecological impacts. *Smart and Sustainable Built Environment, 5*, 47–72.

Tan, R., Chan, S., Loo, A., & Tan, B. (2023). Forest Restoration Action Plan. In L. Chan, D. Ng, L. Lim, L. Chan, D. Ng, & L. Lim (Eds.), *Handbook on Habitat Restoration: General Principles and Case Studies in Singapore* (p. 340). Singapore: National Parks Board. Retrieved from https://www.nparks.gov.sg/-/media/handbook-on-habitat-restoration/handbook-on-habitat-restoration-chapter-04.pdf

Tay, L. S., Choo, R., Khoo, M. D., Kong, E. C., Neo, W. H., Ow, S., . . . Er, K. B. (2024). A suite of wildlife crossing structures facilitates mammal movement across tropical forest fragments in a city. *Ecosphere, 15*(12), e70114.

Teo, R., & Thomas, N. (2019). Updated Inventory of Amphibians, Reptiles and Mammals of the Bukit Timah Nature Reserve, Singapore. *Gardens' Bulletin Singapore 71 (Suppl. 1)*, 145–183.

The Straits Times. (1903). Singapore-Johore Railway. Singapore: The Straits Times. Retrieved from https://eresources.nlb.gov.sg/newspapers/digitised/article/straitstimes19030411-1.2.56

The Straits Times. (22 November, 1975). Bukit Batok Will House 10,000. *The Straits Times*. Singapore. Retrieved 31 May, 2024, from https://eresources.nlb.gov.sg/newspapers/digitised/article/straitstimes19751122-1.2.68

The Straits Times. (18 9, 1985). Bukit Batok at the pinnacle of HDB estate design. *The Straits Times*. Singapore: The Straits Times. Retrieved from https://eresources.nlb.gov.sg/newspapers/digitised/article/straitstimes19850918-1.2.37?qt=bukit,%20batok&q=bukit%20batok

The Straits Times. (31 1, 1996). 'Terrace housing' to dot hilly Bukit Batok area. *The Straits Times*. Singapore. Retrieved from https://eresources.nlb.gov.sg/newspapers/digitised/article/straitstimes19960131-1.2.53.62?qt=bukit,%20batok&q=bukit%20batok

Thein, S. J. (1979). A flow diagram for teaching textureby-feel analysis. *Journal of Agronomic Education 8*, 54-55.

Thorp, J. H., & Covich, A. P. (Eds.). (2001). *Ecology and classification of North American freshwater invertebrates* (2nd ed.). New York: Academic Press. doi:https://doi.org/10.1016/B978-0-12-690647-9.X5000-5

Turner, I. M., & Chua, K. S. (2011). *Checklist of the Vascular Plant Species of the Bukit Timah Nature Reserve.* Singapore: Raffles Museum of Biodiversity Research, Department of Biological Sciences, National University of Singapore. Retrieved from http://www.azkurs.org/pars_docs/refs/27/26054/26054.pdf

Tzi, M. L., Shunari, M., & Lim, K. K. (2010). THE NARROW-WINGED PIPISTRELLE, PIPISTRELLUS STENOPTERUS (DOBSON) IN SINGAPORE (MAMMALIA: CHIROPTERA: VESPERTILIONIDAE). *Nature in Singapore, 3*, 159-165.

URA. (2021). *Former Bukit Timah Fire Station to be rejuvenated as a community node for nature, heritage and adventure lovers*. Retrieved from https://www.ura.gov.sg/Corporate/Media-Room/Media-Releases/pr21-32

Wentworth, C. K. (1922). A Scale of Grade and Class Terms for Clastic Sediments. *The Journal of Geology Vol. 30, No. 5*, 377-392.

Yee, A. T., Chong, K. Y., Neo, L., & Tan, H. T. (2016). Updating the classification system for the secondary forests of Singapore. *Raffles Bulletin of Zoology*, 19.

Yee, A. T., Corlett, R. T., Liew, S. C., & Tan, H. T. (2011). The vegetation of Singapore—an updated map. *Gardens' Bulletin Singapore, 63*(1&2), 205-212.

Yee, A., Chong, K., Seah, W., & Lua, H. (October, 2019). Vegetation of Singapore. *FLORA OF SINGAPORE Volume 1 (pp.47-70)Chapter: 5, 1*, 47-70. doi:10.26492/fos1.2019-05

Yeo, D. C., Wang, L. K., & Lim, K. K. (2010). *Private Lives: An Expose of Singapore's Freshwaters.* Singapore: National University of Singapore.

Yeo, J. H., & Neo, H. (2010). Monkey business: human–animal conflicts in urban Singapore. *Social & Cultural Geography, 11*(7), 681-699.

Yoh N., K. T.-C., Lee, B., Mitchell, S., Bicknell, J., & Struebig, M. (2022). A machine learning framework to classify Southeast Asian echolocating bats. *Ecological Indicators, 136*, 108696.

Yong, D. L., Lim, K. C., & Lee, T. K. (2017). *A Naturalist's Guide to the Birds of Singapore.* Oxford: John Beaufoy Publishing.

Yong, D. L., Lim, K. S., Lim, K. C., Tan, T., Teo, S., & Ho, H. C. (2018). Significance of the globally threatened Straw-headed Bulbul Pycnonotus zeylanicus populations in Singapore: a last straw for the species? *Bird Conservation International, 28*, 133-144.

Zhang, T., Zhou, L., Zhou, Y., Zhang, Y., Guo, J., Han, Y., . . . Brookes, J. (2024). Terrestrial dissolved organic matter inputs accompanied by dissolved oxygen depletion and declining pH exacerbate CO2 emissions from a major Chinese reservoir. *Water Research, 251*, 121155.

Zhou, C., Nakamura, A., Song, X., & Katabuchi, M. (2023). Artificial Light at Night (ALAN) Influences Understory Plant Traits through Ecological Processes: A Two-Year Experiment in a Rubber Plantation in China. *Ecologies*, 704-713.

Zhu, G., Chmura, A., & Zhang, L. (2012). Morphology, echolocation calls and diet of Scotophilus kuhlii (Chiroptera: Vespertilionidae) on Hainan Island, south China. *Acta Chiropterologica, 14*(1), 175-181. doi:https://doi.org/10.3161/150811012X654394

APPENDIX A

List of Plant Species Recorded at Study Area

S/N	Scientific Name	Common Name	Growth Form	Family	Origin	National Status
1	Adenanthera pavonina	Saga, Coral bean tree	Tree	Fabaceae	Non-native	Naturalised
2	Adiantum latifolium	Broadleaf maidenhair	Herb	Pteridaceae	Non-native	Naturalised
3	Agelaea macrophylla	Akar pinang ketul, Akar pinang kutai	Climber, Vine & Liana	Connaraceae	Native	Least Concern
4	Aglaonema commutatum	Chinese evergreen, Silver evergreen	Herb	Araceae	Non-native	Casual
5	Aidia densiflora		Tree	Rubiaceae	Native	Least Concern
6	Alangium griffithii		Tree	Cornaceae	Native	Endangered
7	Alocasia longiloba	Keladi rimau, Keladi ular	Herb	Araceae	Native	Least Concern
8	Alstonia angustiloba	Common pulai, Pulai	Tree	Apocynaceae	Native	Least Concern
9	Alstonia macrophylla	Hard alstonia, Devil-tree, Batino	Tree	Apocynaceae	Non-native	Naturalised
10	Amblovenatum opulentum		Herb	Thelypteridaceae	Native	Least Concern
11	Andira inermis	Brown heart, Cabbage tree	Tree	Fabaceae	Non-native	Casual
12	Antidesma bunius	Chinese laurel, Currantwoo d	Tree	Phyllanthaceae	Non-native	Casual
13	Antidesma cuspidatum	Buni, Kayu buloh	Tree	Phyllanthaceae	Native	Least Concern
14	Aphanamixis polystachya	Pasak lingga, Amoora	Tree	Meliaceae	Native	Least Concern
15	Aporosa benthamiana	Crescent tree	Tree	Phyllanthaceae	Native	Vulnerable
16	Aporosa cf. nervosa		Tree	Phyllanthaceae	Native	Endangered
17	Archidendron cf. jiringa	Jering	Tree	Fabaceae	Native	Vulnerable
18	Ardisia elliptica	Seashore ardisia, Mata pelandok	Tree, Shrub	Primulaceae	Native	Least Concern
19	Artabotrys suaveolens		Climber, Vine & Liana	Annonaceae	Native	Least Concern
20	Arthrophyllum jackianum		Tree	Araliaceae	Native	Least Concern
21	Artocarpus altilis	Breadfruit, Sukun	Tree	Moraceae	Non-native	Casual
22	Artocarpus heterophyllus	Jackfruit, Nangka	Tree	Moraceae	Non-native	Casual
23	Artocarpus integer	Cempedak	Tree	Moraceae	Uncertain	Cryptogenic
24	Averrhoa carambola	Star fruit, Belimbing besi	Tree	Oxalidaceae	Non-native	Casual
25	Axonopus compressus	Tropical carpet grass, Wide-leaved carpet grass	Grass	Poaceae	Non-native	Naturalised
26	Baccaurea motleyana	Rambai, Common rambai	Tree	Phyllanthaceae	Native	Critically Endangered
27	Bambusa vulgaris	Common bamboo, Golden bamboo	Grass	Poaceae	Non-native	Excluded (Cultivated Only)
28	Barringtonia racemosa	Common putat, Fish-killer tree	Tree	Lecythidaceae	Native	Critically Endangered
29	Beilschmiedia madang		Tree	Lauraceae	Native	Vulnerable
30	Bhesa robusta	Red-flowered malayan spindle tree, Biku-biku	Tree	Centroplacaceae	Native	Vulnerable
31	Breynia androgyna	Cekur manis, Chekur manis	Shrub	Phyllanthaceae	Native	Vulnerable
32	Bridelia stipularis	Kenidai, Kernam	Climber, Vine & Liana, Shrub	Phyllanthaceae	Native	Least Concern
33	Calophyllum soulattri	Bintangor bunut, Malang-malang	Tree	Calophyllaceae	Non-native	Excluded
34	Calophyllum tetrapterum		Tree	Calophyllaceae	Native	Vulnerable
35	Campnosperma auriculatum	Terentang, Serentang	Tree	Anacardiaceae	Native	Least Concern
36	Cansjera rheedei		Climber	Opiliaceae	Native	Least Concern

37	Canthiumera robusta	Green coffee	Tree	Rubiaceae	Native	Endangered
38	Carallia suffruticosa	Tulang daing, Sisik puyuh	Tree	Rhizophoraceae	Non-native	Cultivated Only
39	Caryota mitis	Fishtail palm, Common fishtail palm	Cluster Palm, Palm	Arecaceae	Native	Least Concern
40	Causonis trifolia	Three-leaved wild vine	Climber, Vine & Liana	Vitaceae	Native	Data Deficient
41	Cayratia mollissima		Climber, Vine & Liana	Vitaceae	Native	Endangered
42	Cecropia pachystachya	Ambay	Tree	Urticaceae	Non-native	Naturalised
43	Centotheca lappacea	Rumput lilit kain, Rumput darah	Shrub	Poaceae	Native	Least Concern
44	Centrosema molle	Spurred butterfly pea	Climber	Fabaceae	Non-native	Naturalised
45	Cerbera odollam	Pong pong, Pong-pong	Tree	Apocynaceae	Native	Vulnerable
46	cf. Khaya grandifoliola	NA	Tree	Meliaceae	Non-native	Cultivated Only
47	Champereia manillana	False olive, Chemperai	Tree, Shrub	Opiliaceae	Native	Least Concern
48	Chassalia curviflora		Tree, Shrub	Rubiaceae	Native	Vulnerable
49	Christella subpubescens		Fern	Thelypteridaceae	Native	Least Concern
50	Cinnamomum iners	Wild cinnamon, Clove cinnamon	Tree	Lauraceae	Native	Least Concern
51	Cissus hastata		Climber, Vine & Liana	Vitaceae	Native	Least Concern
52	Cissus repens	Malayan wild vine, Carik merah	Climber, Vine & Liana	Vitaceae	Native	Vulnerable
53	Claoxylon indicum	Laping budak, Jarak kayu	Tree, Shrub	Euphorbiaceae	Native	Least Concern
54	Clausena excavata	Pink lime-berry, Cama	Tree, Shrub	Rutaceae	Native	Least Concern
55	Clerodendrum paniculatum	Pagoda flower	Shrub	Lamiaceae	Non-native	Naturalised
56	Clerodendrum villosum		Shrub, Tree	Lamiaceae	Native	Least Concern
57	Cnestis palala		Climber	Connaraceae	Native	Vulnerable
58	Coccinia grandis	Ivy gourd, Scarlet-fruited gourd	Climber, Vine & Liana	Cucurbitaceae	Non-native	Naturalised
59	Cocos nucifera	Coconut, Coconut palm	Palm, Solitary Palm	Arecaceae	Non-native	Naturalised
60	Coffea liberica	Liberian coffee, Liberica coffee	Tree	Rubiaceae	Non-native	Casual
61	Combretum indicum	Rangoon creeper, Drunken sailor	Climber, Vine & Liana	Combretaceae	Non-native	Casual
62	Cryptocarya cf. nitens		Tree	Lauraceae	Native	Critically Endangered
63	Dacryodes cf. costata		Tree	Burseraceae	Native	Endangered
64	Delonix regia	Flame-of-the-forest, Semarak api	Tree	Fabaceae	Non-native	Cultivated Only
65	Dieffenbachia seguine	Dumbcane	Shrub	Araceae	Non-native	Casual
66	Dillenia indica	Elephant apple, Simpoh air	Tree	Dilleniaceae	Non-native	Excluded (Cultivated Only)
67	Dillenia suffruticosa	Simpoh air, Simpuh air	Shrub	Dilleniaceae	Native	Least Concern
68	Dimocarpus lichi	Mata kucing	Tree	Sapindaceae	Native	Data Deficient
69	Dioscorea sansibarensis	Zanzibar yam	Climber, Vine & Liana	Dioscoreaceae	Non-native	Naturalised
70	Diospyros lanceifolia	Common malayan ebony	Tree	Ebenaceae	Native	Least Concern
71	Dracaena fragrans	Corn palm, Palmillo	Shrub	Asparagaceae	Non-native	Casual
72	Dracaena surculosa	Gold dust dracaena, Spotted dracaena	Shrub	Asparagaceae	Non-native	Naturalised
73	Dracaena sanderiana	Lucky bamboo, Belgian evergreen	Shrub	Asparagaceae	Non-native	Naturalised
74	Durio zibethinus	Durian, Durian kampong	Tree	Malvaceae	Non-native	Casual
75	Elaeis guineensis	Oil palm, Macaw fat	Palm, Solitary Palm	Arecaceae	Non-native	Casual
76	Elaeocarpus petiolatus	Broad-leafed oil fruit, Derumun babi	Tree	Elaeocarpaceae	Native	Least Concern

77	Embelia ribes		Climber, Vine & Liana	Primulaceae	Native	Least Concern
78	Epipremnum aureum	Golden pothos, Money plant	Climber, Vine & Liana	Araceae	Non-native	Casual
79	Erycibe tomentosa	Akar pelandok	Climber, Vine & Liana	Convolvulaceae	Native	Least Concern
80	Eulophia graminea	Grass orchid, Bawang hantu	Herb	Orchidaceae	Uncertain	Cryptogenic
81	Falcataria falcata	Albizia, Kayu machis	Tree	Fabaceae	Non-native	Naturalised
82	Erythropalum scandens	Kulim akar	Climber, Vine & Liana	Olacaceae	Native	Vulnerable
83	Ficus aurata	Yellow hairy fig	Tree, Shrub	Moraceae	Native	Least Concern
84	Ficus benjamina	Weeping fig, Java willow	Shrub, Tree	Moraceae	Uncertain	Cryptogenic
85	Ficus caulocarpa	Stem-fruited fig	Tree	Moraceae	Native	Endangered
86	Ficus fistulosa	Common yellow stem-fig, Ara serapat	Tree	Moraceae	Native	Least Concern
87	Ficus cf. glandulifera	Gaping fig	Tree	Moraceae	Native	Endangered
88	Ficus grossularioides	Ara putih, White-leafed fig	Tree, Shrub	Moraceae	Native	Least Concern
89	Ficus heteropleura	Sandy-leafed fig	Tree, Shrub	Moraceae	Native	Least Concern
90	Ficus hispida	Hairy Fig, devil fig, opposite-leaved fig-tree	Tree	Moraceae	Non-native	Casual
91	Ficus microcarpa	Malayan banyan, Jejawi	Tree	Moraceae	Native	Least Concern
92	Ficus punctata	Climbing fig, Tangisong burong	Climber, Vine & Liana	Moraceae	Native	Least Concern
93	Ficus variegata	Common red-stem fig, Variegated fig	Tree	Moraceae	Native	Least Concern
94	Ficus vasculosa	White fig, Ara nasi	Tree	Moraceae	Native	Vulnerable
95	Flagellaria indica	Common flagellaria, Rotan dini	Climber, Vine & Liana	Flagellariaceae	Native	Least Concern
96	Garcinia mangostana var. mangostana	Mangosteen, Manggis	Tree	Clusiaceae	Non-native	Casual
97	Garcinia nigrolineata	Beaked kandis, Kandis hutan	Tree	Clusiaceae	Native	Critically Endangered
98	Gardenia subcarinata			Rubiaceae	Native	Critically Endangered
99	Gironniera nervosa	Kasap, Common rough-laurel	Tree	Cannabaceae	Native	Least Concern
100	Glochidion cf. singaporense		Tree	Phyllanthaceae	Native	Critically Endangered
101	Glochidion lutescens		Shrub	Phyllanthaceae	Native	Critically Endangered
102	cf. Glochidion zeylanicum var. zeylanicum		Tree	Phyllanthaceae	Native	Vulnerable
103	Gnetum gnemon	Belinjau, Meninjau	Tree	Gnetaceae	Native	Critically Endangered
104	Goniophlebium percussum		Epiphyte	Polypodiaceae	Native	Vulnerable
105	Grypothrix triphylla		Herbaceous plant	Thelypteridaceae	Native	Least Concern
106	Gynochthodes rigida		Climber, Vine & Liana	Rubiaceae	Native	Vulnerable
107	Hevea brasiliensis	Para rubber, Rubber tree	Tree	Euphorbiaceae	Non-native	Naturalised
108	Hopea odorata	Chengal pasir, Merawan siput jantan	Tree	Dipterocarpaceae	Non-native	Cultivated Only
109	Horsfieldia cf. polyspherula	Horsfield Tree	Tree	Myristicaceae	Native	Vulnerable
110	Horsfieldia cf. punctatifolia		Tree	Myristicaceae	Native	Endangered
111	Horsfieldia cf. sparsa	Penarahan gajah, Samak pulut	Tree	Myristicaceae	Native	Endangered
112	Hyptis capitata	Lesser roundhead, Knobweed, False ironwort	Herb, Shrub	Lamiaceae	Non-native	Naturalised

113	Ilex cymosa	Marsh holly, Mensirah	Tree	Aquifoliaceae	Native	Least Concern
114	Ixonanthes reticulata	Pagar anak, Ten men tree	Tree	Ixonanthaceae	Native	Least Concern
115	Lansium domesticum	Langsat, Duku	Tree	Meliaceae	Non-native	Casual
116	Lantana camara	Lantana, Common lantana	Shrub	Verbenaceae	Non-native	Naturalised
117	Leea indica	Bandicoot berry, Common tree-vine	Shrub, Tree	Vitaceae	Native	Least Concern
118	Lepisanthes amoena	Kayu mata hari	Tree	Sapindaceae	Non-native	Cultivated Only
119	Lepisanthes rubiginosa	Mertajam, Kelat layu	Tree	Sapindaceae	Native	Least Concern
120	Lindsaea ensifolia		Herb	Lindsaeaceae	Native	Least Concern
121	Litsea elliptica	Medang, Perawas	Tree	Lauraceae	Native	Least Concern
122	Litsea umbellata	Blue laurel, Medang	Tree	Lauraceae	Native	Vulnerable
123	Macaranga bancana		Tree	Euphorbiaceae	Native	Least Concern
124	Macaranga conifera		Tree	Euphorbiaceae	Native	Least Concern
125	Macaranga gigantea	Mahang gajah, Elephant's ear tree	Tree	Euphorbiaceae	Native	Least Concern
126	Macaranga griffithiana	Mahang bulan, Mahang tutup	Tree	Euphorbiaceae	Native	Vulnerable
127	Macaranga hypoleuca		Tree	Euphorbiaceae	Native	Least Concern
128	Madhuca sericea		Tree	Sapotaceae	Native	Critically Endangered
129	Mallotus paniculatus	Turn-in-the-wind, Balik angin	Tree, Shrub	Euphorbiaceae	Native	Least Concern
130	Mangifera indica	Mango, Mangga	Tree	Anacardiaceae	Non-native	Casual
131	Manihot carthagenensis subsp. glaziovii	Ceara rubber tree	Shrub	Euphorbiaceae	Non-native	Naturalised
132	Maranthes corymbosa	Merbatu, Sea beam	Tree	Chrysobalanaceae	Native	Vulnerable
133	Melastoma malabathricum	Common sendudok, Singapore rhododendron	Shrub, Tree	Melastomataceae	Native	Least Concern
134	Melia azedarach			Meliaceae	Non-native	Cultivated Only
135	Melicope cf. glabra		Tree	Rutaceae	Native	Endangered
136	Melicope cf. lunu-ankenda		Tree	Rutaceae	Native	Endangered
137	Memecylon ovatum	Delek air, Bayan	Tree, Shrub	Melastomataceae	Native	Endangered
138	Memecylon paniculatum		Tree	Melastomataceae	Native	Critically Endangered
139	Miconia crenata	Koster's curse	Shrub	Melastomataceae	Non-native	Naturalised
140	Mikania micrantha	American rope, Mile-a-minute weed	Climber, Vine & Liana, Herb, Creeper	Asteraceae	Non-native	Naturalised
141	Mimosa pudica	Sensitive plant, Touch-me-not	Shrub	Fabaceae	Non-native	Naturalised
142	Mimusops elengi	Tanjong tree, Bunga tanjung	Tree	Sapotaceae	Non-native	Casual
143	Morinda citrifolia	Mengkudu besar, Inda	Tree	Rubiaceae	Native	Least Concern
144	Morinda elliptica		Tree	Rubiaceae	Native	Endangered
145	Morus alba	White mulberry, Tut	Tree	Moraceae	Non-native	Cultivated Only
146	Muntingia calabura	Buah cheri, Malayan cherry	Tree	Muntingiaceae	Non-native	Naturalised
147	Nephelium lappaceum	Rambutan, Hairy lychee	Tree	Sapindaceae	Uncertain	Cryptogenic
148	Nephrolepis biserrata	Broad sword fern, Paku larat	Herb	Nephrolepidaceae	Native	Least Concern
149	Nothaphoebe umbelliflora	Medang losa, Medang	Tree	Lauraceae	Native	Least Concern

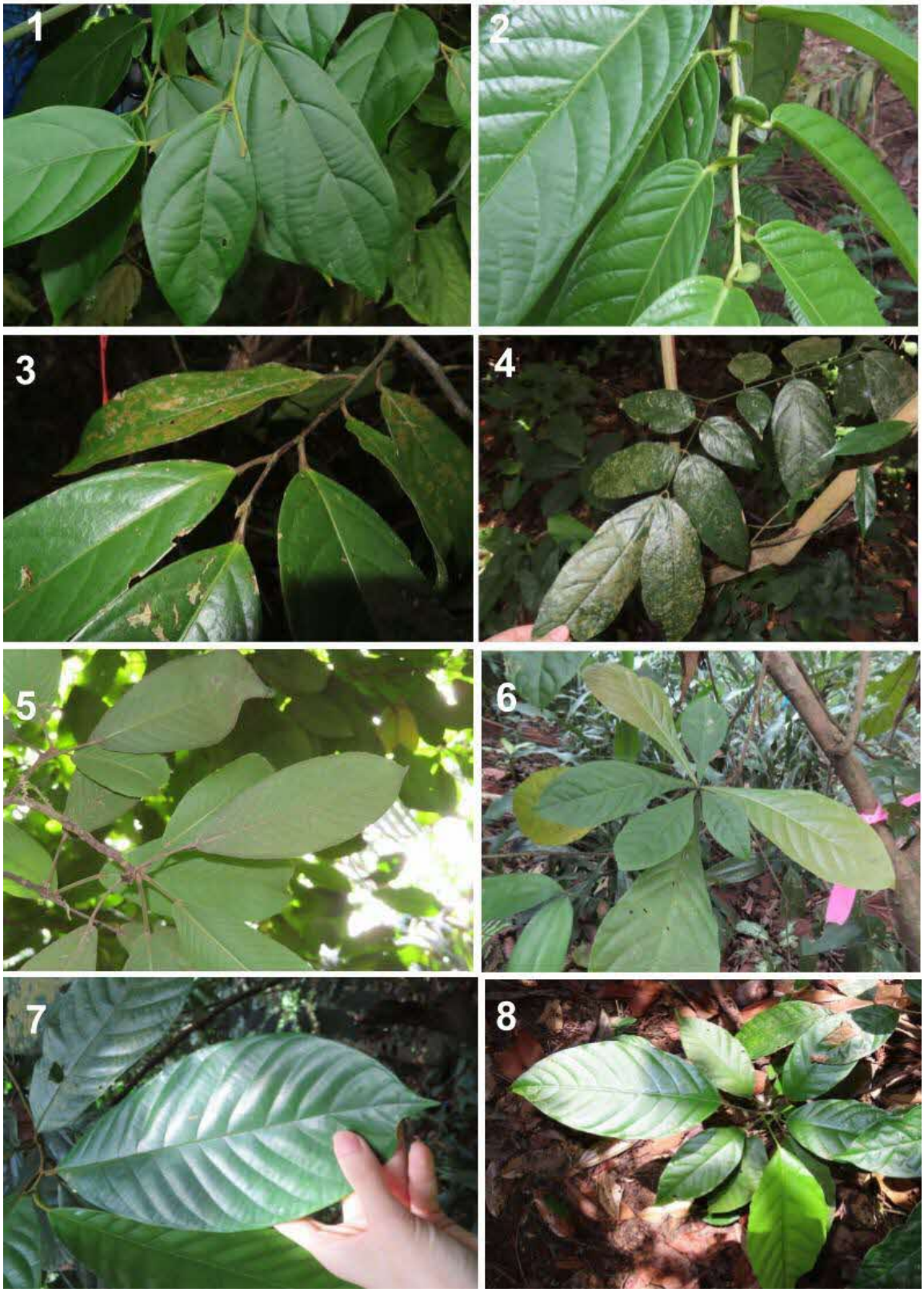
150	Ottochloa nodosa		Herb	Poaceae	Native	Least Concern
151	Oxyceros bispinosus		Climber	Rubiaceae	Native	Least Concern
152	Paederia foetida	Lesser malayan stinkwort, Akar sekentut	Climber, Vine & Liana	Rubiaceae	Native	Least Concern
153	Palaquium gutta	Gutta percha, Getah merah	Tree	Sapotaceae	Native	Critically Endangered
154	Palaquium microphyllum		Tree	Sapotaceae	Native	Critically Endangered
155	Palaquium obovatum		Tree	Sapotaceae	Native	Vulnerable
156	Pandanus amaryllifolius	Pandan, Fragrant pandan	Shrub, Herb	Pandanaceae	Non-native	Casual
157	Passiflora laurifolia	Water lemon, Yellow granadilla	Climber, Vine & Liana	Passifloraceae	Non-native	Naturalised
158	Pellacalyx axillaris	Abu-abu air, Bebuloh	Tree	Rhizophoraceae	Native	Vulnerable
159	Peltophorum pterocarpum	Yellow flame, Jemerlang laut	Tree	Fabaceae	Native	Critically Endangered
160	Piper sarmentosum	Wild pepper, Wild betel	Creeper	Piperaceae	Native	Least Concern
161	Pipturus argenteus	Australian mulberry	Tree, Shrub	Urticaceae	Uncertain	Cryptogenic
162	Planchonella obovata	Sea gutta, Menasi	Tree	Sapotaceae	Native	Least Concern
163	Prunus polystachya	Bat's laurel, Medang kelawar	Tree	Rosaceae	Native	Least Concern
164	Pternandra coerulescens	Cursed shade, Sial menahun	Tree	Melastomataceae	Native	Vulnerable
165	Ptychosperma macarthurii	MacArthur palm, Hurricane palm	Cluster Palm, Palm	Arecaceae	Non-native	Naturalised
166	Rhodamnia cinerea	Silver back tree, Mempoyan	Tree	Myrtaceae	Native	Least Concern
167	Samanea saman	Rain tree, Pukul lima	Tree	Fabaceae	Non-native	Casual
168	Santiria apiculata		Tree	Burseraceae	Native	Least Concern
169	Saribus rotundifolius	Footstool palm, Java palm	Palm, Solitary Palm	Arecaceae	Non-native	Casual
170	Smilax setosa	Bearded smilax, Akar banar	Climber, Vine & Liana	Smilacaceae	Native	Least Concern
171	Solanum torvum	Turkey berry, Devil's fig	Shrub	Solanaceae	Non-native	Naturalised
172	Spathodea campanulata	African tulip tree, Panchot	Tree	Bignoniaceae	Non-native	Naturalised
173	Spatholobus ferrugineus var. ferrugineus		Climber, Vine & Liana	Fabaceae	Native	Least Concern
174	Spermacoce latifolia	Broad-leaved buttonweed, Oval leaf false buttonweed	Herb	Rubiaceae	Non-native	Naturalised
175	Sphaerostephanos heterocarpos		Fern	Thelypteridaceae	Native	Least Concern
176	Stachytarpheta jamaicensis	Brazilian tea, Rooter comb	Shrub	Verbenaceae	Non-native	Naturalised
177	Stenochlaena palustris	Climbing fern, Akar paku	Epiphyte, Herb	Blechnaceae	Native	Least Concern
178	Sterculia cordata	Kelumpang, Kembang	Tree	Malvaceae	Native	Critically Endangered
179	Sterculia parviflora	Common sterculia, Kelumpang burong	Tree	Malvaceae	Native	Critically Endangered
180	Strobilanthes crispa			Acanthaceae	Non-native	Cultivated Only
181	Strombosia javanica	Bayam badak, Dali-dali	Tree	Olacaceae	Native	Vulnerable
182	Suregada glomerulata	Limau-limau, Penawar puteh	Tree	Euphorbiaceae	Native	Critically Endangered
183	Syngonium angustatum	Arrowhead plant	Climber	Araceae	Non-native	Naturalised
184	Syzygium aqueum	Water apple, Jambu air mawar	Tree	Myrtaceae	Non-native	Cultivated Only
185	Syzygium cerasiforme	Common kelat, Gelam tikus	Tree	Myrtaceae	Native	Least Concern
186	Syzygium grande	Sea apple, Jambu laut	Tree	Myrtaceae	Native	Least Concern

187	Syzygium myrtifolium	Kelat oil, Kelat paya	Shrub, Tree	Myrtaceae	Native	Critically Endangered
188	Syzygium pachyphyllum	Thick-leafed jambu, Kelat	Tree	Myrtaceae	Native	Critically Endangered
189	Syzygium polyanthum	Indonesian bayleaf, Salam	Tree	Myrtaceae	Native	Least Concern
190	Syzygium cf. pycnanthum	Wild rose apple, Kelat jambu	Tree	Myrtaceae	Native	Critically Endangered
191	Tabebuia rosea	Trumpet tree, Pink poui	Tree	Bignoniaceae	Non-native	Casual
192	Terminalia catappa	Sea almond, Ketapang	Tree	Combretaceae	Native	Least Concern
193	Tetracera cf. fagifolia		Climber	Dilleniaceae	Native	Critically Endangered
194	Tetracera indica	Mempelas, Akar mempelas	Climber, Vine & Liana	Dilleniaceae	Native	Least Concern
195	Thunbergia fragrans	Angel wings, Fragrant thunbergia	Climber, Vine & Liana	Acanthaceae	Non-native	Naturalised
196	Timonius wallichianus	Silver timon, Triang	Tree	Rubiaceae	Native	Least Concern
197	Tinospora krispura		Climber, Vine & Liana	Menispermaceae	Native	Endangered
198	Triphasia trifolia	Limeberry, Limau keah	Tree, Shrub	Rutaceae	Non-native	Cultivated Only
199	Tristellateia australasiae	Maiden's jealousy, Galphimia vine	Climber, Vine & Liana	Malpighiaceae	Native	Endangered
200	Uncaria cordata	Gambir-gambir hutan	Climber, Vine & Liana	Rubiaceae	Native	Endangered
201	Urceola cf. brachysepala	Akar gerip hitam	Climber, Vine & Liana	Apocynaceae	Native	Least Concern
202	Vitex pinnata	Leban, Malayan teak	Tree	Lamiaceae	Native	Least Concern
203	Xanthophyllum ellipticum	Crenate-leaved xanthophyllum	Tree	Polygalaceae	Native	Critically Endangered
204	Xanthophyllum eurhynchum	Warty fruited xanthophyllum	Tree	Polygalaceae	Native	Vulnerable
205	Xanthophyllum vitellinum	Dedali paya, Big-budded xanthophyllum	Tree	Polygalaceae	Native	Vulnerable
206	Xylopia malayana	Kayu tapis, Krai	Tree	Annonaceae	Native	Vulnerable

APPENDIX B

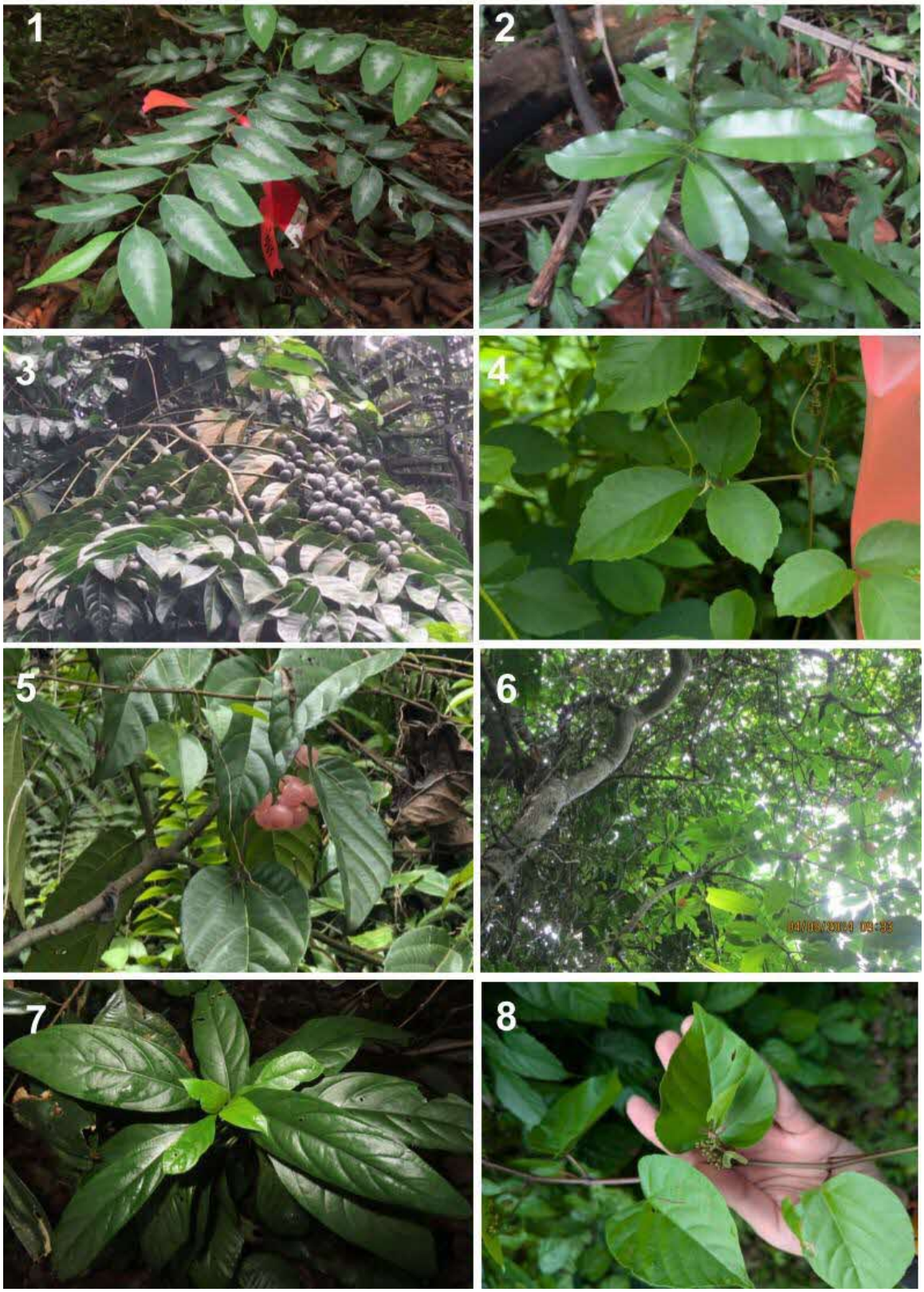
Photographs of Plants Observed at Study Area

Appendix B: Photographs of Selected Flora Species Observed at Study Area



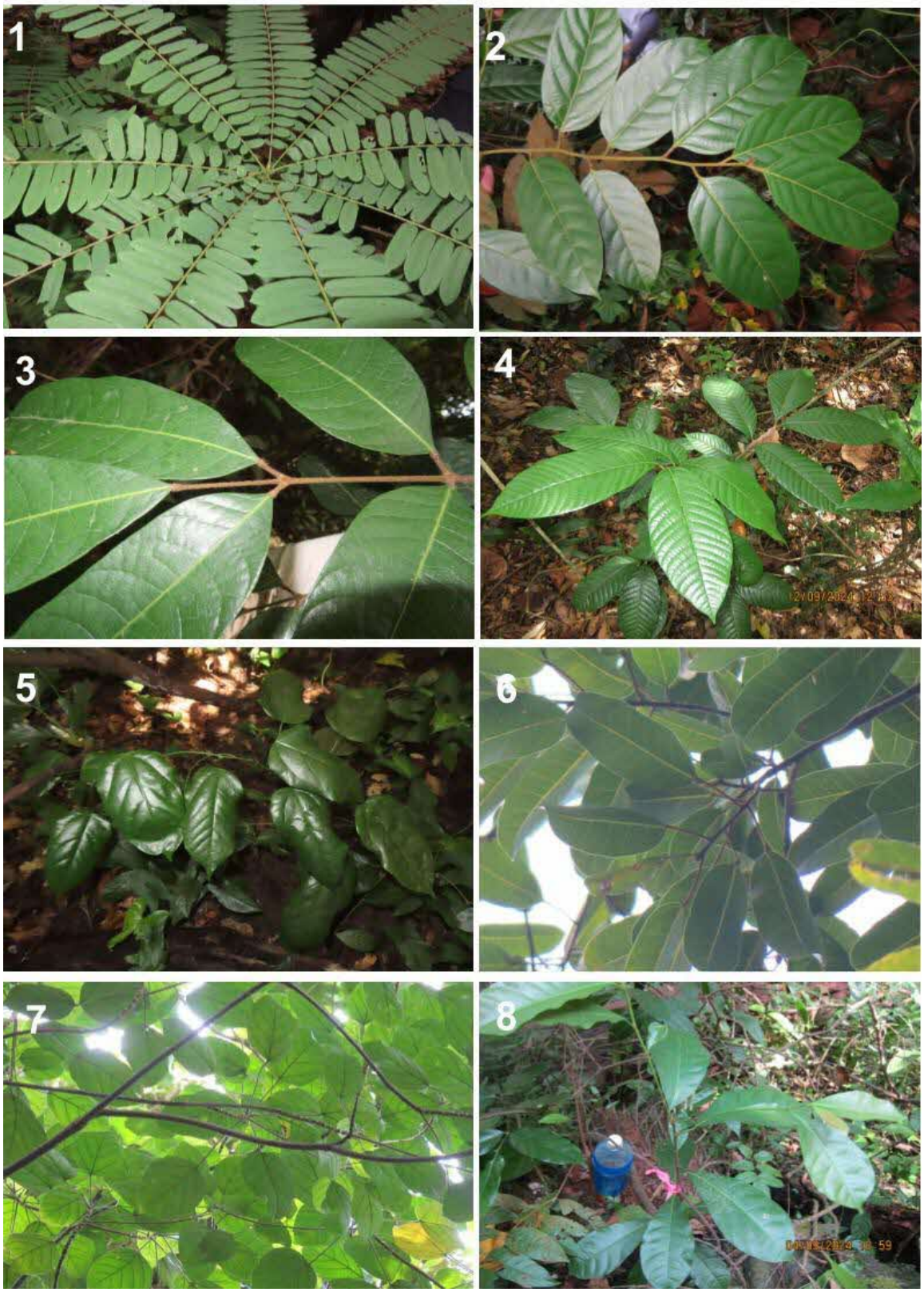
1: *Alangium griffithii*; **2**: *Aporosa benthamiana;* **3**: *Aporosa* cf. *nervosa;* **4**: *Archidendron* cf. *jiringa*; **5**: *Baccaurea motleyana*; **6**: *Barringtonia racemosa*; **7**: *Beilschmiedia madang;* **8**: *Bhesa robusta*

Appendix B: Photographs of Selected Flora Species Observed at Study Area



1: *Breynia androgyna*; **2**: *Calophyllum tetrapterum;* **3**: *Canthiumera robusta*; **4**: *Causonis trifolia*; **5**: *Cayratia mollissima*; **6**: *Cerbera odollam*; **7**: *Chassalia curviflora*; **8**: *Cissus repens*

Appendix B: Photographs of Selected Flora Species Observed at Study Area



1: *Cnestis palala*; **2**: *Cryptocarya* cf. *nitens;* **3**: *Dacryodes* cf. *costata*; **4:** *Dimocarpus lichi*; **5**: *Erythropalum scandens*; **6**: *Ficus caulocarpa*; **7**: *Ficus* cf. *glandulifera*; **8**: *Ficus vasculosa*

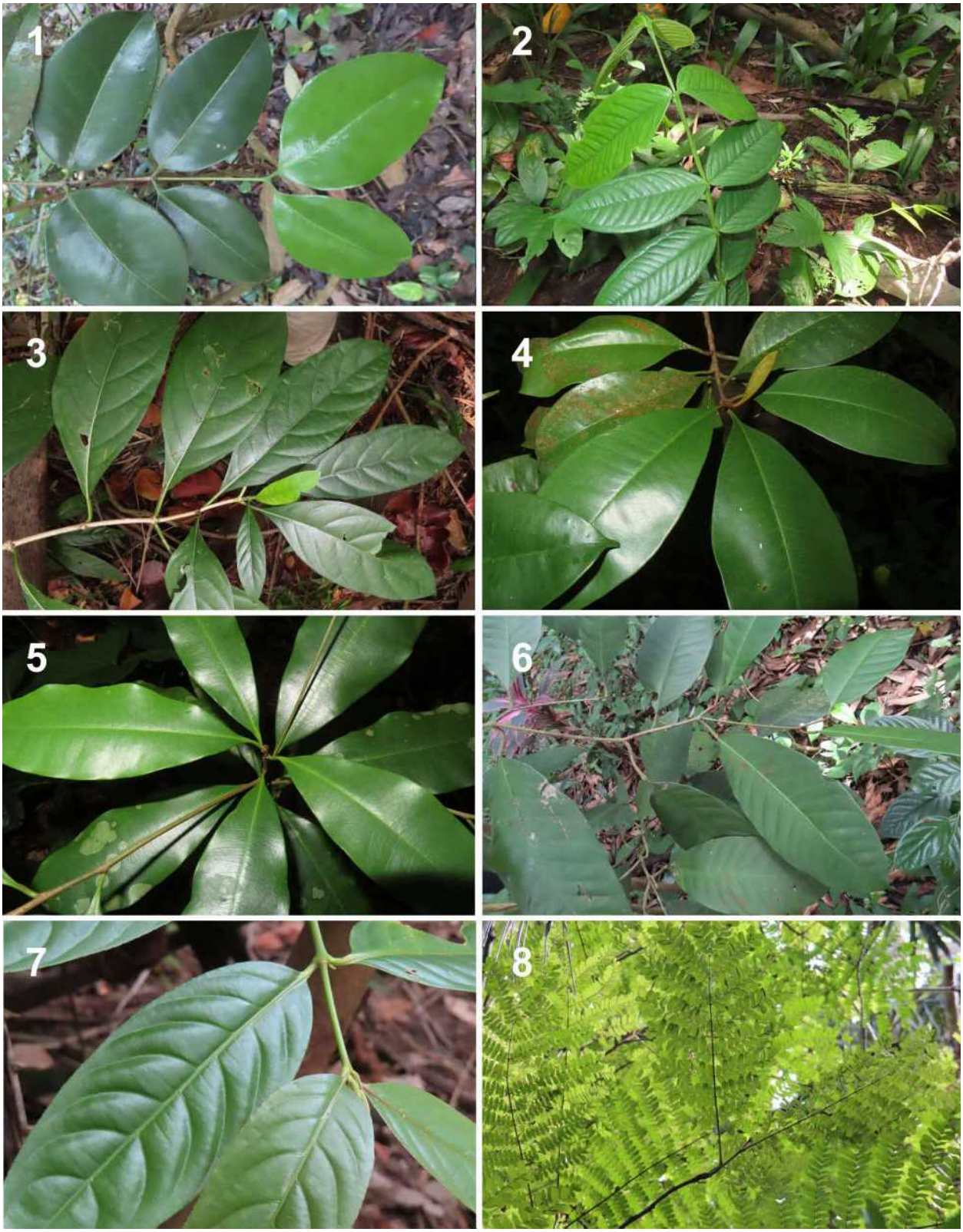
Appendix B: Photographs of Selected Flora Species Observed at Study Area

1: *Garcinia nigrolineata*; **2**: *Gardenia subcarinata*; **3:** *Glochidion* cf. *singaporense;* **4**: cf. *Glochidion zeylanicum var zeylanicum*; **5**: *Gnetum gnemon*; **6:** *Goniophlebium percussum*; **7**: *Gynochthodes rigida*; **8**: *Horsfieldia* cf. *polyspherula*

Appendix B: Photographs of Selected Flora Species Observed at Study Area

1: *Horsfieldia* cf. *punctatifolia*; **2:** *Horsfieldia* cf. *sparsa*; **3:** *Litsea umbellata*; **4:** *Macaranga griffithiana*; **5:** *Madhuca sericea*; **6:** *Maranthes corymbosa*; **7:** *Melicope* cf. *glabra*; **8:** *Melicope* cf. *lunu-ankenda*

Appendix B: Photographs of Selected Flora Species Observed at Study Area



1: *Memecylon ovatum*; **2:** *Memecylon paniculatum*; **3:** *Morinda elliptica*; **4:** *Palaquium gutta*; **5:** *Palaquium microphyllum*; **6:** *Palaquium obovatum*; **7:** *Pellacalyx axillaris*; **8:** *Peltophorum pterocarpum*

Appendix B: Photographs of Selected Flora Species Observed at Study Area

1: *Pternandra coerulescens*; **2:** *Sterculia cordata*; **3:** *Sterculia parviflora*; **4:** *Strombosia javanica*; **5:** *Suregada glomerulata*; **6:** *Syzygium myrtifolium*; **7 & 8:** *Syzygium* cf. *pycnanthum*

Appendix B: Photographs of Selected Flora Species Observed at Study Area

1: *Tetracera* cf. *fagifolia*; **2:** *Tinospora krispura*; **3:** *Tristellateia australasiae*; **4:** *Uncaria cordata*; **5:** *Xanthophyllum ellipticum*; **6:** *Xanthophyllum eurhynchum*; **7:** *Xanthophyllum vitellinum*; **8:** *Xylopia malayana*

APPENDIX C

List of Fauna Species Recorded at Study Area

BIRDS						
No.	Family	Species name	Common Name	Origin	SRDB3	IUCN status
1	Accipitridae	*Haliastur indus*	Brahminy Kite	Native	LC	LC
2	Accipitridae	*Nisaetus cirrhatus*	Changeable Hawk-eagle	Native	VU	LC
3	Aegithinidae	*Aegithina tiphia*	Common Iora	Native	LC	LC
4	Alcedinidae	*Halcyon smyrnensis*	White-throated Kingfisher	Native	LC	LC
5	Alcedinidae	*Todiramphus chloris*	Collared Kingfisher	Native	LC	LC
6	Caprimulgidae	*Caprimulgus macrurus*	Large-tailed Nightjar	Native	LC	LC
7	Cisticolidae	*Orthotomus atrogularis*	Dark-necked Tailorbird	Native	LC	LC
8	Cisticolidae	*Orthotomus sericeus*	Rufous-tailed Tailorbird	Native	NT	LC
9	Cisticolidae	*Orthotomus sutorius*	Common Tailorbird	Native	LC	LC
10	Columbidae	*Chalcophaps indica*	Common Emerald Dove	Native	LC	LC
11	Columbidae	*Ducula bicolor*	Pied Imperial Pigeon	Native + Introduced	DD	LC
12	Columbidae	*Spilopelia chinensis*	Spotted Dove	Native	LC	LC
13	Columbidae	*Treron vernans*	Pink-necked Green Pigeon	Native	LC	LC
14	Coraciidae	*Eurystomus orientalis*	Oriental Dollarbird	Native	LC	LC
15	Corvidae	*Corvus macrorhynchos*	Large-billed Crow	Native	VU	LC
16	Corvidae	*Corvus splendens*	House Crow	Introduced	-	LC
17	Cuculidae	*Eudynamys scolopaceus*	Asian Koel	Native	LC	LC
18	Dicaeidae	*Dicaeum cruentatum*	Scarlet-backed Flowerpecker	Native	LC	LC
19	Dicruridae	*Dicrurus paradiseus*	Greater Racket-tailed Drongo	Native	LC	LC
20	Dicaeidae	*Dicaeum trigonostigma*	Orange-bellied Flowerpecker	Native	NT	LC
21	Hirundinidae	*Hirundo tahitica*	Pacific Swallow	Native	LC	LC
22	Leiothrichidae	*Garrulax leucolophus*	White-crested Laughingthrush	Introduced	-	LC
23	Megalaimidae	*Psilopogon lineatus*	Lineated Barbet	Introduced	-	LC
24	Muscicapidae	*Copsychus saularis*	Oriental Magpie-robin	Native	VU	LC
25	Muscicapidae	*Muscicapa dauurica*	Asian Brown Flycatcher	Native	LC	LC
26	Nectariniidae	*Aethopyga siparaja*	Crimson Sunbird	Native	LC	LC
27	Nectariniidae	*Anthreptes malacensis*	Brown-throated Sunbird	Native	LC	LC
28	Nectariniidae	*Arachnothera longirostra*	Little Spiderhunter	Native	NT	LC
29	Nectariniidae	*Cinnyris jugularis*	Olive-backed Sunbird	Native	LC	LC
30	Oriolidae	*Oriolus chinensis*	Black-naped Oriole	Native	LC	LC
31	Phasianidae	*Gallus gallus*	Red Junglefowl	Native	NT	LC

32	Picidae	*Chrysophlegma miniaceum*	Banded Woodpecker	Native	LC	LC
33	Picidae	*Dinopium javanense*	Common Flameback	Native	LC	LC
34	Picidae	*Micropternus brachyurus*	Rufous Woodpecker	Native	LC	LC
35	Picidae	*Picus vittatus*	Laced Woodpecker	Native	LC	LC
36	Picidae	*Yungipicus moluccensis*	Sunda Pygmy Woodpecker	Native	LC	LC
37	Psittacidae	*Loriculus galgulus*	Blue-crowned Hanging Parrot	Native	LC	LC
38	Psittacidae	*Psittacula alexandri*	Red-breasted Parakeet	Introduced	-	NT
39	Psittacidae	*Psittacula krameri*	Rose-ringed Parakeet	Introduced	-	LC
40	Psittacidae	*Psittacula longicauda*	Long-tailed Parakeet	Native	NT	VU
41	Psittacidae	*Trichoglossus haematodus*	Coconut Lorikeet	Introduced	-	LC
42	Pycnonotidae	*Pycnonotus goiavier*	Yellow-vented Bulbul	Native	LC	LC
43	Pycnonotidae	*Pycnonotus plumosus*	Olive-winged Bulbul	Native	LC	LC
44	Pycnonotidae	*Pycnonotus zeylanicus*	Straw-headed Bulbul	Native	EN	CR
45	Rallidae	*Gallirallus striatus*	Slaty-breasted Rail	Native	LC	LC
46	Strigidae	*Otus lempiji*	Sunda Scops Owl	Native	LC	LC
47	Sturnidae	*Gracula religiosa*	Common Hill Myna	Native	NT	LC
48	Sturnidae	*Acridotheres javanicus*	Javan Myna	Introduced	-	VU
49	Sturnidae	*Aplonis panayensis*	Asian Glossy Starling	Native	LC	LC
50	Timaliidae	*Mixornis gularis*	Pin-striped Tit-babbler	Native	LC	LC
51	Zosteropidae	*Zosterops simplex*	Swinhoe's White-eye	Native + Introduced	VU	LC
52	Apodidae	*Aerodramus* sp.	Unidentified Swiftlet	-	-	-
53	Meropidae	*Merops* sp.	Unidentified Bee-eater	Native	LC	LC
54	Phylloscopidae	*Phylloscopus* sp.	Unidentified Leaf Warbler	Native	-	-
-	Accipitridae	-	Unidentified Raptor	-	-	-

MAMMALS

No.	Family	Species name	Common Name	Origin	SRDB3	IUCN status
1	Cercopithecidae	*Macaca fascicularis*	Long-tailed Macaque	Native	LC	EN
2	Cynocephalidae	*Galeopterus variegatus*	Malayan Colugo	Native	NT	LC
3	Emballonuridae	*Taphozous melanopogon*	Black-bearded Tomb Bat	Native	LC	LC
4	Felidae	*Felis catus*	Feral Cat	-	-	-
5	Manidae	*Manis javanica*	Sunda Pangolin	Native	CR	CR
6	Pteropodidae	*Cynopterus brachyotis*	Lesser Dog-faced Fruit Bat	Native	LC	LC
7	Sciuridae	*Callosciurus notatus*	Plantain Squirrel	Native	LC	LC

8	Sciuridae	*Sundasciurus tenuis*	Slender Squirrel	Native	LC	LC
9	Soricidae	*Suncus murinus*	Asian House Shrew	Native	LC	LC
10	Tupaiidae	*Tupaia glis*	Common Malayan Treeshrew	Native	LC	LC
11	Vespertilionidae	*Myotis muricola*	Whiskered Myotis	Native	LC	LC
12	Vespertilionidae	*Pipistrellus stenopterus*	Narrow-winged pipistrelle	Native	LC	LC
13	Vespertilionidae	*Scotophilus kuhlii*	Lesser Asian House Bat	Native	LC	LC
14	Viverridae	*Paradoxurus musangus*	Common Palm Civet	Native	LC	LC
15	Muridae	-	Unidentified Rat	-	-	-
-	-	-	Unidentified Bat	-	-	-
-	-	-	Unidentified Small Mammal	-	-	-

REPTILES

No.	Family	Species name	Common Name	Origin	SRDB3	IUCN status
1	Agamidae	*Bronchocela cristatella*	Green Crested Lizard	Native	LC	LC
2	Agamidae	*Calotes versicolor*	Changeable Lizard	Introduced	-	LC
3	Colubridae	*Dendrelaphis pictus*	Painted Bronzeback	Native	LC	LC
4	Gekkonidae	*Gekko monarchus*	Spotted House Gecko	Native	LC	LC
5	Gekkonidae	*Hemidactylus frenatus*	Spiny-tailed House Gecko	Native	LC	LC
6	Scincidae	Subdoluseps bowringii	Bowring's Agile Skink	Native	LC	LC
7	Varanidae	*Varanus nebulosus*	Clouded Monitor	Native	LC	NT
8	Varanidae	*Varanus salvator*	Malayan Water Monitor	Native	LC	LC
-	Varanidae	*Varanus* sp.	Unidentified Monitor Lizard	-	-	-

AMPHIBIANS

No.	Family	Species name	Common Name	Origin	SRDB3	IUCN status
1	Bufonidae	*Duttaphrynus bengalensis*	Asian Toad	Introduced	-	LC
2	Microhylidae	*Microhyla* cf. *heymonsi*	Dark-sided Chorus Frog	Native	LC	LC
3	Rhacophoridae	*Polypedates leucomystax*	Four-lined Tree Frog	Native	LC	LC

BUTTERFLIES

No.	Family	Subfamily	Species name	Common Name	Origin	SRDB3	IUCN status
1	Butterflies	Hesperiidae	*Iambrix salsala salsala*	Chestnut Bob	Native	LC	-

2	Butterflies	Hesperiidae	*Pelopidas mathias mathias*	Small Branded Swift	Native	LC	LC
3	Butterflies	Hesperiidae	*Potanthus omaha omaha*	Lesser Dart	Native	LC	-
4	Butterflies	Hesperiidae	*Taractrocera archias quinta*	Yellow Grass Dart	Uncertain	LC	-
5	Butterflies	Lycaenidae	*Catopyrops ancyra aberrans*	Ancyra Blue	Uncertain	LC	-
6	Butterflies	Lycaenidae	*Eooxylides tharis distanti*	Branded Imperial	Native	LC	-
7	Butterflies	Lycaenidae	*Prosotas dubiosa lumpura*	Tailless Line Blue	Native	LC	-
8	Butterflies	Lycaenidae	*Zizeeria maha serica*	Pale Grass Blue	Native	LC	-
9	Butterflies	Lycaenidae	*Zizina otis lampa*	Lesser Grass Blue	Native	LC	LC
10	Butterflies	Lycaenidae	*Zizula hylax pygmaea*	Pygmy Grass Blue	Native	LC	LC
11	Butterflies	Nymphalidae	*Acraea terpsicore*	Tawny Coster	Native	LC	-
12	Butterflies	Nymphalidae	*Cupha erymanthis lotis*	Rustic	Native	LC	-
13	Butterflies	Nymphalidae	*Dryas iulia*	Julia Heliconian	Uncertain	LC	-
14	Butterflies	Nymphalidae	*Elymnias hypermnestra agina*	Common Palmfly	Native	LC	-
15	Butterflies	Nymphalidae	*Junonia almana javana*	Peacock Pansy	Native	LC	LC
16	Butterflies	Nymphalidae	*Junonia hedonia ida*	Chocolate Pansy	Native	LC	-
17	Butterflies	Nymphalidae	*Junonia orithya wallacei*	Blue Pansy	Native	LC	LC
18	Butterflies	Nymphalidae	*Mycalesis mineus macromalayana*	Dark-brand Bush Brown	Native	LC	-
19	Butterflies	Nymphalidae	*Mycalesis perseoides perseoides*	Burmese Bush Brown	Uncertain	LC	-
20	Butterflies	Nymphalidae	*Tanaecia pelea pelea*	Malay Viscount	Native	LC	LC
21	Butterflies	Papilionidae	*Papilio polytes romulus*	Common Mormon	Native	LC	-
22	Butterflies	Pieridae	*Appias olferna olferna*	Striped Albatross	Native	LC	-
23	Butterflies	Pieridae	*Delias hyparete metarete*	Painted Jezebel	Native	LC	-
24	Butterflies	Pieridae	*Eurema hecabe contubernalis*	Common Grass Yellow	Native	LC	LC
25	Butterflies	Pieridae	*Eurema sari sodalis*	Chocolate Grass Yellow	Native	LC	-
-	Butterflies	Nymphalidae	-	Unidentified Bush Brown	-	-	-

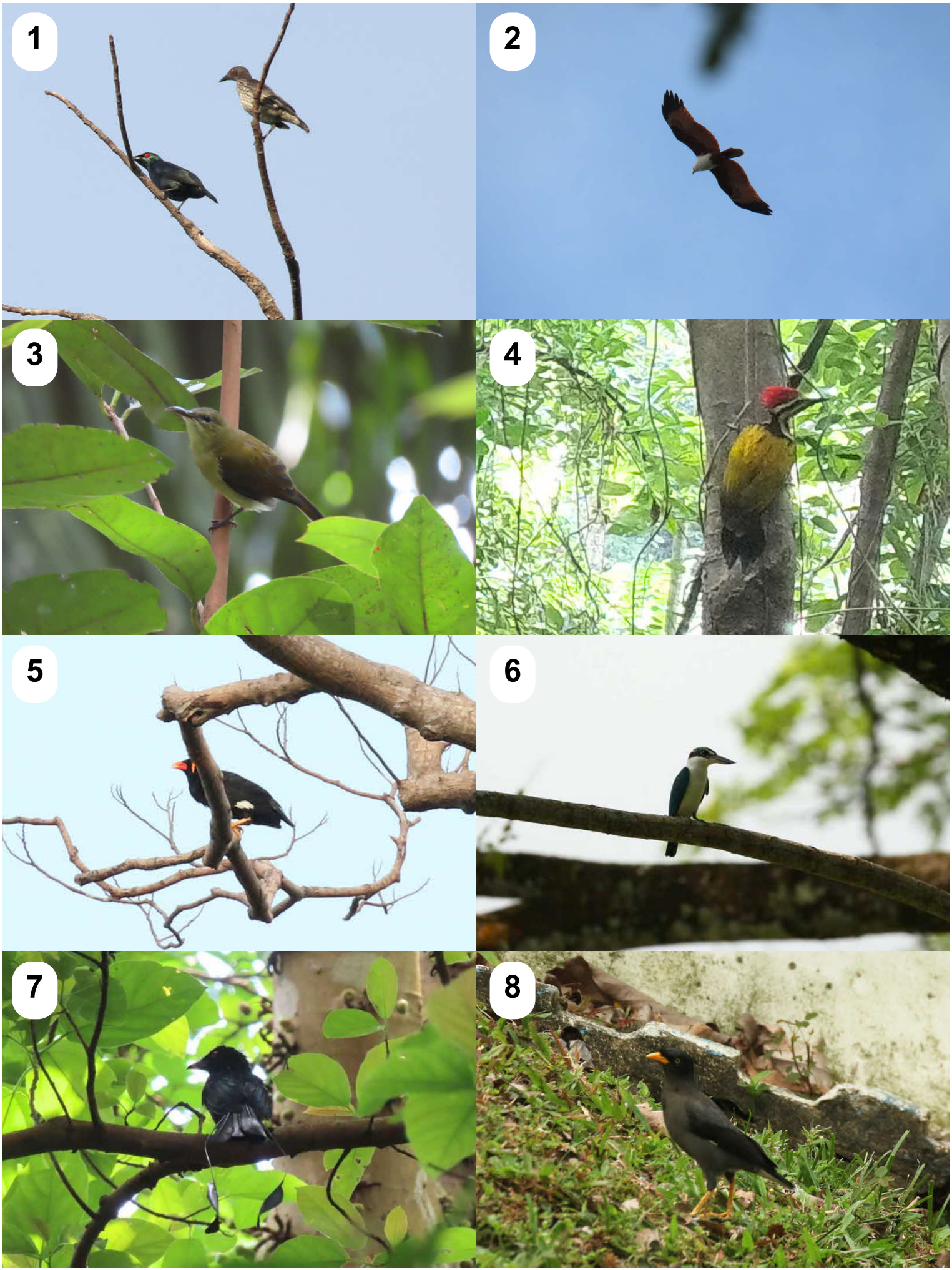
ODONATES

No.	Family	Species name	Common Name	Origin	SRDB3	IUCN status
1	Libellulidae	*Agrionoptera insignis*	Grenadier	-	LC	LC
2	Libellulidae	*Brachydiplax chalybea*	Blue Dasher	-	LC	LC
3	Libellulidae	*Neurothemis fluctuans*	Common Parasol	-	LC	LC
4	Libellulidae	*Orthetrum chrysis*	Spine-tufted Skimmer	-	LC	LC
5	Libellulidae	*Pantala flavescens*	Wandering Glider	-	LC	LC
6	Libellulidae	*Trithemis aurora*	Crimson Dropwing	-	LC	LC

7	Libellulidae	*Trithemis festiva*	Indigo Dropwing	-	LC	LC
FRESHWATER MOLLUSCS						
No.	**Family**	**Species name**	**Common Name**	**Origin**	**SRDB3**	**IUCN status**
1	Physidae	*Physella acuta*	Acute Bladder Snail	Introduced	-	LC

APPENDIX D

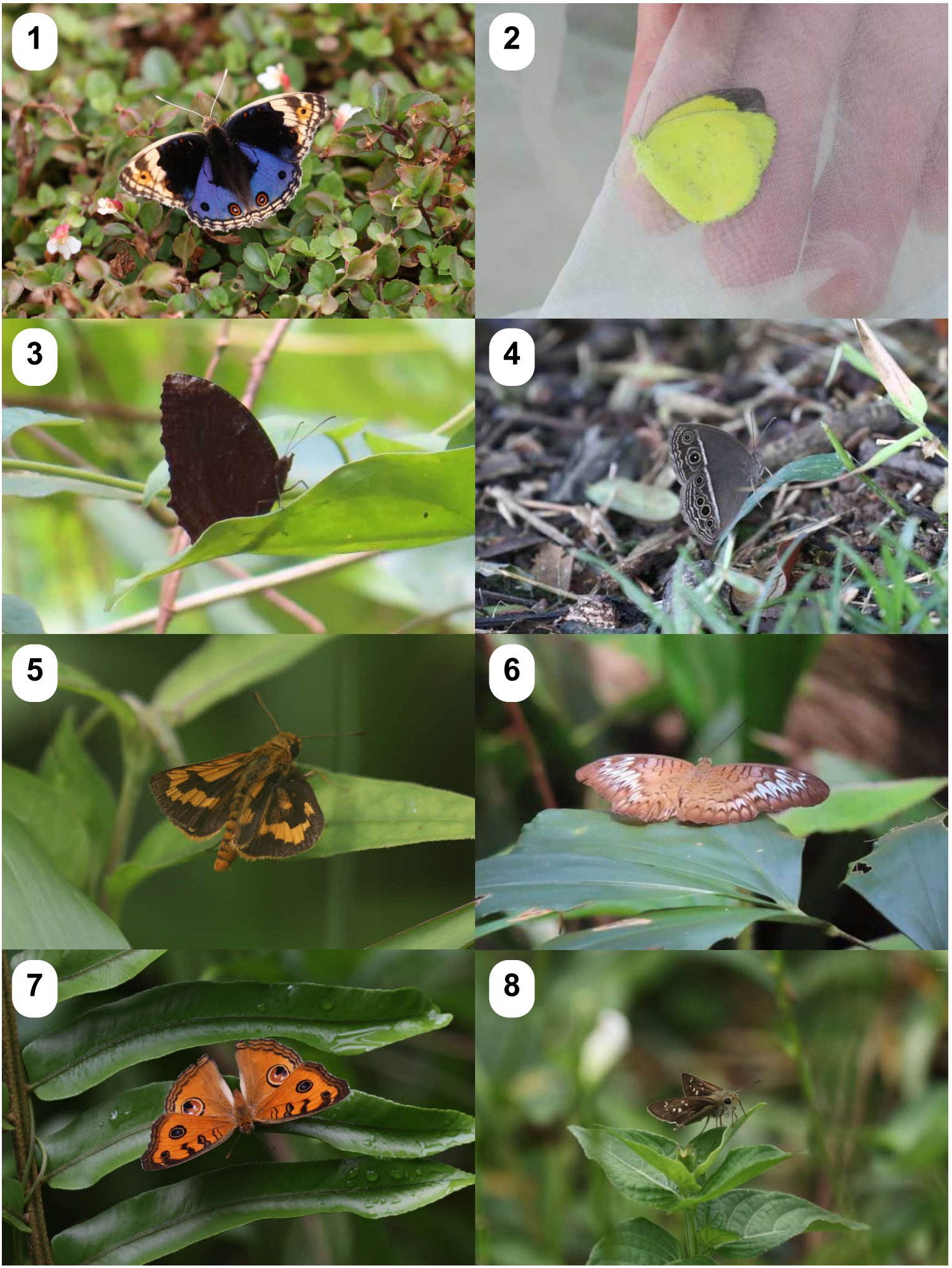
Photographs of Animals Observed at Study Area



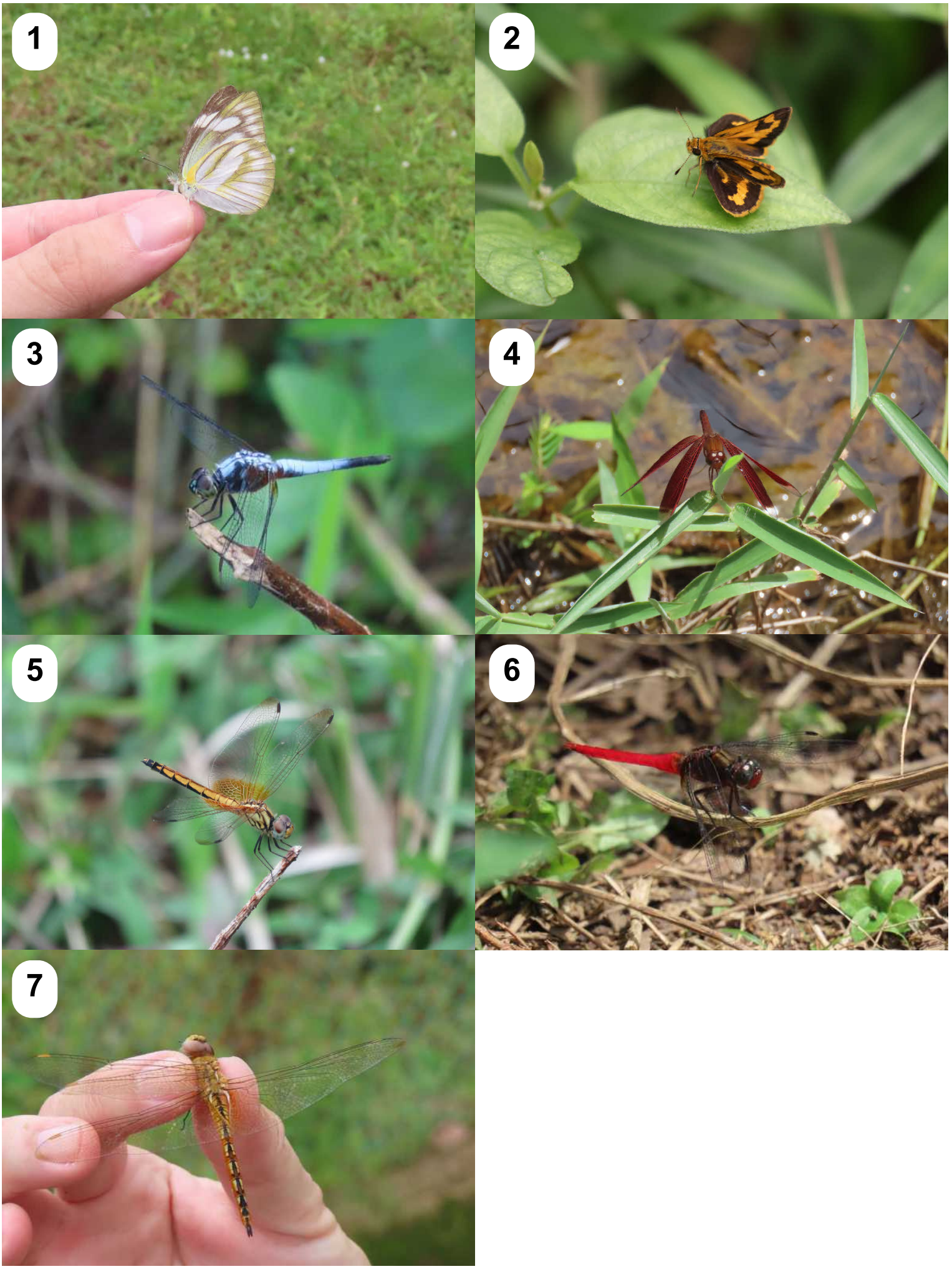
1: Asian glossy starling (*Aplonis panayensis*); **2:** Brahminy kite (*Haliastur indus*); **3:** Brown-throated sunbird (*Anthreptes malacensis*); **4:** Common flameback (*Dinopium javanense*); **5:** Common hill myna (*Gracula religiosa*); **6:** Collared kingfisher (*Todiramphus chloris*); **7:** Greater racket-tailed drongo (*Dicrurus paradiseus*); **8:** Javan myna (*Acridotheres javanicus*)

1: Laced woodpecker (*Picus vittatus*); **2:** Long-tailed parakeet (*Psittacula longicauda*); **3:** Oriental dollarbird (*Eurystomus orientalis*); **4:** Pied imperial pigeon (*Ducula bicolor*); **5:** Red junglefowl (*Gallus gallus*); **6:** Spotted dove (*Spilopelia chinensis*); **7:** Yellow-vented bulbul (*Pycnonotus goiavier*); **8:** Asian house shrew (*Suncus murinus*)

1: Feral cat (*Felis catus*); **2:** Common Malayan treeshrew (*Tupaia glis*); **3:** Lesser dog-faced fruit bat (*Cynopterus brachyotis*); **4:** Long-tailed macaque (*Macaca fascicularis*); **5:** Plantain squirrel (*Callosciurus notatus*); **6:** Spiny-tailed house gecko (*Hemidactylus frenatus*); **7**: Spotted house gecko (*Gekko monarchus*); **8**: Ancyra blue (*Catopyrops ancyra aberrans*)



1: Blue pansy (*Junonia orithya wallacei*); **2:** Common grass yellow (*Eurema hecabe contubernalis*); **3:** Common palmfly (*Elymnias hypermnestra agina*); **4:** Dark-brand bush brown (*Mycalesis mineus macromalayana*); **5:** Lesser dart (*Potanthus omaha omaha*); **6:** Malay viscount (*Tanaecia pelea pelea*); **7:** Peacock pansy (*Junonia almana javana*); **8:** Small branded swift (*Pelopidas mathias mathias*)



1: Striped albatross (*Appias olferna olferna*); **2:** Yellow grass dart (*Taractrocera archias quinta*); **3:** Blue dasher (*Brachydiplax chalybea*); **4:** Common parasol (*Neurothemis fluctuans*); **5:** Crimson dropwing (*Trithemis aurora*); **6:** Spine-tufted skimmer (*Orthetrum chrysis*); **7:** Wandering glider (*Pantala flavescens*)

APPENDIX E

Baseline Water Quality Laboratory Test Report

TEST REPORT

Our Reference No.	:	**R240 7645**	Date Received	: 06/09/2024
Project Code / Ref.	:	**Bukit Batok EIA site - Jalan Jurong Kechil**	Date Commenced	: 06/09/2024
			Date Reported	: 17/09/2024
Customer Ref. No.	:	-		
Customer Name	:	Tembusu Asia Consulting Pte Ltd		
Customer Address	:	1 Commonwealth Ln #06-06 One Commonwealth Singapore 149544		
Attention To	:	Mr Eric Chng		
Sample Description	:	Water Sampling carried out by MLS personnel in accordance to MLS-SOP-ES-001 Rev 4 for 2 Sampling Points		
RESULTS:		Refer to Page 2		

Tan Thuan Piang
Senior Technical Manager

Terms & Conditions:

1) This report shall not be reproduced except in full, unless approval in writing has been given by MLS.
2) The results in this report only apply to the sample received/analysed.
3) MLS agrees to use reasonable diligence in the performance of the service.

Marchwood Laboratory Services Pte Ltd: Co. Reg No. : 201422686C
Main (Office and Laboratory): 116 Tuas South Ave 2, West Point Bizhub Singapore 637163 ☎ : +65 6790 0118 🖷 : +65 6790 0091
Branch (Site and Laboratory): 216 Tuas South Ave 2, West Point Bizhub Singapore 637213 ☎ : +65 6262 3736 (Lab) ☎ : +65 6262 3726 / 3776 (Site)
Website: www.mls.sg

R240 7645

RESULTS

Test Parameter	Unit	Test Method	WQ1 06/09/2024, 1605hrs	WQ3 06/09/2024, 1630hrs	LOR	Watercourse*	Controlled Watercourse#
In-Situ							
Turbidity (On-Site)	NTU	Accredited In-house Method MLS-SOP-ES-004	47.8	136	0.1	-	-
Dissolved Oxygen (On-Site)	mg/L		4.55	1.45	0.1	-	-
pH value (On-Site)	-		5.36	6.08	0.1	6-9	6-9
Salinity (On-Site)	ppt		0.11	0.06	0.01	-	-
Temperature (On-Site)	°C		30.9	33.1	-	45°C	45°C
Ex-Situ							
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.40	0.21	0.025	-	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	ND	2.63	0.01	-	-
Total Organic Carbon, TOC	mg/L	APHA 5310B	500	14.9	1	-	-
Nitrate as NO3-N	mg/L	APHA 4500-NO3 (I)	ND	ND	0.07	-	20
Total Ammonia (NH3-N+NH4-N)	mg/L	APHA 4500-NH3 (H)	ND	ND	0.01	-	-
Phosphate as PO4-P	mg/L	APHA 4500-P (G)	0.17	0.038	0.025	5	2
Total Dissolved Solids, TDS	mg/L	APHA 2540C	165	74.0	10	-	1,000
Total Suspended Solids, TSS	mg/L	APHA 2540D	103	302	10	50	30
Lead as Pb	mg/L	APHA 3125B	ND	ND	0.02	0.1	0.1
Zinc as Zn	mg/L	APHA 3125B	0.070	0.0061	0.002	1	0.5
Mercury as Hg	mg/L	APHA 3125B	ND	ND	0.0002	0.05	0.001
Free Chlorine	mg/L	Lovibond Test Kit (DPD) Rev 1.0	ND	ND	0.2	1	1
Enterococcus	cfu/100mL	APHA 9230C	100	100	1	-	-
Biochemical Oxygen Demand, BOD5	mg/L	APHA 5210B	1,168	27.7	2	50	20

Note:

1. APHA is a standard method for Determination of Water and Waste Water (APHA 24th Edition, 2023).
2. LOR = Limit of Reporting.
3. "ND" = Not detected. The data reported is less than the LOR.
4. * = Allowable Limits for Trade Effluent Discharge to Watercourse, according to Environmental Protection and Management (Trade Effluent) Regulations.
5. # = Allowable Limits for Trade Effluent Discharge to Controlled Watercourse, according to Environmental Protection and Management (Trade Effluent) Regulations.

TEST REPORT

Our Reference No.	:	**R240 7853**	Date Received	:	13/09/2024
Project Code / Ref.	:	**Bukit Batok EIA site - Jalan Jurong Kechil**	Date Commenced	:	13/09/2024
			Date Reported	:	26/09/2024
Customer Ref. No.	:	-			
Customer Name	:	Tembusu Asia Consulting Pte Ltd			
Customer Address	:	1 Commonwealth Ln #06-06 One Commonwealth Singapore 149544			
Attention To	:	Mr Eric Chng			
Sample Description	:	Water Sampling carried out by MLS personnel in accordance to MLS-SOP-ES-001 Rev 4 for 2 Sampling Points			
RESULTS:		Refer to Page 2			

Tan Thuan Piang
Senior Technical Manager

Terms & Conditions:

1) This report shall not be reproduced except in full, unless approval in writing has been given by MLS.
2) The results in this report only apply to the sample received/analysed.
3) MLS agrees to use reasonable diligence in the performance of the service.

R240 7853

RESULTS

Test Parameter	Unit	Test Method	WQ1	WQ3	LOR	Watercourse*	Controlled Watercourse#
			13/09/2024, 1632hrs	13/09/2024, 1651hrs			
In-Situ							
Turbidity (On-Site)	NTU	Accredited In-house Method MLS-SOP-ES-004	67.0	7.31	0.1	-	-
Dissolved Oxygen (On-Site)	mg/L		4.74	7.94	0.1	-	-
pH value (On-Site)	-		6.76	5.61	0.1	6-9	6-9
Salinity (On-Site)	ppt		0.12	0.03	0.01	-	-
Temperature (On-Site)	°C		30.8	33.2	-	45°C	45°C
Ex-Situ							
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.58	0.055	0.025	-	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	3.56	0.45	0.01	-	-
Total Organic Carbon, TOC	mg/L	APHA 5310B	30.0	ND	1	-	-
Nitrate as NO3-N	mg/L	APHA 4500-NO3 (I)	ND	0.33	0.07	-	20
Total Ammonia (NH3-N+NH4-N)	mg/L	APHA 4500-NH3 (H)	0.14	ND	0.01	-	-
Phosphate as PO4-P	mg/L	APHA 4500-P (G)	0.21	0.036	0.025	5	2
Total Dissolved Solids, TDS	mg/L	APHA 2540C	164	41.0	10	-	1,000
Total Suspended Solids, TSS	mg/L	APHA 2540D	28.6	42.6	10	50	30
Lead as Pb	mg/L	APHA 3125B	ND	ND	0.02	0.1	0.1
Zinc as Zn	mg/L	APHA 3125B	0.038	0.023	0.002	1	0.5
Mercury as Hg	mg/L	APHA 3125B	ND	ND	0.0002	0.05	0.001
Free Chlorine	mg/L	Lovibond Test Kit (DPD) Rev 1.0	ND	ND	0.2	1	1
Enterococcus	cfu/100mL	APHA 9230C	2,700	ND	1	-	-
Biochemical Oxygen Demand, BOD5	mg/L	APHA 5210B	108	ND	2	50	20

Note:

1. APHA is a standard method for Determination of Water and Waste Water (APHA 24th Edition, 2023).
2. LOR = Limit of Reporting.
3. "ND" = Not detected. The data reported is less than the LOR.
4. * = Allowable Limits for Trade Effluent Discharge to Watercourse, according to Environmental Protection and Management (Trade Effluent) Regulations.
5. # = Allowable Limits for Trade Effluent Discharge to Controlled Watercourse, according to Environmental Protection and Management (Trade Effluent) Regulations.

TEST REPORT

Our Reference No.	:	**R240 8120**	Date Received	:	23/09/2024
Project Code / Ref.	:	**Bukit Batok EIA site - Jalan Jurong Kechil**	Date Commenced	:	23/09/2024
			Date Reported	:	30/09/2024
Customer Ref. No.	:	-			
Customer Name	:	Tembusu Asia Consulting Pte Ltd			
Customer Address	:	1 Commonwealth Ln #06-06 One Commonwealth Singapore 149544			
Attention To	:	Mr Eric Chng			
Sample Description	:	Water Sampling carried out by MLS personnel in accordance to MLS-SOP-ES-001 Rev 4 for 3 Sampling Points			
RESULTS:		Refer to Page 2			

Tan Thuan Piang
Senior Technical Manager

Terms & Conditions:

1) This report shall not be reproduced except in full, unless approval in writing has been given by MLS.
2) The results in this report only apply to the sample received/analysed.
3) MLS agrees to use reasonable diligence in the performance of the service.

R240 8120

RESULTS

Test Parameter	Unit	Test Method	WQ1	WQ2	WQ3	LOR	Watercourse*	Controlled Watercourse#
			23/09/2024, 1600hrs	23/09/2024, 1612hrs	23/09/2024, 1614hrs			
In-Situ								
Turbidity (On-Site)	NTU	Accredited In-house Method MLS-SOP-ES-004	38.8	27.1	38.6	0.1	-	-
Dissolved Oxygen (On-Site)	mg/L		5.88	6.38	5.22	0.1	-	-
pH value (On-Site)	-		6.14	6.1	5.5	0.1	6-9	6-9
Salinity (On-Site)	ppt		0.06	0.02	0.03	0.01	-	-
Temperature (On-Site)	°C		28.4	27.7	28.1	-	45°C	45°C
Ex-Situ								
Total Phosphorus as TP	mg/L	APHA 4500-P (J)	0.37	0.17	0.16	0.025	-	-
Total Nitrogen as TN	mg/L	APHA 4500-P (J)	1.77	1.28	0.96	0.01	-	-
Total Organic Carbon, TOC	mg/L	APHA 5310B	8.11	4.89	3.27	1	-	-
Nitrate as NO3-N	mg/L	APHA 4500-NO3 (I)	ND	0.55	0.55	0.015	-	20
Total Ammonia (NH3-N+NH4-N)	mg/L	APHA 4500-NH3 (H)	0.099	0.12	0.086	0.01	-	-
Phosphate as PO4-P	mg/L	APHA 4500-P (G)	0.045	0.036	0.030	0.025	5	2
Total Dissolved Solids, TDS	mg/L	APHA 2540C	78.0	30.0	38.0	10	-	1,000
Total Suspended Solids, TSS	mg/L	APHA 2540D	20.4	15.0	23.2	10	50	30
Lead as Pb	mg/L	APHA 3125B	ND	ND	ND	0.02	0.1	0.1
Zinc as Zn	mg/L	APHA 3125B	0.11	0.080	0.0030	0.002	1	0.5
Mercury as Hg	mg/L	APHA 3125B	ND	ND	ND	0.0002	0.05	0.001
Free Chlorine	mg/L	Lovibond Test Kit (DPD) Rev 1.0	ND	ND	ND	0.2	1	1
Enterococcus	cfu/100mL	APHA 9230C	1,600	1,100	1,000	1	-	-
Biochemical Oxygen Demand, BOD5	mg/L	APHA 5210B	32	ND	ND	2	50	20

Note:

1. APHA is a standard method for Determination of Water and Waste Water (APHA 24th Edition, 2023).
2. LOR = Limit of Reporting.
3. "ND" = Not detected. The data reported is less than the LOR.
4. * = Allowable Limits for Trade Effluent Discharge to Watercourse, according to Environmental Protection and Management (Trade Effluent) Regulations.
5. # = Allowable Limits for Trade Effluent Discharge to Controlled Watercourse, according to Environmental Protection and Management (Trade Effluent) Regulations.

APPENDIX F

Baseline Noise Monitoring Results

TEST REPORT

Our Reference No.	:	**R240 8819/2**	Date of Monitoring	:	13/09/24 to 05/10/24
Project Code / Ref.	:	-	Date Reported	:	18/10/24

Customer Ref. No.	:	TAC / 24021 /SC 06
Customer Name	:	TEMBUSU Asia Consulting Pte Ltd
Customer Address	:	1 Commonwealth Lane, #06-06, One Commonwealth, Singapore 149544
Attention To	:	Mr Eric Chng

Subject	:	**Noise Monitoring for Bukit Batok EIA**
Description	:	Baseline Noise Monitoring at 3 locations between 13/09/24 to 05/10/24

Toh Teck Yeow

Snr Manager, Env Services

Marchwood Laboratory Services Pte Ltd: Co. Reg No.: 201422686C
Main (Office and Laboratory): 116 Tuas South Ave 2, West Point Bizhub Singapore 637163 ☎ : +65 6790 0118 🖷 : +65 6790 0091
Branch (Site and Laboratory): 216 Tuas South Ave 2, West Point Bizhub Singapore 637213 ☎ : +65 6262 3736 (Lab) ☎ : +65 6262 3726 / 3776 (Site)
Website: www.mls.sg

SCOPE OF WORK

Baseline Noise Monitoring was carried out at 3 locations from 13/09/24 to 05/10/24. The description of location and scope of work are as described in Table 1A and 1B.

Table 1A: Scope of work carried out

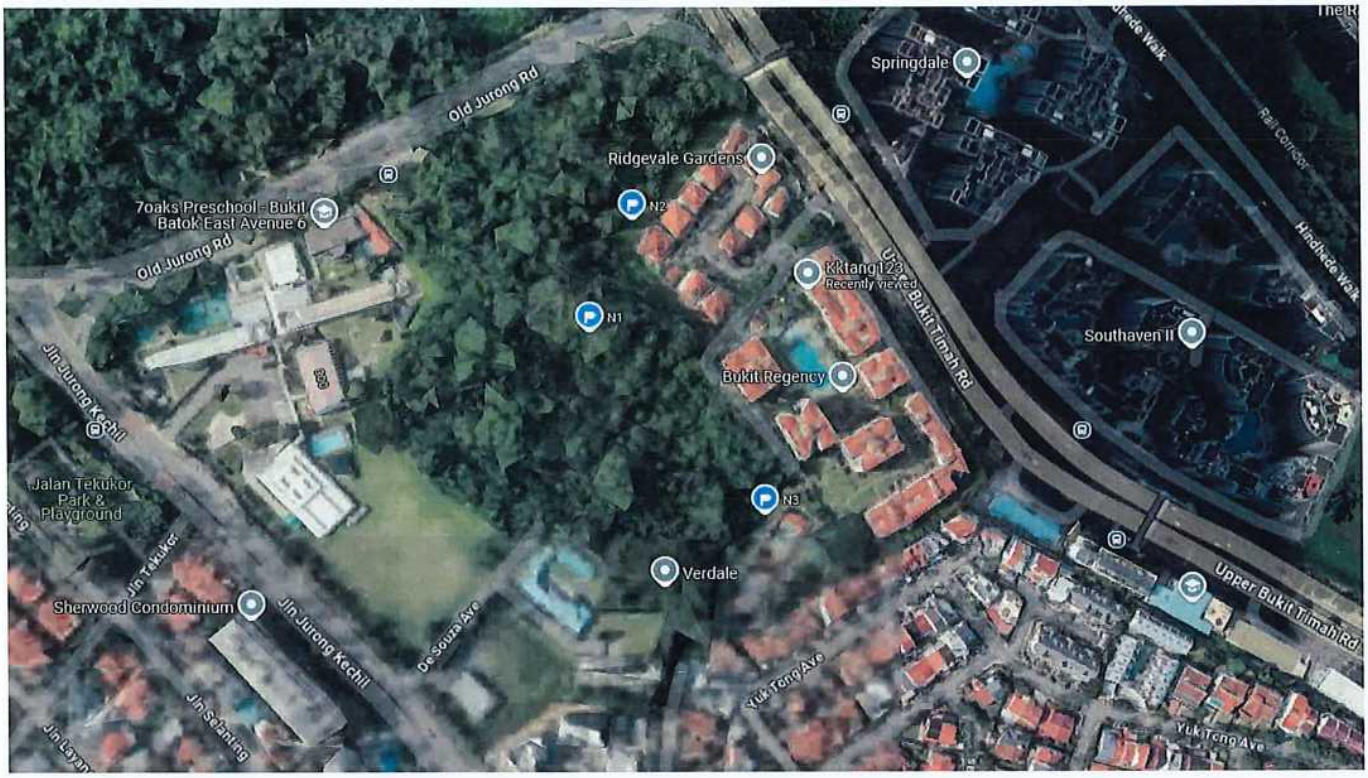
Location ID	Monitoring Period	Parameters	Data
N1	29/09/24, 1200am to 05/10/24, 1159pm	LAeq	LAeq 5min LAeq 1hr LAeq 12hr
N2	21/09/24, 1200am to 27/09/24, 1159pm		
N3	13/09/24, 1200am to 20/09/24, 1159pm		

Table 1B: Scope of work carried out

Locations	GPS Coordinates	Description
N1	1°20'49.1"N 103°46'10.9"E	Middle of forested area south west of Upper Bukit Timah View
N2	1°20'51.3"N 103°46'11.7"E	Open grass patch behind 32 Upper Bukit Timah View
N3	1°20'45.4"N 103°46'14.3"E	Beside tennis court north of Yuk Tong Ave

MONITORING LOCATIONS

The monitoring locations are shown below. Site photos are in Appendix B.



SAMPLING METHODOLOGY AND EQUIPMENT

Noise levels were monitored using a Type 1 Sound Level Meters at all locations listed below. The equipment was battery operated with solar panel and was housed in an environmental enclosure for field deployment.

Sound Level Meter

1) Svantek Model SVAN971 (Serial No. 60603)
(V_01 - Pre Calibration: 114.0 dBA; Post Calibration: 114.0 dBA)

Data was logged every 1 second at slow response at A weighting over the frequency of 10Hz to 20khz. The 1 second data is then used to calculate 5min, 1-hour and 12-hour equivalent readings. The Sound Level Meter is calibrated before and after the deployment at each location using the Acoustic Calibrator (Svantek Model SVAN SV33A, Serial No. 58609) producing 114dBA at 1000Hz. Calibration certificates are attached in Appendix A of this report.

MONITORING RESULTS

The data from continuous baseline monitoring for all 3 locations were calculated and presented as minimum and maximum LAeq 5min at each hour as well as LAeq 1hr and 12hrs. Raw data was sent electronically.

Monitoring Date : 29-Sep-24 to 30-Sep-24
Location: N1
Job Number: R240 8819/2

Period: All Days

Period	5 min LAeq, dBA		1hr LAeq, dBA	12hr LAeq, dBA
	Min	Max	Results	
0000 - 0100	40.8	42.2	41.4	46.6
0100 - 0200	39.9	43.1	40.9	
0200 - 0300	39.1	44.8	40.4	
0300 - 0400	38.6	44.1	40.7	
0400 - 0500	39.3	42.6	41.1	
0500 - 0600	37.3	45.4	41.1	
0600 - 0700	38.1	53.7	48.4	
0700 - 0800	45.0	54.4	49.4	
0800 - 0900	45.5	55.2	51.2	
0900 - 1000	46.0	52.3	49.1	
1000 - 1100	44.4	47.0	45.9	
1100 - 1200	42.8	54.0	47.6	
1200 - 1300	43.0	47.3	44.9	55.7
1300 - 1400	42.0	51.1	45.6	
1400 - 1500	43.6	48.4	46.3	
1500 - 1600	45.6	67.8	61.5	
1600 - 1700	45.7	52.8	48.8	
1700 - 1800	44.3	48.7	46.4	
1800 - 1900	44.5	47.2	45.9	
1900 - 2000	44.7	60.9	58.7	
2000 - 2100	58.4	60.6	59.3	
2100 - 2200	57.2	60.1	58.9	
2200 - 2300	53.2	56.9	55.7	
2300 - 0000	43.4	52.6	47.4	

Monitoring Date : 30-Sep-24 to 01-Oct-24
Location: N1
Job Number: R240 8819/2

Period: All Days

Period	5 min LAeq, dBA		1hr LAeq, dBA	12hr LAeq, dBA
	Min	Max	Results	
0000 - 0100	39.5	43.9	42.2	53.9
0100 - 0200	39.8	41.8	41.2	
0200 - 0300	40.6	45.8	42.5	
0300 - 0400	37.9	41.3	40.3	
0400 - 0500	39.2	41.3	40.4	
0500 - 0600	40.3	66.0	57.6	
0600 - 0700	48.7	65.0	61.7	
0700 - 0800	48.1	55.6	51.8	
0800 - 0900	46.9	54.3	51.0	
0900 - 1000	47.0	55.6	52.2	
1000 - 1100	48.4	59.9	53.1	
1100 - 1200	48.4	54.1	52.0	
1200 - 1300	47.1	53.2	50.8	61.1
1300 - 1400	48.5	60.8	52.9	
1400 - 1500	46.8	61.1	52.3	
1500 - 1600	44.8	63.2	53.5	
1600 - 1700	45.4	53.6	48.3	
1700 - 1800	46.4	75.5	70.6	
1800 - 1900	48.0	63.7	55.9	
1900 - 2000	48.7	62.7	59.2	
2000 - 2100	56.9	58.5	57.7	
2100 - 2200	56.3	59.3	57.6	
2200 - 2300	56.1	58.9	57.9	
2300 - 0000	53.3	57.1	55.8	

Monitoring Date : 01-Oct-24 to 02-Oct-24
Location: N1
Job Number: R240 8819/2

Period: All Days

Period	5 min LAeq, dBA		1hr LAeq, dBA	12hr LAeq, dBA
	Min	Max	Results	
0000 - 0100	51.1	54.2	53.0	51.6
0100 - 0200	41.5	50.9	48.1	
0200 - 0300	41.4	54.7	49.4	
0300 - 0400	39.0	55.1	49.3	
0400 - 0500	40.0	51.2	44.8	
0500 - 0600	40.8	45.9	42.3	
0600 - 0700	41.6	52.4	47.8	
0700 - 0800	45.7	50.8	48.1	
0800 - 0900	44.1	64.6	56.0	
0900 - 1000	45.3	63.6	56.6	
1000 - 1100	48.9	53.4	51.1	
1100 - 1200	48.3	55.3	51.4	
1200 - 1300	47.6	55.5	52.6	53.1
1300 - 1400	51.2	59.1	56.2	
1400 - 1500	48.3	58.7	53.2	
1500 - 1600	45.3	59.3	51.4	
1600 - 1700	46.3	53.9	48.2	
1700 - 1800	47.1	54.4	51.2	
1800 - 1900	47.7	53.1	51.6	
1900 - 2000	45.1	59.7	55.8	
2000 - 2100	51.7	58.4	54.4	
2100 - 2200	51.3	56.6	54.5	
2200 - 2300	42.1	55.0	52.7	
2300 - 0000	41.3	43.8	42.1	

Monitoring Date : 02-Oct-24 to 03-Oct-24
Location: N1
Job Number: R240 8819/2

Period: All Days

Period	5 min LAeq, dBA		1hr LAeq, dBA	12hr LAeq, dBA
	Min	Max	Results	
0000 - 0100	40.4	42.8	41.7	50.0
0100 - 0200	40.2	42.0	41.0	
0200 - 0300	39.7	43.4	41.2	
0300 - 0400	40.1	43.2	41.3	
0400 - 0500	41.7	44.5	42.7	
0500 - 0600	40.6	44.7	42.8	
0600 - 0700	40.2	56.0	46.7	
0700 - 0800	46.2	54.7	50.9	
0800 - 0900	48.3	56.6	53.3	
0900 - 1000	47.0	58.0	53.0	
1000 - 1100	47.0	60.5	56.4	
1100 - 1200	44.2	54.3	49.3	
1200 - 1300	43.4	66.3	56.6	51.3
1300 - 1400	44.0	63.5	53.5	
1400 - 1500	47.0	50.2	48.0	
1500 - 1600	44.2	61.1	53.7	
1600 - 1700	44.2	47.5	45.4	
1700 - 1800	44.5	53.4	47.8	
1800 - 1900	43.2	47.9	46.3	
1900 - 2000	42.4	61.5	53.3	
2000 - 2100	42.6	46.8	44.5	
2100 - 2200	43.5	50.7	47.8	
2200 - 2300	50.4	52.6	51.2	
2300 - 0000	43.4	51.1	47.7	

Monitoring Date : 03-Oct-24 to 04-Oct-24
Location: N1
Job Number: R240 8819/2

Period: All Days

Period	5 min LAeq, dBA		1hr LAeq, dBA	12hr LAeq, dBA
	Min	Max	Results	
0000 - 0100	40.4	44.2	42.1	46.2
0100 - 0200	38.7	41.9	40.4	
0200 - 0300	38.4	42.4	39.7	
0300 - 0400	38.4	42.4	39.8	
0400 - 0500	37.8	42.0	40.3	
0500 - 0600	39.8	43.3	41.0	
0600 - 0700	40.1	52.8	48.3	
0700 - 0800	45.3	48.8	46.9	
0800 - 0900	46.7	51.9	49.7	
0900 - 1000	46.8	49.0	48.1	
1000 - 1100	46.7	50.9	49.0	
1100 - 1200	46.3	52.3	48.8	
1200 - 1300	45.3	52.3	49.0	45.8
1300 - 1400	44.3	51.4	48.4	
1400 - 1500	45.6	48.5	47.2	
1500 - 1600	41.9	47.4	45.6	
1600 - 1700	42.6	46.6	44.2	
1700 - 1800	43.8	51.4	46.3	
1800 - 1900	42.8	51.0	47.6	
1900 - 2000	41.8	47.3	44.1	
2000 - 2100	41.3	42.4	41.8	
2100 - 2200	40.9	42.3	41.9	
2200 - 2300	41.0	43.3	42.3	
2300 - 0000	40.7	43.0	41.9	

Monitoring Date : 04-Oct-24 to 05-Oct-24
Location: N1
Job Number: R240 8819/2

Period: All Days

Period	5 min LAeq, dBA		1hr LAeq, dBA	12hr LAeq, dBA
	Min	Max	Results	
0000 - 0100	40.2	44.2	41.5	
0100 - 0200	39.8	41.5	40.5	
0200 - 0300	39.2	41.6	40.2	
0300 - 0400	39.3	42.1	40.4	
0400 - 0500	39.3	41.9	40.5	
0500 - 0600	37.9	41.4	39.5	
0600 - 0700	39.4	53.4	49.0	47.4
0700 - 0800	44.2	51.4	47.4	
0800 - 0900	44.8	51.7	49.6	
0900 - 1000	46.6	54.0	49.9	
1000 - 1100	46.1	50.3	47.5	
1100 - 1200	47.0	61.3	53.4	
1200 - 1300	47.0	64.2	58.4	
1300 - 1400	46.4	62.5	53.7	
1400 - 1500	44.0	54.7	50.6	
1500 - 1600	43.7	55.8	50.0	
1600 - 1700	44.5	64.5	55.4	
1700 - 1800	47.8	62.2	55.0	59.2
1800 - 1900	48.4	70.8	63.5	
1900 - 2000	49.0	72.0	64.8	
2000 - 2100	54.9	59.5	58.0	
2100 - 2200	59.7	61.1	60.5	
2200 - 2300	57.0	60.0	58.4	
2300 - 0000	53.1	56.9	55.9	

Monitoring Date : 05-Oct-24 to 06-Oct-24
Location: N1
Job Number: R240 8819/2

Period: All Days

Period	5 min LAeq, dBA		1hr LAeq, dBA	12hr LAeq, dBA
	Min	Max	Results	
0000 - 0100	44.0	49.9	46.8	60.6
0100 - 0200	42.7	52.5	47.4	
0200 - 0300	47.9	52.5	50.8	
0300 - 0400	46.8	74.9	70.7	
0400 - 0500	52.4	62.8	58.2	
0500 - 0600	44.8	57.0	51.5	
0600 - 0700	45.3	51.1	48.4	
0700 - 0800	46.5	57.5	53.4	
0800 - 0900	50.4	61.4	56.1	
0900 - 1000	45.8	55.6	51.5	
1000 - 1100	45.7	54.0	48.6	
1100 - 1200	45.7	51.5	48.5	
1200 - 1300	41.9	50.3	46.2	51.0
1300 - 1400	43.7	54.1	49.2	
1400 - 1500	45.1	54.3	49.8	
1500 - 1600	46.8	52.6	49.3	
1600 - 1700	44.4	50.1	47.7	
1700 - 1800	42.9	50.3	46.5	
1800 - 1900	42.0	57.1	51.2	
1900 - 2000	41.4	58.1	53.1	
2000 - 2100	51.2	59.2	55.0	
2100 - 2200	48.2	57.4	53.8	
2200 - 2300	47.9	53.7	50.5	
2300 - 0000	46.9	53.6	49.6	

Monitoring Date : 21-Sep-24 to 22-Sep-24
Location: N2
Job Number: R240 8819/2

Period: All Days

Period	5 min LAeq, dBA		1hr LAeq, dBA	12hr LAeq, dBA
	Min	Max	Results	
0000 - 0100	58.5	63.8	60.9	56.9
0100 - 0200	54.7	59.3	56.6	
0200 - 0300	55.3	61.7	58.7	
0300 - 0400	55.4	63.2	60.5	
0400 - 0500	51.6	63.5	58.0	
0500 - 0600	50.1	52.8	51.9	
0600 - 0700	51.5	56.6	54.2	
0700 - 0800	52.5	55.9	53.5	
0800 - 0900	52.5	58.7	55.0	
0900 - 1000	52.5	57.3	55.0	
1000 - 1100	52.4	55.9	53.9	
1100 - 1200	51.7	55.0	53.1	
1200 - 1300	52.6	56.2	53.3	62.2
1300 - 1400	51.7	55.9	53.4	
1400 - 1500	52.1	54.3	53.0	
1500 - 1600	50.2	54.6	52.0	
1600 - 1700	50.6	52.7	51.7	
1700 - 1800	51.5	55.3	52.8	
1800 - 1900	51.4	53.1	52.4	
1900 - 2000	51.5	72.1	68.5	
2000 - 2100	64.2	71.9	69.6	
2100 - 2200	60.1	64.2	61.5	
2200 - 2300	58.4	59.7	59.1	
2300 - 0000	50.8	58.6	55.4	

Monitoring Date : 22-Sep-24 to 23-Sep-24
Location: N2
Job Number: R240 8819/2

Period: All Days

Period	5 min LAeq, dBA		1hr LAeq, dBA	12hr LAeq, dBA
	Min	Max	Results	
0000 - 0100	49.8	52.6	50.9	51.9
0100 - 0200	50.2	52.7	51.6	
0200 - 0300	50.8	52.6	51.5	
0300 - 0400	48.1	52.0	50.4	
0400 - 0500	48.1	50.9	49.8	
0500 - 0600	48.3	51.0	49.6	
0600 - 0700	50.3	54.4	52.3	
0700 - 0800	51.4	55.7	53.1	
0800 - 0900	50.7	55.6	53.9	
0900 - 1000	51.2	57.0	54.2	
1000 - 1100	50.1	53.2	51.4	
1100 - 1200	50.2	52.7	51.3	
1200 - 1300	50.6	53.0	51.6	52.9
1300 - 1400	49.8	51.9	50.9	
1400 - 1500	50.5	53.1	52.1	
1500 - 1600	49.9	52.3	51.0	
1600 - 1700	50.1	52.4	51.1	
1700 - 1800	49.8	52.4	50.9	
1800 - 1900	50.2	60.0	54.6	
1900 - 2000	49.5	55.2	51.4	
2000 - 2100	54.9	57.0	56.3	
2100 - 2200	52.7	55.5	54.0	
2200 - 2300	50.9	55.8	53.2	
2300 - 0000	51.7	54.5	53.0	

Monitoring Date : 23-Sep-24 to 24-Sep-24
Location: N2
Job Number: R240 8819/2

Period: All Days

Period	5 min LAeq, dBA		1hr LAeq, dBA	12hr LAeq, dBA
	Min	Max	Results	
0000 - 0100	48.9	51.8	50.2	54.4
0100 - 0200	47.9	52.8	50.4	
0200 - 0300	49.2	53.0	51.1	
0300 - 0400	49.2	50.5	49.9	
0400 - 0500	47.5	50.9	49.3	
0500 - 0600	48.3	50.0	49.3	
0600 - 0700	49.8	54.1	52.2	
0700 - 0800	54.6	59.7	56.7	
0800 - 0900	56.6	60.6	58.1	
0900 - 1000	52.1	57.1	54.0	
1000 - 1100	51.2	65.3	58.9	
1100 - 1200	50.2	61.8	55.4	
1200 - 1300	49.9	53.0	51.0	63.0
1300 - 1400	49.7	56.7	52.6	
1400 - 1500	52.3	73.2	66.9	
1500 - 1600	53.7	69.8	63.2	
1600 - 1700	53.6	57.8	55.8	
1700 - 1800	52.6	54.0	53.2	
1800 - 1900	52.7	54.7	53.6	
1900 - 2000	51.1	71.5	67.1	
2000 - 2100	65.7	71.5	69.8	
2100 - 2200	51.1	65.0	57.3	
2200 - 2300	50.9	53.2	51.9	
2300 - 0000	49.9	53.6	51.8	

Monitoring Date : 24-Sep-24 to 25-Sep-24
Location: N2
Job Number: R240 8819/2

Period: All Days

Period	5 min LAeq, dBA		1hr LAeq, dBA	12hr LAeq, dBA
	Min	Max	Results	
0000 - 0100	49.0	54.1	52.0	54.7
0100 - 0200	49.0	54.6	52.5	
0200 - 0300	49.0	53.1	51.1	
0300 - 0400	47.1	54.2	52.1	
0400 - 0500	47.3	52.1	49.8	
0500 - 0600	48.2	50.8	49.9	
0600 - 0700	50.6	55.1	52.8	
0700 - 0800	53.1	58.6	54.8	
0800 - 0900	54.6	62.3	58.9	
0900 - 1000	53.1	61.0	55.5	
1000 - 1100	53.4	63.8	58.0	
1100 - 1200	52.2	61.0	56.4	
1200 - 1300	50.4	56.8	53.1	57.3
1300 - 1400	53.8	60.7	58.0	
1400 - 1500	55.2	71.1	61.9	
1500 - 1600	52.2	61.1	56.2	
1600 - 1700	52.4	57.5	54.6	
1700 - 1800	52.1	55.3	53.5	
1800 - 1900	52.0	56.1	53.9	
1900 - 2000	50.7	64.1	60.2	
2000 - 2100	52.1	63.4	60.3	
2100 - 2200	51.7	53.4	52.6	
2200 - 2300	55.6	56.8	56.1	
2300 - 0000	50.1	57.3	52.8	

Monitoring Date : 25-Sep-24 to 26-Sep-24
Location: N2
Job Number: R240 8819/2

Period: All Days

Period	5 min LAeq, dBA		1hr LAeq, dBA	12hr LAeq, dBA
	Min	Max	Results	
0000 - 0100	49.4	53.6	50.8	55.0
0100 - 0200	51.2	53.8	52.5	
0200 - 0300	50.5	53.0	51.4	
0300 - 0400	50.2	52.5	51.5	
0400 - 0500	48.9	51.3	50.1	
0500 - 0600	49.6	52.0	50.7	
0600 - 0700	51.4	54.6	52.9	
0700 - 0800	53.0	54.7	53.8	
0800 - 0900	52.9	65.5	57.8	
0900 - 1000	53.1	56.1	54.3	
1000 - 1100	51.9	63.5	57.4	
1100 - 1200	51.2	65.7	60.5	
1200 - 1300	52.4	74.3	69.4	63.8
1300 - 1400	51.7	56.2	53.5	
1400 - 1500	51.8	60.1	54.2	
1500 - 1600	52.0	65.1	57.6	
1600 - 1700	51.8	53.1	52.6	
1700 - 1800	52.6	53.9	53.3	
1800 - 1900	51.8	56.7	53.7	
1900 - 2000	51.4	73.3	69.1	
2000 - 2100	53.6	73.0	69.7	
2100 - 2200	52.3	55.4	54.2	
2200 - 2300	50.9	53.4	52.2	
2300 - 0000	49.8	51.9	51.0	

Monitoring Date : 26-Sep-24 to 27-Sep-24
Location: N2
Job Number: R240 8819/2

Period: All Days

Period	5 min LAeq, dBA		1hr LAeq, dBA	12hr LAeq, dBA
	Min	Max	Results	
0000 - 0100	49.1	52.1	50.4	
0100 - 0200	48.3	50.3	49.8	
0200 - 0300	48.1	49.7	48.8	
0300 - 0400	48.8	51.3	49.7	
0400 - 0500	49.2	51.3	50.1	
0500 - 0600	50.4	51.4	50.7	
0600 - 0700	50.8	55.0	53.2	56.3
0700 - 0800	53.0	54.2	53.5	
0800 - 0900	53.5	65.4	63.3	
0900 - 1000	54.6	61.8	57.8	
1000 - 1100	57.5	60.9	59.4	
1100 - 1200	53.2	61.7	56.3	
1200 - 1300	52.1	60.2	54.7	
1300 - 1400	51.5	56.0	54.0	
1400 - 1500	46.5	57.8	52.8	
1500 - 1600	44.9	52.4	50.3	
1600 - 1700	44.6	53.6	48.4	
1700 - 1800	45.9	55.6	51.4	52.6
1800 - 1900	48.5	57.7	53.5	
1900 - 2000	50.3	57.6	53.6	
2000 - 2100	46.9	56.2	52.2	
2100 - 2200	47.9	54.3	51.0	
2200 - 2300	49.1	55.6	53.1	
2300 - 0000	48.4	56.2	52.8	

Monitoring Date : 27-Sep-24 to 28-Sep-24
Location: N2
Job Number: R240 8819/2

Period: All Days

Period	5 min LAeq, dBA		1hr LAeq, dBA	12hr LAeq, dBA
	Min	Max	Results	
0000 - 0100	51.2	69.4	60.1	56.2
0100 - 0200	52.4	57.9	55.4	
0200 - 0300	52.7	60.1	55.9	
0300 - 0400	48.6	56.6	53.8	
0400 - 0500	49.5	56.7	53.3	
0500 - 0600	47.9	56.2	52.8	
0600 - 0700	47.7	59.3	53.9	
0700 - 0800	47.9	55.0	52.3	
0800 - 0900	50.3	57.0	54.8	
0900 - 1000	51.1	58.0	54.5	
1000 - 1100	49.2	56.9	52.9	
1100 - 1200	51.4	70.7	61.4	
1200 - 1300	50.2	71.5	65.2	59.5
1300 - 1400	49.8	69.0	59.7	
1400 - 1500	48.9	61.4	56.4	
1500 - 1600	46.2	60.7	55.2	
1600 - 1700	49.1	73.4	63.5	
1700 - 1800	51.0	69.0	61.7	
1800 - 1900	49.8	68.1	60.9	
1900 - 2000	47.0	52.9	50.0	
2000 - 2100	48.1	51.8	50.1	
2100 - 2200	48.9	55.7	53.0	
2200 - 2300	48.9	54.2	52.0	
2300 - 0000	49.2	56.5	52.9	

Monitoring Date : 13-Sep-24 to 14-Sep-24
Location: N3
Job Number: R240 8819/2

Period: All Days

Period	5 min LAeq, dBA		1hr LAeq, dBA	12hr LAeq, dBA
	Min	Max	Results	
0000 - 0100	44.7	59.1	51.5	48.9
0100 - 0200	47.5	50.6	49.3	
0200 - 0300	47.5	51.0	49.4	
0300 - 0400	44.9	51.4	48.7	
0400 - 0500	45.8	48.8	47.6	
0500 - 0600	43.3	49.1	46.7	
0600 - 0700	43.7	50.5	47.5	
0700 - 0800	43.8	48.2	45.9	
0800 - 0900	45.0	52.3	48.9	
0900 - 1000	45.7	54.9	50.9	
1000 - 1100	44.5	54.4	49.9	
1100 - 1200	45.7	48.6	46.7	
1200 - 1300	44.3	54.5	49.6	50.5
1300 - 1400	44.2	61.0	54.5	
1400 - 1500	47.3	58.5	53.0	
1500 - 1600	48.2	59.2	53.2	
1600 - 1700	45.5	54.8	48.9	
1700 - 1800	46.2	59.7	53.2	
1800 - 1900	44.9	54.4	48.7	
1900 - 2000	42.5	47.7	44.5	
2000 - 2100	43.4	46.6	45.1	
2100 - 2200	45.2	47.7	47.0	
2200 - 2300	45.7	47.6	46.6	
2300 - 0000	45.1	47.9	46.6	

Monitoring Date : 14-Sep-24 to 15-Sep-24
Location: N3
Job Number: R240 8819/2

Period: All Days

Period	5 min LAeq, dBA		1hr LAeq, dBA	12hr LAeq, dBA
	Min	Max	Results	
0000 - 0100	44.5	46.6	45.4	58.1
0100 - 0200	44.4	47.9	45.8	
0200 - 0300	47.8	49.7	48.6	
0300 - 0400	48.8	72.0	68.1	
0400 - 0500	51.6	60.9	56.6	
0500 - 0600	46.7	53.6	49.9	
0600 - 0700	44.8	48.4	47.1	
0700 - 0800	45.2	54.5	51.2	
0800 - 0900	50.9	56.5	53.3	
0900 - 1000	47.4	52.6	50.5	
1000 - 1100	45.8	49.4	47.2	
1100 - 1200	45.4	50.7	47.7	
1200 - 1300	43.2	48.3	45.6	49.5
1300 - 1400	44.0	51.8	47.9	
1400 - 1500	46.2	49.9	47.9	
1500 - 1600	46.3	50.0	48.3	
1600 - 1700	44.3	50.2	46.7	
1700 - 1800	44.2	47.5	46.0	
1800 - 1900	43.8	55.2	49.1	
1900 - 2000	41.8	56.8	51.9	
2000 - 2100	51.8	56.3	53.5	
2100 - 2200	49.8	52.4	51.2	
2200 - 2300	49.2	50.6	49.8	
2300 - 0000	48.1	49.8	48.8	

Monitoring Date : 15-Sep-24 to 16-Sep-24
Location: N3
Job Number: R240 8819/2

Period: All Days

Period	5 min LAeq, dBA		1hr LAeq, dBA	12hr LAeq, dBA
	Min	Max	Results	
0000 - 0100	47.8	49.2	48.8	51.5
0100 - 0200	45.1	48.4	46.9	
0200 - 0300	44.4	48.0	46.5	
0300 - 0400	42.9	47.7	45.2	
0400 - 0500	43.0	47.3	45.7	
0500 - 0600	42.7	47.9	46.2	
0600 - 0700	42.6	48.7	46.0	
0700 - 0800	47.3	52.1	49.0	
0800 - 0900	46.3	51.8	48.8	
0900 - 1000	43.3	50.4	47.6	
1000 - 1100	45.6	51.6	49.3	
1100 - 1200	49.1	68.7	60.3	
1200 - 1300	42.2	47.2	44.2	49.9
1300 - 1400	42.9	48.9	45.4	
1400 - 1500	45.3	50.5	48.0	
1500 - 1600	48.1	51.5	50.0	
1600 - 1700	48.2	51.2	50.0	
1700 - 1800	44.3	48.5	46.6	
1800 - 1900	44.5	60.4	52.4	
1900 - 2000	47.2	53.4	51.0	
2000 - 2100	52.3	56.2	54.7	
2100 - 2200	47.7	54.6	50.1	
2200 - 2300	45.7	48.8	47.2	
2300 - 0000	45.6	48.2	47.5	

Monitoring Date : 16-Sep-24 to 17-Sep-24
Location: N3
Job Number: R240 8819/2

Period: All Days

Period	5 min LAeq, dBA		1hr LAeq, dBA	12hr LAeq, dBA
	Min	Max	Results	
0000 - 0100	45.3	48.7	47.1	
0100 - 0200	47.2	49.4	48.4	
0200 - 0300	45.0	48.2	46.5	
0300 - 0400	45.0	48.3	46.2	
0400 - 0500	44.0	47.6	45.3	
0500 - 0600	44.8	47.2	45.9	
0600 - 0700	47.4	53.7	49.6	50.6
0700 - 0800	44.4	51.1	48.2	
0800 - 0900	44.8	53.7	49.4	
0900 - 1000	47.0	53.9	50.6	
1000 - 1100	47.1	67.5	57.9	
1100 - 1200	45.1	57.0	50.6	
1200 - 1300	43.3	54.0	47.3	
1300 - 1400	44.8	49.3	46.6	
1400 - 1500	47.7	57.2	52.5	
1500 - 1600	45.6	53.3	49.4	
1600 - 1700	43.6	56.0	51.5	
1700 - 1800	45.7	59.0	51.8	
1800 - 1900	46.2	62.0	56.0	51.2
1900 - 2000	42.3	62.1	55.1	
2000 - 2100	42.9	54.2	49.0	
2100 - 2200	44.4	54.3	47.3	
2200 - 2300	45.1	46.3	45.9	
2300 - 0000	44.7	46.9	46.3	

Monitoring Date : 17-Sep-24 to 18-Sep-24
Location: N3
Job Number: R240 8819/2

Period: All Days

Period	5 min LAeq, dBA		1hr LAeq, dBA	12hr LAeq, dBA
	Min	Max	Results	
0000 - 0100	46.6	48.9	47.9	49.0
0100 - 0200	45.6	49.3	47.0	
0200 - 0300	46.4	47.4	46.9	
0300 - 0400	47.3	48.0	47.7	
0400 - 0500	47.2	48.6	47.9	
0500 - 0600	44.1	49.0	46.8	
0600 - 0700	44.1	46.5	45.2	
0700 - 0800	46.7	52.1	49.2	
0800 - 0900	46.4	49.8	48.5	
0900 - 1000	49.3	55.2	53.1	
1000 - 1100	45.3	55.9	52.5	
1100 - 1200	45.7	50.5	47.6	
1200 - 1300	45.7	48.1	46.9	53.7
1300 - 1400	46.4	55.3	50.8	
1400 - 1500	50.0	55.3	52.0	
1500 - 1600	47.0	63.2	56.4	
1600 - 1700	44.8	60.4	53.3	
1700 - 1800	44.0	56.7	51.6	
1800 - 1900	44.4	61.2	55.2	
1900 - 2000	46.5	68.9	59.7	
2000 - 2100	44.6	50.2	48.1	
2100 - 2200	51.0	57.0	52.6	
2200 - 2300	47.5	51.9	50.1	
2300 - 0000	46.4	48.8	47.6	

Monitoring Date : 18-Sep-24 to 19-Sep-24
Location: N3
Job Number: R240 8819/2

Period: All Days

Period	5 min LAeq, dBA		1hr LAeq, dBA	12hr LAeq, dBA
	Min	Max	Results	
0000 - 0100	43.0	47.8	45.7	
0100 - 0200	45.4	47.3	46.2	
0200 - 0300	44.1	47.7	46.3	
0300 - 0400	44.4	47.7	45.9	
0400 - 0500	46.6	48.9	47.3	
0500 - 0600	44.6	49.0	47.5	49.8
0600 - 0700	44.8	54.7	47.9	
0700 - 0800	45.5	53.6	49.9	
0800 - 0900	47.6	53.6	50.9	
0900 - 1000	47.4	56.1	52.1	
1000 - 1100	46.5	62.1	55.5	
1100 - 1200	45.0	54.4	48.2	
1200 - 1300	44.4	55.8	49.4	
1300 - 1400	45.9	50.6	48.5	
1400 - 1500	44.7	52.8	47.2	
1500 - 1600	46.2	56.1	51.1	
1600 - 1700	45.0	48.6	47.2	
1700 - 1800	46.0	50.0	47.8	54.5
1800 - 1900	44.0	50.2	47.9	
1900 - 2000	44.4	66.3	60.7	
2000 - 2100	47.6	66.7	61.9	
2100 - 2200	45.8	51.4	48.9	
2200 - 2300	44.0	47.7	46.4	
2300 - 0000	43.9	48.3	45.5	

Monitoring Date : 19-Sep-24 to 20-Sep-24
Location: N3
Job Number: R240 8819/2

Period: All Days

Period	5 min LAeq, dBA		1hr LAeq, dBA	12hr LAeq, dBA
	Min	Max	Results	
0000 - 0100	43.0	47.7	45.2	50.1
0100 - 0200	41.6	46.8	44.7	
0200 - 0300	41.2	46.4	44.1	
0300 - 0400	42.3	46.5	44.6	
0400 - 0500	42.1	47.8	45.6	
0500 - 0600	42.9	46.7	45.3	
0600 - 0700	45.7	50.6	47.7	
0700 - 0800	45.2	50.1	47.8	
0800 - 0900	46.9	59.5	56.3	
0900 - 1000	47.0	57.5	52.2	
1000 - 1100	49.8	56.6	53.3	
1100 - 1200	46.6	56.7	50.2	
1200 - 1300	45.9	55.6	49.5	46.8
1300 - 1400	45.4	51.5	48.7	
1400 - 1500	43.0	49.7	46.8	
1500 - 1600	40.2	45.6	44.3	
1600 - 1700	41.6	47.9	43.6	
1700 - 1800	41.6	49.0	45.1	
1800 - 1900	43.6	51.8	47.4	
1900 - 2000	44.8	51.8	47.6	
2000 - 2100	43.9	47.7	46.1	
2100 - 2200	43.7	47.7	45.7	
2200 - 2300	44.0	48.9	46.9	
2300 - 0000	44.1	48.1	46.4	

Calibration Certificates for SVANTAK 971 Type 1 Sound Level Meter

Absolute Laboratories

Calibration Certificate

Calibration Number: 240300280131

Customer Name	: Marchwood Laboratory Services Pte Ltd	**Job Reference No**:	24030028
Customer Address	: 116 Tuas South Ave 2 West Point Bizhub Singapore 637163	**Certificate Issue Date**:	13/03/2024
Manufacturer	: Svantek	**Calibration Date**:	13/03/2024
Item Description	: Sound Level Meter Class I	**Test Conditions**:	
Model Number	: SVAN 971	Ambient Temperature:	23 °C
Serial Number	: 60603	Relative Humidity:	57 %R.H.
Sub-Assemblies S/N	: SV18 62704/ 7052E 88354	Pressure:	100 kPa

This certificate provides traceability of measurement to the International System of Units (SI).
Absolute Laboratories Pte. Ltd. certifies that the above product listed was calibrated in compliance with a quality management system using the applicable and approved Absolute Laboratories Pte. Ltd. calibration procedures as specified.
The reported expanded uncertainty is based on the standard uncertainty multiplied by a factor k = 2 (degrees of freedom = ∞) or as specified in the calibration report, which corresponds to a level of confidence of approximately 95%.

Calibration Method:
The instrument was calibrated following AL calibration procedure WI- 23-Rev-1

Calibration Equipment(s) Used			
Apparatus	**Serial Number**	**Cal Due Date**	**Certificate Number**
Arbitrary Function Generator	C015037	13/09/2024	SST/SA/R/2023I/1004
Calibrator	QOG060008	02/10/2024	231000092680
Sound Source	KZF070009	22/05/2024	230501491510
Digital Multimeter	MY57230283	03/11/2024	WO-00631175

Ambient Condition Range:
Temperature: (20-26)°C , Humidity: (25-70)%RH, Pressure: (80-105)kPa

Calibration By :
Han Chun Keong
Calibration Officer

Reviewed/Approved By :
Ang Siong Cheaw
Approving Officer

Absolute Laboratories Pte. Ltd. is an affiliated company of Absolute Instrument Systems (Pte.) Ltd.

Absolute Laboratories Pte. Ltd.
11 Kallang Place #06-01 Singapore 339155
Tel: 65 6296 8012 Fax: 65 6296 3242

Calibration Certificate for SV33A Acoustic Calibrator

Absolute Laboratories

Calibration Certificate

Calibration Number: 240300290132

Customer Name	: Marchwood Laboratory Services Pte Ltd	**Job Reference No:**	24030029
Customer Address	: 116 Tuas South Ave 2 West Point Bizhub Singapore 637163	**Certificate Issue Date:**	12/03/2024
Manufacturer	: Svantek	**Calibration Date:**	04/03/2024
Item Description	: Acoustic Calibrator	**Test Conditions:**	
Model Number	: SV 33A	Ambient Temperature:	22 °C
Serial Number	: 58609	Relative Humidity:	58 %R.H.
Sub-Assemblies S/N	: N.A.	Pressure:	100 kPa

This certificate provides traceability of measurement to the International System of Units (SI).
Absolute Laboratories Pte. Ltd. certifies that the above product listed was calibrated in compliance with a quality management system using the applicable and approved Absolute Laboratories Pte. Ltd. calibration procedures as specified.
The reported expanded uncertainty is based on the standard uncertainty multiplied by a factor k = 2 (degrees of freedom = ∞) or as specified in the calibration report, which corresponds to a level of confidence of approximately 95%.

Calibration Method:
The instrument was calibrated following AL calibration procedure WI- 44-Rev-4

Calibration Equipment(s) Used			
Apparatus	**Serial Number**	**Cal Due Date**	**Certificate Number**
Digital Multimeter	MY59007880	18/01/2025	WO-00690621
Microphone Calibration System	3049731/ 3175486	19/04/2024	AL001548

Ambient Condition Range:
Temperature: (20-26)°C , Humidity: (25-70)%RH, Pressure: (80-105)kPa

Calibration By : Han Chun Keong, Calibration Officer

Reviewed/Approved By : Ang Siong Cheaw, Approving Officer

Absolute Laboratories Pte. Ltd. is an affiliated company of Absolute Instrument Systems (Pte.) Ltd.

Absolute Laboratories Pte. Ltd.
11 Kallang Place #06-01 Singapore 339155
Tel: 65 6296 8012 Fax: 65 6296 3242

Photo 1: Noise Monitoring Station at N1 (29/09/24 to 05/10/24)

Photo 2: Noise Monitoring Station at N2 (21/09/24 to 27/09/24)

Photo 3: Noise Monitoring Station at N3 (13/09/24 to 19/09/24)

APPENDIX G

Baseline Air Quality Monitoring Results

TEST REPORT

Our Reference No.	:	**R240 8819/1**	Date of Monitoring	:	13/09/24 to 05/10/24
Project Code / Ref.	:	-	Date Reported	:	18/10/24

Customer Ref. No.	:	TAC / 24021 /SC 06
Customer Name	:	TEMBUSU Asia Consulting Pte Ltd
Customer Address	:	1 Commonwealth Lane, #06-06, One Commonwealth, Singapore 149544
Attention To	:	Mr Eric Chng
Subject	:	**Air Quality Monitoring for Bukit Batok EIA**
Description	:	Air Quality Monitoring at 3 locations between 13/09/24 to 05/10/24

Toh Teck Yeow

Snr Manager, Env Services

Terms & Conditions:

1) This report shall not be reproduced except in full, unless approval in writing has been given by MLS.
2) The results in this report only apply to the sample received/analysed.
3) MLS agrees to use reasonable diligence in the performance of the service.

Marchwood Laboratory Services Pte Ltd:
Main (Office and Laboratory):
Branch (Site and Laboratory):
Website:

Co. Reg No.: 201422686C
116 Tuas South Ave 2, West Point Bizhub Singapore 637163
216 Tuas South Ave 2, West Point Bizhub Singapore 637213
www.mls.sg

: +65 6790 0118
: +65 6262 3736 (Lab)
: +65 6790 0091
: +65 6262 3726 / 3776 (Site)

SCOPE OF WORK

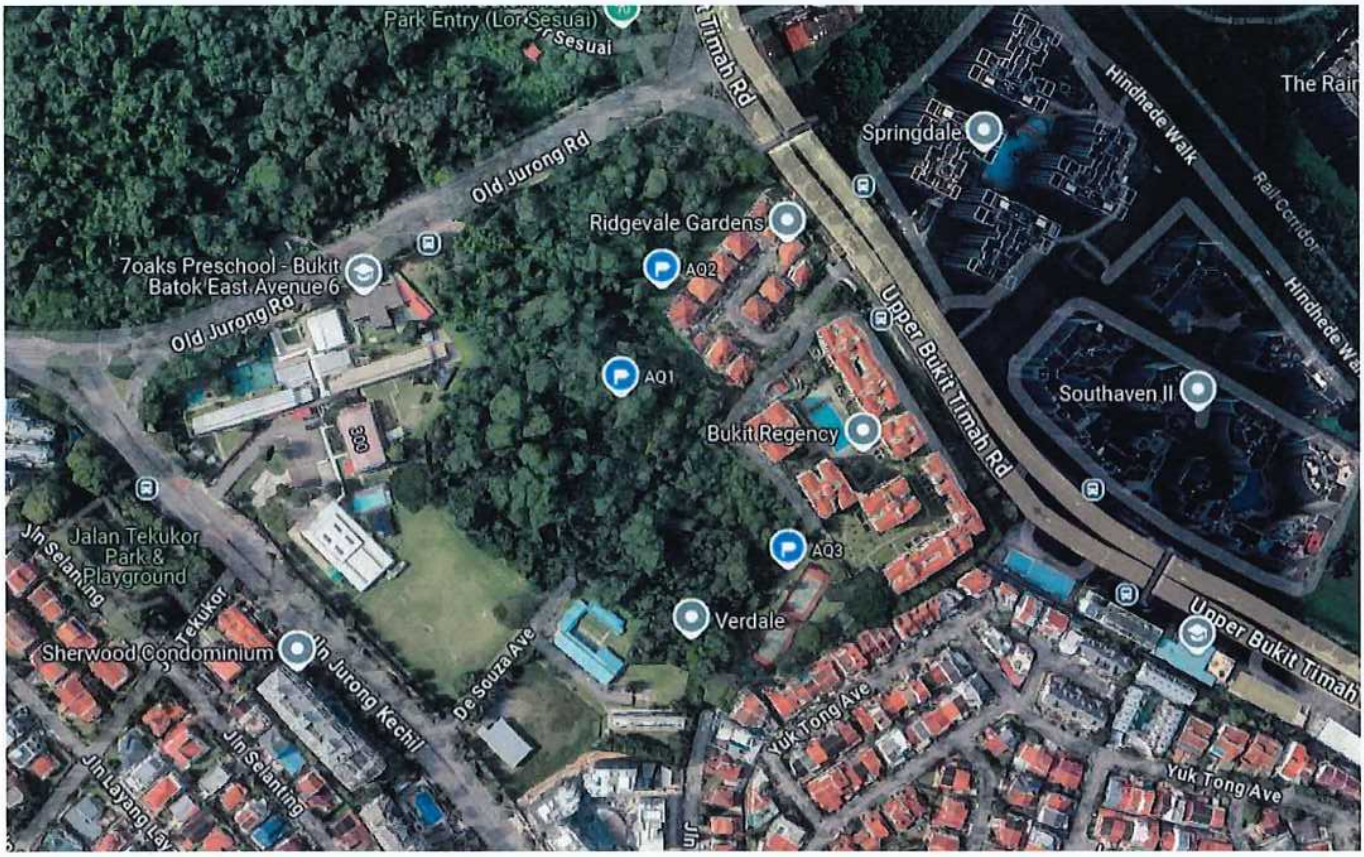
Baseline Ambient Air Monitoring was carried out at 3 locations from 13/09/24 to 05/10/24.

Table 1: Scope of work carried out

Locations	Parameters	Limit of Reporting / Detection Limit	Data Logging Interval
AQ1 1°20'49.1"N 103°46'10.9"E	PM_{10}	0 - 10000 μg/m³	10-min Avg
	$PM_{2.5}$	0 - 2000 μg/m³	
AQ2 1°20'51.3"N 103°46'11.7"E	SO_2	0 - 10000 ppb	5-min Avg
	CO	0 - 12000 ppb	
AQ3 1°20'45.4"N 103°46'14.3"E	NO_2	0 - 5000 ppb	
	O_3	0 - 2000 ppb	

MONITORING LOCATION

The monitoring location is shown in the Google Map image below. Refer to Appendix B for site photo.



SAMPLING METHODOLOGY AND EQUIPMENT

Kunak AIR Pro (S/N: 0324130184)

PM10 and PM2.5 were monitored using an onboard Optical Particle Counter (OPC) capable of measuring particles from 0.3 µm up to 40 µm. PM1, PM2.5, PM4, PM10, Total Suspended Particles (TSP) and Total Particle Counter (TPC) are calculated assuming a particle density profile. SO_2, CO, NO_2 and O_3 are measured by individual electrochemical sensors installed. The instrument is powered by solar. This instrument model is UKAS M-CERTS certified (certificate number: CSA MC230418/00). Calibration certs are shown in Appendix A.

SINGAPORE AMBIENT AIR QUALITY TARGETS

Table 3: The following table summarises the Singapore Ambient Air Quality Guidelines

Pollutant	Singapore Long Term Targets
Particulate Matter ($PM_{2.5}$)	**24-hour mean: 25 µg/m³**
Particulate Matter (PM_{10})	**24-hour mean: 50 µg/m³**
Sulphur Dioxide (SO_2)	**24-hour mean: 20 µg/m³**
Carbon Monoxide (CO)	**8-hour mean: 10 mg/m³**
	1-hour mean: 30 mg/m³
Nitrogen Dioxide (NO_2)	**1-hour mean: 200 µg/m³**
Ozone (O_3)	**8-hour mean: 100 µg/m³**

MONITORING RESULTS

The results were summarised in the following table. Raw air quality data are submitted electronically.

Table 4: Summary of 24-hour mean for PM_{10} and $PM_{2.5}$ for AQ1

Pollutants		PM_{10}	$PM_{2.5}$
Averaging Period		24 hours	
Unit		$\mu g/m^3$	
AQ1	29-Sep-24	18.9	8.6
	30-Sep-24	28.4	10.6
	01-Oct-24	15.2	5.3
	02-Oct-24	14.3	6.0
	03-Oct-24	14.3	6.1
	04-Oct-24	20.5	11.7
	05-Oct-24	16.0	7.3
Singapore's Ambient Air Quality Long Term Targets		50	25

Table 5: Summary of 24-hour mean for SO_2 and Max 1hr NO_2 for AQ1

Pollutants		SO_2	NO_2
Averaging Period		24 hours	Max 1 hour
Unit		$\mu g/m^3$	
AQ1	29-Sep-24	< 8	4.7
	30-Sep-24	< 8	11.3
	01-Oct-24	28.1	6.9
	02-Oct-24	15.8	< 4
	03-Oct-24	< 8	30.9
	04-Oct-24	16.3	22.9
	05-Oct-24	< 8	< 4
Singapore's Ambient Air Quality Long Term Targets		20	200

Table 6: Summary of Max 8hr O_3, Max 8hr and 1hr CO for AQ1

Pollutants		O_3	CO	
Averaging Period		Max 8 hours	Max 8 hours	Max 1 hour
Unit		µg/m³	mg/m³	
AQ1	29-Sep-24	18.2	0.39	0.53
	30-Sep-24	28.4	0.36	0.54
	01-Oct-24	16.4	0.42	0.69
	02-Oct-24	9.3	0.37	0.52
	03-Oct-24	20.3	0.40	0.59
	04-Oct-24	34.1	0.52	0.59
	05-Oct-24	26.8	0.40	0.44
Singapore's Ambient Air Quality Long Term Targets		100	10	30

Table 7: Summary of 24-hour mean for PM_{10} and $PM_{2.5}$ for AQ2

Pollutants		PM_{10}	$PM_{2.5}$
Averaging Period		24 hours	
Unit		µg/m³	
AQ2	21-Sep-24	21.1	9.3
	22-Sep-24	23.4	12.1
	23-Sep-24	27.1	13.7
	24-Sep-24	32.5	15.7
	25-Sep-24	26.1	13.3
	26-Sep-24	15.7	5.7
	27-Sep-24	17.7	7.3
Singapore's Ambient Air Quality Long Term Targets		50	25

Table 8: Summary of 24-hour mean for SO_2 and Max 1hr NO_2 for AQ2

Pollutants		SO_2	NO_2
Averaging Period		24 hours	Max 1 hour
Unit		µg/m³	
AQ2	21-Sep-24	< 8	15.7
	22-Sep-24	< 8	28.5
	23-Sep-24	< 8	21.4
	24-Sep-24	23.8	27.8
	25-Sep-24	19.2	22.5
	26-Sep-24	< 8	4.7
	27-Sep-24	13.8	6.7
Singapore's Ambient Air Quality Long Term Targets		20	200

Table 9: Summary of Max 8hr O_3, Max 8hr and 1hr CO for AQ2

Pollutants		O_3	CO	
Averaging Period		Max 8 hours	Max 8 hours	Max 1 hour
Unit		$\mu g/m^3$	mg/m^3	
AQ2	21-Sep-24	25.8	0.44	0.69
	22-Sep-24	55.1	0.43	0.60
	23-Sep-24	47.1	0.37	0.56
	24-Sep-24	31.0	0.53	0.83
	25-Sep-24	24.6	0.53	0.90
	26-Sep-24	15.9	0.35	0.58
	27-Sep-24	28.6	0.42	0.80
Singapore's Ambient Air Quality Long Term Targets		100	10	30

Table 10: Summary of 24-hour mean for PM_{10} and $PM_{2.5}$ for AQ3

Pollutants		PM_{10}	$PM_{2.5}$
Averaging Period		24 hours	
Unit		$\mu g/m^3$	
AQ3	13-Sep-24	22.4	10.0
	14-Sep-24	18.3	7.4
	15-Sep-24	22.5	10.9
	16-Sep-24	24.7	12.3
	17-Sep-24	20.0	8.2
	18-Sep-24	14.7	4.5
	19-Sep-24	25.4	12.4
Singapore's Ambient Air Quality Long Term Targets		50	25

Table 11: Summary of 24-hour mean for SO_2 and Max 1hr NO_2 for AQ3

Pollutants		SO_2	NO_2
Averaging Period		24 hours	Max 1 hour
Unit		$\mu g/m^3$	
AQ3	13-Sep-24	< 8	15.3
	14-Sep-24	< 8	17.5
	15-Sep-24	< 8	12.5
	16-Sep-24	< 8	8.7
	17-Sep-24	< 8	12.2
	18-Sep-24	< 8	13.2
	19-Sep-24	< 8	10.5
Singapore's Ambient Air Quality Long Term Targets		20	200

Table 12: Summary of Max 8hr O_3, Max 8hr and 1hr CO for AQ3

Pollutants		O_3	CO	
Averaging Period		Max 8 hours	Max 8 hours	Max 1 hour
Unit		$\mu g/m^3$	mg/m^3	
AQ3	13-Sep-24	40.6	0.27	0.45
	14-Sep-24	38.3	0.36	0.57
	15-Sep-24	32.8	0.44	0.58
	16-Sep-24	47.1	0.32	0.63
	17-Sep-24	50.8	0.29	0.32
	18-Sep-24	32.8	0.27	0.36
	19-Sep-24	62.7	0.36	0.71
Singapore's Ambient Air Quality Long Term Targets		100	10	30

Note:

1) All the monitoring dates represent data collected from 0000hrs to 2359hrs.
2) PM results are adjusted based on resulting slope and intercept derived from collocation with USEPA approved air monitors done from 01/05/24 to 08/05/24.

MCERTS Certificate for Kunak AIR Pro

PRODUCT CONFORMITY CERTIFICATE

This is to certify that the

Kunak AIR Pro

Manufactured by:

Kunak Technologies SL
Parque Empresarial La Muga, 9
Floor 4, Office 1 – Orcoyen
Navarra
Spain

has been assessed by CSA Group
and for the conditions stated on this certificate complies with:

MCERTS Performance Standards for Indicative Ambient Particulate Monitors, Environment Agency, August 2017, version 4

Certification ranges:

$PM_{2.5}$ 0-1,500 µg/m^3
PM_{10} 0-2,000 µg/m^3

Project No.:	80150788
Certificate No:	CSA MC230418/00
Initial Certification:	9 June 2023
This Certificate issued:	9 June 2023
Renewal Date:	8 June 2028

Andrew Young
Environmental Team Manager

MCERTS is operated on behalf of the Environment Agency by

CSA Group Testing UK Ltd
Unit 6, Hawarden Industrial Park
Hawarden, Deeside, CH5 3US
Tel: +44 (0)1244 670 900

Form 1335
Issue 11

Certificate Contents

Approved Site Application

Any potential user should make sure, in consultation with the manufacturer, that the monitoring system is suitable for the intended application. For general guidance on monitoring techniques refer to the Environment Agency guidance available at www.mcerts.net

The indicative dust monitoring analyser(s) can be operated in one of two ways:

For qualitative measurements: Providing qualitative measurement data for the analysis of particulate pollution trends, and source identification studies based for example on pollution roses etc. Such application can rely on instrument factory calibration only.

For quantitative measurements: Providing measurement data with the uncertainty defined for indicative instruments (+/- 50%). This can be achieved on condition that each instrument used for measurement has been calibrated on the specific site where monitoring is taking place against a standard reference method for a period of two weeks and the resulting slope and intercept have been used for instrument calibration. Using non-standard filters and procedures for this purpose is not acceptable. To maintain the validity of data this calibration has to be repeated at least every twelve months or when the instrument is moved to a different site.

They **cannot** be used on national automatic monitoring networks for compliance reporting against the Ambient Air Quality Directives.

The field tests were carried out from the 1 April 2022 to the 7 February 2023 on two candidate 'Kunak AIR Pro' samplers, collocated with a Palas Fidas 200 (the reference method). The location of the field test was University of Manchester, Fallowfield, Manchester, UK. The serial numbers of the two 'Kunak AIR Pro' monitors were '0321 180036' and '0321 180037'.

Basis of Certification

This certification is based on the following test report(s) and on CSA Group's assessment and ongoing surveillance of the product and the manufacturing process:

Bureau Veritas, test report ref. AIR17810339, dated June 2023, "Kunak, Test of the Air Pro for use as an Indicative Monitor for PM_{10} and $PM_{2.5}$"

Product Certified

The 'Kunak AIR Pro' measuring system consists of the following parts:

- Base Station includes data storage with eSIM cellular communications.
- Power Pack embedded in the base station.
- Particulate sensor cartridge to measure $PM_{2.5}$ and PM_{10}.
- Solar protected shield.

Sensor type and firmware version
Alphasense OPC-N3 with firmware version 1.32.DT

Algorithm Version (note 5.)
KAIR_OPCN3_31

The particle firmware - Senor type OPC-N3 firmware version 1.17a.B with algorithm version KAIR_OPCN3_30.

This certificate applies to all instruments fitted with serial number 0321 180037 onwards.

Certified Performance

Test (***Laboratory***)	Results expressed as % of the certification range				Other results	MCERTS specification
	<0.5	<1	<2	<5		
Constancy of the sample volumetric flow					Not applicable Note 1	To remain constant within ± 3%
Tightness of the sampling system			1.44%			Leakage not to exceed 2% of sampled volume

Certificate No: CSA MC230418/00
This Certificate issued: 9 June 2023

CSA GROUP™ MCERTS Environment Agency

Test (**Field**)	Results expressed as % of the certification range				Other results	MCERTS specification
	<0.5	<1	<2	<5		
Intra-instrument uncertainty for the reference method						
PM_{10}					0.33µg/m³	≤2.5µg/m³
$PM_{2.5}$					0.25µg/m³	≤2.5µg/m³
Intra-instrument uncertainty for the candidate method						
PM_{10}						
All data (n=306)					1.74µg/m³	≤5µg/m³ for all data as well as for the subsets: < or ≥ 30 µg/m³
≥ 30 µg/m³ (n=4)					2.47µg/m³	
< 30 µg/m³ (n=302)					1.74µg/m³	
$PM_{2.5}$						
All data (n=306)					0.81µg/m³	≤5µg/m³ for all data as well as for the subsets: < or ≥ 30 µg/m³
≥ 18 µg/m³ (n=14)					1.64µg/m³	
< 18 µg/m³ (n=292)					0.75µg/m³	
Highest resulting uncertainty estimate comparison against data quality objective (Measurement Uncertainty)						$W_{CM} \leq 50\%$ $W_{CM} \leq W_{dqo}$ (W_{dqo} Measurement uncertainty defined as 50% for indicative instruments)
PM_{10}						
All data (n=306)					81.1%	
All data (slope corrected) (n=306)					12.2% (note 2)	
≥ 30 µg/m³ (slope corrected) (n=4)					46.6%	
$PM_{2.5}$						
All data (n=306)					67.0%	
All data (slope corrected) (n=306)					10.6% (note 3)	
≥ 18 µg/m³ (slope corrected) (n=14)					40.9% (note 3)	
Maintenance Interval					44 weeks Note 4	≥2 weeks

Note 1 - The Kunak AIR Pro utilises a fan and not a pump, therefore it was agreed that this test was not applicable.
Note 2 - This data was slope corrected by dividing by 0.596. All users must slope correct PM 10 data by dividing by 0.596 - it is recommended that the manufacturer program this value into their algorithm in order to avoid confusion to end users. End users should check with the manufacturers that this has been carried out.
Note 3 - This data was slope corrected by dividing by 0.667. All users must slope correct $PM_{2.5}$ data by dividing by 0.667 - it is recommended that the manufacturer program this value into their algorithm in order to avoid confusion to end users. End users should check with the manufacturers that this has been carried out.
Note 4 - Maintenance - the manufacturer recommends that users clean the PM inlet if it becomes dirty. If a problem arises, such as sensor malfunction or obstruction, then the software will detect it automatically and will invalidate the measurements and advise the user to carry out specific maintenance. It is further recommended to change the PM sensor after 2 years operation.
Note 5 - The Kunak AIR Pro must be set up using the configuration, as follows; i) Alphasense OPC-N3 sensor with firmware version '1.32.DT', and ii) Algorithm version: KAIR_OPCN3_31. The firmware version incorporates slope correction – firmware version '31' is approved and no slope correction required.

Certificate No: CSA MC230418/00
This Certificate issued: 9 June 2023

Description

The Kunak AIR Pro has a particulate matter sensor that consists of an optical particle counter (OPC) capable of measuring particles from 0.3µm up to 40µm. $PM_{2.5}$ and PM_{10} are calculated assuming a particle density profile.
The effect of humidity is corrected using the embedded algorithm. The particle size distributions are available on Kunak Cloud.

The Kunak AIR Pro communicates using GPRS, 3G, 4G, ethernet and Modbus RTE Slave. Secure encryption and direct communication protocols, results in bi-directional communications and facilitates remote configuration, firmware update and sensor calibration of the devices through the Kunak Cloud web platform.

Kunak AIR Pro is equipped with an internal rechargeable battery. The battery can be powered either through a small solar panel to facilitate the installation of the device or by an outdoor charger to via the main network.

General Notes

1. This certificate is based upon the equipment tested. The Manufacturer is responsible for ensuring that on-going production complies with the standard(s) and performance criteria defined in this certificate. The manufacturer is required to maintain an approved quality management system controlling the manufacture of the certified product. Both the product and the quality management system shall be subject to regular surveillance according to 'Regulations Applicable to the Holders of CSA Group Testing UK Ltd Certificates'.

2. The design of the product certified is defined in the CSA Group design schedule V00 for certificate no. CSA MC230418/00.

3. If a certified product is found not to comply, CSA Group should be notified immediately at the address shown on this certificate.

4. The certification marks that can be applied to the product or used in publicity material are defined in 'Regulations Applicable to the Holders of CSA Group Testing UK Ltd Certificates'.

5. This document remains the property of CSA Group and shall be returned when requested by CSA Group.

CHARACTERIZATION AND CALIBRATION CERTIFICATE

KUNAK TECHNOLOGIES S.L., as manufacturer of the product, certifies that the cartridge meets the internal manufacturing quality conditions, as well as the laboratory tests and the correct calibration of the cartridges according to the QA&QC proccedings.

Cartridges are tested according to the laboratory pre-test specified in CEN/TS 17660-1:2021 "Air quality - Performance evaluation of air quality sensor systems - Part 1: Gaseous pollutants in ambient air", regarding the Response Time (t90), Limit of Detection (LOD) and Repeatability (Rep).

CERTIFIED CARTRIDGE

Cartridge type:	Carbon monoxide (CO)	**Manufacture Date:**	2023-06-20
P/N:	K-CO-A-01	**Expiration Date:**	2025-08-20
S/N:	3023070059		

TEST 1: ENVIRONMENTAL CHARACTERIZATION TEST

Environmetal characterization test - not required for Carbon monoxide (CO) cartridges.

TEST 2: LABORATORY TEST

The Response Time, the Limit of Detection and the Repeatability of the cartridge are calculated using certified gas bottles according to the CEN/TS 17660-1:2021.

- **Response Time:** The response time of the sensor systems is estimated using t90 (the time required for the sensor system to reach 90% of the final stable value).
- **Limit of Detection:** Value of the measured quantity that gives the probability of falsely asserting the absence or presence of a component.
- **Repeatability:** closeness of the agreement between the results of successive measurements of the same measure and carried out under the same conditions of measurement.

Test	Cartridge S/N	Kunak requirement	TS 17660-1:2021 requirement	STATUS
Response Time	3023070059	< 30 s	< 360 s	PASS
Limit of Detection	3023070059	< 10 ppb	< 150 ppb	PASS
Repeatability	3023070059	< 20 ppb	< 50 ppb	PASS

REMARKS

The results indicated refer exclusively to the cartridge subjected to the characterization and laboratory tests and described in this certificate.

Signature:

KUNAK TECHNOLOGIES, S.L.
C.I.F. B71110837
Parque Empresarial La Muga, 9 Plt. 4 Ofi. 1
31160 ORKOIEN (Navarra)

kunak®
SENSING ANYWHERE

CHARACTERIZATION AND CALIBRATION CERTIFICATE

KUNAK TECHNOLOGIES S.L., as manufacturer of the product, certifies that the cartridge meets the internal manufacturing quality conditions, as well as the laboratory tests and the correct calibration of the cartridges according to the QA&QC proccedings.

Cartridges are tested according to the laboratory pre-test specified in CEN/TS 17660-1:2021 "Air quality - Performance evaluation of air quality sensor systems - Part 1: Gaseous pollutants in ambient air", regarding the Response Time (t90), Limit of Detection (LOD) and Repeatability (Rep).

CERTIFIED CARTRIDGE

Cartridge type:	Ozone (O3)	**Manufacture Date:**	2023-06-20
P/N:	K-O3-A-01	**Expiration Date:**	2025-08-20
S/N:	3323190108		

TEST 1: ENVIRONMENTAL CHARACTERIZATION TEST

Typical baseline error in the whole temperature (<45ºC) and humidity range.

Test	Cartridge S/N	Test results	Kunak requirement	STATUS
Environmetal characterization	3323190108	4.05 ppb	< 12 ppb	PASS

TEST 2: LABORATORY TEST

The Response Time, the Limit of Detection and the Repeatability of the cartridge are calculated using certified gas bottles according to the CEN/TS 17660-1:2021.

- **Response Time:** The response time of the sensor systems is estimated using t90 (the time required for the sensor system to reach 90% of the final stable value).
- **Limit of Detection:** Value of the measured quantity that gives the probability of falsely asserting the absence or presence of a component.
- **Repeatability:** closeness of the agreement between the results of successive measurements of the same measure and carried out under the same conditions of measurement.

Test	Cartridge S/N	Kunak requirement	TS 17660-1:2021 requirement	STATUS
Response Time	3323190108	< 120 s	< 360 s	PASS
Limit of Detection	3323190108	< 3 ppb	< 10 ppb	PASS
Repeatability	3323190108	< 4 ppb	< 4 ppb	PASS

REMARKS

The results indicated refer exclusively to the cartridge subjected to the characterization and laboratory tests and described in this certificate.

Signature:

KUNAK TECHNOLOGIES, S.L.
C.I.F. B71110837
Parque Empresarial La Muga, 9 Plt. 4 Ofi. 1
31160 ORKOIEN (Navarra)

kunak®
SENSING ANYWHERE

CHARACTERIZATION AND CALIBRATION CERTIFICATE

KUNAK TECHNOLOGIES S.L., as manufacturer of the product, certifies that the cartridge meets the internal manufacturing quality conditions, as well as the laboratory tests and the correct calibration of the cartridges according to the QA&QC proccedings.

Cartridges are tested according to the laboratory pre-test specified in CEN/TS 17660-1:2021 "Air quality - Performance evaluation of air quality sensor systems - Part 1: Gaseous pollutants in ambient air", regarding the Response Time (t90), Limit of Detection (LOD) and Repeatability (Rep).

CERTIFIED CARTRIDGE

Cartridge type:	Sulphur dioxide (SO2)	**Manufacture Date:**	2023-06-20
P/N:	K-SO2-A-01	**Expiration Date:**	2025-08-20
S/N:	3523120056		

TEST 1: ENVIRONMENTAL CHARACTERIZATION TEST

Typical baseline error in the whole temperature (<45ºC) and humidity range.

Test	Cartridge S/N	Test results	Kunak requirement	STATUS
Environmetal characterization	3523120056	12.51 ppb	< 30 ppb	PASS

TEST 2: LABORATORY TEST

The Response Time, the Limit of Detection and the Repeatability of the cartridge are calculated using certified gas bottles according to the CEN/TS 17660-1:2021.

- **Response Time:** The response time of the sensor systems is estimated using t90 (the time required for the sensor system to reach 90% of the final stable value).
- **Limit of Detection:** Value of the measured quantity that gives the probability of falsely asserting the absence or presence of a component.
- **Repeatability:** closeness of the agreement between the results of successive measurements of the same measure and carried out under the same conditions of measurement.

Test	Cartridge S/N	Kunak requirement	TS 17660-1:2021 requirement	STATUS
Response Time	3523120056	< 120 s	< 360 s	PASS
Limit of Detection	3523120056	< 3 ppb	< 10 ppb	PASS
Repeatability	3523120056	< 4 ppb	< 4 ppb	PASS

REMARKS

The results indicated refer exclusively to the cartridge subjected to the characterization and laboratory tests and described in this certificate.

Signature:

KUNAK TECHNOLOGIES, S.L.
C.I.F. B71110837
Parque Empresarial La Muga, 9 Plt. 4 Ofi. 1
31160 ORKOIEN (Navarra)

kunak®
SENSING ANYWHERE

CHARACTERIZATION AND CALIBRATION CERTIFICATE

KUNAK TECHNOLOGIES S.L., as manufacturer of the product, certifies that the cartridge meets the internal manufacturing quality conditions, as well as the laboratory tests and the correct calibration of the cartridges according to the QA&QC proccedings.

Cartridges are tested according to the laboratory pre-test specified in CEN/TS 17660-1:2021 "Air quality - Performance evaluation of air quality sensor systems - Part 1: Gaseous pollutants in ambient air", regarding the Response Time (t90), Limit of Detection (LOD) and Repeatability (Rep).

CERTIFIED CARTRIDGE

Cartridge type:	Nitrogen dioxide (NO2)	**Manufacture Date:**	2023-06-20
P/N:	K-NO2-A-01	**Expiration Date:**	2025-08-20
S/N:	3223160120		

TEST 1: ENVIRONMENTAL CHARACTERIZATION TEST

Typical baseline error in the whole temperature (<45ºC) and humidity range.

Test	Cartridge S/N	Test results	Kunak requirement	STATUS
Environmetal characterization	3223160120	5.33 ppb	< 20 ppb	PASS

TEST 2: LABORATORY TEST

The Response Time, the Limit of Detection and the Repeatability of the cartridge are calculated using certified gas bottles according to the CEN/TS 17660-1:2021.

- **Response Time:** The response time of the sensor systems is estimated using t90 (the time required for the sensor system to reach 90% of the final stable value).
- **Limit of Detection:** Value of the measured quantity that gives the probability of falsely asserting the absence or presence of a component.
- **Repeatability:** closeness of the agreement between the results of successive measurements of the same measure and carried out under the same conditions of measurement.

Test	Cartridge S/N	Kunak requirement	TS 17660-1:2021 requirement	STATUS
Response Time	3223160120	< 120 s	< 360 s	PASS
Limit of Detection	3223160120	< 3 ppb	< 10 ppb	PASS
Repeatability	3223160120	< 4 ppb	< 4 ppb	PASS

REMARKS

The results indicated refer exclusively to the cartridge subjected to the characterization and laboratory tests and described in this certificate.

Signature:

KUNAK TECHNOLOGIES, S.L.
C.I.F. B71110837
Parque Empresarial La Muga, 9 Plt. 4 Ofi. 1
31160 ORKOIEN (Navarra)

kunak®
SENSING ANYWHERE

Photos: Ambient Air Monitoring Station at AQ1 (29/09/24 to 05/10/24)

Photos: Ambient Air Monitoring Station at AQ2 (21/09/24 to 27/09/24)

Photos: Ambient Air Monitoring Station at AQ3 (13/09/24 to 19/09/24)

APPENDIX H

Colugo Connectivity Study Report

OLD JURONG ROAD ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

Colugo Connectivity Study Report

12 November 2025

Intended for
Urban Redevelopment Authority

Document type
TAC/24021/Colugo Connectivity Study Report

TEMBUSU Asia

Description	**Colugo Connectivity Study Report for Old Jurong Road Environmental Impact Assessment (EIA)**
Project Ref	**TAC/24021/Colugo Connectivity Study Report**

TEMBUSU Asia Consulting Pte Ltd
1 Commonwealth Lane #06-06
One Commonwealth Building
Singapore 149544
T +65 6238 4009
F +65 6570 5254
Co. Reg. No. 201732581C

CONTENT

FIGURES

TABLES

1 INTRODUCTION

1.1 Project Background

In Singapore, gliding mammals such as the Malayan colugo (*Galeopterus variegatus*) and Horsfield's flying squirrel (*Iomys horsfieldii*) are known to largely occur in and around Bukit Timah Nature Reserve (BTNR), Central Catchment Nature Reserve (CCNR) and Bukit Batok Nature Park (BBNP) (NParks, 2022; NParks, 2024). These mammals possess skin membranes, which allow them to use gliding as a rapid form of locomotion, providing access to foraging patches that may otherwise be inaccessible via movement through the canopy (Byrnes, Libby, Lim, & Spence, 2011). Indeed, despite the extensive road network separating forest patches where they occur, colugos have been regularly observed to use roadside trees to traverse roads to move between forest patches.

Given the known presence of colugos in and around the study area, and a published connectivity model for colugos (Lee, et al., 2023), a colugo connectivity study was proposed, using the Malayan colugo as a proxy for gliding mammals.

The aims of the colugo connectivity study are:

1. To study existing connectivity for the Malayan colugo between BBNP, BTNR and the study area
2. To determine the importance of the study area in facilitating crossing between BBNP and BTNR via path 2, relative to path 1 (Figure 1.1)
3. To propose optimal colugo pole positions to mitigate any losses in connectivity from development (if required)

Figure 1.1 Possible crossing pathways for the Malayan colugo (*Galeopterus variegatus*) between BBNP and BTNR

1.2 Study Area

For this study, all trees within a 50m buffer from the road reserve line of Upper Bukit Timah Road and Old Jurong Road were included for analysis (Figure 1.2). These included trees within nature areas, roadside trees and trees on the road centre divider.

Figure 1.2 Map showing the colugo connectivity study area

Three development scenarios are considered as follows (Figure 1.3):

(i) Pre-development, where all existing trees are included for analysis

(ii) Scenario A, where all trees within the study area are cleared and two roadside trees and one centre divider tree along Old Jurong Road are removed for road works

(iii) Scenario B, where all trees within a Proposed Retained Area (PRA) are retained and two roadside trees and one centre divider tree along Old Jurong Road are removed for road works

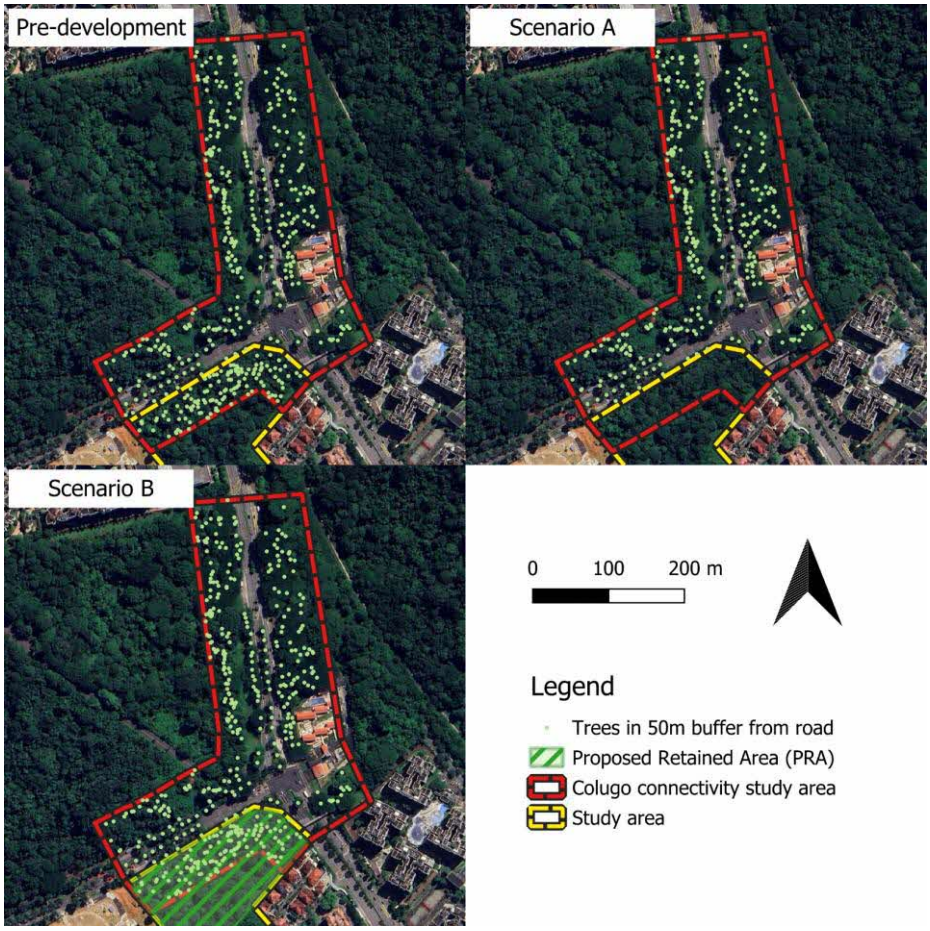


Figure 1.3 Map showing the three development scenarios

2 METHODS

2.1 DEM and large tree data preparation

The components required for colugo connectivity modelling include a Digital Elevation Model (DEM) which contains elevation data in raster format, and data of large trees in shapefile format. LIDAR data was obtained from the client for the colugo connectivity study area as indicated in Figure 1.2. The LIDAR data was then examined under QGIS LAStools toolbox using the 'lasview' function and converted into DEM using 'las2dem' function keeping only the ground points. The resulting DEM was then compared with the ground control point values within the study area obtained by topography surveyor. The resulting DEM has an elevation range of 21.28m to 43.96m SHD, which was in general similar to that of the ground control points (Figure 2.1).

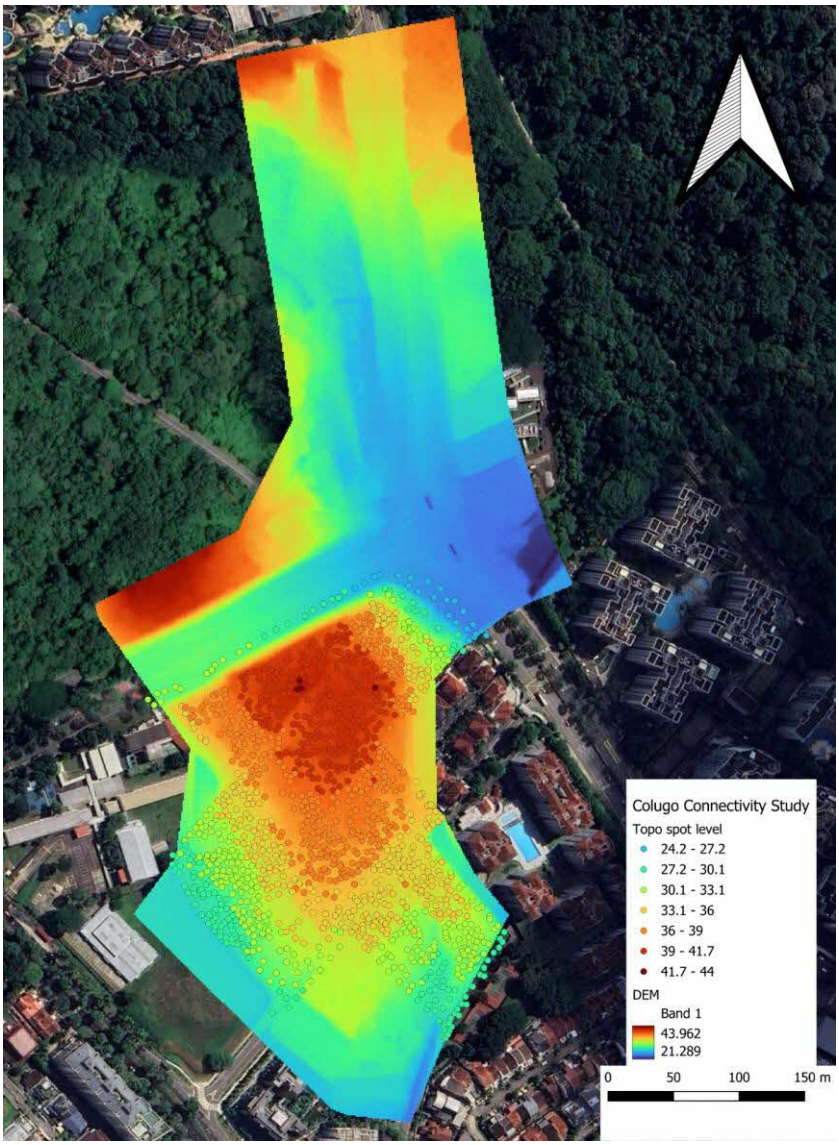


Figure 2.1 DEM of colugo connectivity study area compared with topo spot level of environmental baseline study area

The data of large trees was obtained from baseline surveys at the study area, tree mapping

along Old Jurong Road and Upper Bukit Timah Road and existing data from other technical agencies, which include information on tree ID, species, latitude, longitude and height. The elevation data of the trees was then extracted from the DEM using the QGIS plugin 'point sampling tool', and the locations of the trees were classified into: Bukit Batok Nature Park, Bukit Timah Nature Reserve, centre divider (Upper Bukit Timah Road), center divider (Old Jurong Road) and environmental baseline study area.

2.2 Colugo connectivity modelling

Following Lee et al. (2023), a vector-based approach was undertaken to quantify changes in connectivity for the Malayan colugo pre- and post-development, assuming that the study area would be fully developed. The following parameters were determined for each tree located within the colugo connectivity study area: (i) height of tree; (ii) location of tree; and (iii) elevation of tree, derived from the DEM.

For each tree, a buffer of estimated glide distance was generated based on a glide ratio value of 3 due to the approximate width of 30m of Upper Bukit Timah Road, using the glide ratio model described in Lee et al. (2023). The estimated glide distance (*estD*) of the large trees was then obtained using the formula $estD$ = 3 × (0.8 × $Height$ + 10). Line vectors between each pair of departure and landing tree located in a different location within the buffer were generated, with the following assumptions: (i) the top 20% of tree height was unusable due to the presence of foliage; and (ii) the minimum landing height was 1.5m (Figure 2.2). Subsequently, only feasible glide paths which fulfil two conditions – (i) the difference between 80% of departure tree height and minimum departure height is positive; and (ii) landing tree is tall enough to support colugo landing, taking into account elevational differences – were retained.

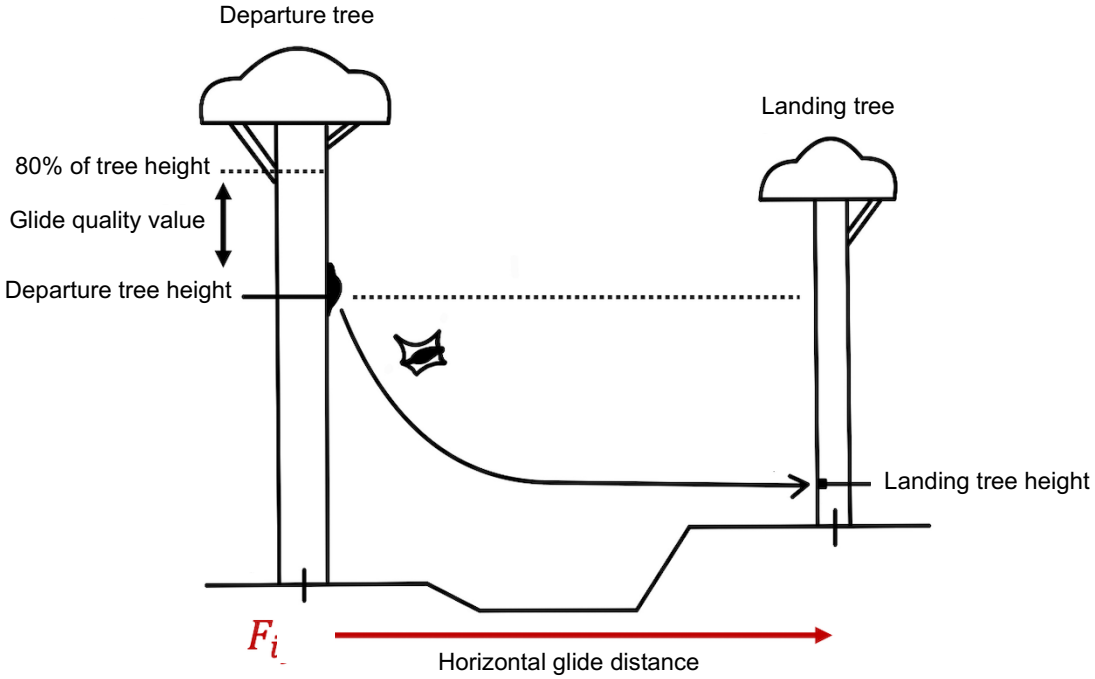


Figure 2.2 Diagram depicting departure and landing tree height, horizontal glide distance and glide quality value (adapted from Lee et al. (2023))

Glide quality value was also calculated by the difference between 80% of departure tree height and minimum departure height (Figure 2.2). The greater the glide quality value, the more vertical allowance there is on the departure tree for the colugo to utilise. Glide paths that had glide quality values identified as outliers were determined to be of high quality.

The analysis was repeated for three scenarios: (i) pre-development; (ii) Scenario A; and (iii) Scenario B.

3 RESULTS AND DISCUSSION

3.1 Pre- and post-development glide paths

There were 2352 feasible glide paths in the colugo connectivity study area pre-development, with a mean minimum departure tree height of 16.03m (Table 3.1). Glide paths with glide quality values above 9.81m were considered of high quality, and were largely concentrated across Old Jurong Road (Figure 3.1).

Table 3.1 Summary of the number of feasible glide paths (*n*), minimum departure tree height and glide quality value

		Minimum departure tree height (m)		Glide quality value (m)			
	n	Minimum	Mean	Mean	Median	IQR	Outlier
Pre-development	2352	6.60	16.03	3.18	2.61	3.46	9.81 – 13.80
Scenario A	1104	6.60	14.21	3.13	2.43	3.40	9.74 – 13.18
Scenario B	2253	6.60	16.14	3.14	2.58	3.41	9.68 – 13.80

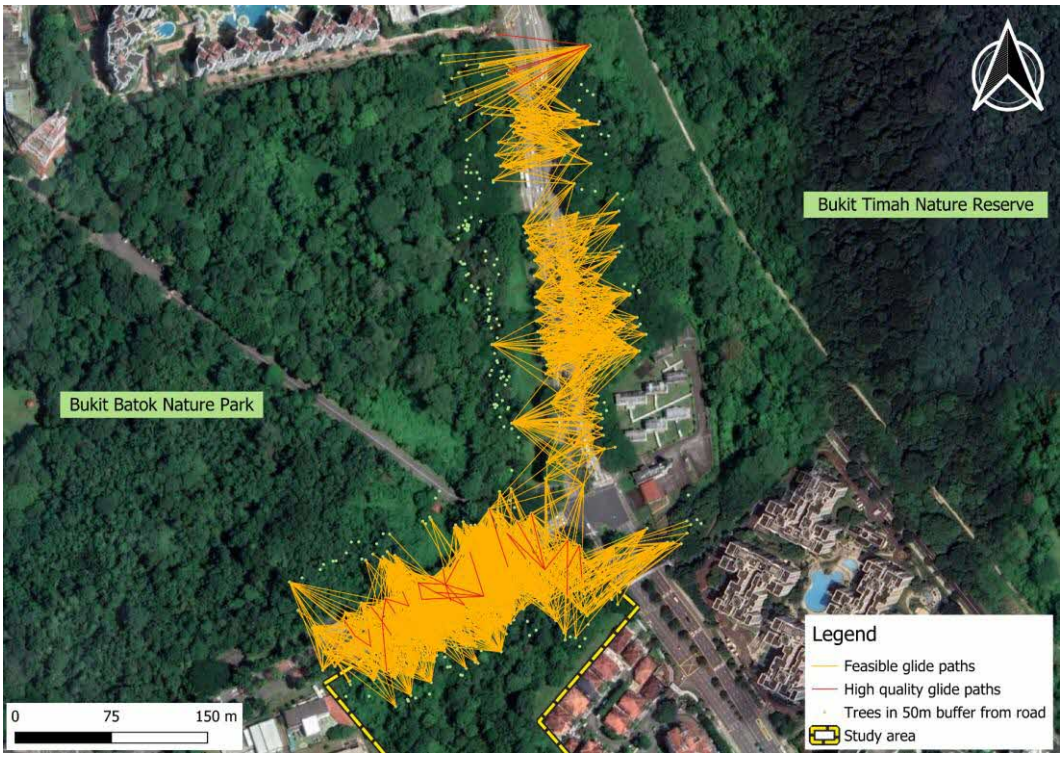


Figure 3.1 Map showing all feasible glide paths in orange and high quality glide paths that are outliers (1.5 times above upper bound quartile) in red

The top three departure tree species were *Samanea saman*, *Ficus variegata* and *Khaya grandifoliola* (number of feasible glide paths from species = 501, 256 and 205, respectively). Of the top 10 departure trees, eight were located within the study area (Figure 3.2), with the top three being T0653 (*Falcataria falcata*), T0890 (*Syzygium grande*) and C108 (*Falcataria falcata*) (number of feasible glide paths from tree = 42, 38 and 37, respectively).

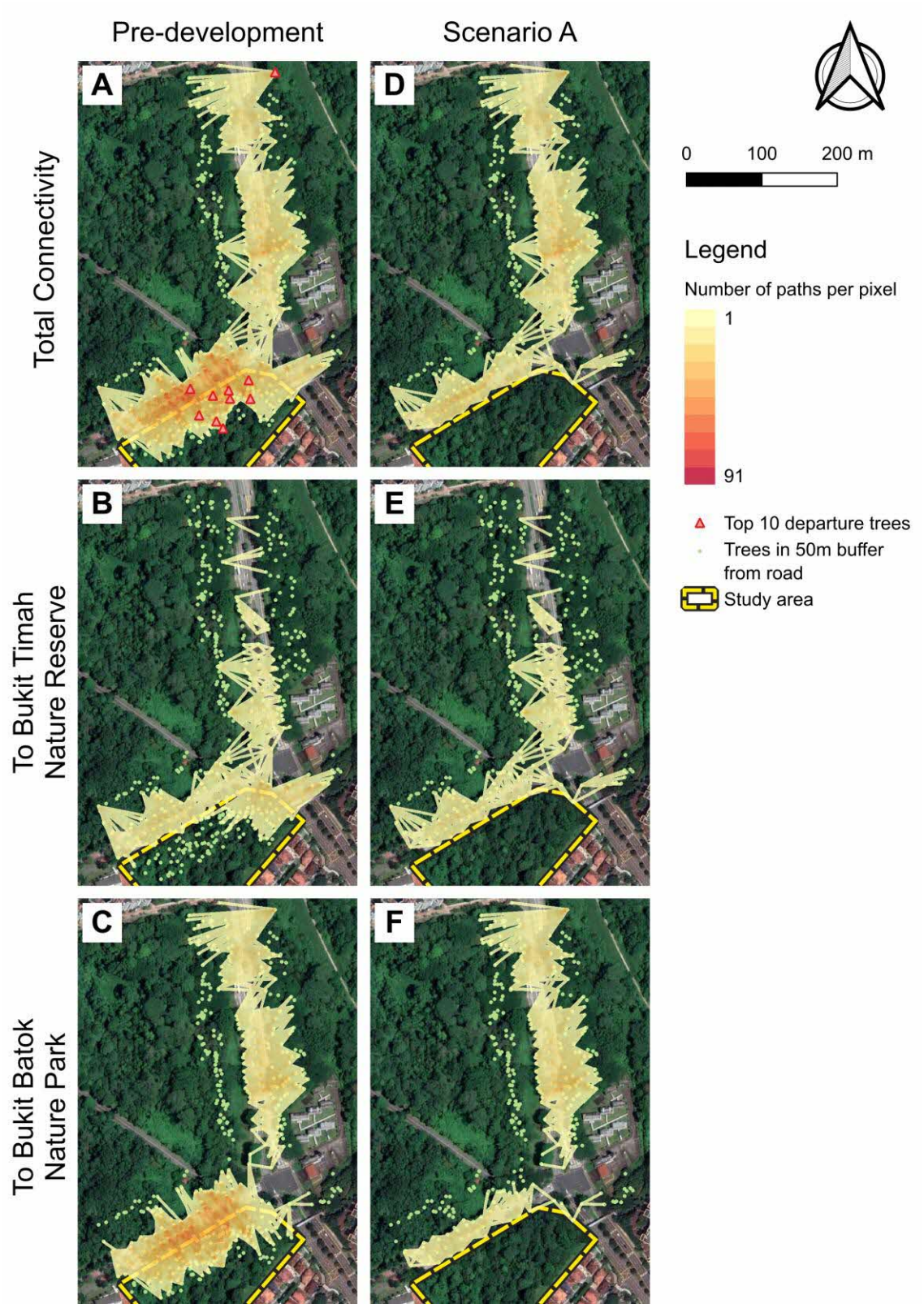


Figure 3.2 Heatmap of connectivity present for the Malayan colugo (*Galeopterus variegatus*) between the study area, Bukit Timah Nature Reserve and Bukit Batok Nature Park. **A-C**: Pre-development; **D-F**: Post-development (assuming study area is fully cleared); **A & D**: Total connectivity; **B & E**: Unidirectional connectivity towards Bukit Timah Nature Reserve; **C & F**: Unidirectional connectivity towards Bukit Batok Nature Park

Should the study area be fully developed with no retained trees (Scenario A), the number of feasible glide paths decreases by 53.1% from 2352 to 1104 (Table 3.1). From Figure 3.1 and Figure 3.2, there is both a higher quality and density of feasible glide paths involving trees in the study area, especially across Old Jurong Road. Furthermore, towards Bukit Timah Nature Reserve, the crossing between trees in the study area and those beside Old Jurong Fire Station appear to be significant, considering the relative paucity of feasible glide paths across Upper Bukit Timah Road (Figure 3.2). This suggests the importance of the study area in maintaining connectivity between Bukit Timah Nature Reserve and Bukit Batok Nature Park for the Malayan colugo.

This result can be attributed to a combination of factors. First, Upper Bukit Timah Road is a major six-lane road while Old Jurong Road is a narrower four-lane road. This increases the horizontal glide distance required by colugos to cross the road, reducing the number of feasible glide paths. Second, while both roads feature trees planted on the centre divider, the trees on Upper Bukit Timah Road are shorter *Peltophorum pterocarpum* trees (height = 9.8 – 17.6m, mean = 12.7m), as opposed to the taller *Hopea odorata* trees (height = 18.0 – 25.6 m, mean = 20.6 m) on Old Jurong Road. Indeed, the trees on the centre divider on Old Jurong Road are hotspots of feasible glide paths, evidenced by the high density of glide paths on the trees (Figure 3.2). Third, the relatively higher elevation of the study area allowed for a greater number of feasible departures from trees in the study area to those in the surrounding areas.

Should trees in the study area be retained as part of the PRA scenario, the loss of feasible glide paths is greatly reduced, with a decrease by 4.2% from 2352 to 2253 for Scenario B compared to pre-development (Table 3.1 and Figure 3.3). Under Scenario B, no colugo poles are required as the impact on existing glide paths is minimal.

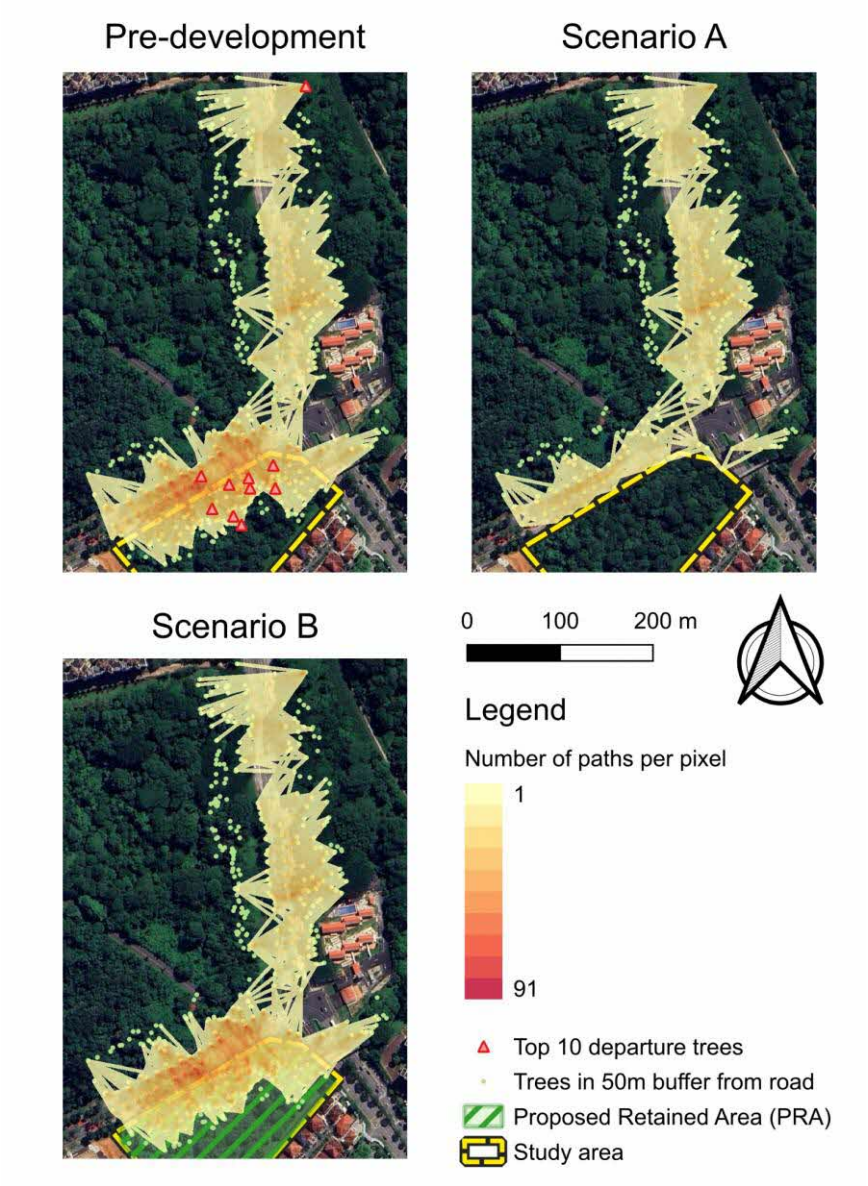


Figure 3.3 Comparison of total connectivity between development scenarios

While the above study only depicts potential glide paths and not actual observed glide paths, colugos were observed on trees on the centre divider along Old Jurong Road and within the site during surveys. Given that colugos often glide to the same spot on the same trees nightly (Nowak, 1999, as cited in Dzulhelmi & Abdullah, 2009), retaining their preferred trees via the PRA scenario would be beneficial in maintaining connectivity for gliding mammals.

REFERENCES

Byrnes, G., Libby, T., Lim, N. T., & Spence, A. J. (2011). Gliding saves time but not energy in Malayan colugos. *The Journal of Experimental Biology, 214*, 2690-2696.

Dzulhelmi, M. N., & Abdullah, M. T. (2009). An ethogram construction for the Malayan Flying Lemur (Galeopterus variegatus) in Bako National Park, Sarawak, Malaysia. *Journal of Tropical Biology and Conservation, 5*, 31-42.

Lee, R. S., Mendes, C. P., Liang, S. S., Yang, V. W., Eng, D. K., Ong, W. B., . . . Lim, N. T. (2023). Bridging the gap: Optimising connectivity solutions for an arboreal gliding mammal. *Journal of Applied Ecology, 60*, 778-789.

National Parks Board. (7 January, 2022). *Iomys horsfieldii (Waterhouse, 1838)*. Retrieved from Flora & Fauna Web: https://www.nparks.gov.sg/florafaunaweb/fauna/2/3/236

National Parks Board. (29 Jaunary, 2024). *Galeopterus variegatus*. Retrieved from Flora & Fauna Web: https://www.nparks.gov.sg/florafaunaweb/fauna/4/7/478

Nowak, R. M. (1999). *Mammals of the World* (6th ed.). Baltimore: John Hopkins University Press.

APPENDIX I

Wildlife Incident Form

WILDLIFE INCIDENT FORM

Part A – Wildlife Incident Details

The CEMMP In-charge is to complete the Form and submit to PM within 24 hours of reporting incident.

Reference No. (by CEMMP In-charge)			
Personnel	**Reporting Person**	**Witness**	
Name:			
Contact Number:			
Title / Company:			
Time / Date of Wildlife Encounter	**Date**	**Time**	
Affected Area			
Weather:	☐ Clear	☐ Overcast	☐ Thunderstorm
	☐ Sunny	☐ Others (To Describe):	
Actual Location:			
Description of Area:	☐ Vegetated area	☐ Non-vegetated area	
	☐ Excavated area	☐ Others (to describe):	
Activities Carried Out Nearby at Time of Incident:	If there are no active works near wildlife encountered, please state so.		

Details of Animal			
Animal:	Where identifiable, please provide [Common Name (Scientific Name)] If animal cannot be identified, carcass to be described to the best of ability.		
Animal Condition:	☐ Active	☐ Outwardly injured (e.g. bleeding, limping)	☐ Flattened
	☐ Stationary	☐ Decomposed	☐ Trapped
	☐ Others (to describe):		
Photographs:	1) Close-up of Animal ☐ No Close-up available Please provide reason here if close-up photographs could not be obtained, e.g. unsafe to approach		
	2) Animal with surroundings or showing full width of road (if roadkill), indicating where the animal is.		
	☐ No photographs available. Reason: e.g. animal moved away too quickly		

Incident Details	
Incident Summary: To be filled by reporting party	Briefly describe when, what, who, where and how the incident happened. *Sample incident summary:* *[Personnel] was conducting [activity] on [date/time] when he observed an [animal] at [location]. The animal was observed to be [condition]. [Personnel] reported the incident to [contractor representative] who contacted the WMO. While awaiting wildlife response, [contractor] barricaded the area and continued monitoring for movement of animal.* If EMMP Specialist (Fauna) visited site: Recommended actions
Follow-up Actions: To be filled by CEMMP In-charge	☐ Animal rescued to NParks Shelter ☐ Immediate relocation ☐ Carcass transported to disposal location ☐ Others:_____
	☐ No Action Taken by CEMMP In-charge

Part B – Closure of Incident

Possible Causes What is/are the possible cause/s of the incident? (Man / Machine / Management / Medium / Mission)		
Preventive/Corrective Actions To be filled by CEMMP In-charge	**Close-up** To be filled by reporting party	
1)	Close-up Action.	Close-up Date
2)		Close-up Date
Closure of Incident Report		
Date of Closure of Incident Report:		
Acknowledged by PM (Name/Title):		