Specialist Consultancy Services for Environmental Impact Assessment (EIA) at Gillman Barracks

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Final EIA Report
8 July 2026

Specialist Consultancy Services for Environmental Impact Assessment (EIA) at Gillman Barracks

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Acronyms and Abbreviations

APHA	American Public Health Association
ALARP	As Low As Reasonably Practicable
AMWQC	ASEAN Marine Water Quality Management Guidelines
ARI	Average Recurrence Interval
BCA	Building and Construction Authority
BIA	Biodiversity Impact Assessment
BMP	Best management practice
BOD	Biological Oxygen Demand
BS	British Standards
C&D	Construction and demolition
CEMMP	Contract-Specific Environmental Management and Monitoring Plan
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
COD	Chemical Oxygen Demand
COP	Code of Practice
COPSWD	Code of Practice on Surface Water Drainage
dB	decibels
DEM	Digital Elevation Model
DGPS	Differential Global Positioning System
DIV	Dutch Intervention Values
DO	Dissolved Oxygen
ECB	Erosion control blanket
EDB	Economic Development Board
ECM	Earth Control Measures
ECO	Environmental Control Officer
EIA	Environmental Impact Assessment
EIS	Environmental Impact Study
EMMP	Environmental Management and Monitoring Plan
EOS	Earth Observing System
EPHA	Environmental Public Health Act

EPMA	Environmental Protection and Management Act
EPRP	Emergency Preparedness and Response Plan
ESA	Environmental Site Assessment
ESRI	Environmental Systems Research Institute
F&B	Food and beverage
GHS	Globally Harmonised System
GIS	Geographic Information System
GPS	Global Positioning System
ha	Hectare
HDB	Housing and Development Board
HK EPD	Hong Kong Environmental Protection Department
INLIS	Integrated Land Information Service
ISA	International Society of Arboriculture
IUCN	International Union for Conservation of Nature
JTC	Jurong Town Corporation
LTA	Land Transport Authority
MOM	Minutes of meeting
MSS	Meteorological Service Singapore
MUSLE	Modified Universal Soil Loss Equation
NAC	National Arts Council
NEA	National Environment Agency
NG	Nature Group
NHB	National Heritage Board
NMP	Noise management plan
NParks	National Parks Board
NRCS	Natural Resources Conservation Service
NSR	Noise Sensitive Receiver
NTU	Nanyang Technological University
NUS	National University of Singapore
PH	Public Holiday
PME	Power mechanical equipment

PNCB	Permanent Noise Control Barriers
PRO	Public Relation Officer
PSA	Port of Singapore Authority
PUB	Public Utilities Board
QECP	Qualified Erosion Control Professional
QGIS	Quantum Geographic Information System
QP	Qualified Person
Qpre	Pre-development peak flows
Qpost	Post-development peak flows
RFI	Request for Information
RFQ	Request for Quotation
RIAM	Rapid Impact Assessment Matrix
SAC-SINGLAS	Singapore Laboratory Accreditation Scheme
SDA	Sewerage and Drainage Act
SDS	Safety Data Sheets
SGBA	Singapore Biodiversity Accounting Tool
SHD	Singapore Height Datum
SI	Soil Investigation
SIDS	Silty Imagery Detection System
SING	Singapore Botanic Gardens' Herbarium
SLA	Singapore Land Authority
SO	Superintending Officer
SRDB	Singapore Red Data Book
SWL	Sound power level
TBHP	Telok Blangah Hill Park
TDS	Total Dissolved Solids
TIW	Toxic Industrial Waste
TN	Total Nitrogen
TNCB	Temporary Noise Control Barriers
TOC	Total Organic Carbon
TOP	Temporary Occupation Permit

TP	Total Phosphorous
TPZ	Tree Protection Zone
TSS	Total Suspended Solids
URA	Urban Redevelopment Authority
USDA	United States Department of Agriculture
US EPA	United States Environmental Protection Agency
USLE	Universal Soil Loss Equation

1. Introduction

1.1 Overview

The "Specialist Consultancy Services for Environmental Impact Assessment (EIA) at Gillman Barracks hereinafter referred to as "the EIA Study", was awarded to Jacobs (operating under the contracting entity of CH2M Hill Singapore Pte Ltd), commissioned by the National Parks Board (NParks) on behalf of Housing and Development Board (HDB) on 26 July 2024. The EIA Study would give clarity to future developer(s)/ developing agencies on what needs to be considered during detailed planning and refinement of the development plans for Gillman Barracks (hereafter referred to as the "proposed development").

1.2 EIA Requirement for the Proposed Development

The Gillman Barracks area is currently occupied by various interim uses, such as office spaces, creative lifestyle uses, art galleries, food and beverage (F&B) uses, Nanyang Technological University (NTU) Centre for Contemporary Art Singapore, private residential homes, Academy of Singapore Teachers, as well as a school. The area is also in close proximity to several nature areas such as the Southern Ridges, Labrador Nature Reserve, and Berlayar Creek. Given the ecological significance of the area, an EIA is required to assess the ecological value of the area and guide the proposed development to mitigate potential environmental impacts.

The purpose of the EIA is to assess potential impacts from the proposed development on existing environmental receptors that are sensitive to biodiversity, water quality, topography and hydrological changes. The EIA is intended to be conducted in the least environmentally intrusive manner, with information gathered contributing to decision making on:

- The overall acceptability of any environmental impacts likely to arise from the proposed development.
- The conditions and requirements necessary to mitigate environmental impacts during proposed development, whenever practicable.
- The acceptability of residual environmental impacts after implementing recommended mitigation measures.

The findings of the EIA will guide agencies to sensitively plan for future uses at Gillman Barracks, in consideration of environmental sensitivity and maintain ecological connectivity between Gillman Barracks and other vegetated areas in the vicinity.

1.2.1 EIA Objectives for the Proposed Development

The objectives of the EIA are outlined below. The content of this draft EIA Report is organised in alignment with these objectives.

a) Identify and describe the elements of the community and environment likely to be affected by the proposed development and/or likely to cause impacts to the proposed development, including both natural and man-made environments, as well as associated environmental constraints.

b) Describe the baseline conditions of EIA Study Area and its environmental constraints.

c) Identify, quantify, and assess potential impacts and determine their significance on sensitive receptors.

d) Propose and justify effective mitigation measures (if any) to minimise environmental impacts (i.e., pollution, disturbance and nuisance) during pre-construction, construction and post-construction/ operational phase of the proposed development.

e) Identify, predict, and evaluate the residual environmental impacts (i.e., after practicable mitigation) and cumulative effects expected to arise during proposed development in relation to the sensitive receptors and potential affected uses.

f) Specify methods, measures and standards, to be incorporated during proposed development to mitigate residual environmental impacts and cumulative effects, reducing them to minimal levels.

g) Investigate the extent of the secondary environmental impacts that may result from the recommended mitigation measures and identify any constraints or necessary modifications associated with these.

h) Propose an Environmental Management and Monitoring Plan (EMMP) to document specific monitoring and environmental impact management procedures for the proposed development.

1.2.2 EIA Study Area Definition

The EIA Study Area, according to the endorsed Inception Report, encompasses approximately 47 ha with the boundary outlined in **Figure 1-1**.

Given that the indicative boundary of future development area lies at the edge of the EIA Study Area, a 150 m buffer offset from the EIA Study Area is proposed for noise assessment purposes. This approach aligns with local regulation set by National Environment Agency (NEA), specifically the Environmental Protection and Management (Control of Noise at Construction Sites) Regulations and international guidelines, such as the Technical Memorandum Annex 13: Guidelines for Noise Assessment published by Hong Kong Environmental Protection Department (HK EPD), for determining noise sensitive area.

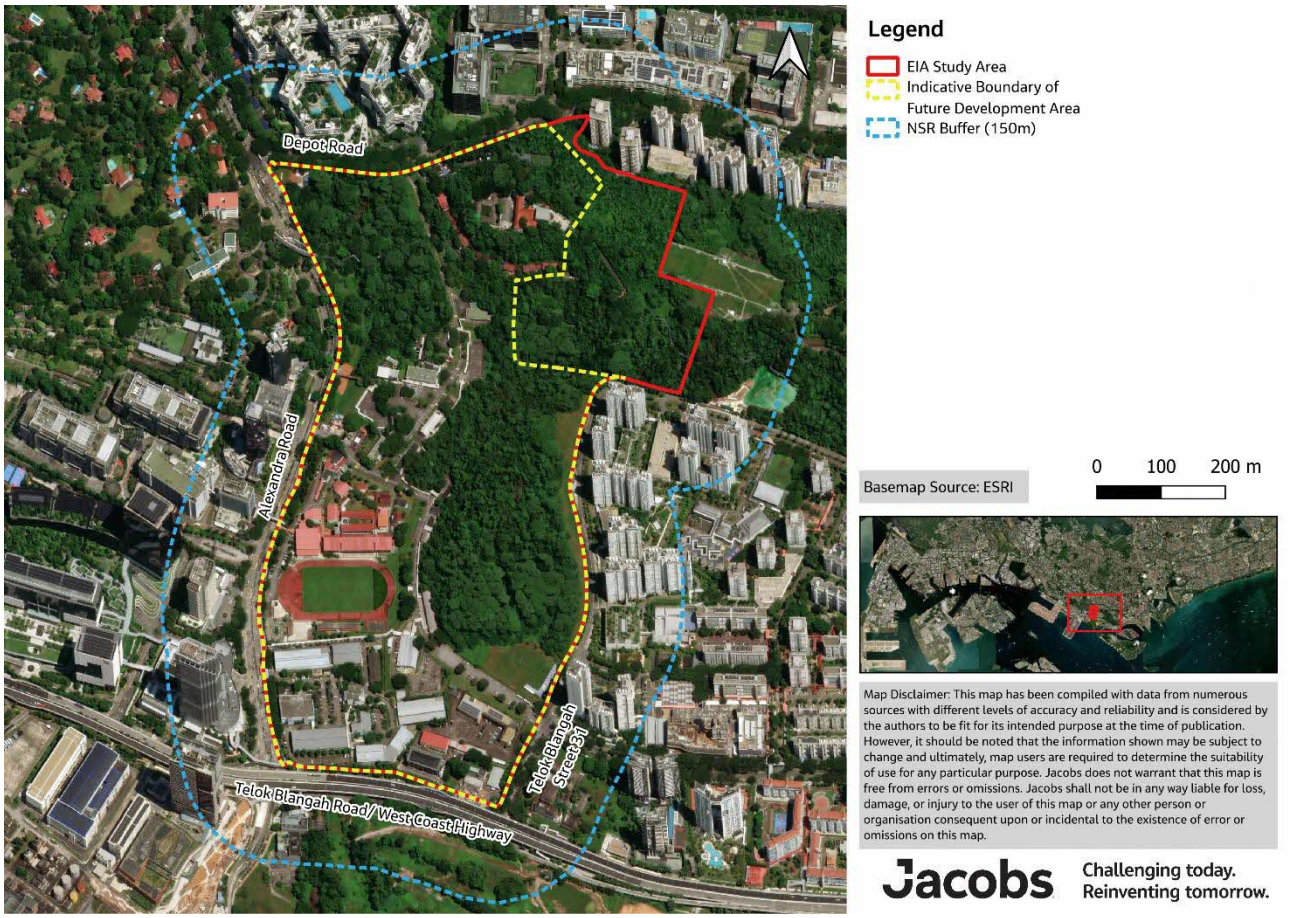


Figure 1-1: EIA Study Area

1.2.3 Applicable Environmental Legislation

The EIA has adopted and referred to applicable standards and references that are relevant to the proposed development, the establishment of baseline conditions, impact assessment, and mitigation measures recommendations, as follows:

- Singapore's laws, acts, rules, and regulations as well as relevant Codes of Practices (COPs) and Guidelines as listed in **Appendix 1A**.
- International ordinances and standards – Hong Kong Environmental Protection Department Technical Memorandum on EIA Process, British Standards (BS) COP for noise and vibration control on construction and open sites – Part 1: Noise.
- Guidance documents – COPs.

1.2.4 Limitation and Disclaimer

In preparing this Report, we have utilised information related to the proposed development provided by the developing agencies and third parties. The findings and conclusions presented herein are compiled on a best-effort basis and are based on the data and information available at the time of writing.

The assessment reflects an approximation of the environmental conditions within the EIA Study Area at the time of reporting, based on available literature, expert observations, and professional judgement. Baseline information obtained from public domain may be limited, as environmental data are generally not publicly accessible or obtainable within a reasonable timeframe. Consequently, the EIA Study relies on information readily available during the allocated EIA Study period.

It is important to note that fauna surveys may not have recorded all species present within the EIA Study Area due to factors such as the limited study duration, species activity patterns, weather conditions, seasonal variations, and other environmental considerations. To address these limitations, species identified through literature reviews were also considered in the baseline and impact assessment. Surveys were conducted by experienced field biologists with extensive knowledge of local fauna.

For tree and flora survey, despite the sub-meter location accuracy of Differential Global Positioning System (DGPS), slight deviations may occur when overlaying tree locations onto the provided topographical plans. In cases where trees are clustered closely together, their positions were mapped relative to a pre-determined quadrat or transect.

This Report has been prepared for the sole use of HDB, Urban Redevelopment Authority (URA) and NParks. It is not intended for distribution, disclosure, or reliance by any third party without prior written consent, which may be granted or withheld at our discretion.

2. Project Description

2.1 Project Location

The "proposed development" refers to the proposed residential developments with supporting facilities at Gillman Barracks. The proposed development area is bounded by Depot Road, Alexandra Road, Telok Blangah Road/ West Coast Highway and Telok Blangah Street 31. The estimated future development area is about 40 ha with its indicative boundary shown in **Figure 2-1**. Telok Blangah Hill Park (TBHP) is outside of this indicative development planning and will not be affected by the proposed development works.

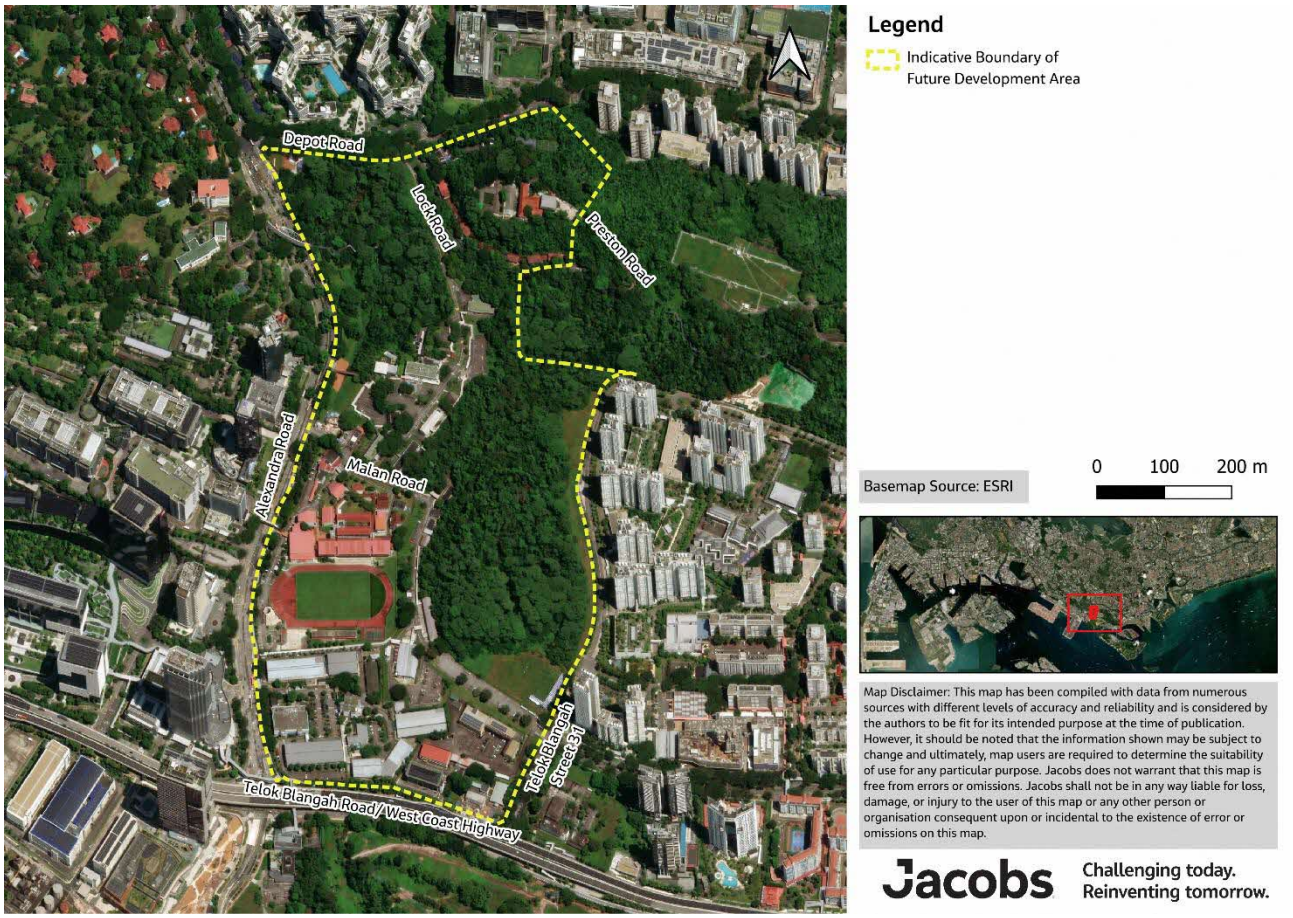
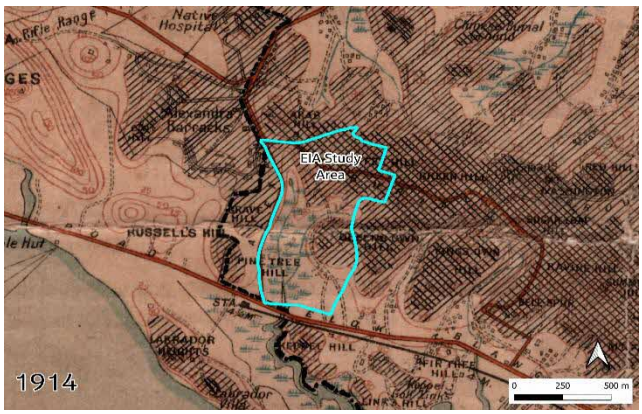


Figure 2-1: Indicative Boundary of Future Development Area

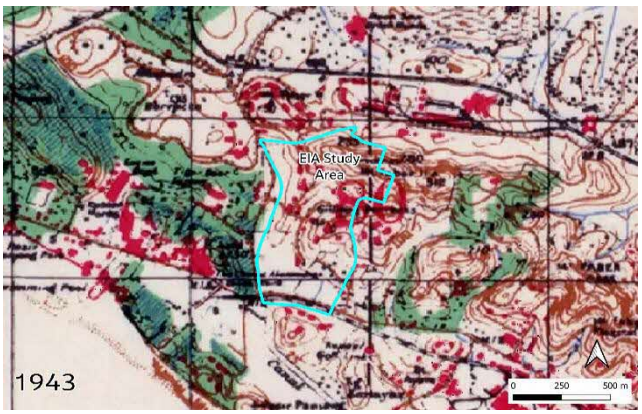
2.2 Land Use

2.2.1 Historical Land Use

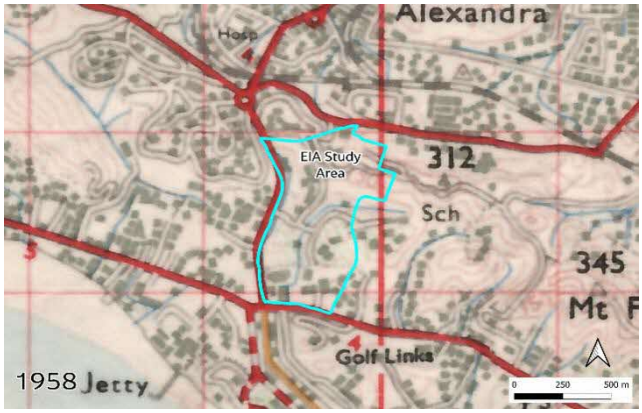
The EIA Study Area has undergone significant changes, evolving from a military zone to a creative lifestyle and arts enclave. Prior to the 1930s, the land primarily consisted of low-lying swampy grounds, agricultural plantations and was also home to Chinese villages (**Figure 2-2**) (Chew, 2017). Gillman Barracks was established as a barracks for the British Army to expand the British infantry in Singapore, early photos of Gillman Barracks are shown in **Picture 2-1** sourced from the National Archives Singapore. In 1971, the ownership of Gillman Barracks was transferred to the Singapore government and was used by the Singapore Armed Forces as an army training camp. The site remained in institutional use until the 1990s, after which it was gradually redeveloped and repurposed for commercial, residential and educational functions.



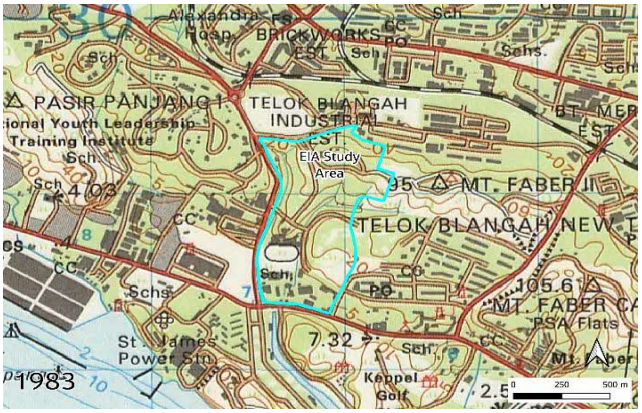
(a) 1914 Historical Map



(b) 1943 Historical Map



(c) 1958 Historical Map



(d) 1983 Historical Map

Figure 2-2: Historical Maps for Gillman Barracks during 1914, 1943, 1958 and 1983 (National Archives Singapore, n.d.-a)

Picture 2-1: Gillman Barracks, Singapore (Photograph by Wright in1937)

Note: View from Lock Road Towards Malan Road and The Hill at Telok Blangah. The Two Buildings at The Foot of The Hill Are Block 37 (Left) and Block 38 (Right). Middlesex Regiment Badge is Halfway Up the Hill.

Source: National Archives Singapore, n.d.-b

2.2.2 Current Land Use

The EIA Study Area is characterised by a mix of interim residential, commercial, creative lifestyle, educational uses and forested areas forming part of the Southern Ridges. With reference to **Figure 2-1**, in the northern region, the area west of Lock Road is forested, while to the east of Lock Road, there is the ISS International School and several interim residential dwellings. The mid-region of the EIA Study Area, flanking Lock Road and Malan Road, comprises interim uses at former Gillman Barracks which features event spaces, exhibitions, art galleries, and dining establishments, serving as a hub for entertainment and culture. To the west of Malan Road is the Academy of Singapore Teachers, while the east of Malan Road is largely forested. In the southern region, the area consists of buildings that house a variety of commercial businesses and dining establishments as well as other utility structures.

2.2.3 Future Land Use

Based on the URA Master Plan 2025 shown in **Figure 2-3**, the EIA Study Area is intended to be used mainly for residential (subject to detailed planning), park and utility uses. This follows the announcement over the Committee of Supply (COS) debate in 2024 to reflect agencies' planning intention to study the redevelopment of Gillman Barracks area for housing with supporting amenities and public spaces, to meet the growing demand for housing closer to the city centre.

It is noted that, at the time of writing, no detailed development plan has been made available. Currently the development planning will not affect the Telok Blangah Hill Park (TBHP) boundary. The aim of the future development is to focus on environmental sustainability, with appropriate monitoring and management measures in place to minimise potential environmental impacts and ensure long-term ecological resilience of the area.

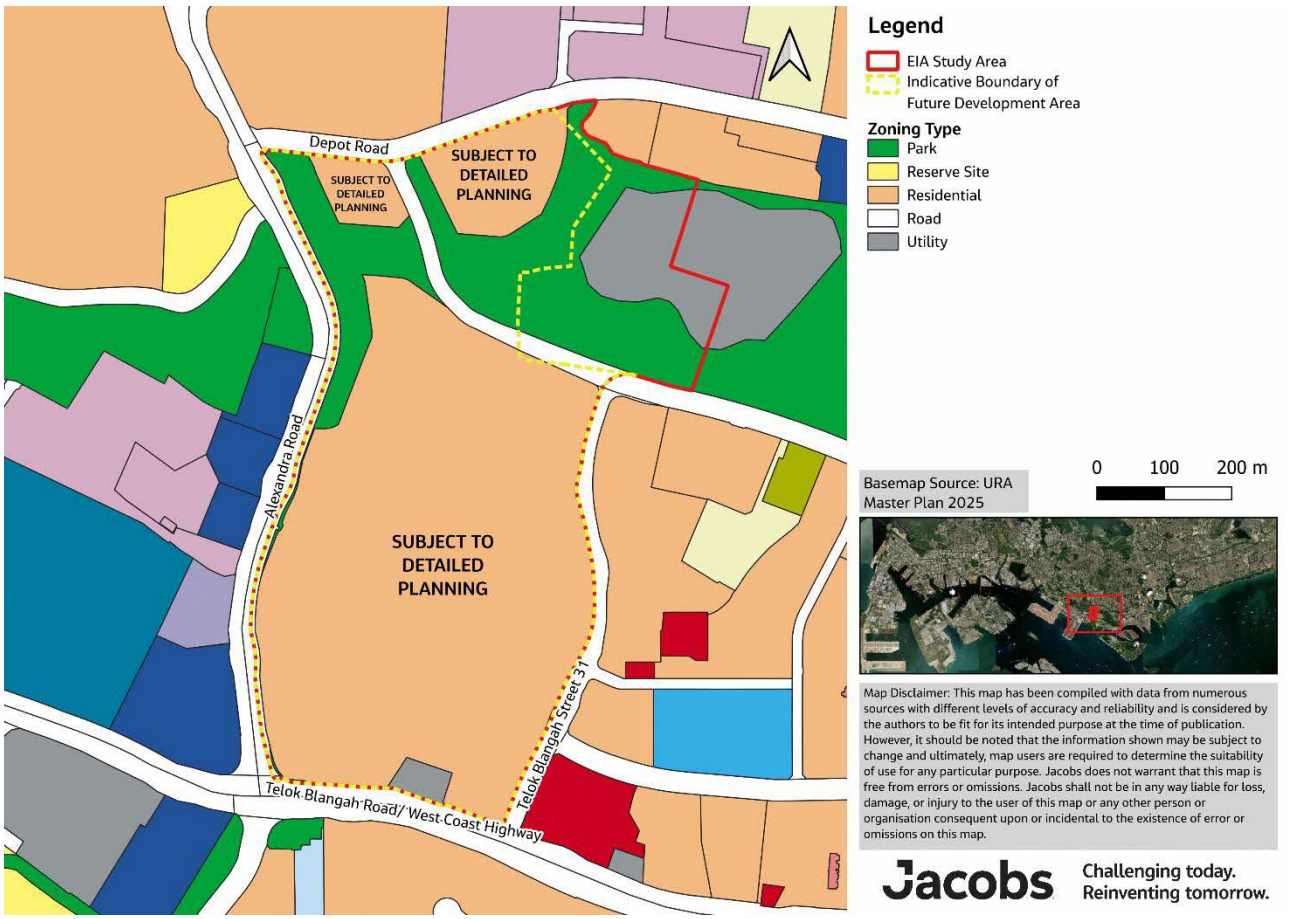


Figure 2-3: URA Master Plan 2025

2.3 Environmentally Sensitive Receptors

Environmentally sensitive receptors within the EIA Study Area include a range of areas and entities that may be affected by environmental changes or disturbances. These receptors are typically characterised by a mix of residential, recreational and institutional spaces, reflecting the area's diverse urban fabric.

2.3.1 Overview of Ecology and Biodiversity Environment

Some of the green areas surrounding the EIA Study Area are categorised as secondary regrowth forests. Despite being degraded and disturbed from its natural state, secondary forests still play a vital role in providing refuge and resource pools to local biodiversity (Neo et al., 2013). Local secondary forests have been recorded to support the populations of birds, butterflies and frogs (Neo et al., 2013).

The EIA Study Area is partially located within the Southern Ridges, which is a 10-km stretch of green area connecting multiple parks and nature areas including HortPark, Mount Faber Park, Telok Blangah Hill Park, Kent Ridge Park, and Labrador Nature Reserve. These parks serve as ecological connection for many species including birds, bats, and butterflies (Lim et al., 2020; Jain et al., 2017) and are sensitive ecological receptors (**Figure 2-4**).

Figure 2-4: Ecologically Sensitive Receptors within the EIA Study Area and Its Vicinity

Studies in nature parks in the area have recorded species of dragonflies and orthoptera (i.e., grasshoppers and crickets) (Ngiam & Davison, 2011). Though these nature parks are small and urbanised, rediscovered species and threatened species have been recorded, highlighting the important role of secondary forests in the conservation of odonates and orthoptera in Singapore. For example, species such as the Vulnerable emerald (*Hemicordulia tenera*) were mainly found at the Southern Ridges (Cheong, 2011). Additionally, the Southern Ridges is suggested to be an important habitat for the rare and vulnerable butterfly species – silver royal

(*Ancema blanka blanka*) and golden royal (*Pseudotajuria donatana donatana*) (Kong & Lim, 2022). Birds of conservation significance are also known to use the habitats provided by the Southern Ridges, including observations of the endangered straw-headed bulbul (*Pycnonotus zeylanicus*) (NParks, n.d.).

The green areas surrounding Gillman Barracks are also home to a rich diversity of flora species. For example, the endangered creeper *Geophila repens* was found at Mount Faber Park and Kent Ridge (Ooi, 2014; Chua, 2018). Telok Blangah Hill Park is also home to a living gallery of giant tree species threatened in the region, with more than 600 trees and 55 species planted (NParks, n.d.).

2.3.2 Overview of Human Environments within the EIA Study Area

Located along the Southern Ridges, the EIA Study Area is nestled within a lush, green environment with Telok Blangah Hill Park to the north, and Berlayar Creek and Labrador Nature Reserve to the south. To the east and further north, there are existing residential neighbourhoods, comprising high-rise public housing developments and condominiums. Within the EIA Study Area, there are also interim residential dwellings located along Preston Road. To the southwest, Berlayar is currently being developed as a residential neighbourhood. The area and its surroundings are dotted with educational institutions such as ISS International School, SP Jain School of Global Management, and Academy of Singapore Teachers, as well as several commercial hubs, including Alexandra Retail Centre and nearby offices (**Figure 2-5**).

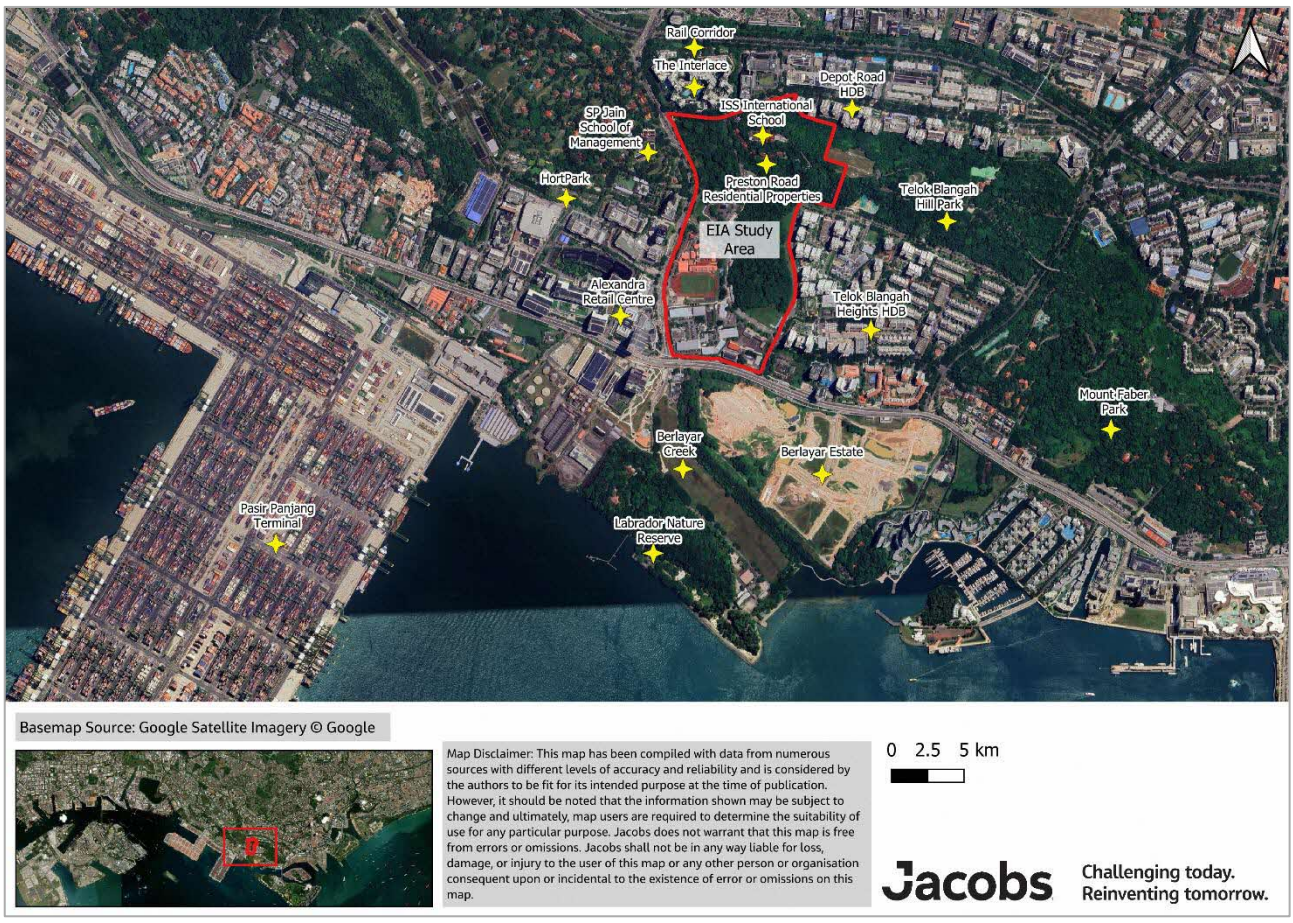


Figure 2-5: Human-sensitive Receptors within the EIA Study Area and Its Vicinity

2.4 Proposed Development Works

The major activities for the proposed development involve:

- Demolition works.
- Site investigation works (e.g. cable detection, soil investigation, trial trench).
- Site clearance (removal of existing trees and vegetation).
- Earthworks cutting/ filling within site to achieve desirable platform levels required for the proposed residential development from the drainage and sewerage catchment perspectives.
- Slope formation and construction of earth retaining structure (if necessary), to retain high grounds and achieve a stable slope profile.
- Infrastructure works including road, drainage, sewerage and commuter facilities.
- Building works including construction of new foundation, utilities/ services laying, and superstructure construction.

Key activities in various development stages of the proposed development and its correspondence potential source of impact are indicated in **Table 2-1**.

Table 2-1: Key Project Activities and Potential Sources of Impact for Various Development Stages

Stage	Key Project Activities	Potential Sources of Impact
Pre-construction	• Demolition works • Site investigation works (e.g. cable detection, soil investigation, trial trench) • Site clearance (removal of existing trees and vegetation) • Perimeter hoarding installation • Mitigation measures erection (i.e., Earth Control Measures (ECM) plant, wash trough, noise barrier, etc.)	• Operation of machineries/ equipment/ tools • Construction and demolition (C&D) waste • Noise nuisances from equipment/ tools/ machinery • Sediment-laden site runoff • Pollutive substances
Construction	• Earthworks cutting/ filling within site to achieve desirable platform levels • Slope formation and construction of earth retaining structure, if necessary, to retain high grounds and achieve a stable slope • Infrastructure works including road, drainage, sewerage and commuter facilities • Building works including construction of new foundation, utilities/services laying and superstructure construction	• Terrain changes • Operation of machineries/ equipment/ tools • C&D waste • Noise nuisances from equipment/ tools/ machinery • Sediment-laden site runoff • Pollutive substances
Post-construction (Future Land Use)	• Occupation of the residents	• Human activities • Lights • General waste

2.5 Concurrent Developments

Desktop studies were conducted to identify concurrent developments within the 2-km radius of the EIA Study Area. **Figure 2-6** shows the indicative location and **Table 2-2** details the identified concurrent developments with respect to the EIA Study Area.

Table 2-2: Concurrent Developments within the 2-km Radius of the EIA Study Area

Development Name	Land Use	Type of Development	Estimated TOP
Alexandra Peaks	Residential	Public	2029
Bukit Merah Ridge		Public	2028
Berlayar Estate		Public and Private	Unavailable
Queen's Arc		Public	2027
Queensway Canopy		Public	2028
Stirling Horizon		Public	2030
Telok Blangah Beacon		Public	2027
Terra Hill		Private	2028
Queenstown ActiveSG Stadium	Sports and Recreation	Sports	Unavailable

Source: ActiveSG, 2025; AECOM, 2022; HDB, 2021; HDB, 2022a; HDB, 2022b; HDB, 2023a; HDB, 2023b; HDB, 2025; SRX, 2025; Terra Hill, 2018.

*Note: *TOP - Temporary Occupation Permit (TOP)*

The construction phase of future developments within the EIA Study Area may experience cumulative impacts from works at the Berlayar estate due to their close proximity. Berlayar is currently being redeveloped for housing, where the first residential parcel was launched in 2025.

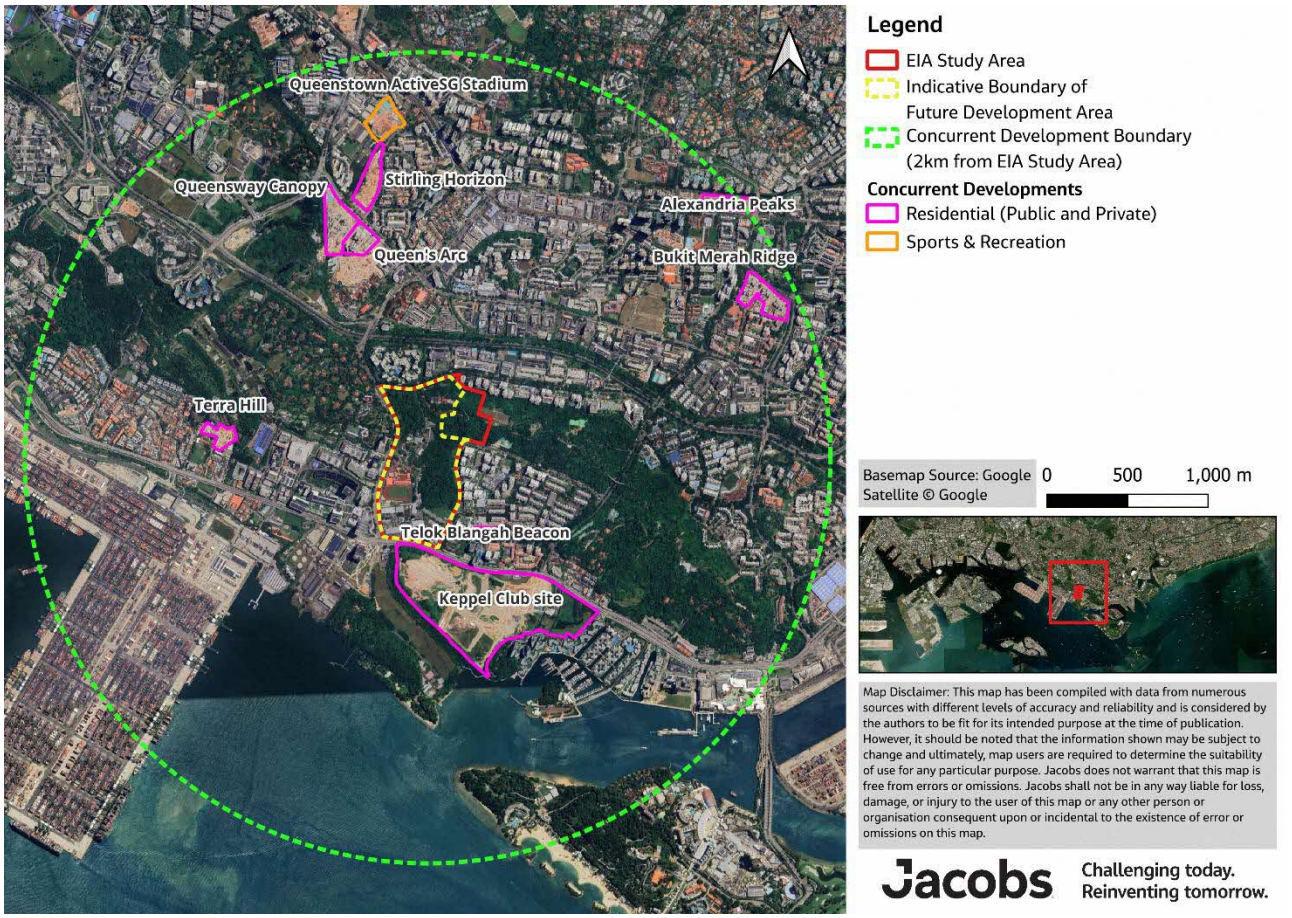


Figure 2-6: Concurrent Development in the Vicinity of EIA Study Area

Note: Concurrent boundary source: URA Master Plan 2025

2.6 Project Implementation Schedule

The physical site works of the proposed development are expected to be conducted in sequence or concurrently over a period of 10 to 15 years (subject to review).

3. Approach and Methodology

3.1 Overall EIA Approach

The approach and methodology (**Figure 3-1**) adopted for this EIA include evaluating the existing pre-construction baseline environmental conditions within the EIA Study Area, followed by an objective assessment of potential environmental impacts arising from both pre-construction and post-construction/ operation activities of the proposed development. The assessment also considers related activities by various agencies that may take place concurrently in the vicinity. All components of the assessment are conducted in compliance with the relevant legislation, regulations and guidelines. Based on these findings, appropriate mitigation measures are recommended to minimise adverse environmental impacts during both the construction and post-construction/ operation phases.

A preliminary Environmental Management and Monitoring Plan (EMMP) will also be prepared as part of the EIA to outline the management framework, monitoring requirements, and indicative actions needed to address potential environmental issues of concern. This EIA-stage EMMP provides an initial structure to allow the recommended mitigation measures to be effectively implemented and monitored and will be further detailed and refined during subsequent project stages as design and construction plans are confirmed.

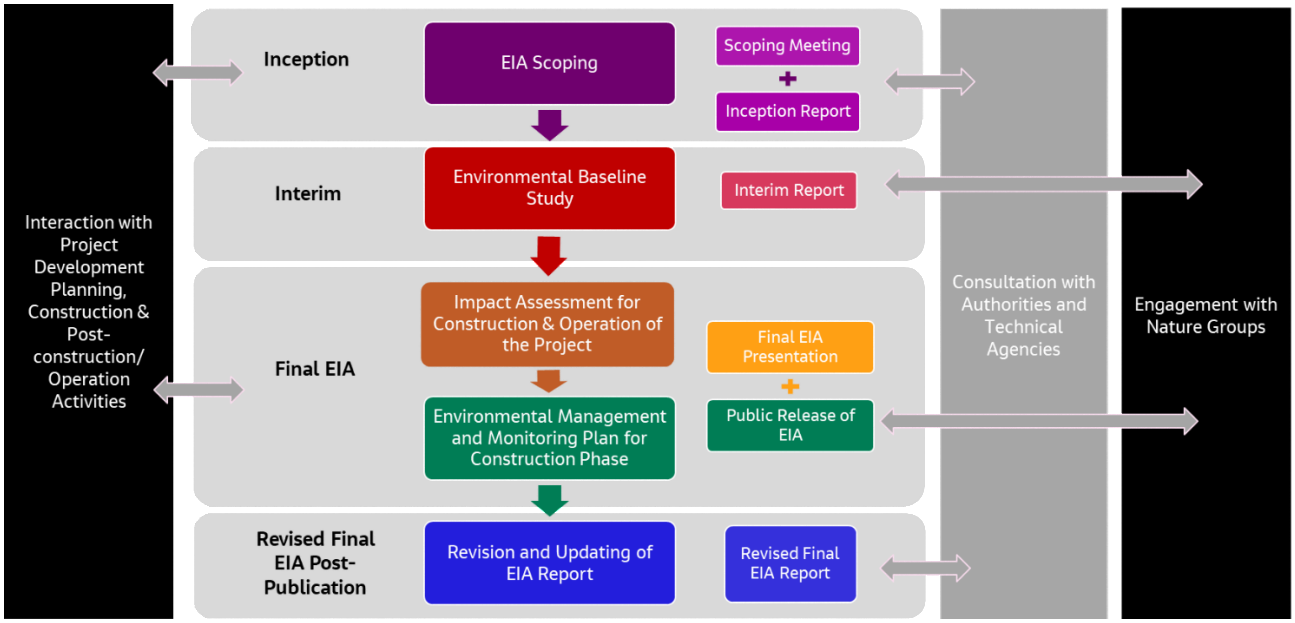


Figure 3-1: EIA Approach

3.2 Environmental Baseline Study

The environmental baseline study aims to establish the existing pre-construction environmental conditions at the EIA Study Area before occurrence of any construction activities and provide a benchmark against which the potential impact of the proposed development can be assessed to determine its significance.

As endorsed in the EIA Inception Report, the various environmental baseline aspects to be studied, including the Noise Sensitive Receivers (NSR) buffer, as per the endorsed EIA Inception Report, are detailed in **Table 3-1**.

Table 3-1: Mode of Baseline Data Collection within the EIA Study Area and NSR Buffer

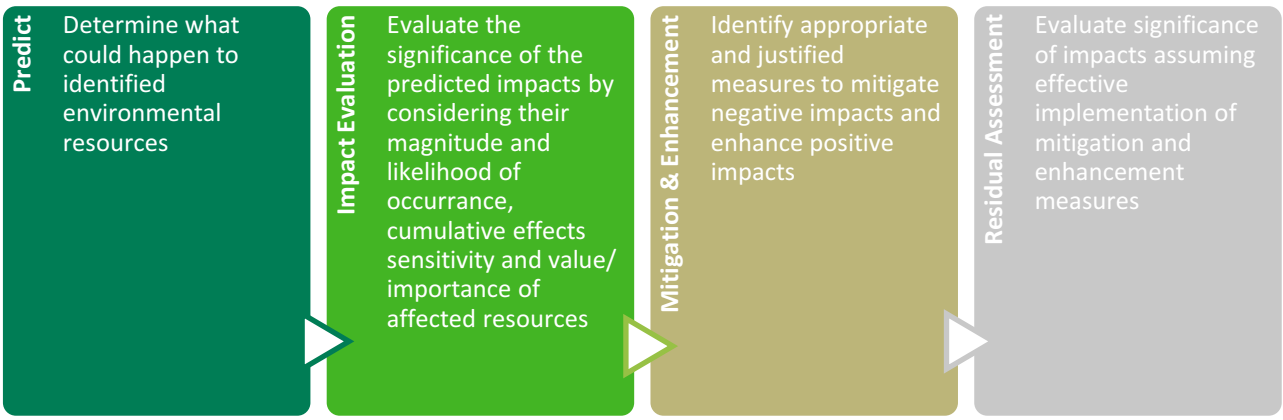
Type of Environment	Environmental Aspect	Mode of Data Collection
Biological	Habitat	Primary (Field survey) and Secondary (Desktop)
	Trees	
	Flora and vegetation	
	Fauna	
Physical	Topography	Primary (Field survey) and Secondary (Desktop)
	Hydrology	Primary (Field survey) and Secondary (Desktop)
	Groundwater	Secondary (Desktop)
	Surface water quality	Primary (Field survey) and Secondary (Desktop)
Human	Ambient Noise	Primary (Field survey) and Secondary (Desktop)

The current conditions of the identified environmental aspects/ resources/ receptors listed above were documented via a combination of a desktop study reviewing existing available information (secondary information) and the gathering of primary data through site visits and field surveys, conducted between November 2024 and March 2025. Seasonal variation throughout the course of the EIA baseline study was considered, such as bird migratory and breeding season, and wet or dry weather.

The assembling and evaluation of the baseline data on the physical, biological and human environment was restricted to within the defined EIA Study Area and the 150 m NSR buffer (for airborne noise). The environmental parameters were collected, measured and presented in accordance with applicable environmental standards, norms and requirements both national and international. Secondary data from the desktop assessment was used to support and refine primary baseline collection precisely of the EIA Study Area.

3.3 Overall Impact Assessment Approach and Methodology

The impact assessment approach and methodology for the EIA has been described in the endorsed EIA Inception Report with the summary given below:



The impact assessment has evaluated changes in environmental aspects scoped for the EIA, quantified their impacts where feasible, and established appropriate tolerance limits, considering seasonal variations as necessary. The assessment of key environmental impacts considered the advance works, construction, and post-construction phases of the proposed development. The assessment also evaluated residual impacts

(decrease in level of impact) following the implementation of mitigation measures. Assessment methodology complied with the requirements of relevant authorities (e.g. NParks, HDB, PUB, URA, and NEA) is in accordance with international standards and practices, where applicable. Other key impacts of the proposed development were also required to be identified and assessed.

We applied Modified Rapid Impact Assessment Matrix (RIAM) to assess impacts during the construction and post-construction/operation phases of the proposed development. RIAM is a semi-quantitative impact assessment method modified/ adopted from Pastakia (1998) and Ijas et al. (2009). This modified RIAM approach applies scoring matrix (quantitative indicators) for impact evaluation in the form of Environmental Scores (ES) which range from extreme positive impact to critically negative impact for each specific project activity with consideration of the sensitivity level of the existing baseline environmental condition.

The criteria used for the assessment fall into two groups, Group A and Group B, with their respective factors of assessing indicated in **Figure 3-2**.

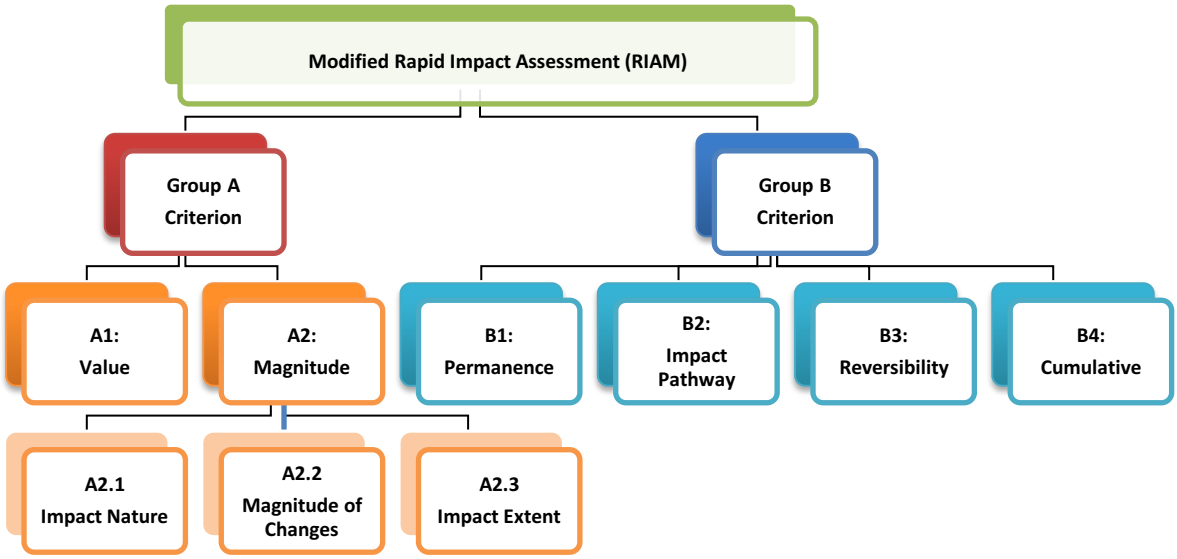


Figure 3-2: Assessment Criteria for Impact Significance following the RIAM Method

3.3.1 Group A Criterion

Group A Criterion is the measure of importance of the existing sensitive receiver characteristic with value level (A1) against the magnitude (scale) of the changes whether the impact nature is a beneficial or dis-beneficial impact (A2). Score for Group A is calculated using multiplication, i.e. (A1) x (A2.1) x (A2.2) x (A2.3) = AT, where (A1) to (A2.3) are the individual criteria scores in Group A and (AT) is the result of multiplication of all Group A scores. The definition and score general criteria considered for Group A is given on **Table 3-2**.

Table 3-2: Definition and Score Criteria for Group A Criterion

Group A Criterion	Score/ General Criteria Considered	
A1 – Value **Sensitive Receiver Characteristic**	**4:**	Important to international interest (beyond Singapore) (Very High)
	3:	Important to national/ regional interest (within Singapore context) (High)
	2:	Important to area immediately outside local condition (i.e., EIA Study Area and the150 m NSR buffer) (Medium)
	1:	Important to local condition (within the indicative boundary of future development area) (Low)
	0:	No importance, i.e., value does not carry important role in local interest (Not Important)

Group A Criterion	Score/ General Criteria Considered	
A2 – Magnitude **Measure of the scale of benefit/dis-benefit (impact nature) of an impact or a condition**	**A2.1 – Impact Nature (Benefit or Dis-benefit)**	
	+1:	Positive impact
	-1:	Negative impact
	0:	Negligible impact/ no change/ status quo
	A2.2 – Magnitude of Changes*	
	3:	High impact/ changes
	2:	Medium impact/ changes
	1:	Low impact/ changes
	0:	No change/ status quo/ negligible
	A2.3 – Impact Extent (Geographical Extent of the Induced Change)	
	4:	Impact extends up to National boundary
	3:	Impact beyond EIA Study Area up to 2 km extent
	2:	Impact extends immediately beyond indicative boundary of future development area, i.e., within EIA Study Area and 150 m NSR buffer
	1:	Impact within local area, i.e., within the indicative boundary of future development area
	0:	No change/ status quo

*Note: *Magnitude of changes – there will be specific definition of magnitude for each environmental component/ aspect given in their respective evaluation section.*

3.3.2 Group B Criterion

Group B Criterion is the measure of value to the situation but individually should not be capable of changing the score obtained. The criteria factors definition with their individual scope in this group is shown on **Table 3-3.**

Score for the criteria in Group B is calculated using summation, i.e. (B1) + (B2) + (B3) + (B4) = BT, where (B1) to (B4) are the individual criteria scores in Group B and (BT) is the result of summation of all Group B scores.

Table 3-3: Definition and Score Criteria for Group B Criterion

Group B Criterion	Scores/ Definition	
B1 – Permanence **Whether a condition is temporary or permanent and should be seen only as a measure of the temporal status of the condition. The time period over which a resource/ receptor is affected**	4:	Long-term effects, i.e., > 15 years (over the lifetime of the proposed development)
	3:	Medium-term, i.e., ≥ 3 years ≤ 15 years
	2:	Short-term, i.e., less than 3 years
	1:	Temporary, i.e., less than one month

Group B Criterion	Scores/ Definition	
B2 – Impact Pathway **Whether the receivers are directly or indirectly impacted**	3:	Direct impact
	2:	Indirect impact
	1:	No change/ not applicable (N.A.)
B3 – Reversibility **Whether a condition can be changed and is a measure of the control over the effect of the conditions**	3:	Irreversible
	2:	Reversible
	1:	No change/ not applicable (N.A.)
B4 – Cumulative **Whether the effect will have a single direct impact or whether there will be a cumulative effect over time or synergistic effect with other conditions**	3:	Cumulative/ synergistic
	2:	Non-cumulative/ single
	1:	No change/ not applicable (N.A.)

3.3.3 Impact Severity/ Significance

The impact severity/ significance is evaluated against the impact criterions (Group A and Group B), and for each criterion a score is determined, which provides a measure of the impact severity expected for the potential impact identified.

The total environmental score (ES) is calculated using the equation **(AT) x (BT) = ES**.

The severity of impact for each of the evaluated potential impact identified has been categorised using a qualitative scale of severity with range bands as indicated in **Table 3-4**.

Table 3-4: Range Bands of Environmental Score (ES) and The Corresponding Level of Impact Significance

Environmental Score (ES)	Impact Severity/ Significance	Definition
468 to 624	**Extreme Positive Effect**	Impact which causes great improvement or benefit to the existing environment
312 to 467	**Major Positive Effect**	Impact which causes major improvement or benefit to the existing environment
121 to 311	**Moderate Positive Impact**	Impact which causes noticeable improvement or benefit to the existing environment
53 to 120	**Minor Positive Impact**	Impact which causes minor improvement or benefit to the existing environment
1 to 52	**Slight Positive Impact**	Impact which causes slight improvement or benefit to the existing environment
0	**No Change/ Status Quo**	No discernible deterioration or improvement to the existing environment
-1 to -52	**Slight Negative Impact**	Impact which causes slight deterioration or dis-benefit to the existing environment
-53 to -120	**Minor Negative Impact**	Impact which causes minor deterioration or dis-benefit to the existing environment

Environmental Score (ES)	Impact Severity/ Significance	Definition
-121 to -311	Moderate Negative Impact	Impact which causes a noticeable deterioration or dis-benefit to the existing environment
-312 to -468	Major Negative Impact	Impact which causes major deterioration or dis-benefit to the existing environment
-468 to -624	Critically Negative Impact	Impact which causes critical deterioration or dis-benefit to the existing environment

3.4 Recommendation of Mitigation Measures

As the impact significance is evaluated, preventive measures and/or mitigation measures are determined. The mitigation hierarchy is shown in **Figure 3-3**.

Figure 3-3: Mitigation Hierarchy

The priority of Mitigation Hierarchy is to first apply feasible preventive/ mitigation/ control measures to the source of impact, i.e., avoid or reduce the magnitude of impact or alleviate the significance of any negative impacts identified from the associated design initiatives, construction method approach, construction activities and operation events to as low as reasonably practicable (ALARP) using the following types of control method as shown in **Figure 3-4**.

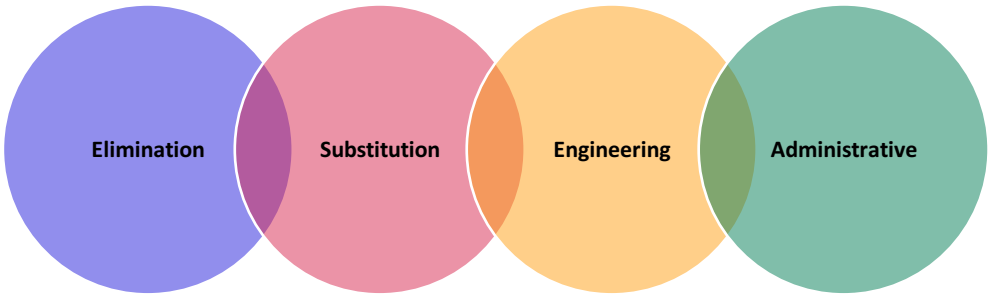


Figure 3-4: Control Method

The recommended mitigation measures have been comprehensively assessed for their effectiveness, integration within the proposed development design, safety, practicality and overall feasibility for implementation in relation to the proposed development's design initiatives, construction methodology, project schedule and spatial constraints. Any anticipated impacts on specific environmental aspects, resources or receptors will be addressed through appropriate abatement strategies, compensatory measures or offset mechanisms. Recommended mitigation measures incorporate provisions to safeguard ecological corridors associated with the adjacent Berlayar site and have considered the recommendations of the heritage study.

Upon confirmation of the recommended mitigation measures, the next step will involve evaluating the significance of any residual impact. Residual impacts that persist following the implementation of the recommended mitigation measures will adopt the RIAM methodology. This approach incorporates the consideration of cumulative impacts and evaluates the extents to which the proposed development may contribute to overall environmental effects. The approach for assessing cumulative impacts from the proposed development and its associated facilities, together with other activities affecting the same resource or receptor,

considers the approval status or existence of these activities, as well as the availability and reliability of information needed to predict their respective impact magnitudes.

3.5 Environmental Management and Monitoring Plan

Based on the findings from the impact assessments, an EMMP will be developed with specific environmental procedures for management and monitoring for the various phases of the development (i.e., pre-construction, construction and post-construction/ operation phases). The EMMP will consist of a system of reports and submissions on monitoring plans and data by the responsible party to verify implementation of the recommended mitigation measures.

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4. Assessment of Ecology and Biodiversity

4.1 Applicable Legislation Standards

The National Parks Board (NParks) administers the Parks and Trees Act which regulates the planting, maintenance and conservation of trees and plants within national parks, nature reserves, tree conservation areas, heritage road green buffers and other specified areas, and the Wildlife Act which enacts protection, preservation, and management of wildlife for the purposes of maintaining healthy ecosystems.

The Biodiversity Impact Assessment (BIA) Guidelines (latest revision in May 2024) was released by NParks as a non-prescriptive guide and reference to recognise the basic requirements for the biodiversity component of an EIA.

4.2 Methodology for Ecological Assessment

To establish a biodiversity baseline understanding of the EIA Study Area, a baseline study was conducted through a combination of desktop research and field surveys.

Desktop research involved a review of biodiversity records, including data from the Environmental Impact Study (EIS) for Berlayar (Former Keppel Club), Port of Singapore Authority (PSA) Club, Bukit Chermin, Berlayar Creek, and the Former BP Oil Refinery Site (AECOM, 2022), published literature, citizen science records, and consultations with taxonomic experts. Field surveys were then carried out, as detailed in **Section 4.2.4**.

The baseline findings informed the assessment of habitat types as well as floral and fauna of high ecological value. Proposed Retained Area and Area of Habitat Creation (hereon abbreviated as 'PRA/AHC') were then identified accordingly, in the subsequent stages of the EIA Study. The baseline findings will also be used to evaluate the impacts that may arise from the proposed development, and to recommend mitigation measures to reduce and/or minimise these impacts.

4.2.1 Taxonomy and Nomenclature

The taxonomy and nomenclature used in this report are based on recognised books, scientific publications, and online databases. Key local and regional sources for the various taxonomic groups are listed in **Table 4-1**.

Table 4-1: Key References for The Nomenclature and Taxonomy for Each Taxonomic Group

Taxon	Key References
Plants	▪ Flora of Singapore: Checklist and bibliography (Lindsay et al., 2022) ▪ A Checklist of the Total Vascular Plant Flora of Singapore: Native, Naturalised and Cultivated Species (Chong et al., 2009) ▪ Singapore Red Data Book 3 (SRDB3) (Davison et al., 2024)
Odonates	▪ SRDB3 (Davison et al., 2024)
Butterflies	▪ SRDB3 (Davison et al., 2024)
Aculeate hymenopterans	▪ Bee species guide and world checklist, (Hymenoptera: Apoidea: Anthophila) (Ascher & Pickering, 2018) ▪ The bees of Singapore (Hymenoptera: Apoidea: Anthophila): First comprehensive country checklist and conservation assessment for a Southeast Asian bee fauna (Ascher et al., 2022) ▪ SRDB3 (Davison et al., 2024)

Taxon	Key References
Herpetofauna (amphibians and reptiles)	▪ Singapore's herpetofauna: updated and annotated checklist, history, conservation, and distribution (Figueroa et al., 2023)
Birds	▪ IOC World Bird List (v15.1) (Gill et al., 2025)
Mammals (including bats)	▪ SRDB3 (Davison et al, 2024)
Freshwater Fish	▪ SRDB3 (Davison et al, 2024) ▪ The fishes of the inland waters of Southeast Asia: A catalogue and core bibliography of the fishes known to occur in freshwaters, mangroves and estuaries (Kottelat, 2013) ▪ Redescription of Rhinogobius similis Gill 1859 (Gobiidae: Gobionellinae), the type species of the genus Rhinogobius Gill 1859, with designation of the neotype (Suzuki et al., 2015) ▪ A Guide to the Freshwater Fauna of Nee Soon Swamp Forest (Ho et al., 2016)
Freshwater decapod crustaceans	▪ The Conservation Status of Freshwater Prawns and Crabs in Singapore with Emphasis on the Nature Reserves (Ng, 1997) ▪ Freshwater shrimps of the family Atyidae (Crustacea: Decapoda: Caridea) from Peninsular Malaysia and Singapore (Cai et al., 2007)

4.2.2 Species of Conservation Significance

The identification of species of conservation significance ('CS species') is important for assessing conservation needs and priorities.

4.2.2.1 Flora

Plant species were assessed for their conservation significance with reference to their threatened status on the Flora of Singapore checklist (Lindsay et al., 2022) and the Singapore Red Data Book 3 (National Parks Board et al., 2024). These references classify species as Vulnerable, Endangered, Critically Endangered, or Presumed Extinct (the latter referring to species that were rediscovered).

The assessment of whether a species is of conservation significance was also based on, but not limited to, information on the following: (1) presence of large parent tree(s); (2) historical data from previous observations, studies, and environmental impact assessments; (3) land use history records, which chronicle disturbance to primary vegetation for development, cultivation, or other purposes; (4) reforestation efforts; (5) natural range; and (6) importance for associated fauna.

While the national threatened status of plant species typically applies to wild populations that have originated without direct human intervention, some populations may be relics of past cultivation or escapees from ongoing cultivation and may not represent native genetic stock.

In cases where the origin of a threatened species population is unclear or disputed, a precautionary approach is taken: such populations were considered to be of conservation significance, regardless of whether field surveys provide corroborating evidence. This approach allows for conservation needs to be prioritised and appropriate resources to be allocated for their protection.

4.2.2.2 Fauna

Faunal CS species are those considered native to Singapore and classified as Vulnerable, Endangered, Critically Endangered, or Extinct at the national or global level. National conservation statuses follow the Singapore Red

Data Book 3 (Davison et al., 2024), while global statuses are based on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species (IUCN, 2025).

4.2.3 Desktop Assessment

4.2.3.1 Faunal Species of Probable Occurrence

A list of faunal species of conservation significance that are likely to occur at the site (termed thereafter as "CS species of probable occurrence") was drafted.

This list is meant to complement the species that were recorded during field assessment, as the absence of detections does not confirm the absence of species. Given the rarity and elusiveness of many CS species, it is probable that some would remain undetected despite rigorous survey effort. Thus, the inclusion of the CS species of probable occurrence is a cautionary approach ensures that potential impacts are comprehensively anticipated and that appropriate mitigation measures are in place.

The list was generated in consultation with taxonomic experts, with the following inputs:

- Habitat types and condition (from field assessment, see **Section 4.2.4.1**).
- Faunal records (from field assessment, see **Section 4.2.4.2**).
- Past faunal records derived from past biodiversity studies (in and around the vicinity of the EIA Study Area).
- Data from taxonomic experts and nature groups (e.g., Singapore Pangolin Working Group).
- Publicly available credible secondary sources (e.g., websites, citizen science platforms).

The assessments were conducted by the following taxon specialists, who were also part of the field team:

- **Birds:** Mr. Movin Nyanasengeran and Ms. Chloe Tan.
- **Butterflies**: Mr. Simon Chan Kee Mun and Ms Chloe Tan.
- **Odonates**: Mr. Robin Ngiam and Ms Chloe Tan.
- **Herpetofauna**: Mr. Law Ing Sind and Ms. Cheo Zi Han.
- **Aquatic Fauna**: Mr. Movin Nyanasengeran and Ms. Sheryl Seet.
- **Aculeate Hymenopteran**: Mr. John Lee.

4.2.4 Field Surveys

The field surveys were conducted between 21 October 2024 and 21 March 2025.

4.2.4.1 Floristic Field Assessment

The field assessment for flora consists of (1) habitat and vegetation mapping; (2) general walking floristic surveys; and (3) tree mapping assessment.

4.2.4.1.1 Habitat and Vegetation Mapping

A preliminary vegetation map was first prepared based on visual interpretations of satellite images from Google Earth Pro 7.3.3.7786 (Google Inc. 2020). Preliminary classification of the vegetation types was determined using visual features, such as textures and colours, observed in the satellite images. Adjustments were then made to the preliminary maps according to actual observations during ground truthing. Ground truthing was conducted throughout the survey area with the aid of a Global Positioning System (GPS) receiver (Garmin

GPSMap® 64s). Photographs of the vegetated areas were also be taken. The boundaries of each vegetation type were tracked on the GPS receiver and mapped out on Google Earth 7.3.3.7786. The classification of vegetation type references NParks' BIA Guidelines (National Parks Board, 2024).

4.2.4.1.2 General Walking Floristic Surveys

All plants observed within accessible locations in the EIA Study Area during floristic surveys were identified to species whenever possible, and a checklist of all the plant species recorded from the present floristic surveys was compiled.

For plants that could not be immediately identified with certainty in the field, photographs and/or voucher specimens were taken. These were then identified using identification keys, taxonomic descriptions, online plant photo databases, with the help of taxonomic experts, and/or by matching the pressed and dried collected specimens with existing specimens in the Singapore Botanic Gardens' Herbarium (SING). For very tall trees that are unidentifiable, with leaves that are too high in the canopy to photograph, dried leaves matching these trees were collected from the forest floor and used to aid in species identification.

Species of Conservation Significance

The geographic locations of plants of conservation significance, i.e., listed in Lindsay et al. (2022) and SRDB3 as nationally Vulnerable, Endangered, Critically Endangered or Presumed Extinct (which indicates rediscovery), were marked using a GPS receiver (Garmin GPSMap ® 64s), which records locations with accuracy of ±4 m, during floristic surveys. Where there were clusters of plants of conservation significance, i.e., more than one individual occurring within 5 m or less of another individual, the approximated centre of the area was marked using the GPS receiver.

Large Plant Specimens

Similarly, the GPS receiver was used to record locations of all trees of ≥ 3 m girth, as well as bamboo clusters, palm clusters, and strangling *Ficus* species of ≥ 3 m spread. Individuals were identified as species whenever possible. The girth (for trees) and spread (for bamboo clusters, palm clusters, and strangling *Ficus* species) were measured and estimated, respectively. The height of all specimens was also estimated.

Other Plant Specimens of Value

Locations of other plants specimens that are of value but do not meet the minimum size requirement, as detailed above, were also recorded using the GPS receiver. Examples of such include bamboo clusters of < 3 m spread that may be important refugia for nationally threatened Bamboo bats, exotic trees of < 3 m girth with active raptor nests, amongst others.

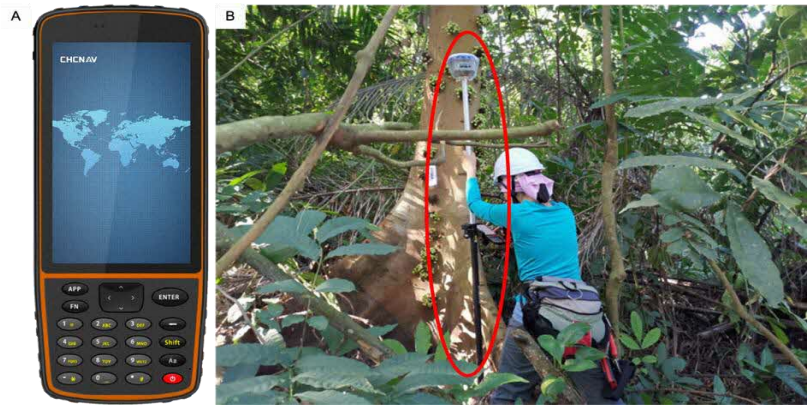
4.2.4.1.3 Tree Mapping Assessment

Tree mapping was carried out for the EIA Study Area. All trees, single-stemmed palms (i.e., defined as having one obvious and erect stem), strangling *Ficus* species of ≥ 1.0 m girth or spread were tagged with a unique serial number. Other specimens that are considered of conservation significance with ≥ 0.3 m girth or spread were tagged on a best-effort basis, depending on the availability of resources. Geographic locations, girth/spread and height were also recorded.

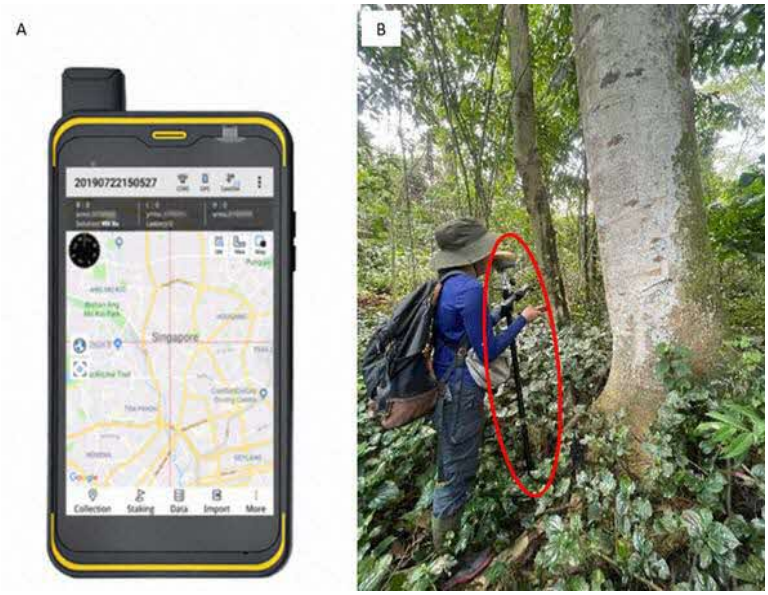
For trees within Telok Blangah Hill Park and private property temporary red-and-white tape tree tags were used until topographic readings were recorded. The tags were then removed from the trees and discarded. For trees within the EIA Study Area but outside Telok Blangah Hill Park, weatherproof paper tags were secured with nails and high-visibility pink tape (**Picture 4-1**).

Picture 4-1: Method of Attaching Weatherproof Paper Tag with Nail

The DGPS **(Picture 4-2, Picture 4-3)** that can achieve up to sub-meter accuracy was used to record the geographic locations of the specimens using the SVY21 plane coordinate system. This local datum gives a more accurate representation of the areas of coverage in Singapore compared to a global datum and is used by the Singapore Land Authority (SLA). Where there are clusters of specimens of the same species occurring within 1–2 m of each other, only one specimen was tagged, and its location was marked using the DGPS.



Picture 4-2: (A) Trimble® Geo 7X Handheld Controller (Source: Gpsforestry-Suppliers.Com); (B) How it is used in the field



Picture 4-3: (A) CHC® Navigation HCE320 GNSS Data Controller (Source: Geo-Matching.Com); (B) How it is used in the field

Where there are specimens that are inaccessible due to obstructions, (e.g., streams, nearby tree falls, steep or otherwise dangerous terrain), specimens were not given a physical tag on site. However, the locations of these specimens were still geo-tagged using the DGPS.

Additionally, the assessment of trees was conducted by International Society of Arboriculture (ISA) certified arborists. Plant health and structural stability were assessed by observing for damages, decays, and/or canopy asymmetry, which if present may compromise plant longevity and stability. Other characteristics that were recorded include presence of habitats and canopy linkages (branches) for arboreal fauna, across roads with green areas on both sides (**Figure 4-1**). The arborist also provided recommendations on whether assessed individuals are suitable for transplantation based on the initial health assessment and survival rates post-transplantation. These findings were used to inform mitigation measures outlined in **Section 4.5**.

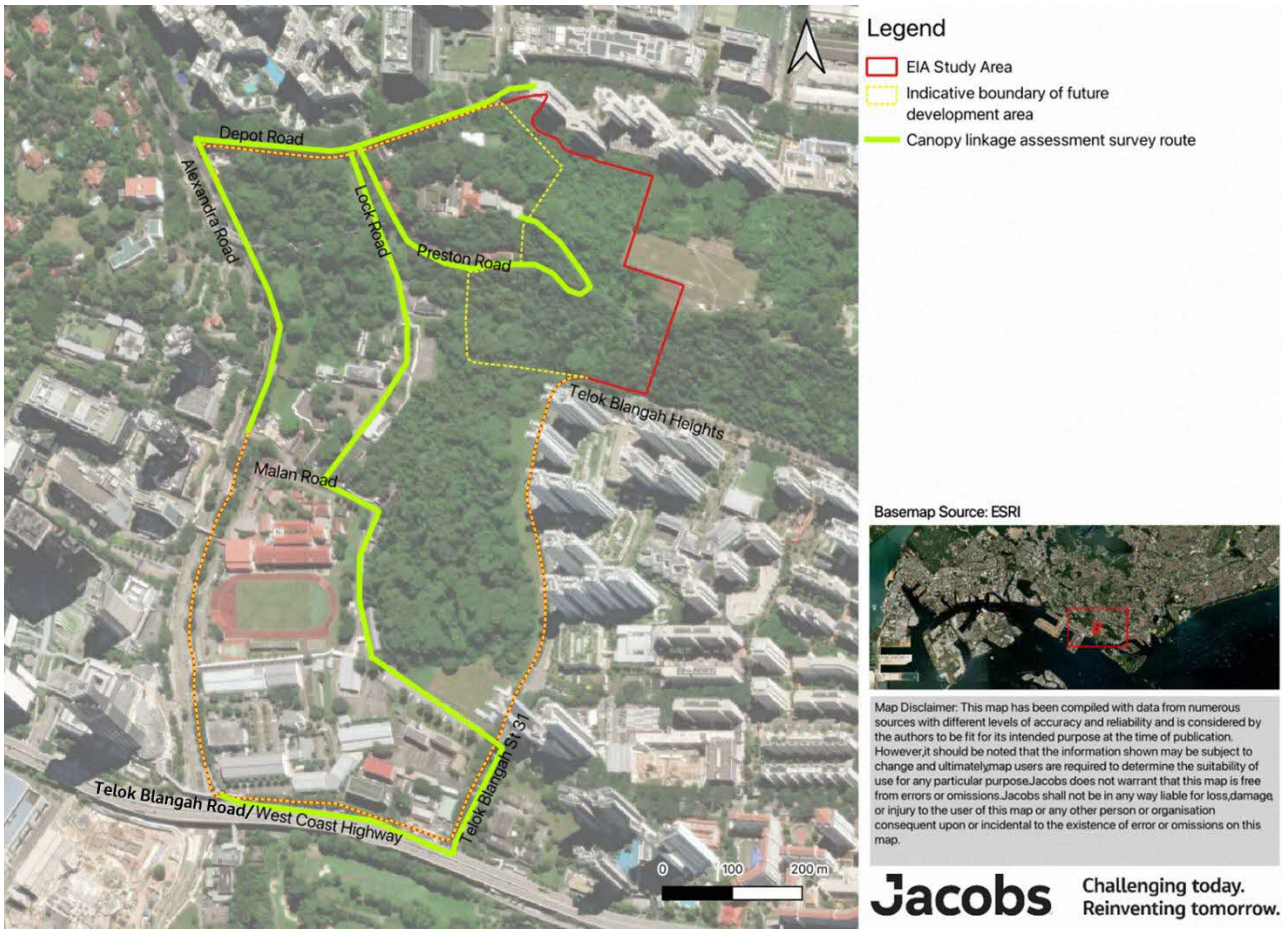


Figure 4-1: Canopy Linkage Assessment Route

4.2.4.2 Faunistic Field Assessment

Surveys were carried out for the following faunal taxa: (1) aculeate hymenopterans (bees and stinging wasps); (2) butterflies; (3) odonates (damselflies and dragonflies); (4) herpetofauna (amphibians and reptiles); (5) birds; (6) mammals (including bats); and (7) freshwater fauna (fish and decapod crustaceans). These surveys were conducted between 21 October 2024 and 7 March 2025 at the EIA Study Area.

The locations and number of sampling units were finalised upon completion of site reconnaissance surveys (**Figure 4-2**). **Table 4-2** summarises all the surveys that were carried out for fauna. Each survey was performed by at least two surveyors. All fauna encountered were identified to species, or to the next lowest taxonomic level possible, and the location of each individual was recorded using a handheld GPS receiver (Garmin GPSMAP 64s). The number of individuals observed was also documented.

All observations of notable species from the aforementioned taxa were also recorded if seen outside the stated survey times. A checklist of all species of fauna observed from the surveys was compiled.

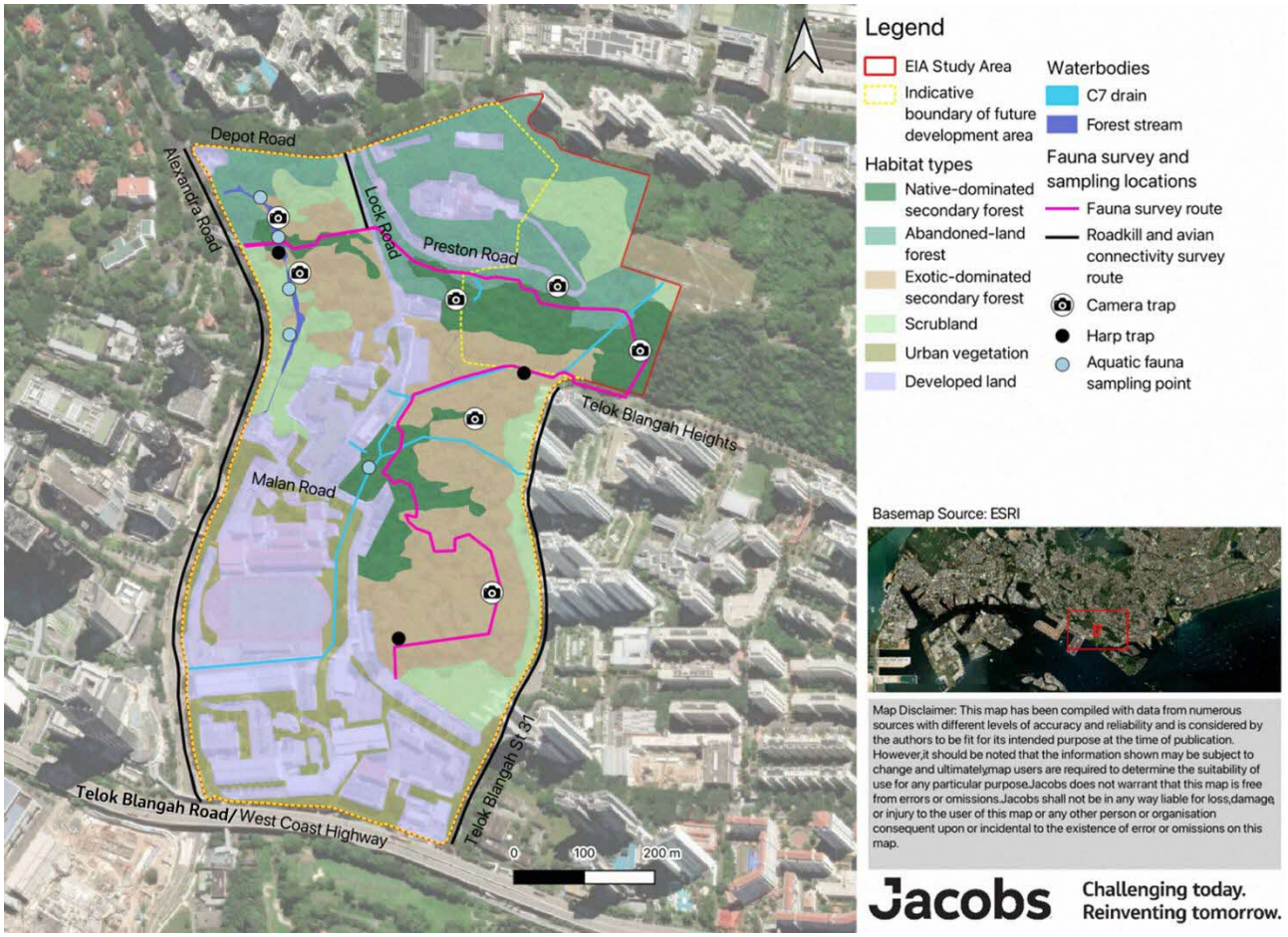


Figure 4-2: Fauna Terrestrial Transect, Aquatic Sampling Point, and Camera Trap Locations

Table 4-2: Summary of Fauna Survey Methods

Survey Type	Taxon	Timing (h)	Duration	Sampling Unit*	Technique	Data Collected
Diurnal transect surveys	Butterflies	0900-1200	20–30 minutes per transect; two cycles	200-m continuous transects along a sampling route	Visual only; up to 10 m left, right, and front of surveyor	Location, species, quantity, date, time
	Odonates (damselflies and dragonflies)	0900-1200	20–30 minutes per transect; two cycles	200-m continuous transects along a sampling route	Visual only; up to 10 m left, right, and front of surveyor	Location, species, quantity, date, time

Survey Type	Taxon	Timing (h)	Duration	Sampling Unit*	Technique	Data Collected
Diurnal transect surveys	Hymenopterans (bees and wasps)	0900-1200	20–30 minutes per transect; two cycles	200-m continuous transects along a sampling route	Visual only; up to 10 m left, right, and front of surveyor	Location, species, quantity, date, time
Aquatic point counts	Odonates (damselflies and dragonflies)	0900–1200	20 minutes per point with two surveyors; two cycles	Sampling transects of 10-m length at every 50-m interval	Visual only; up to 10 m from sampling point or the extent of waterbodies, whichever is smaller	Location, species, quantity, date, time
	Herpetofauna (amphibians and reptiles)	0900–1600; 2000–2300	20 minutes per point with two surveyors; two cycles	Sampling transects of 10-m length at every 50-m interval	Visual and auditory; up to 25 m from sampling point or the extent of waterbodies, whichever is smaller	Location, species, quantity, date, time
	Aquatic fauna (fish and decapod crustaceans)	0900–1600; 2000–2300	10 minutes per point with two surveyors; two cycles	Sampling transects of 10-m length at every 50-m interval	Visual only; up to 25 m from sampling point or the extent of waterbodies, whichever is smaller	Location, species, quantity, date, time
Diurnal and nocturnal transect surveys	Herpetofauna (amphibians and reptiles)	0700–1000; 2000–2300	20–30 minutes per transect; two cycles	200-m continuous transects along a sampling route	Visual and auditory; up to 50 m left, right, and front of surveyor	Location, species, quantity, date, time
	Birds	0700–1000; 2000–2300	20–30 minutes per transect; two cycles	200-m continuous transects along a sampling route	Visual and auditory; up to 50 m left, right, and front of surveyor	Location, species, quantity, date, time
	Mammals (non-volant)	0700–1000; 2000–2300	20–30 minutes per transect; two cycles	200-m continuous transects along a sampling route	Visual and auditory; up to 50 m left, right, and front of surveyor	Location, species, quantity, date, time

Survey Type	Taxon	Timing (h)	Duration	Sampling Unit*	Technique	Data Collected
Camera trapping	Mammals (non-volant)	24 h a day;	60 days per camera trap	24-h continuous period of recording on a camera trap	Infrared motion sensing	Location, species, quantity, date, time
Bioacoustic surveys (handheld bat detector)	Mammals (bats)	2000–2300	20–30 minutes per transect; two cycles	200-m continuous transects along a sampling route	Auditory only	Location, species, date, time
Bioacoustic surveys for bamboo clusters	Mammals (Bamboo bats only)	Overnight (30 min before sunset to 30 min after sunrise)	Once per bamboo cluster	Bamboo clusters	Auditory only	Presence/ absence of Bamboo bats, location, date, time
Harp trap	Mammals (Bamboo bats only)	1930-2100; 2100-0800	Once per location	Harp trap	Live trapping	Location, species, quantity, date, time
Push and scoop netting	Aquatic fauna (fish, decapod crustaceans)	0900–1600	20 minutes per netting event with two surveyors; one cycle	Sampling transects of 10-m length at 50-m intervals	–	Location, species, quantity, date, time
Minnow trapping	Aquatic fauna (fish and decapod crustaceans)	Over-night	Once per sampling point	Traps inside stream at 50-m intervals	Baited	Location, species, quantity, date, time
Roadkill and Avian Connectivity surveys	Terrestrial fauna	0700–1000	Two cycles	Along Alexandra Road, Lock Road and Telok Blangah Street 31	Visual and auditory	Location, species, quantity, date, time

*A sampling unit is the building block of the dataset that will be used for statistical analyses. For transect surveys, one sampling unit is defined as a 200-m long transect. Hence, a sampling route may consist of several 200 m transects.

a) Butterflies

Diurnal transect surveys were conducted for adult butterflies along 200-m continuous transects on the sampling route between 0900h and 1200h. Butterfly caterpillars, pupae, eggs, and host plants were also recorded when observed. Adult butterflies were identified visually (with binoculars where necessary), photographed, or caught using insect nets where required. Captured individuals were released immediately after identification.

b) Odonates (Dragonflies and Damselflies)

Diurnal transect surveys were conducted for adult damselflies and dragonflies along 200-m continuous transects on the sampling route between 0900h and 1200h. 20-minute point counts were also conducted at suitable aquatic sampling points with two surveyors. Each point count was carried out along a 10-m transect at every 50-m interval, where possible, considering limitations imposed by steep terrain and/or dense vegetation. Owing to difficulties in sampling and identification, aquatic larvae and exuviae were not surveyed. Adult odonates were identified visually (with binoculars where necessary), photographed, or caught using insect nets, where required. Captured individuals were released immediately after identification.

c) Aculeate hymenopterans (Bees and Stinging Wasps)

Diurnal transect surveys were conducted for aculeate hymenopterans along 200-m continuous transects on a sampling route between 0900h and 1200h. Aculeate hymenopterans were identified visually (with binoculars where necessary), photographed, or caught using insect nets, where required. Captured individuals were released immediately after identification. When identification in the field is not possible, live specimens were collected and examined *post-hoc* under a microscope. The specimens were identified to the lowest taxonomic level using relevant references, identification keys, or in consultation with taxonomic experts.

d) Herpetofauna (Amphibians and Reptiles)

Diurnal (0700h–1000h) and nocturnal (2000h–2300h) surveys were conducted for amphibians and reptiles along 200-m continuous transects on a sampling route. 20-minute point counts were also conducted at aquatic sampling points with two surveyors. Each point count was carried out along a 10-m transect at every 50 m interval, where possible, considering limitations imposed by steep terrain and/or dense vegetation. As herpetofauna occupy a wide range of habitat types, both the diurnal and nocturnal surveys also involved active searches for individuals on the ground, below rocks, logs, leaf litter and debris, in the water, and/or on vegetation. Rocks, logs, and other structures were returned to their original positions if moved during the searches. Torches and/or headlamps were used to elicit eyeshine during nocturnal surveys. Vocalising fauna were also located or identified by call recognition, whenever possible. For species that are capable of quick retreats and escapes, the individuals were captured by hand, or dip nets for identification. Captured individuals were released immediately after identification.

e) Birds

Diurnal (0700h–1000h) and nocturnal (2000h–2300h) surveys were conducted for birds along 200-m continuous transects on a sampling route. Birds were identified visually (with binoculars where necessary) and photographed. Torches and/or headlamps were used to elicit eyeshine during nocturnal surveys. Vocalising birds were also located or identified by call recognition, whenever possible. Both cycles of the surveys were conducted during peak migratory bird season in Singapore, which is between September and February (Lim, 2009).

To study avian connectivity in the area, two cycles of diurnal (0700h–1000h) bird survey were conducted along Alexandra Road, Lock Road and Telok Blangah Street 31.

f) Mammals (Non-Volant)

Diurnal (0700h–1000h) and nocturnal (2000h–2300h) surveys were conducted for non-volant mammals along 200-m continuous transects on a sampling route. Both the diurnal and nocturnal surveys also involved searches in burrows and tree holes. Tracks and scats were also recorded. Mammals were identified visually (with binoculars where necessary) and photographed. Torches and/or headlamps were used to elicit eyeshine during nocturnal surveys. Vocalising mammals, such as the squirrels, were also located or identified by call recognition, whenever possible.

In addition to the transect surveys, mammals were also surveyed via camera trapping. Seven camera traps were deployed across the EIA Study Area, with approximately one camera deployed for every 6.25 ha of forest (**Figure 4-3**).

Each camera trap was set up approximately 20–30 cm above ground (**Picture 4-4)**. They operated 24 hours a day and were programmed to record one 10-second footage per motion trigger with a 10-second quiet period following each trigger. Each camera trap was deployed for at least 60 days. The model of camera trap used was Browning Dark Ops HD Pro X BTC-6HDPX.

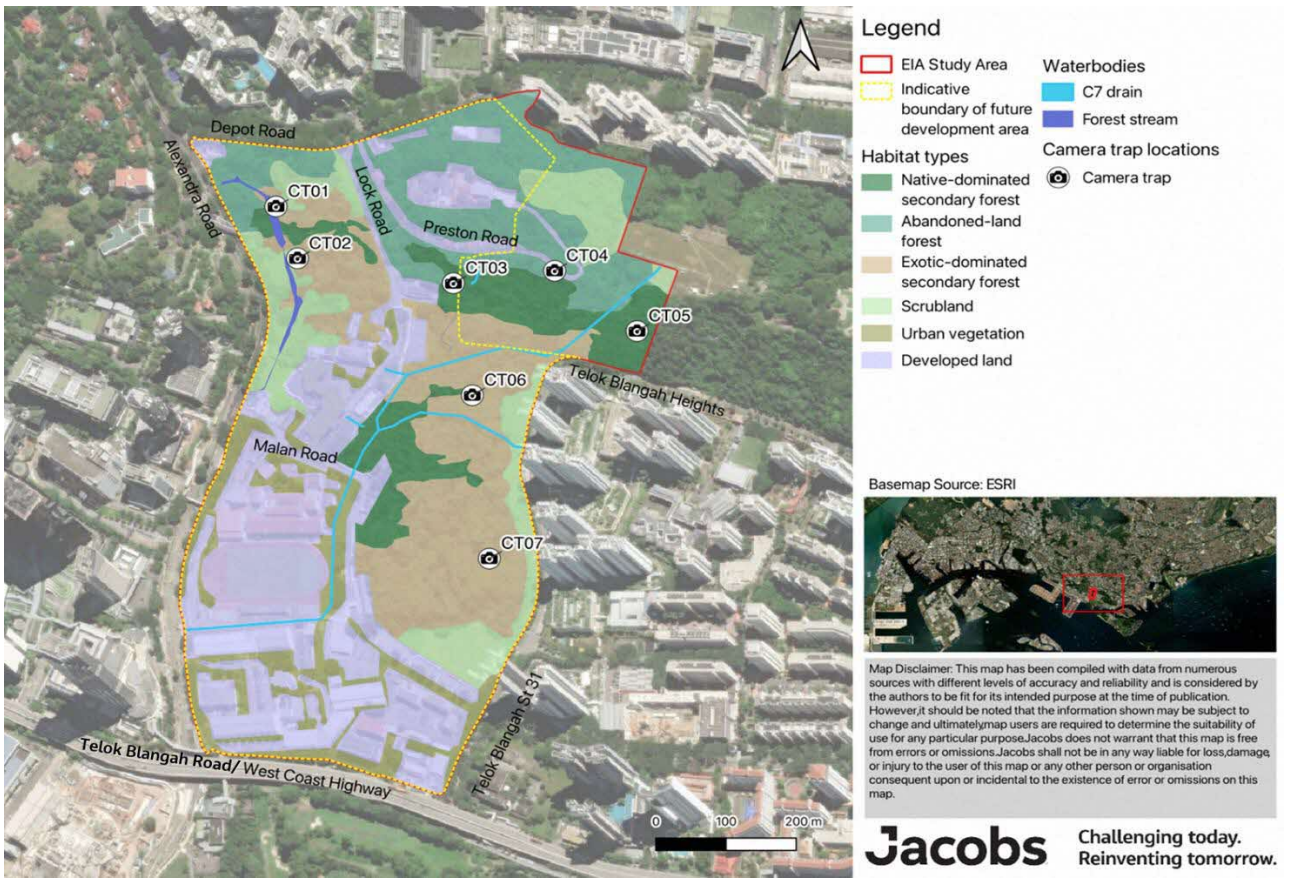


Figure 4-3: Map of the Camera Traps Deployed

Picture 4-4: Terrestrial Camera Trap Set up

g) Mammals (Bats only)

Acoustic surveys were conducted for bats along 200 m continuous transects on a sampling route between 2000h and 2300h. An unattended bat detector (Song Meter Mini Bat) was used to record, and attenuate ultrasonic calls between 18 and 192 kHz at a sampling frequency of 384 kHz to low frequency signals below 20 kHz, a range that is audible to the human ear.

Harp traps were deployed strategically at three locations (1 per 20 ha of forest) at potential flyways across the EIA Study Area to improve accuracy of species identification. The harp traps were set up between 1730h–1930h and trapping duration occurred between 1930h–2100h, during which traps were repeatedly checked. The traps were left overnight and checked the following morning between 0800h and 0900h and removed. Bats collected in the traps were handled safely by trained personnel and released immediately upon identification, sexing, and aging. Where identification is difficult, photographs, weight, and forearm length may be taken. Ultrasonic recordings may also be taken when releasing the bats to aid in species identification.

Acoustic surveys were also conducted to determine the presence of Bamboo bats (*Tylonycteris* spp.) at bamboo clusters overnight (30 min before sunset to 30 min after sunrise). An unattended bat detector (Song Meter Mini Bat) was deployed at each bamboo cluster to record ultrasonic calls (**Picture 4-9**). Where there were several bamboo clusters located close together, the unattended bat detector(s) were deployed such that each detector targeted the bamboo clusters within a 30 m radius.

Picture 4-5: (A) Unattended Bat Detector (Song Meter Mini Bat) Deployed to Detect Bamboo Bats at a Bamboo Cluster; (B) Harp Trap for Bat Trapping

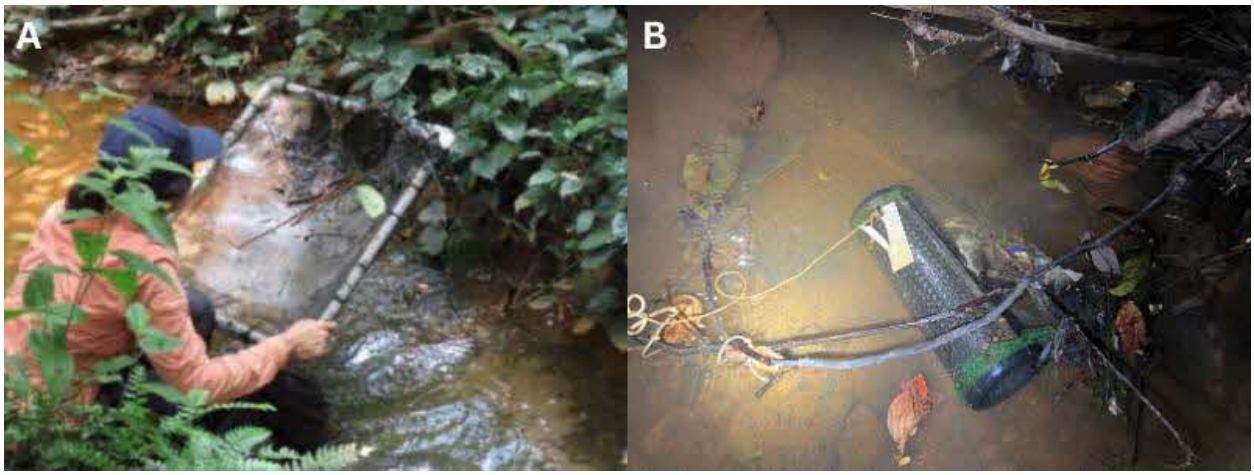
Bat recordings were processed using Kaleidoscope v.5.6.8 (Wildlife Acoustics, Inc., 2025) to separate extraneous noise from files with bat echolocation calls. The signal parameters for recognising a potential bat echolocation call were configured as follows: frequency range of 20–200 kilohertz (kHz), duration of 2–500 millisecond (ms), maximum inter-syllable gap of 500 ms and a minimum of two pulses. These files were then visually processed to identify bat species based on call structures, peak frequency, minimum frequency and call duration (Pottie et al., 2005). They were identified with reference to those in Pottie et al. (2005) which provide echolocation signatures for bats in Singapore, and other relevant references (Collen, 2012; Hughes et al., 2011).

h) Freshwater Fauna

Freshwater fauna, including freshwater fish and decapod crustaceans, was surveyed. Diurnal and nocturnal point counts of 20 min were conducted at aquatic sampling points in the stream between 0900h and 1600h, and 2000h and 2300h with at least two surveyors. Each point count was carried out along a 10-m transect at every 50-m interval, where possible, considering limitations imposed by steep terrain and/or dense vegetation. Torches and/or headlamps were used to elicit eyeshine during nocturnal surveys.

Push and scoop netting were carried out for freshwater fish and decapod crustaceans at sampling points inside waterbodies during the day. Push netting was carried out in deeper waters, using a rigid-frame tray net (61 × 49 cm; 5 mm mesh) to catch specimens on the banks or the streambed **(Picture 4-6A)**. Scoop netting was carried out, usually in shallower waters, using hand nets (net size 25 × 18 cm; 2 mm mesh) to catch specimens within the stream column. Captured individuals were released immediately after identification.

Minnow traps baited with halal meat (e.g., sausage) were deployed once at each suitable location within the stream, approximately 30m apart **(Picture 4-6A, B)** The traps were left overnight, then checked and removed the following morning. All caught individuals were released immediately upon identification.



Picture 4-6: (A) Push Netting; (B) Minnow Trapping

4.2.5 Data Analysis

4.2.5.1 Species Distribution Maps

Locations of species of conservation significance were presented on maps to shows their distribution within the EIA Study Area. All maps were prepared and generated using the mapping software QGIS 3.38.1 (QGIS, 2024).

4.2.5.2 Bat Sound File Analysis

Bat sound files were processed using Kaleidoscope v5.4.6 (Wildlife Acoustics, Inc.) to separate extraneous noise from files with bat echolocation calls. The signal parameters for recognising a potential bat echolocation call were configured as follows: frequency range of 20–200 kHz, duration of 2–500 ms, maximum inter-syllable gap of 500 ms and a minimum of two pulses. These files were visually processed to identify bat species based on call structures, with reference to relevant publications reporting echolocation signatures for bat species in Singapore (Pottie et al., 2005; Hughes et al., 2011, Collen, 2012).

4.2.5.3 Taxon Sampling Curves

Taxon sampling curves were plotted for taxa with sufficient occurrences during targeted surveys, as large sample sizes are required for a robust estimation of sample coverage (Chao & Jost, 2012). Incidence data was used to estimate sample coverage and species richness. Species richness was plotted against sample coverage, as opposed to survey effort. Sample coverage refers to "the proportion of the total number of species in a community that belongs to the species represented in the sample", i.e., how extensively the species in the community was sampled, as described by Chao and Jost (2012).

The taxon sampling curve was extrapolated to provide an estimation of species richness and sample coverage if the sample size was doubled. The associated standard error and 95% confidence interval were also computed. Standard error refers to the range of uncertainty of the estimate, while the 95% confidence interval is the interval in which there is a 0.95 probability of containing the estimated true species richness. As some species will always remain undetected, total species richness had to be estimated via extrapolation. This was done using the Chao estimator. All statistical analyses were carried out in the statistical programming environment R version 4.4.1 (R, 2024) using the "iNEXT" package 3.0.1.

4.3 Baseline Findings

This section presents biodiversity baseline field findings from surveys conducted as detailed in **Section 4.3.**

4.3.1 Habitat and Vegetation Types

The EIA Study Area comprises six terrestrial habitat types and two aquatic habitat types: native-dominated secondary forest, abandoned-land forest, exotic-dominated secondary forest, scrubland/ grassland, urban vegetation, developed land; as well as forest stream and concrete drain/canal (**Table 4-3**; and **Figure 4-4**).

Amongst the vegetated habitat types, exotic-dominated secondary forest covers the largest area at 10.1 ha, or 21.1% of the EIA Study Area, while urban vegetation covers the smallest area at 4.6 ha or 9.6% of the EIA Study Area.

Table 4-3: Absolute (ha) and Relative (%) Areas of each Habitat Type in the EIA Study Area

Habitat and Vegetation Type	Absolute Area (ha)	Relative Area (%)
Native-dominated Secondary Forest	4.7	9.8%
Abandoned-land Forest	7.0	14.6%
Exotic-dominated Secondary Forest	10.1	21.1%
Scrubland/ grassland	5.4	11.3%
Urban Vegetation	4.6	9.6%
Developed Land	15.7	32.9%
Forest Stream	0.2	0.4%
Concrete Drain/ Canal	0.1	0.2%
Total	47.8 ha	100.0%

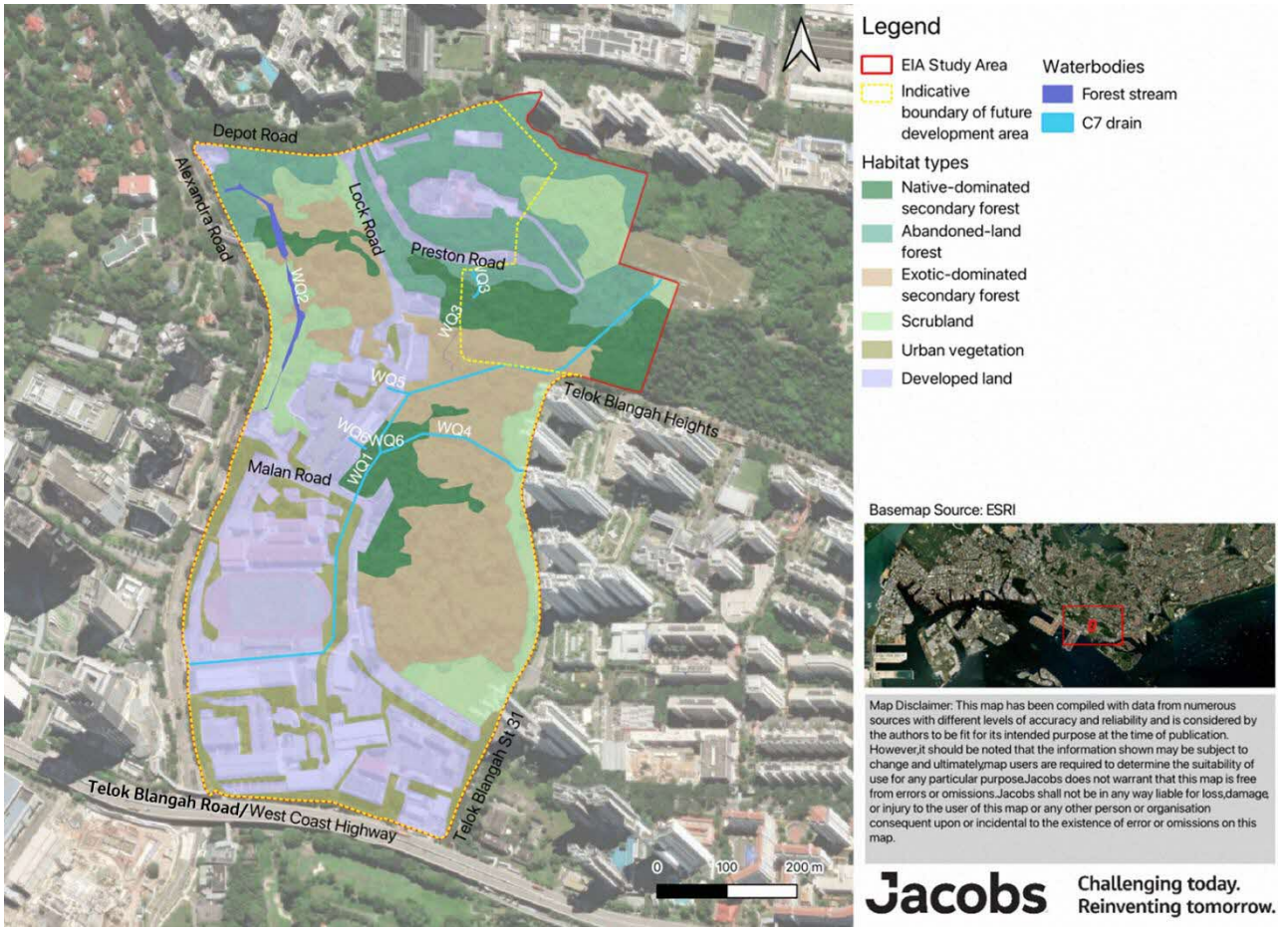


Figure 4-4: Habitat and Vegetation Map of the EIA Study Area

4.3.1.1.1 Native-Dominated Secondary Forest

Native-dominated secondary forest covers 4.7 ha, or 9.8% of the EIA Study Area, and predominantly spans east to west across the northern half of the EIA Study Area, within the boundaries of Telok Blangah Hill Park. A second, substantially large patch is found in the centre of the EIA Study Area, at the junction of Malan and Lock Roads, extending eastward.

Species characteristic of this forest type like Wild cinnamon (*Cinnamomum iners*), Sea almond (*Terminalia catappa*), Tembusu (*Cyrtophyllum fragrans*), Malayan teak (*Vitex pinnata*), and Medang (*Litsea elliptica*), were recorded here occurring both as large, canopy-forming trees, as well as small saplings in the understorey layer (**Picture 4-7**). The native-dominated secondary forest patches of the EIA Study Area also hold several large (≥3m girth/spread) native trees, palms, and keystone species of the genus *Ficus*, as well as large bamboo clusters. The nationally vulnerable *Endospermum peltatum* (two individuals) and endangered *Archidendron contortum* (30 individuals) were also recorded here.

The presence of native saplings is a positive and encouraging sign of active recruitment, in an otherwise rare habitat type in modern-day Singapore.

Picture 4-7: Representative Species of Native-Dominated Secondary Forest Within the EIA Study Area. (A) Wild cinnamon (*Cinnamomum iners*), (B) Sea almond (*Terminalia catappa*), (C) Tembusu (*Cyrtophyllum fragrans*), (D) *Endospermum peltatum*, (E) *Archidendron contortum*

4.3.1.2 Abandoned-Land Forest

Abandoned-land forest covers 7.0 ha or 14.6% and is solely distributed in the northern half of the EIA Study Area. It is interspersed with smaller areas of developed land and scrubland/ grassland and is bisected by Lock Road and Preston Road.

In the eastern half, the rubber tree (*Hevea brasiliensis*) is ubiquitous, strongly suggesting plantation activities in the past. In the western half, fruit trees like durian (*Durio zibethinus*), rambutan (*Nephelium lappaceum* var. *lappaceum*), as well as other crop species like oil palm (*Elaeis guineensis*) and coconut (*Cocos nucifera*), suggest small-scale plantation efforts and/or the cultivation trees for personal consumption by the past inhabitants of the area.

Although the abandoned-land forests are generally dominated by exotic cultivated species, they have been shown to support the re-colonisation of native species (Lugo & Helmer 2004; Mcshea et al., 2009; Edwards et al., 2011). Supporting this notion are the records of native tree species like Wild cinnamon (*Cinnamomum iners*) and Medang (*Litsea elliptica*), along with three other species of conservation significance: *Palaquium obovatum*, *Geophila herbacea* and *Goniophlebium percussum* observed in this habitat (**Picture 4-8**).

Picture 4-8: Representative Species from the Abandoned-land Forest within the EIA Study Area. (A) Durian (*Durio zibethinus*), (B) Rambutan (*Nephelium lappaceum* var. *lappaceum*), (C) Coconut (*Cocos nucifera*), (D) *Palaquium obovatum*, (E) *Geophila herbacea*

4.3.1.3 Exotic-Dominated Secondary Forest

Exotic-dominated secondary forest covers 10.1 ha or 21.1% of the EIA Study Area and forms the largest vegetated habitat type. It is largely concentrated in the eastern half, bounded between Telok Blangah Street 31 and Lock Road. A substantial area of this forest type also extends to the north-western corner of the EIA Study Area.

Much of this habitat is dominated by the very fast-growing, early successional species Albizia (*Falcataria falcata*), which covers large swathes of the EIA Study Area, amongst which are also *Acacia auriculiformis* concentrated in the central region. In the north-western corner however, the number of Albizia (*Falcataria falcata*) is greatly reduced, seemingly replaced by Saga (*Adenanthera pavonina*) and a few African tulip (*Spathodea campanulata*).

Although canopy species diversity is lower (compared to native-dominated secondary forest) in this habitat type, many large (≥3-m girth) individuals were recorded here including those of Albizia (*Falcataria falcata)*, Nibong palm (*Oncosperma tigillarium*), and Tembusu (*Cyrtophyllum fragrans*). The habitat is also host to keystone species like the common Red-stem fig (*Ficus variegata*) and Malayan banyan (*Ficus microcarpa*). Species of conservation significance are also evenly distributed throughout most of the habitat – notably, two critically endangered species, *Ficus sinuata* (7 individuals) and *Antiaris toxicaria* (1 individual) were recorded here, along with the vulnerable species *Horsfieldia polyspherula* (4 individuals) and white fig (*Ficus vasculosa,* 4 individuals) (**Picture 4-9**).

Picture 4-9: Representative Species of the Exotic-Dominated Secondary Forest Within the EIA Study Area. (A) Saga (*Adenanthera pavonina*), (B) Albizia (*Falcataria falcata*), (C) Nibong palm (*Oncosperma tigillarium*), (D) *Ficus sinuata*, (E) *Horsfieldia polyspherula*

4.3.1.4 Scrubland/ Grassland

Scrubland/ grassland covers 5.4 ha or 11.3%, broadly distributed towards the outer margins of the EIA Study Area. Large areas of this habitat type are found in the upper western half of the EIA Study Area running parallel to Alexandra Road, bordering exotic-dominated secondary forest and Telok Blangah Hill Park, and also on the eastern flank, running parallel to Telok Blangah Street 31 where it also borders exotic-dominated secondary forest, terminating as part of the Telok Blangah Archery Club compound in the south-east of the EIA Study Area.

This habitat type is dominated by numerous species of grasses and related genera, often in open areas with high exposure. Within the EIA Study Area, two main types of this habitat were recorded: Simpoh air (*Dillenia suffruticosa*) scrubland, and grassland. The Simpoh air (*Dillenia suffruticosa*) scrubland is characterised by dense stands of the native shrub, forming a short canopy and dim understory layer. In grassland, the habitat is characterised by the dense growth of grasses, small to medium-sized herbaceous species, often co-dominated by the fern *Nephrolepis biserrata* (**Picture 4-10**). The absence of a canopy layer often results in grasslands being exposed to strong light, air or wind movement, and fluctuating humidity levels.

A notable record from the habitat is *Burmannia coelestis*, an endangered native species of shrub. It was recorded as a substantially sized colony growing alongside other common scrubland species like *Utricularia caerulea* and *Palhinhea cernua*, at the eastern edge of EIA Study Area adjacent to the PUB Mount Faber Service Reservoir.

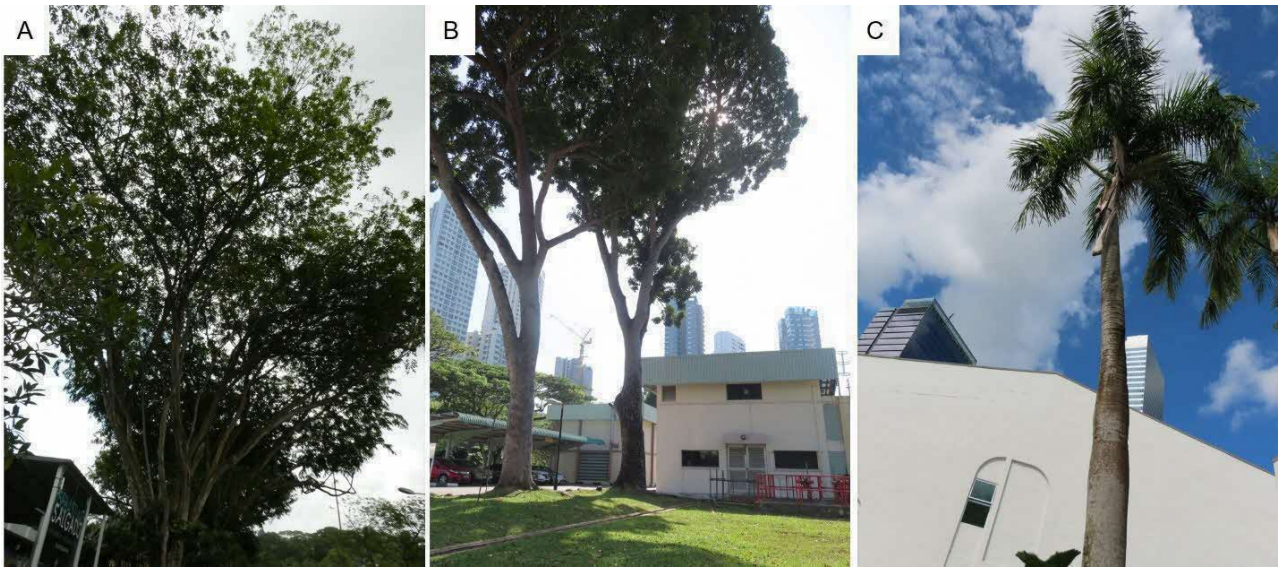
Picture 4-10: The Scrubland Habitat of the EIA Study Area. (A): Simpoh air (*Dillenia suffructicosa*) Scrubland, (B) Open Grassland at edge of Exotic-Dominated Secondary Forest at Lock Road, (C) *Burmannia coelestis*, (D) Habitat of Recorded B. *coelestis*

4.3.1.5 Urban Vegetation

Urban vegetation covers 4.6 ha or 9.6% and is the smallest vegetated habitat type within the EIA Study Area. It comprises a mix of cultivated exotics, streetscape trees, and managed turf, concentrated in and around the developed regions of the EIA Study Area starting from the cluster of former barrack buildings along Lock Road, extending south and south-east to 991 Alexandra Road and the PUB Telok Blangah Pumping Station.

Within the main cluster of former barrack buildings along Lock Road, there are ten recorded large (≥3-m girth/ spread) specimens: four Angsana (*Pterocarpus indicus*), three Malayan banyan (*Ficus microcarpa*), and one specimen each of Weeping fig (*Ficus benjamina*), Indian rubber tree (*Ficus elastica*) and Rain tree (*Samanea saman*). These were all recorded as streetscape trees lining Lock Road and associated car parks and service roads nearby (**Picture 4-11**).

Ten large specimens were also recorded in the south-eastern corner of the EIA Study Area, occupied by the PUB Telok Blangah Pumping Station and SP Group Telok Blangah District Office (partially vacated at time of study). These include five records of Rain tree (*Samanea saman*), two records each of Angsana (*Pterocarpus indicus*) and Senegal mahogany (*Khaya senegalensis*), and a single Weeping fig (*Ficus benjamina*) planted as hedging along the fence line of an office building.



Picture 4-11: Urban Vegetation of the EIA Study Area. (A) A Large Angsana (*Pterocarpus indicus*) along Lock Road, (B) Two Large Senegal Mahogany (*Khaya senegalensis*) on Managed Turf at the PUB Telok Blangah Pumping Station, (C) A Streetscape Palm, *Archontophoenix alexandrae*, at 991 Alexandra Road

4.3.1.6 Developed Land

Developed land covers the largest area of all the habitat types at 15.7 ha or 32.9% and is the only non-vegetated habitat type found within the EIA Study Area (**Picture 4-12**). This comprises interim residential dwellings, commercial properties, roads and related amenities such as car parks, and associated infrastructure. These areas are usually paved, with little to no planted vegetation.

Picture 4-12: Developed Land Within the EIA Study Area. (A) SP Group Telok Blangah District Office, (B) Gillman Barracks Core

4.3.2 Floristic Field Findings

A total of 293 plant species and species groups belonging to 97 families were recorded from the EIA Study Area (**Table 4-4**; **Appendix 4A**). Of these, 156 (53.2%) are native, 118 (40.3%) exotic, seven (2.4%) cryptogenic, ten (3.4%) have not been assessed, and two (0.7%) could not be identified to the species level.

There are 14 species groups in total, defined as plants that cannot be identified to species with certainty, comprising: (1) *Angelesia* cf. *splendens*; (2) *Callicarpa* cf. *longifolia;* (3) *Garcinia* cf. *nigrolineata;* (4) *Harpullia* cf. *ramiflora*; (5) *Hopea* cf. *sangal*; (6) *Ixonanthes* cf. *recticulata*; (7) *Knema* cf. *cinerea*; (8) *Litsea* cf. *castanea*; (9) *Memecylon* cf. *edule* var. *edule*; (10) *Parkia* cf. *sumatrana*; (11) *Shorea* cf. *roxburghii*; (12) *Shorea* cf. *sumatrana*; (13) *Syzygium* cf. *antisepticum*; and (14) *Syzygium* cf. *zeylanicum*. The two unidentified species groups comprise: (1) *Pandanus* cultivar, commonly known as pandan; and (2) *Renanthera* cultivar, an exotic orchid hybrid. Cryptogenic species represent those of uncertain origin despite being a species described.

The distribution of native species is higher in the central and northern areas of the EIA Study Area, where they expectedly concentrate in native-dominated secondary forests including Telok Blangah Hill Park but are also found throughout the EIA Study Area in urban vegetation as streetscape trees and cultivated specimens. Exotic species have an even distribution throughout the vegetated parts of the EIA Study Area.

Plants of conservation significance represent a group of native, nationally threatened species that have been accorded the following statuses: Vulnerable, Endangered, Critically Endangered, or Presumed Extinct. 67 of such species and species groups were recorded from the EIA Study Area (**Table 4-4**). However, a distinction was made to determine whether threatened species are indeed from native wild populations or instead cultivated specimens and escapees. Species belonging to the latter category may not be of conservation significance even though they have been accorded with a threatened status.

Table 4-4: Overall Number and Percentage of Plant Species, Including Cultivated Specimens

Origin	Status	Number of Species	Percentage (%)
Native	**Total**	**156**	**53.2**
	Least Concern	89	57.1
	Vulnerable	20	12.8
	Endangered	16	10.3
	Critically Endangered	30	19.2
	Presumed Extinct	1	0.6
Exotic	**Total**	**118**	**40.3**
	Cultivated Only	47	39.5
	Casual	37	31.9
	Naturalised	34	28.6
Cryptogenic	-	**7**	**2.4**
Unassessed	-	**10**	**3.4**
Unknown to Species Level	-	**2**	**0.7**
	Total	**293**	**100.0**

4.3.2.1 Plants of Conservation Significance

A total of 22 plant species and species groups of conservation significance were recorded in the EIA Study Area, including a single species group, *Litsea* cf. *castanea* (**Appendix 4B**). The other 45 threatened species are not considered of conservation significance because they are likely escapees from present-day cultivation, relics that have persisted from past cultivation, or are found within the managed landscaped spaces of the EIA Study Area, such as streetscape trees and cultivated areas of Telok Blangah Hill Park (**Table 4-5**). **Section 4.2.2** details the assessment criteria to determine if a threatened plant species is of conservation significance.

Altogether, 96 specimens and clusters were recorded, present in all vegetated habitat types except urban vegetation and distributed with a slight concentration in the upper half of the EIA Study Area (**Table 4-6; Figure 4-5**). A significant population of 25 specimens and clusters of the endangered *Archidendron contortum* are concentrated in the eastern edge of Telok Blangah Hill Park within the EIA Study Area boundary. Although these occur close to cultivated areas of the park, they were determined to be a natural population. The two recorded critically endangered species *Antiaris toxicaria* (1 specimen) and *Ficus sinuata* (8 specimens), both occur in exotic-dominated secondary forest patches adjacent to native-dominated secondary forest (**Figure 4-5**).

Table 4-5: Overview of Plant Species of Conservation Significance

	Vulnerable	Endangered	Critically Endangered	Presumed Extinct	Total
Non-cultivated Species	13	7	2	0	**22**
Cultivated Species	7	9	28	1	**45**
Total	20	16	30	1	**67**

Table 4-6: Distribution of Plant Species of Conservation Significance by Habitat Type

	Vulnerable	Endangered	Critically Endangered	Presumed Extinct	Total Number of CS Specimens/Clusters
Native-dominated Secondary Forest	9	28	1	0	38
Abandoned-land Forest	20	5	0	0	25
Exotic-dominated Secondary Forest	17	4	8	0	29
Scrubland/ Grassland	3	1	0	0	4
Urban Vegetation	0	0	0	0	0
Total	49	38	9	0	96

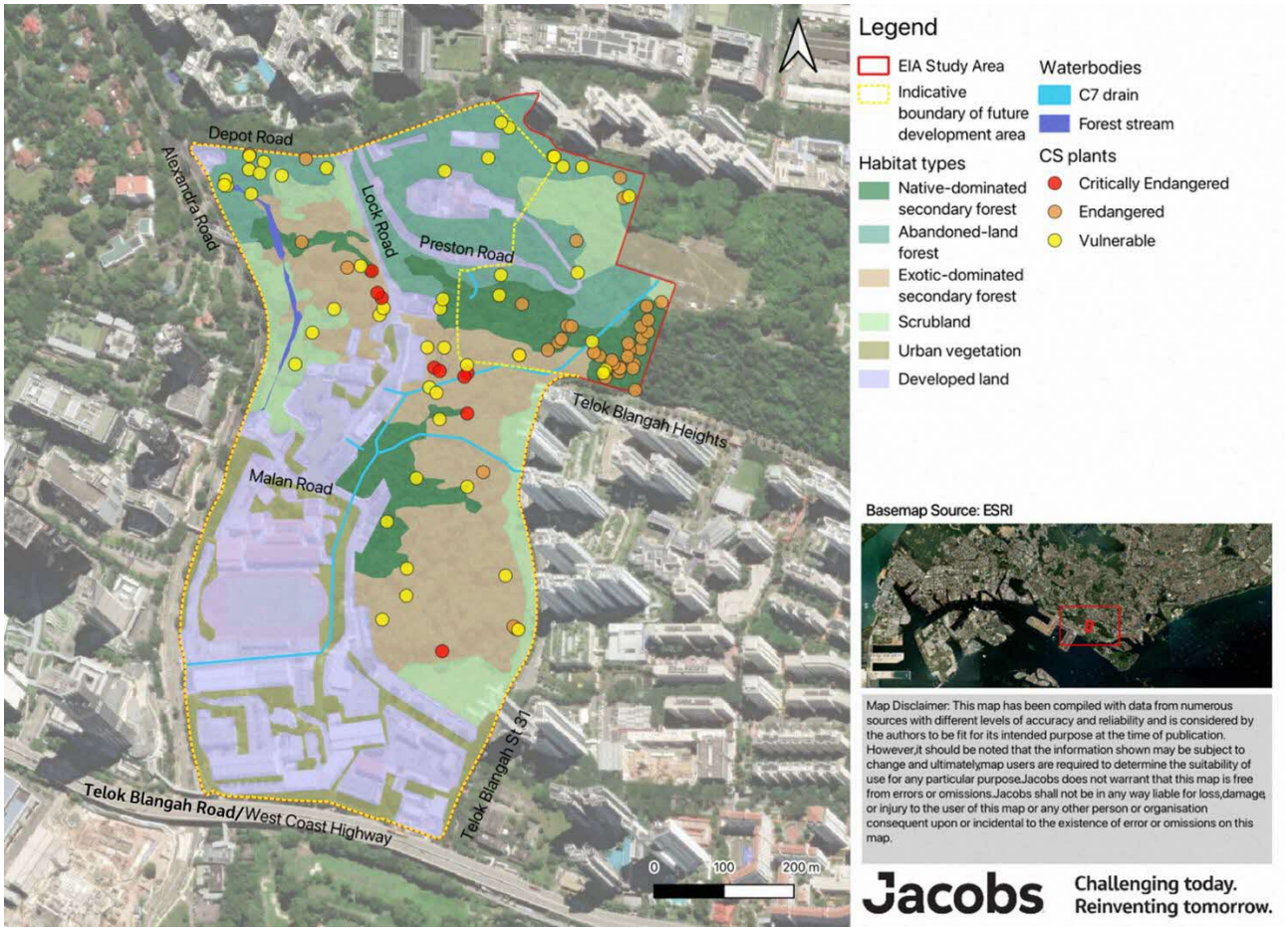


Figure 4-5: Distribution of Plants of Conservation Significance

4.3.2.2 Large Specimens

Large specimens are defined as having a spread or girth of at least 3.0 m. A total of 176 large plant specimens belonging to 23 species of native and exotic origin were recorded in the EIA Study Area (**Figure 4-6**; **Appendix 4C**), comprising 122 trees (3 to 6.2-m girth), 25 stranglers (3 to 20-m spread), 20 bamboo clusters (3–20-m spread) and 9 palms (3-10.2m spread). Large specimens are quite evenly distributed across the EIA Study Area, with notable clusters of Tembusu (*Cyrtophyllum fragrans*) and *Bambusa vulgaris* in the native-dominated secondary forest. No large specimens of species of conservation significance were recorded.

The three most abundant tree species in the EIA Study Area are (in descending order): Albizia (*Falcataria falcata*) (50 specimens), Rain tree (*Samanea saman*, 21 specimens), and Tembusu (*Cyrtophyllum fragrans*, 12 specimens). While of exotic origin, the clusters of *Bambusa vulgaris* are still valuable because they are refugia for Bamboo bats (*Tylonycteris* spp.) (**Picture 4-13D**).

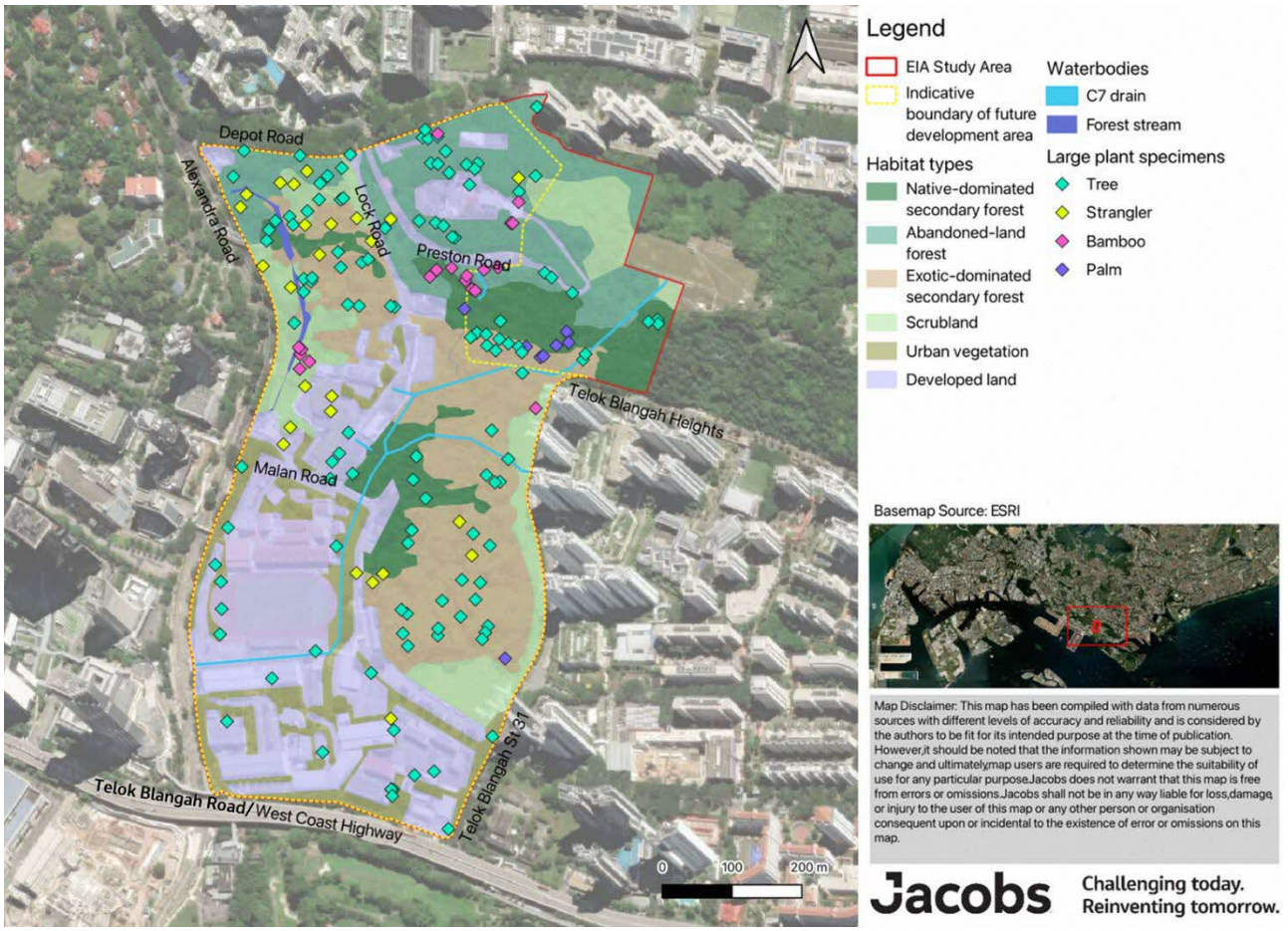


Figure 4-6: Distribution of Large Plant Specimens

Picture 4-13: Large Specimens Recorded Within the EIA Study Area. (A) Albizia (*Falcataria falcata*), (B) Rain Tree (*Samanea saman*), (C) Tembusu (*Cyrtophyllum fragrans*), (D) *Bambusa vulgaris*

4.3.2.3 Other Specimens of Value

40 other specimens of value were recorded, with a higher number occurring in the top half of the EIA Study Area. Eight specimens each were recorded from native- and exotic-dominated secondary forests and abandoned-land forests, 13 from urban vegetation (as streetscape and/or cultivated trees), and three from scrubland (**Figure 4-7**, **Appendix 4D**). Most specimens of value (35 specimens) are keystone species, species that play a disproportionately large role in their ecological community, belonging to the genus *Ficus*. Of the specimens recorded in exotic-dominated secondary forest, one specimen of Albizia (*Falcataria falcata*) holds a raptor nest, which at the point of observation, could not be determined as active. Four *Bambusa vulgaris* clusters (of less than 3-m spread) were also recorded – three bordering Preston Road, and one within the ISS International School compound as a cultivated specimen (**Picture 4-14**).

Picture 4-14: Other Plant Specimens of Value Recorded within the EIA Study Area. (A) Red-stem fig (*Ficus variegata*), (B) Raptor nest (purple arrow) in Albizia (*Falcataria falcata*), (C) *Bambusa vulgaris*

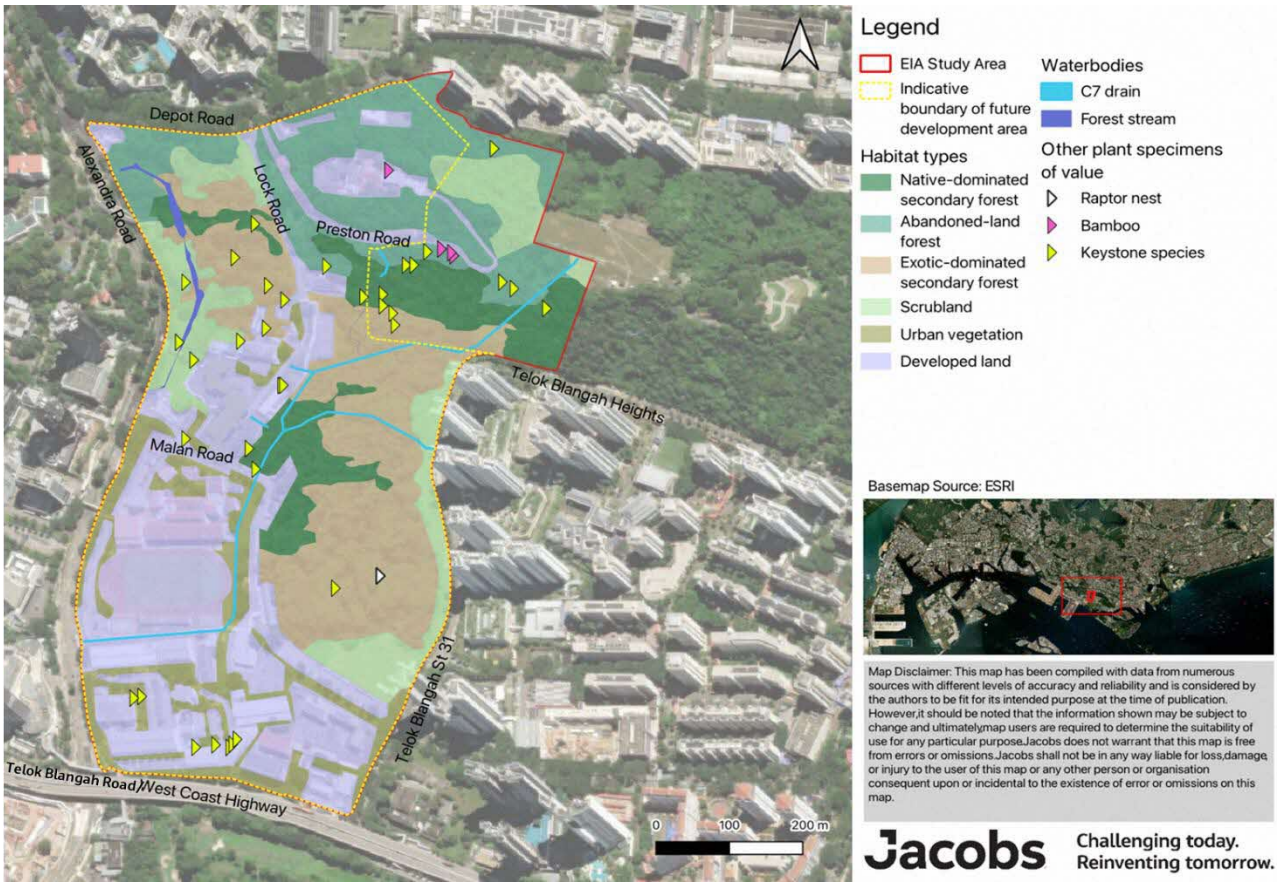


Figure 4-7: Distribution of Other Plant Specimens of Value

4.3.2.4 Tree Distribution

A total of 1,566 trees of girth ≥1m were mapped within the EIA Study Area **(Figure 4-8, Appendix 4E),** of which 406 are native (25.93%), 1,117 exotic (71.33%), and 43 (2.74%) are of cryptogenic origin. The number of specimens recorded in each vegetated habitat type is summarised in **Table 4-7**.

Table 4-7: Distribution of Trees ≥1m girth

	Native-dominated Secondary Forest	Abandoned-land Forest	Exotic-dominated Secondary Forest	Scrubland/ Grassland	Urban Vegetation	Developed Land	Total
Number of Trees (≥1m girth)	273	320	621	79	73	200	**1,566**
Percentage (%) of Total	17.4	20.4	39.7	5.0	4.7	12.8	**100**

The exotic-dominated secondary forest contains the highest number of mapped trees amongst the habitat types at 621 trees or 39.7%. This can be attributed to the abundance of the very fast-growing, early successional species Albizia (*Falcataria falcata*), which accounts for most of the mapped trees within exotic-dominated secondary forests in the EIA Study Area.

A total of nine specimens of species of conservation significance were tagged, comprising four different species: (1) *Endospermum peltatum* (3 specimens; girth 1.3-1.7 m; height 15-25 m), (2) common Red-stem fig (*Ficus vasculosa;* 4 specimens; girth 1.1-2.1 m; height 16-20 m), (3) *Palaquium obovatum* (1 specimen; girth 1.4 m; height 14 m), and (4) *Symplocos adenophylla* (1 specimen; girth 0.3 m; height 5 m).

The three most abundant species tagged, in descending order, are: (1) Albizia (*Falcataria falcata*) (360 specimens); (2) Rubber (*Hevea brasililensis*, 285 specimens); and (3) Saga (*Adenanthera pavonina*, 62 specimens).

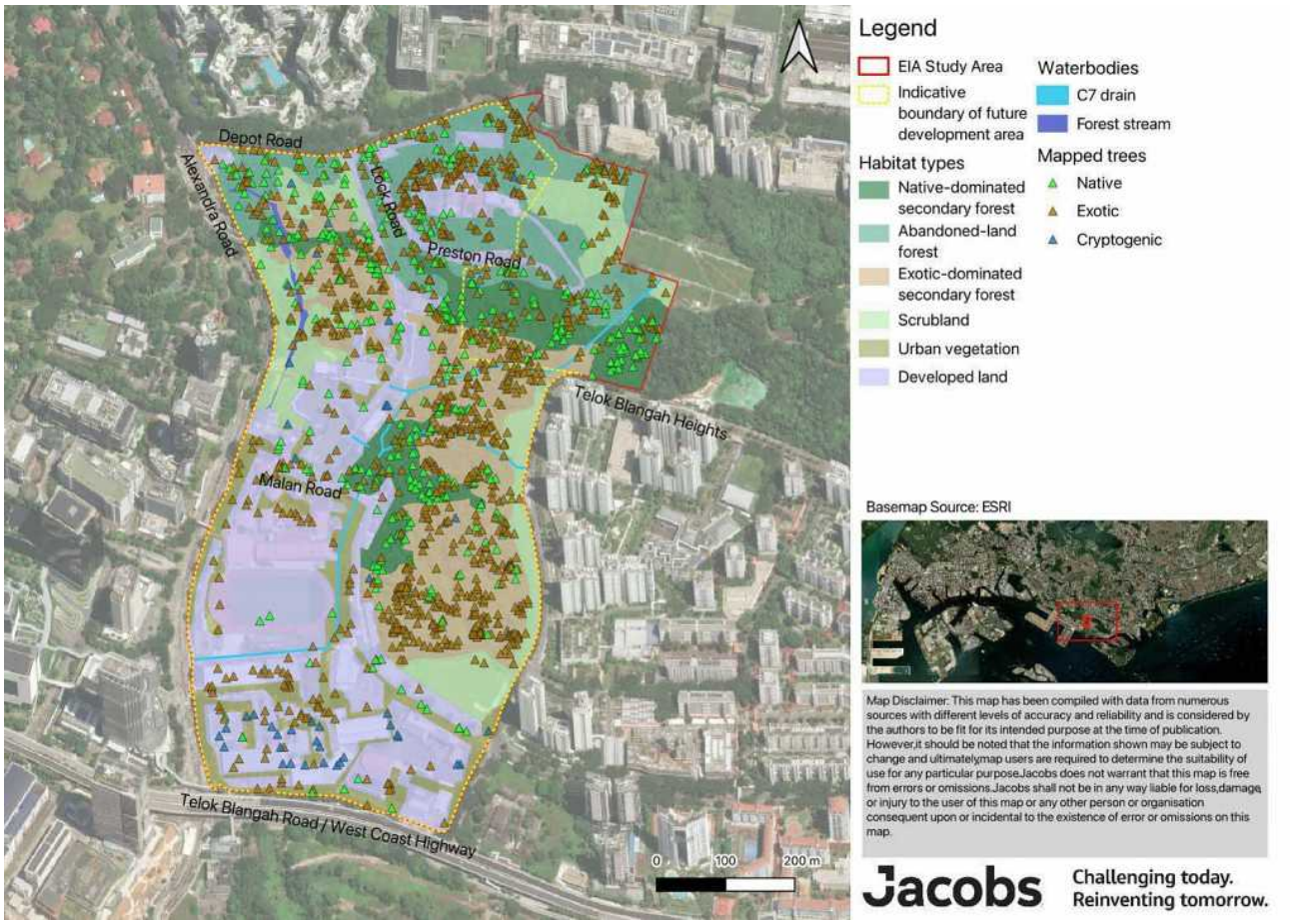


Figure 4-8: Distribution of Trees (≥1-m girth) within the EIA Study Area

4.3.3 Faunistic Field Findings

4.3.3.1 Overall

A total of 178 species were observed during field assessment, of which 11 were of conservation significance **(Table 4-8)**. The findings for each faunal group are presented in **Section 4.3.3.4** to **Section 4.3.3.11**.

Table 4-9 outlines the faunal species of conservation significance along with their respective conservation statuses. The majority of them were birds, which were distributed across the EIA Study Area (**Figure 4-9**). Bamboo bats were also detected roosting in bamboo clusters within the EIA Study Area (**Figure 4-10**).

In addition to the species recorded during field assessment, CS species of probable occurrence were also included also included in **Table 4-8**. The full list of species, including recorded species and CS species of probable occurrence, is given in **Appendix 4F**. Detailed faunal survey data and camera trap results can be found in **Appendix 4G** and **Appendix 4H**, respectively.

Table 4-8: Summary of Recorded Faunal Species

Faunal Group	Total No. of Recorded Species		CS Species of Probable Occurrence
	All Species	CS Species	CS Species
Aculeata	**20**	**0**	**0**
Odonates	**12**	**0**	**1**
Dragonflies	10	0	1
Damselflies	2	0	0
Butterflies	**38**	**0**	**36**
Herpetofauna	**17**	**0**	**5**
Amphibians	6	0	0
Reptiles	11	0	5
Birds	**77**	**10**	**24**
Mammals	**9**	**1**	**7**
Non-volant Mammals	4	0	3
Bats	5	1*	4*
Fish	**5**	**0**	**0**
Total	**178**	**11**	**73**

*Note: *One recorded species could not be determined to species level from field survey data, and is recorded at the genus level as unidentified Bamboo bat (Tylonycteris sp.) As it is represented by either the Greater bamboo bat (Tylonycteris malayana) or Lesser Bamboo bat (Tylonycteris fulvida), both of which were as probable species, there is an overlap of one species in the total recorded species and probable species count.*

Table 4-9: List of Faunal Species of Conservation Significance Recorded

	Taxon	Species	Common Name	Global Status	National Status
1	Bird	*Pycnonotus zeylanicus*	Straw-headed bulbul	Critically Endangered	Endangered
2	Bird	*Psittacula longicauda*	Long-tailed parakeet	Vulnerable	Near Threatened
3	Bird	*Chrysococcyx xanthorhynchus*	Violet cuckoo	Least Concern	Vulnerable
4	Bird	*Copsychus saularis*	Oriental magpie-robin	Least Concern	Vulnerable
5	Bird	*Corvus macrorhynchos*	Large-billed crow	Least Concern	Vulnerable
6	Bird	*Ixobrychus cinnamomeus*	Cinnamon bittern	Least Concern	Vulnerable
7	Bird	*Ixobrychus sinensis*	Yellow bittern	Least Concern	Vulnerable
8	Bird	*Nisaetus cirrhatus*	Changeable hawk-eagle	Least Concern	Vulnerable
9	Bird	*Surniculus lugubris*	Square-tailed drongo-cuckoo	Least Concern	Vulnerable
10	Bird	*Zosterops simplex*	Swinhoe's white-eye	Least Concern	Vulnerable
11	Mammal	*Tylonycteris* sp.	Unidentified Bamboo bat	Least Concern	Vulnerable

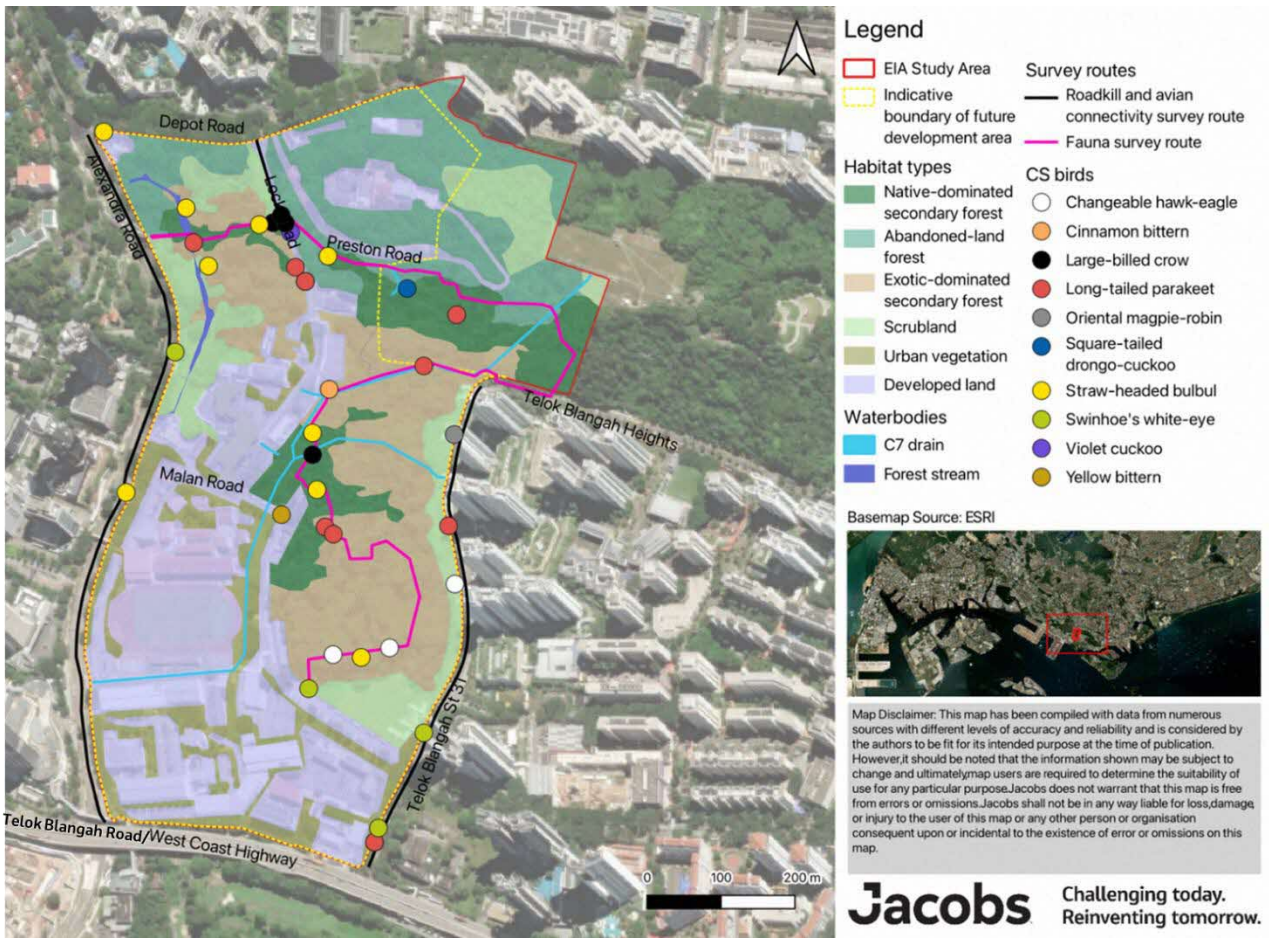


Figure 4-9: Distribution of Species of Conservation Significance (Birds)

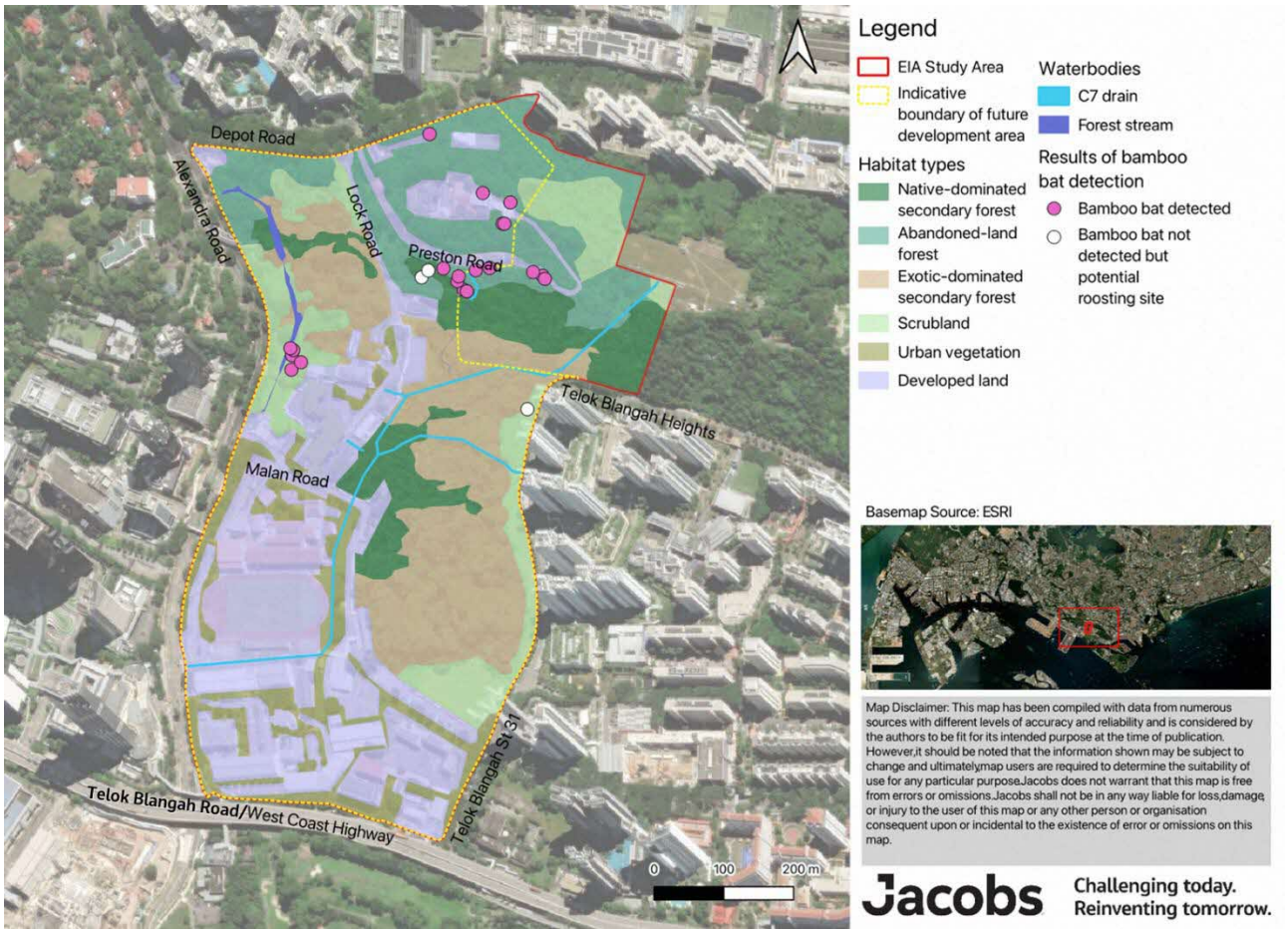


Figure 4-10: Distribution of Species of Conservation Significance (Bamboo Bats)

4.3.3.2 Taxon Sampling Curves

Taxon sampling curves were generated to estimate the sample completeness of our surveys.

Sampling coverage was generally high across both terrestrial and aquatic surveys, exceeding 80% for most taxa (**Figure 4-11; Figure 4-12**). The exception was odonates, with lower coverage observed in both terrestrial (71.3%) and aquatic (72.7%) surveys. This may be attributed to the survey period coinciding with the Northeast Monsoon (late 2024 to early 2025), during which frequent rainfall and cloudy weather was observed. Under such conditions, odonates are typically less active and harder to detect.

With doubled sampling effort, additional species may be detected, with species richness estimates at 95% interval confidence shown in **Table 4-10** and **Table 4-11**.

The sampling curve for the aculeate was omitted due to the high diversity of the taxon. Given this, two survey cycles are inherently insufficient to capture species richness, and the resulting curve would not be a meaningful indicator of sampling coverage.

Table 4-10: Taxon Sample Coverage for Terrestrial Transects

Taxon	Sample Coverage (%)	Observed	Estimated ±S.E.	Richness Estimate (95% lower)	Richness Estimate (95% upper)
Bird	87.7	49	64.3	54.0	96.0
Butterfly	82.1	37	54.0	42.5	89.5

Taxon	Sample Coverage (%)	Observed	Estimated ±S.E.	Richness Estimate (95% lower)	Richness Estimate (95% upper)
Herpetofauna	88.9	16	27.6	18.1	80.5
Mammal	89.5	6	6.9	6.1	19.0
Odonata	71.3	9	20.8	10.6	97.8

Table 4-11: Taxon Sample Coverage for Aquatic Surveys

Taxon	Sample Coverage (%)	Observed	Estimated ±S.E.	Richness Estimate (95% lower)	Richness Estimate (95% upper)
Amphibian	83.1	4	4.9	4.1	16.3
Fish	96.9	5	5.5	5.0	12.9
Odonata	72.7	7	14.3	7.9	66.6

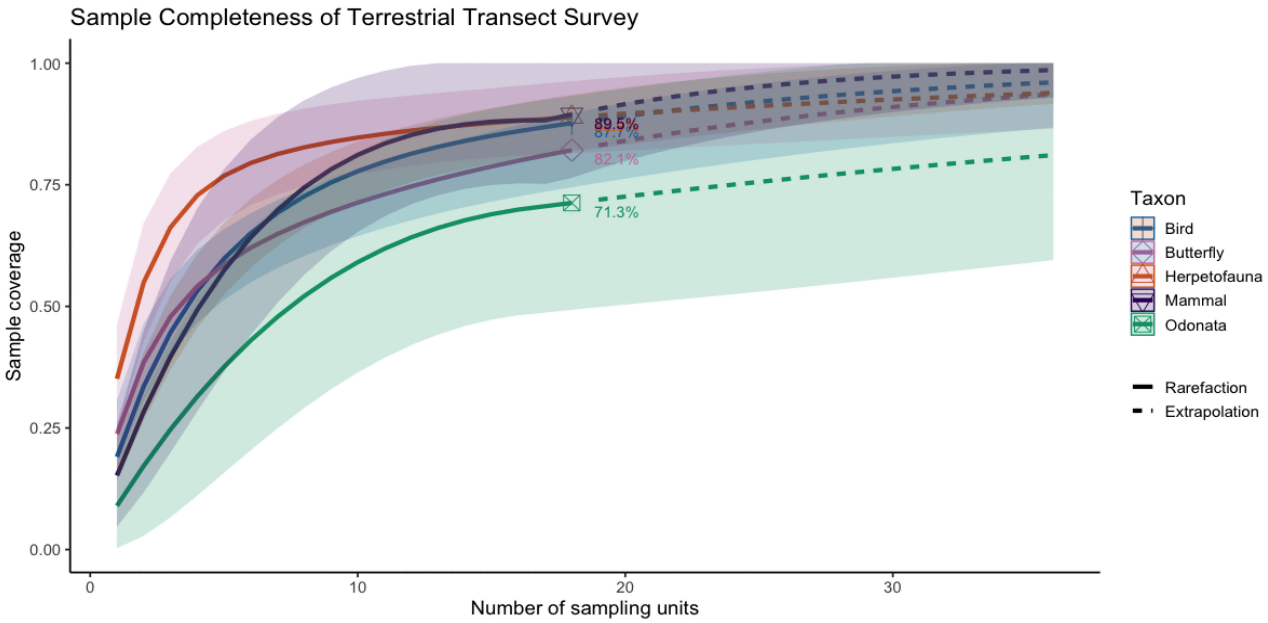


Figure 4-11: Taxon Sampling Curves for Faunal Groups (Terrestrial)

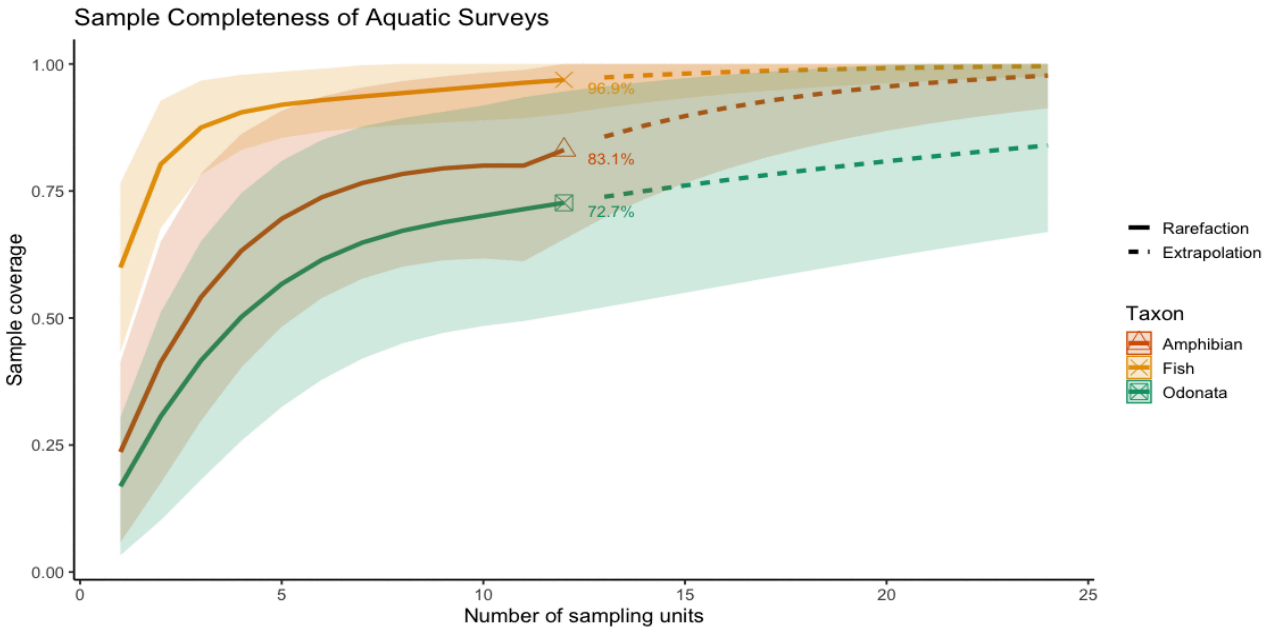


Figure 4-12: Taxon Sampling Curves for Faunal Groups (Aquatic)

4.3.3.3 Aculeata

A total of 20 species of aculeate hymenopterans were recorded, with 9 species of bees and 11 species of wasps. None of the aculeata were of conservation significance.

The most common aculeata recorded was the Asian honeybee (*Apis cerana*). Fifty individuals were seen feeding on the fruits of a fishtail palm at the abandoned-land Forest in the south of the EIA Study Area.

Several of the species observed are forest-dependent species, including the *Ropalidia erythrospila, and Liostenogaster varipicta* (J. X. Q. Lee, personal communication, 11 July 2025).

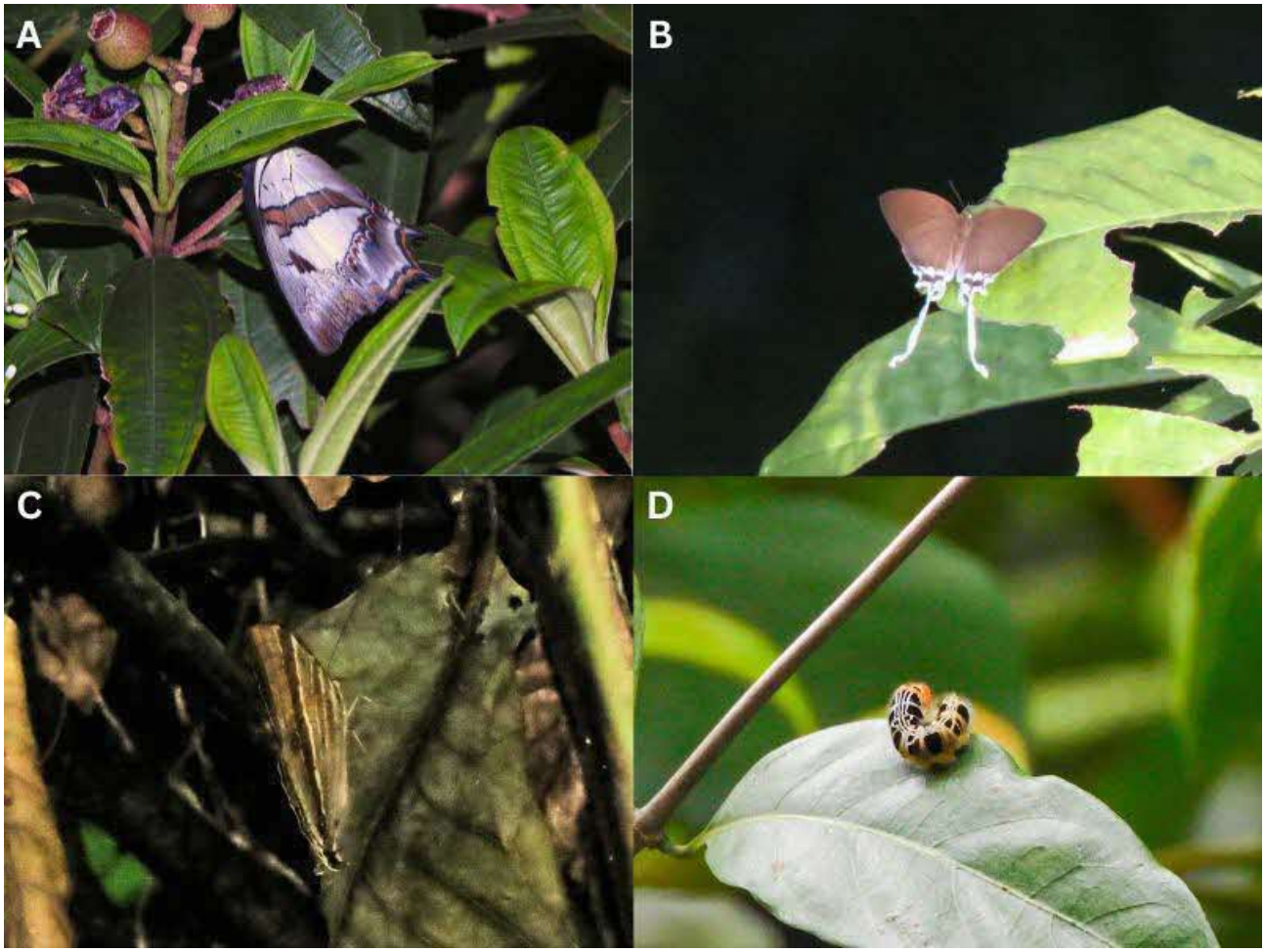
One nest belonging to a species of Hover wasps (*Parischnogaster mellyi*) was observed **(Picture 4-15)**. This indicates the suitability of the forests as a nesting and breeding ground for bee species.

Picture 4-15: *Parischnogaster mellyi* specimen from the EIA Study Area

4.3.3.4 Butterflies

During field assessment, 38 species of butterflies were recorded within the EIA Study Area. None of the recorded species are of conservation significance.

Of the recorded species, four are considered moderately rare in Singapore: the Blue nawab (*Polyura schreiber tisamenus*), Common imperial (*Cheritra freja frigga*), Palm king (*Amathusia phidippus phidippus*), and Orange awlet (*Bibasis harisa consobrina*) (**Picture 4-16**).



Picture 4-16. Moderately Rare Butterflies Observed During Field Surveys (A) Blue nawab; (B) Common imperial; (C) Palm king; (D) Orange awlet

Many species observed are commonly associated with open habitats (Khew, 2015). This includes Bush brown species like the Burmese bush brown (*Mycalesis perseoides persoides*) and Long brand bush brown (*Mycalesis visala phamis*).

Additionally, species associated with forest edges and urban parks were also sighted, including the Common imperial (*Cheritra freja frigga*), Scarce silverstreak (*Iraota rochana boswelliana*), and Palm king (*Amathusia phidippus phidippus*) (Khew, 2015).

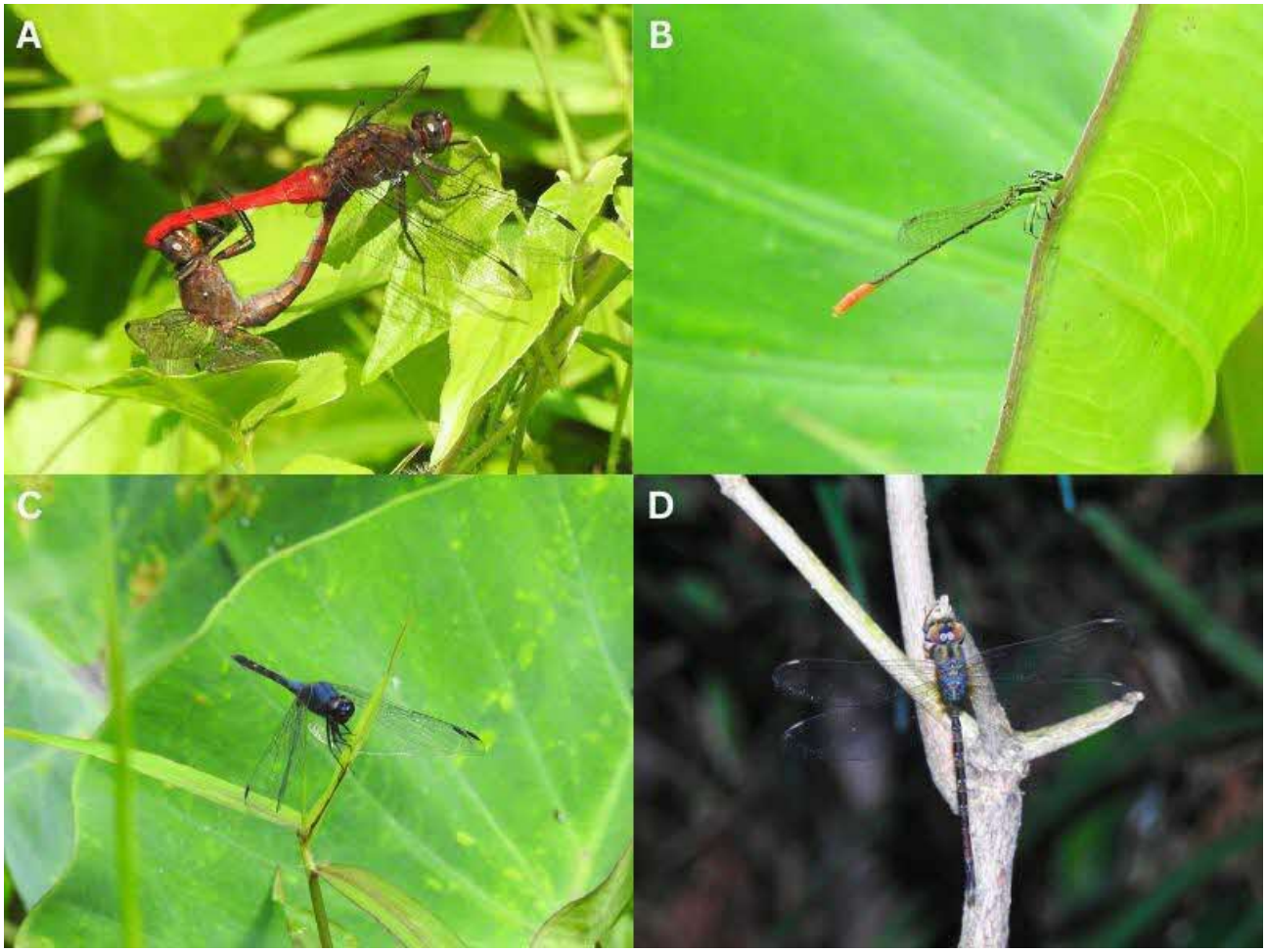
A few forest-dependent species were also recorded. Two observations are of note: the Orange awlet (*Bibasis harisa consobrina*) and Branded imperial (*Eooxylides tharis distanti*) were recorded at two separate patches of native-dominated secondary forest within the EIA Study Area. Both species are rarely seen outside of Singapore's nature reserves, and their presence highlight the quality of the EIA Study Area's mature secondary forests (Khew, 2015).

4.3.3.5 Odonates

During field assessment, 12 species of odonates were recorded, including 10 dragonflies and two damselflies. All but one species is widespread and common. The Dingy duskhawker (*Gynacantha subinterrupta*) is widespread but uncommon. All odonate species sighted are native to Singapore and none are of conservation significance.

Six of the species observed have high tolerance to human disturbance (Ngiam & Ng, 2022). These include the Spine-tufted skimmer (*Orthetrum chrysis*) and Variable wisp (*Agriocnemis femina*) (**Picture 4-17**).

Most observations were made along the natural stream WQ2 in the north-western part of the EIA Study Area.



Picture 4-17: Odonates Observed During Field Assessment: (A) A Mating Pair of Spine-Tufted Skimmers; (B) Variable Wisp; (C) Indigo Dropwing; (D) Dingy Duskhawker

4.3.3.6 Amphibians

Six species of amphibians were recorded, of which three are non-native. None of them are of conservation significance.

The assemblage is dominated by species commonly found in urban areas, parks and gardens, such as Bengal toad (*Duttaphrynus bengalensis*), Four-lined tree frog (*Polypedates leucomystax*) (**Picture 4-18**) and Greenhouse frog (*Eleutherodactylus planirostris*) (Baker & Lim, 2008). These species are widespread and common and are tolerant of disturbance. They can be found near or in human habitation (Baker & Lim, 2008).

In addition, three species of Microhylid frogs were recorded: Painted chorus frog (*Microhyla butleri*), Dark-sided chorus frog (*Microhyla heymonsi*), and Mukhlesur's chorus frog (*Microhyla mukhlesuri*).

Picture 4-18: Mating Pair of Four-Lined Tree Frogs Found in an Ephemeral Waterbody within the EIA Study Area

4.3.3.7 Reptiles

Eleven species of reptiles were recorded during field assessment. This comprised seven lizard, three snake, and one turtle species.

Most of the species observed were common and well-adapted to disturbed or urban habitats (Baker & Lim, 2008). Geckos such as the Spiny-tailed house gecko (*Hemidactylus frenatus*), Spotted house gecko (*Gekko monarchus*), and Four-clawed gecko (*Gehyra mutilata*) were found along the bridges in the EIA Study Area.

The forest-dependent Green-crested lizard (*Bronchocela cristatella*), which is widespread but uncommon, was also recorded (**Picture 4-19A**). This native species used to be common in Singapore, but their population has declined in recent years (Baker & Lim, 2008). It is hypothesised to be a result of displacement by the Changeable lizard (*Calotes versicolor*), an introduced species which was also observed in the EIA Study Area (Baker & Lim, 2008).

Three snake species were observed, including the Oriental whip snake (*Ahaetulla prasina*) and Painted bronzeback (*Dendrelaphis pictus*), both commonly associated with urban parks and forest edges **Picture 4-19 B, C)** (Baker & Lim, 2008). A single individual of the White-spotted slug snake (*Pareas margaritophorus*), an uncommon non-native species, was also observed (**Picture 4-19D**).

Additionally, Monitor lizards (*Varanus sp.*), were recorded at two camera trap locations. A Red-eared slider (*Trachemys scripta*), a non-native turtle commonly released from the pet trade, was observed in one of the waterbodies.

Picture 4-19: Reptiles Observed During Field Assessment: (A) Green-Crested Lizard; (B) Oriental Whip Snake; (C) Painted Bronzeback; (D) White-Spotted Slug Snake

4.3.3.8 Birds

A total of 77 bird species were recorded during the field assessment, reflecting a relatively high level of avian diversity across the EIA Study Area.

The assemblage was dominated by resident species, many of which are commonly associated with forested habitats. Typical forest species observed included the Pin-striped tit-babbler (*Mixornis gularis*), Pink-necked green pigeon (*Treron vernans*), and Greater racket-tailed drongo (*Dicrurus paradiseus*). In addition, several uncommon forest-dependent species were recorded, such as Square-tailed drongo-cuckoo (*Surniculus lugubris*) and Violet cuckoo (*Chrysococcyx xanthorhynchus*), both of which are species that are locally Vulnerable.

Ten of the recorded species are of conservation significance. Of note was the globally critically endangered Straw-headed bulbul (Pycnonotus zeylanicus), a forest-dependent species which was observed multiple times throughout the EIA Study Area. The Straw-headed bulbul is a highly sought-after for the songbird trade due to its melodious song. This has resulted in its extirpation throughout much of its range and is consequently listed as a Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)-protected species. Its global conservation status was revised from Endangered to Critically Endangered in 2018 as populations declined rapidly. According to Yong et al (2018), up to one-third of the global population occurs

in Singapore, with a local population size of slightly over 200 birds. Although the local population has grown more stable, with its local status revised from critically endangered to endangered in the Singapore Red Data Book (3rd edition), habitat loss to development remains a primary threat to species (Davison et al., 2024). Thus, given that multiple observations of the Straw-headed bulbul were made across the EIA Study Area, it is essential for parts of the forests to be conserved to maintain a viable population of this species. The species is also associated with waterbodies (Lim et al., 2023).

Raptors were also well-represented. Multiple observations of the vulnerable Changeable hawk-eagle (*Nisaetus cirrhatus*), alongside other species like the Oriental honey buzzard (*Pernis ptilorhynchus*) and Crested goshawk (*Accipiter trivirgatus*) were made. A raptor nest was noted near some of these observations, suggesting potential breeding activity (see **Figure 4-9**). Raptors are typically associated with wooded environments and benefit from mature forest cover.

Water birds such as Cinnamon bittern (*Ixobrychus cinnamomeus*) and Yellow bittern (*Ixobrychus sinensis*) were also recorded near the C7 drain (WQ1 and WQ3-5), indicating that the C7 drains within the central portion of the EIA Study Area support wildlife (**Picture 4-20D**). Both species are considered locally vulnerable.

Picture 4-20: Birds of Conservation Significance Observed: (A) Square-tailed Drongo-Cuckoo; (B) Straw-headed Bulbul; (C) Changeable Hawk-Eagle; (D) Cinnamon Bittern

Outside of the forested areas, urban-adapted species were also observed. These included the Yellow-vented bulbul (*Pycnonotus goiavier*), White-throated kingfisher (*Halcyon smyrnensis*), and Golden-bellied gerygone (*Gerygone sulphurea*). The Oriental magpie-robin (*Copsychus saularis*), a vulnerable species due to pressure from the songbird trade, was also recorded.

In addition to resident birds, several migratory species were observed. Common winter visitors included the Blue-throated bee-eater (*Merops viridis*), Asian brown flycatcher (*Muscicapa dauurica*), and Arctic warbler

(*Phylloscopus borealis*). Uncommon migrants included the Crow-billed drongo (*Dicrurus annectans*) and Malayan night heron (*Gorsachius melanolophus*), the latter of which is an elusive forest species that was only observed on camera traps (**Picture 4-21A**) (Bird Society of Singapore, n.d.). Particularly notable were rare migrants such as the Slaty-legged crake (*Rallina eurizonoides*) and Oriental scops owl (*Otus sunia*). These observations indicate the value of the site as a stopover or wintering habitat for migratory birds (**Picture 4-21B, C**).

The presence of forest-dependent, water-associated, and migratory species—alongside urban-adapted taxa—highlights the ecological richness of the EIA Study Area. In particular, the forested sections play a vital role in sustaining both common and species of conservation significance, underscoring the importance of retaining these habitats.

Picture 4-21: Uncommon and Rare Migratory Birds Observed: (A) Malayan Night Heron; (B) Slaty-Legged Crake; (C) Oriental Scops-Owl

4.3.3.9 Mammals (Non-Volant)

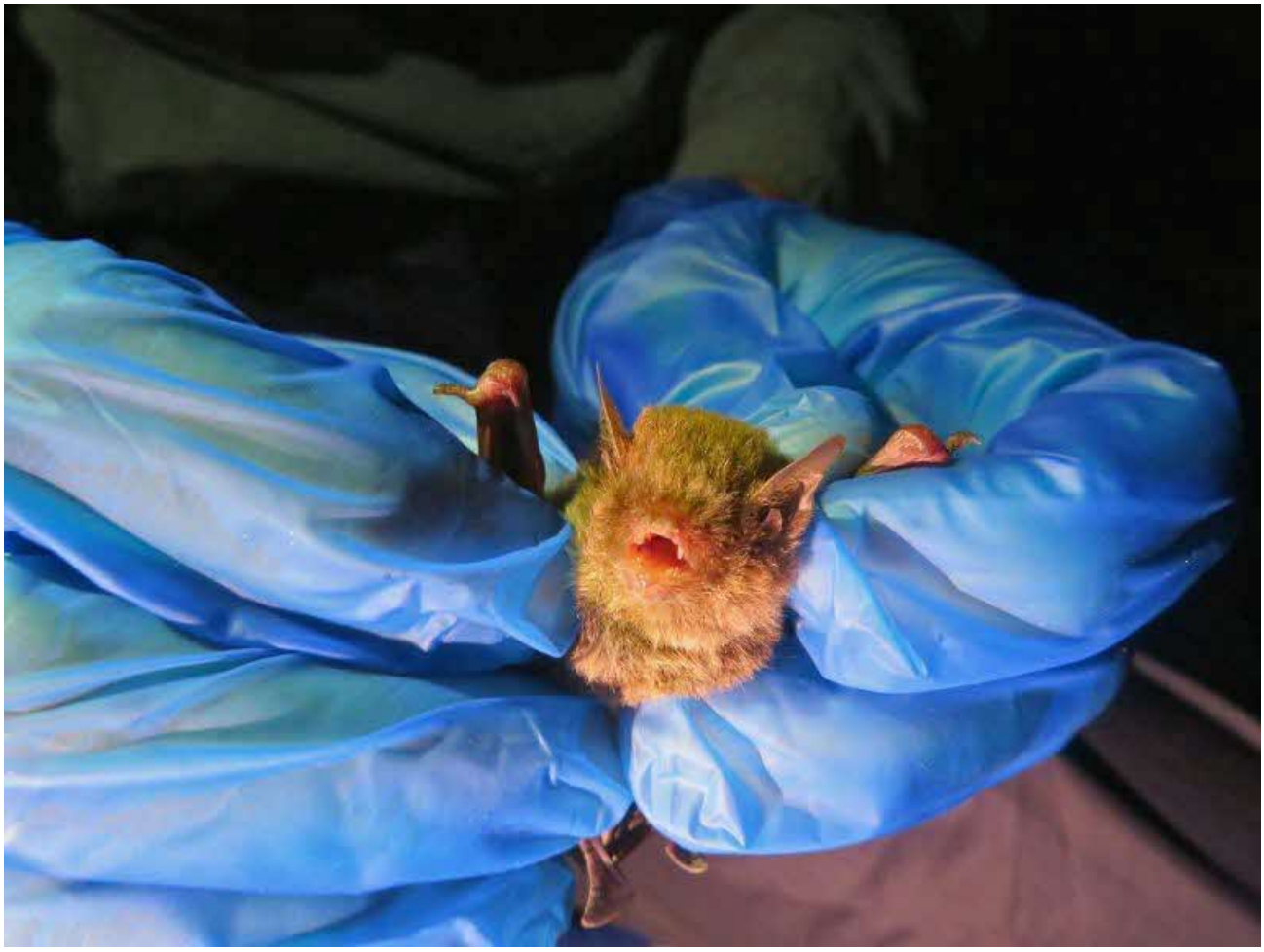
Four species of non-volant mammals were recorded during the field assessment: the Common treeshrew (*Tupaia glis*), Plantain squirrel (*Callosciurus notatus*), Sumatran palm civet (*Paradoxurus musangus*), and an unidentified rat species (*Rattus* sp.). None of the species are of conservation significance.

All four species were detected through both transect surveys and camera traps. Camera trap data yielded 129 independent detections of unidentified rats, 70 independent detections of Common treeshrew, 50 independent detections of Plantain squirrels, and 21 independent detections of Sumatran palm civets, including a juvenile (**Picture 4-22**).

Picture 4-22: A Juvenile Sumatran Palm Civet Recorded by a Camera Trap

4.3.3.10 Mammals (Bats only)

During the field assessment, five species of bats were recorded. Four species of insectivorous bats were detected, primarily through acoustic recordings. They include the Black-bearded tomb bat (*Taphozous melanopogon*), which is widespread but rare. All other species recorded, the Pouch tomb bat (*Saccolaimus saccolaimus*), Asian whiskered myotis (*Myotis muricola*) and Lesser Asian house bat (*Scotophilus kuhlii*) are widespread and common. One specimen of the Asian whiskered myotis was caught during the harp trapping and promptly released after measurements were taken (**Picture 4-23**).



Picture 4-23: Asian Whiskered Myotis Specimen from Harp Trapping

One species of frugivorous bat, the Lesser short-nosed fruit bat (*Cynopterus brachyotis*) was detected during the transect surveys. Notably, multiple individuals were sighted feeding at a *Ficus variegata* specimen, highlighting the ecological importance of floral keystone species in the habitat (**Picture 4-24**).

Picture 4-24: Multiple Lesser Short-Nosed Fruit Bats (Circled in White) Foraging at a *Ficus variegata* Specimen

Additionally, Bamboo bats (*Tylonycteris* sp.) were detected at several bamboo clusters across the EIA Study Area, with clusters near the southern part of the forest stream WQ2, and along Preston Road (**Figure 4-13; Figure 4-10**). While the two species that are present in Singapore cannot be reliably distinguished through acoustic recordings, both the Greater bamboo bat (*Tylonycteris malayana*) and Lesser bamboo bat (*Tylonycteris fulvida*) are listed as locally vulnerable (National Parks Board et al., 2024). The presence of Bamboo bats has important implications for future development, as these species roost within bamboo stems and are particularly susceptible to injury and mortality during bamboo felling. As such, any bamboo felling during site clearance will require further monitoring and mitigation measures under the EMMP, including clusters where bats were not detected during this current study.

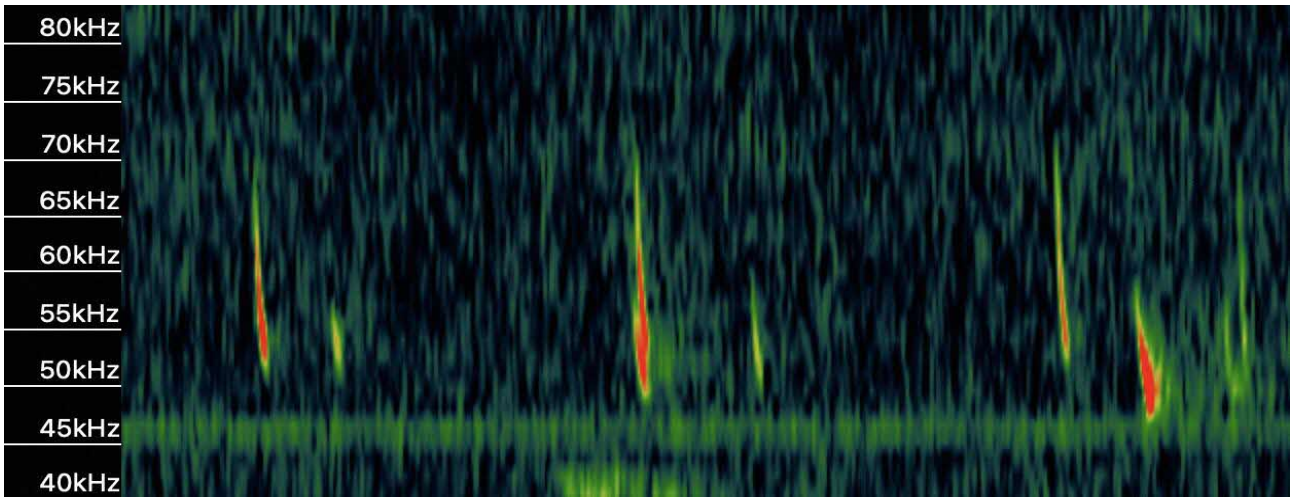


Figure 4-13: Acoustic Recording Capturing Bamboo Bat Calls

4.3.3.11 Fish

Five species of fish were detected in the freshwater habitats of the EIA Study Area. None of them are of conservation significance.

Two native species were observed, included the Oriental swamp eel (*Monopterus albus*) and Common walking catfish (*Clarias batrachus*), both of which are tolerant of low-oxygen conditions and can survive in disturbed habitats (**Picture 4-25**) (Ho et al., 2016).

Large numbers of exotic species including the Guppy (*Poecilia reticulata*) and Mosquitofish (*Gambusia affinis*), were observed. A single Southern platy (*Xiphophorus maculatus*) was also recorded. These were likely introduced from the aquatic pet trade.

Picture 4-25: Freshwater Fish: (A) Common Walking Catfish, (B) Oriental Swamp Eel

4.3.4 Faunal Connectivity and Comparison with the Berlayar (Former Keppel Club) EIS

The EIA Study Area is located in the centre of the Labrador Nature Park Network, established based on NParks Ecological Profiling Exercise (National Parks Board, n.d.) (**Figure 4-14**). The EIA Study Area thus serves as an ecological corridor in the Labrador Nature Park Network, making the assessment of faunal connectivity a key consideration in planning and conservation.

Immediately south of the EIA Study Area is the Berlayar estate, for which an EIS was conducted by AECOM Environment Team in 2022. Gillman Barracks and Berlayar are separated by Telok Blangah Road and the West Coast Highway. Given their proximity, they are likely to share overlapping faunal species, especially among volant taxa like birds. In the following section, we compare the distribution of CS birds across both sites and discuss its implications on avifaunal connectivity.

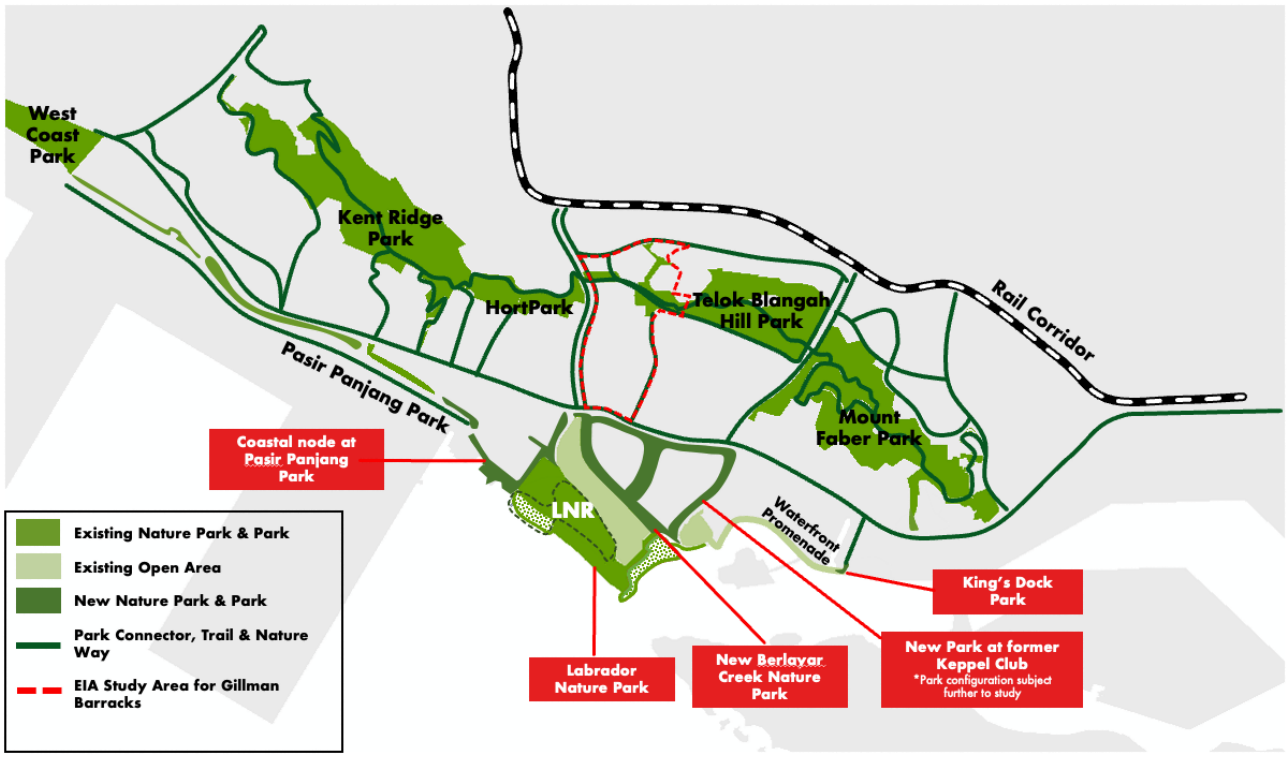


Figure 4-14: Map of the Labrador Nature Park Network and the Southern Ridges (National Parks Board, n.d.).

4.3.4.1 Comparison with Berlayar (former Keppel Club) Environmental Impact Study (EIS)

The conservation statuses of the birds recorded in the former Keppel Club site, now known as Berlayar, were updated based on the Singapore Red Data Book 3 to reflect the most current assessments. **Figure 4-15** shows all CS bird species recorded across both study areas.

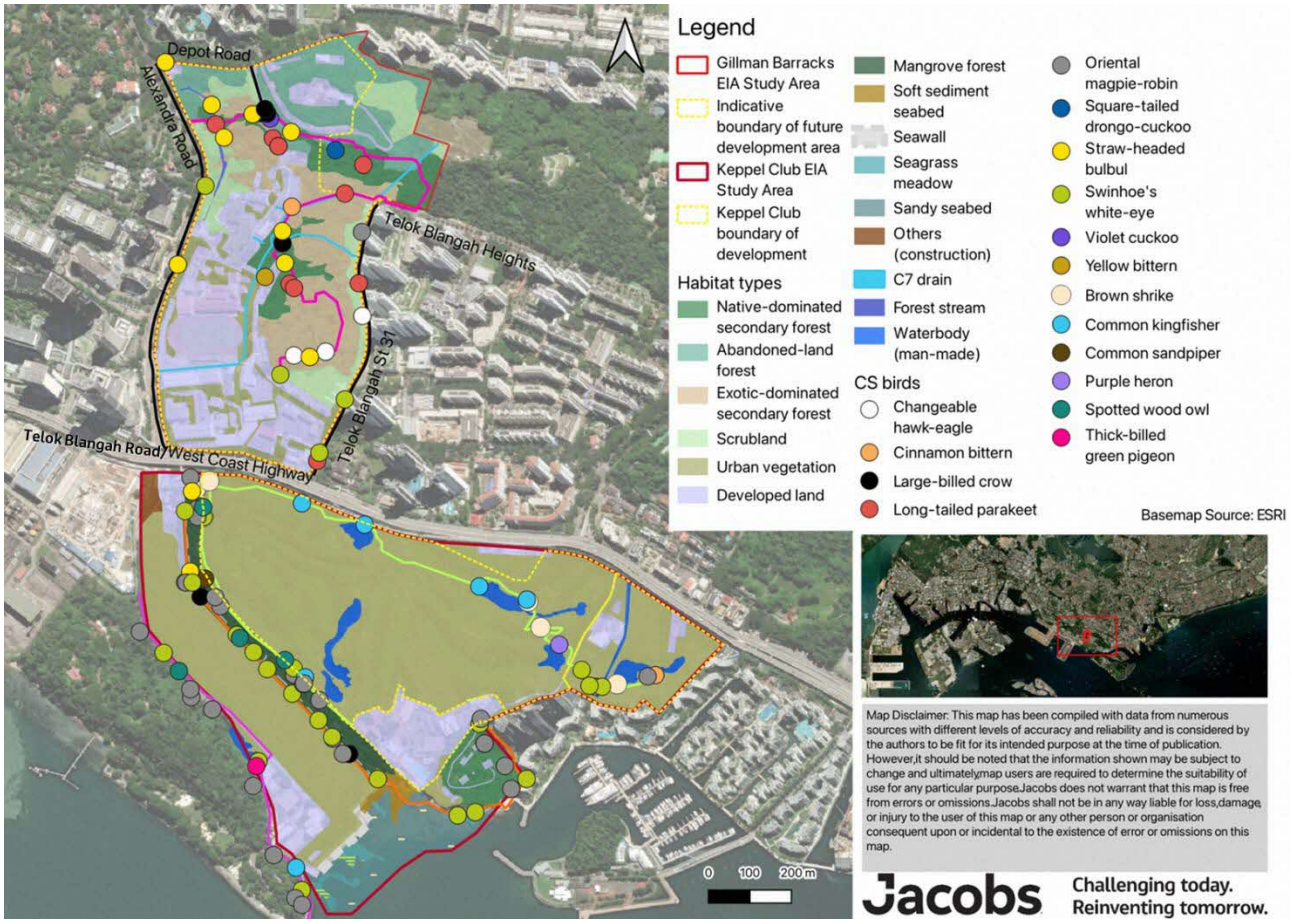


Figure 4-15: Distribution map of CS birds recorded at the EIA Study Area and the adjacent Berlayar (former Keppel Club site) prior to development. Each coloured line represents a terrestrial transect.

A total of 16 CS bird species were recorded across both sites, with six overlapping species **(Figure 4-16)**. The difference in species composition between the two areas can likely be attributed to differences in habitat types. The key habitat types at Gillman Barracks were terrestrial forests, while Berlayar was primarily composed of urban vegetation (i.e., golf courses), mangrove forest and marine habitats (**Figure 4-16**).

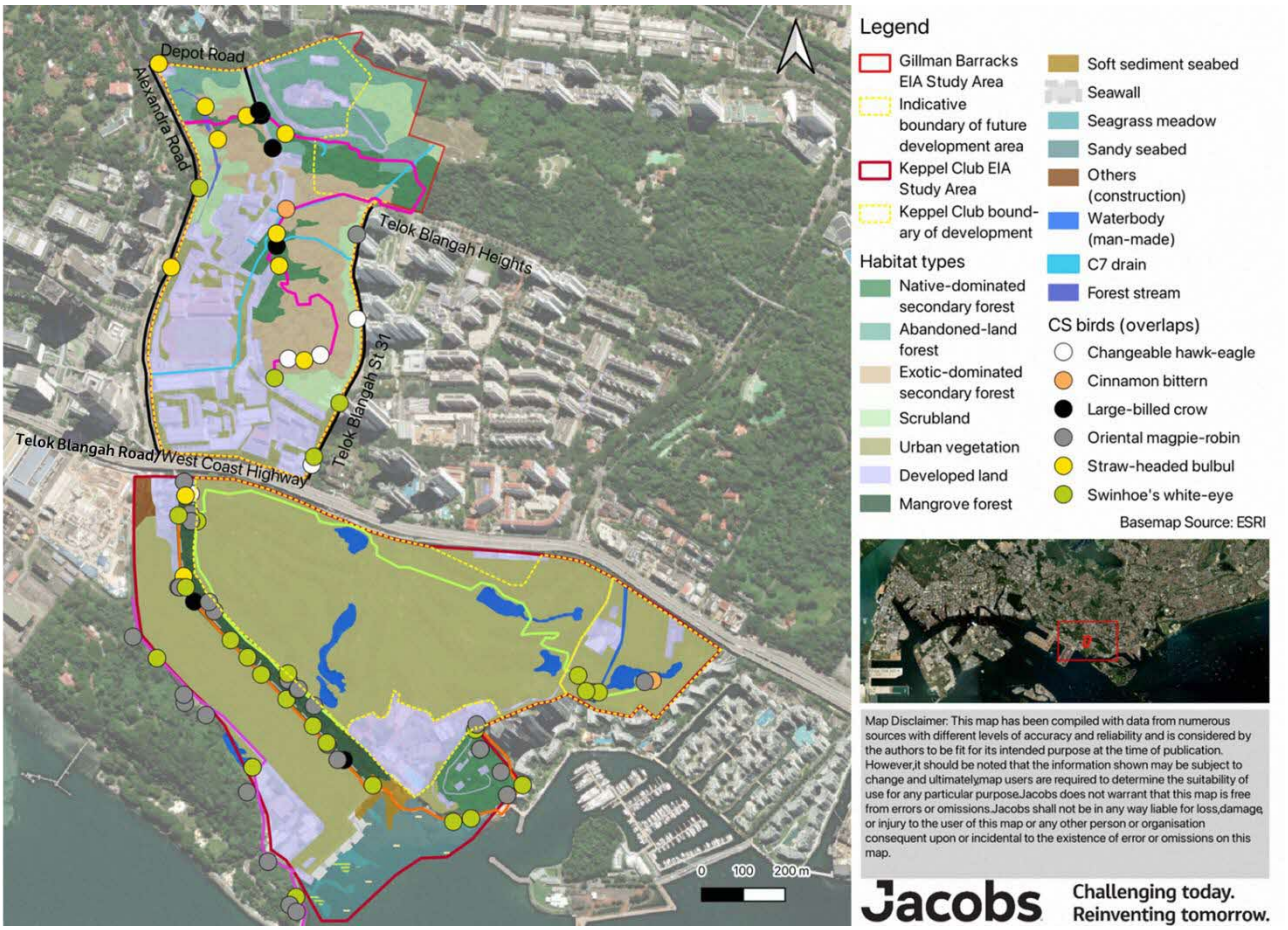


Figure 4-16: Distribution of CS Bird Species Found at both Gillman Barracks and Berlayar (Former Keppel Club Site)

Of the six overlapping CS bird species, four are typically associated with secondary forest and woodland habitats but are occasionally found in parklands. These include the changeable hawk-eagle, large-billed crow, Oriental magpie-robin and Swinhoe's white-eye (Lim et al., 2023). The remaining two species include the forest-dependent Straw-headed bulbul, and the wetland-associated cinnamon bittern (Lim et al., 2023).

Additionally, six other CS species recorded at Berlayar were also identified as probable species at Gillman Barracks based on past records and the presence of suitable habitats. These include the water-associated purple heron, common kingfisher and common sandpiper, the spotted wood owl and brown shrike (which inhabit forest edges, woodlands and scrublands), as well as the thick-billed green pigeon (which inhabits secondary forests) (Lim et al., 2023).

The distribution of the Straw-headed bulbul is of particular interest given its global conservation significance. As detailed in **Section 4.3.3.8**, field survey results indicate that the EIA Study Area hosts a population of this forest-dependent bird. In comparison, only two records were made during the Berlayar EIS, both located along the northern edge of Berlayar Creek (**Figure 4-17**).

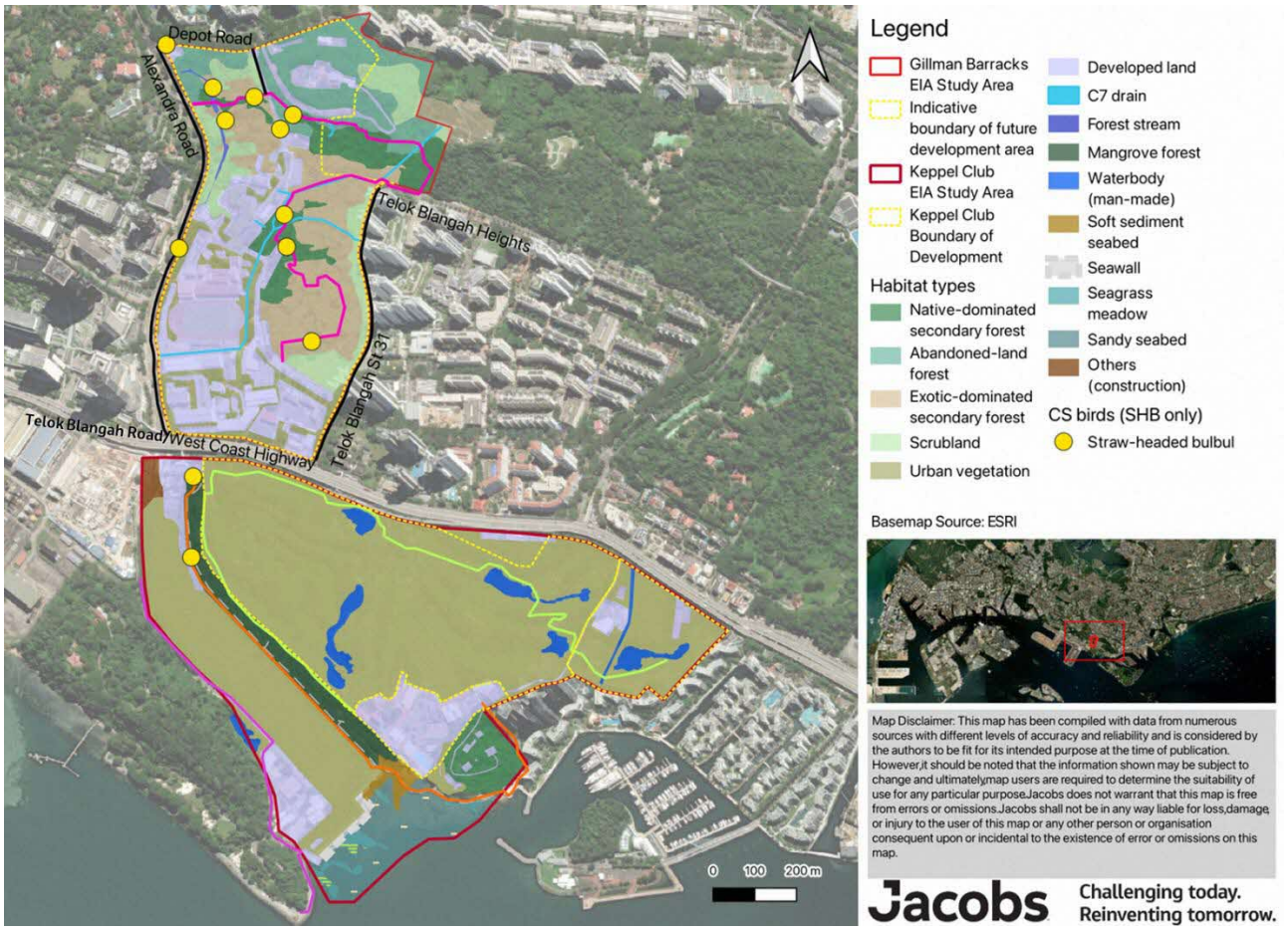


Figure 4-17: Distribution Map of Straw-headed Bulbul Recorded at the EIA Study Area and the Adjacent Berlayar (Former Keppel Club Site)

This spatial distribution suggests that Gillman Barracks serves as a corridor between the Southern Ridges and Berlayar Creek. With adequate connective habitats, it may also facilitate movement further south to Labrador Nature Reserve, where the forested habitats can support the species. This is consistent with the dispersive nature of the Straw-headed bulbul, which is known to be capable of crossing distances of up to 100 m, including across busy highways (M. Nyanasengeran, personal communication, 10 July 2025). As such, the preservation and enhancement of habitats in the south of the EIA Study Area should be considered a priority to maintain avifaunal connectivity between Gillman Barracks, Berlayar and Labrador Nature Reserve.

The records of Straw-headed bulbuls along Alexandra Road also indicate that forest-edge frugivores use existing streetscape greenery for movement (**Figure 4-17**). The enhancement of nature ways offers opportunities for strengthening ecological connectivity even beyond the EIA Study Area.

It should be noted that Berlayar had undergone vegetation clearance at the time of this EIA Study. While some birds may have been displaced from Berlayar to Gillman Barracks, particularly species utilising similar habitat types, the substantial differences in habitat composition between the two sites suggest that not all species would have relocated. The future vegetation and ecological connectivity between the sites is discussed below in **Section 4.4**.

In sum, the EIA Study Area's strategic position within the Labrador Nature Park Network, combined with evidence of faunal movement to adjacent sites, underscores the critical importance of maintaining and enhancing habitat linkages in future planning and development.

4.4 Impact Assessment

4.4.1 Assessment of Ecological Value

The Impact Assessment is conducted for biodiversity receptors of high ecological value. This section defines the methodology for assessing ecological value and the criteria used to identify receptors requiring detailed impact assessment.

4.4.1.1 Habitat

The ecological value assessment for habitats references the distinctiveness criteria in the Singapore Biodiversity Accounting Tool (SGBA) (AECOM & Camphora, 2024). Habitats were assessed and scored based on four criteria: i) flora and fauna species richness; ii) irreplaceability; iii) local rarity of habitats; and iv) unique flora and fauna species. All habitats were then accorded an ecological value, i.e., high, medium, low or zero, based on the overall scoring (**Table 4-12**; and **Table 4-13**). Reference values for species richness and number of unique species were derived from aggregated datasets across Singapore's habitats, including published surveys and EIA reports (Davidson et al., 2025).

Table 4-12: Habitat Distinctiveness Criteria from the Singapore Biodiversity Accounting Metric

Criteria	High (3)	Medium (2)	Low (1)	Zero (0)
Terrestrial Habitats				
SPECIES RICHNESS: The total number of flora (vascular plant) and fauna (bird, butterfly, odonate, amphibian, reptile, mammal) species that can be expected to occur in the habitat, excluding introduced fauna species.	High flora and fauna species richness (900 or more species)	Moderate flora and fauna species richness (600 to 899 species)	Low flora and fauna species richness (300 to 599 species)	Very low flora and fauna species richness (Less than 300 species)
IRREPLACEABILITY: The difficulty of recreating or replacing the habitat to its ecologically optimal structure and species composition via human intervention, natural or accelerated succession within 30 years. This also considers re-establishing of habitat or ecosystem health, and ecological (biotic and abiotic) dynamics required to establish an effectively functioning habitat.	Impossible to recreate/ replace (e.g., lowland dipterocarp primary forest)	Difficult to recreate/ replace (e.g., native-dominated secondary forest)	Easy to recreate/ replace	Not ideal to recreate/ replace for biodiversity

Criteria	High (3)	Medium (2)	Low (1)	Zero (0)
RARITY: Area of a particular habitat type remaining as a percentage of all terrestrial land mass in Singapore.	Habitat is rare in Singapore (e.g., lowland dipterocarp primary forest, native-dominated secondary forest, grassland) (Less than 5%)	Habitat is uncommon in Singapore (e.g., abandoned-land forest, exotic-dominated secondary forest, scrubland) (5% to 30%)	Habitat is common in Singapore (e.g., streetscape, urban park/ garden, turf) (More than 30%) Habitat types that support less than 300 species are assumed to be of lowest priority for biodiversity and automatically fall under this category	Habitat is ubiquitous in Singapore (e.g., buildings)
UNIQUE SPECIES: The total number of unique flora (vascular plant) and fauna (bird, butterfly, odonate, amphibian, reptile, mammal) species that can be expected to occur in the habitat. Unique species are those that are not typically found in other habitats.	Supports a high number of unique flora and fauna species (15 or more species)	Supports some unique flora and fauna species (10 to 14 species)	Supports few unique flora and fauna species (Less than 10 species)	Does not support any unique flora and fauna species
Freshwater Habitats				
SPECIES RICHNESS: The total number of flora (vascular aquatic plants including submerged, partially submerged and floating species) and water-dependent fauna (bird, odonate, amphibian, reptile, mammal, decapod crustacean, fish, mollusc) species that can be expected to occur in the habitat, excluding introduced fauna species.	High flora and fauna species richness (136 or more species)	Moderate flora and fauna species richness (90 to 135 species)	Low flora and fauna species richness (45 to 89 species)	Very low flora and fauna species richness (Less than 45 species)
IRREPLACEABILITY: The difficulty of recreating or replacing the habitat to its ecologically optimal structure and species composition with reference to known localities where such habitats have been successfully recreated in Singapore.	Impossible to recreate/ replace (e.g., quarry lake)	Difficult to recreate/ replace (e.g., forest stream)	Easy to recreate/ replace (e.g., naturalised stream, managed soft-bank pond, rain garden, swale, biotope)	Not ideal to recreate/ replace for biodiversity (e.g., concrete drain, hard-bank pond)

Criteria	High (3)	Medium (2)	Low (1)	Zero (0)
RARITY: Known rarity of habitat within Singapore, based upon local knowledge and literature	Habitat is rare in Singapore (e.g., freshwater swamp forest)	Habitat is uncommon in Singapore (e.g., forest stream)	Habitat is common in Singapore (e.g., naturalised stream, managed soft-bank pond, hard-bank pond, rain garden, swale, biotope)	Habitat is ubiquitous in Singapore (e.g., concrete drain)
UNIQUE SPECIES: The total number of unique flora (vascular aquatic plants including submerged, partially submerged and floating species) and water-dependent fauna (bird, odonate, amphibian, reptile, mammal, decapod crustacean, fish, mollusc) species that can be expected to occur in the habitat. Unique species are those that are not typically found in other habitats.	Supports a high number of unique flora and fauna species (35 or more species)	Supports some unique flora and fauna species (23 to 34 species)	Supports few unique flora and fauna species (Less than 23 species)	Does not support any unique flora and fauna species

Source: AECOM & Camphora, 2024

Table 4-13: Total Distinctiveness Score from the Singapore Biodiversity Accounting Metric and Corresponding Ecological Value of Habitat Types

Ecological Value	Total Distinctiveness Score from SGBA
High	≥ 8
Medium	6 – 7
Low	≤ 5

The ecological value of five terrestrial and two aquatic habitat types within the EIA Study Area were assessed based on the above criteria.

One terrestrial habitat type (native-dominated secondary forest) was assessed to have high ecological value. Two terrestrial (abandoned-land forest and exotic-dominated secondary forest) and one aquatic (forest stream) habitat types were assessed to have medium ecological values. Two terrestrial (scrubland/ grassland and urban vegetation) and one aquatic (concrete drain) habitat types were assessed to have low ecological values. The paragraphs below detail how the assigned ecological values were derived and a summary is provided in **Table 4-14**.

Table 4-14: Assessment of Ecological Value of Habitat Types in the EIA Study Area

Criterion	Terrestrial Habitat					Aquatic Habitat	
	Native-Dominated Secondary Forest	Abandoned-land Forest	Exotic-Dominated Secondary Forest	Scrubland/ Grassland	Urban Vegetation	Forest Stream	Concrete Drain/ Canal
Flora and Fauna Species Richness	3	2	2	1	1	3	1
Irreplaceability	3	1	1	1	1	2	0
Rarity	3	2	2	1	1	2	0
Unique Flora and Fauna Species	1	1	1	2	0	0	1
Total Score	**10**	**6**	**6**	**5**	**3**	**7**	**2**
Ecological Value	**High**	**Medium**	**Medium**	**Low**	**Low**	**Medium**	**Low**
A1 (Value) Score	**3**	**2**	**2**	**1**	**1**	**2**	**1**

4.4.1.1.1 Native-dominated Secondary Forest

Native-dominated secondary forests are regrowth forests that are dominated by native plant species. In the EIA Study Area, the canopy of this habitat type comprises mainly *Terminalia catappa* and *Cyrtophyllum fragrans*, with common native species such as the *Cinnamomum iners* and threatened species *Ficus sinuata*, *Archidendron contortum*, and *Ficus vasculosa* in the understorey. The presence of thriving native saplings is also evidence of forest regeneration. Native-dominated secondary forests typically have high flora and fauna species richness (Score 3) and are known to support few unique flora and fauna species (Score 1). Due to the complexities and intricacies of this habitat type, it is impossible to recreate or replicate the native-dominated secondary forest to its ecologically optimal structure and species composition within 30 years. Native-dominated secondary forests are hence scored medium in irreplaceability (Score 3). This habitat type is currently considered rare in Singapore (Score 3) with increasing urbanisation.

Scoring highly on three criteria assessed (Score 3) and low on one (Score 1), the overall score for the native-dominated secondary forest is 10, which translates to high ecological values across all terrestrial habitats in Singapore and an A1 (Value) score of 3.

4.4.1.1.2 Abandoned-land Forest

Abandoned-land forests are regrowth forests developed from abandoned villages, orchards, or plantations, usually dominated by fruit trees, cultivated crops, or ornamental plants. In the EIA Study Area, the canopy is mostly dominated by rubber (*Hevea brasiliensis*) and oil palm (*Elaeis guineensis*) and interspersed with fruit trees such as coconut (*Cocos nucifera*). Abandoned-land forests generally have medium flora and fauna species richness (Score 2), supporting few unique flora and fauna species (Score 1). As the main composition of this habitat type can be replanted and be established within 30 years, abandoned-land forests are easy to recreate or replace, rendering it a low score in irreplaceability (Score 1). Nonetheless, this habitat type is uncommon in Singapore (Score 2) due to increasing urbanisation.

With two criteria assessed to be medium (Score 2) and two criteria assessed to be low (Score 1), the overall score for the abandoned-land forest is 6, which translates to medium ecological values across all terrestrial habitats in Singapore and an A1 (Value) score of 2.

4.4.1.1.3 Exotic-dominated Secondary Forest

Exotic-dominated secondary forests are regrowth forests arising from land clearance. In the EIA Study Area, the canopy is mostly dominated by *Falcataria falcata*, *Acacia auriculiformis*, and *Adenanthera pavonina*. Exotic-dominated secondary forests generally have medium flora and fauna species richness (Score 2), supporting few unique flora and fauna species (Score 1). As this habitat type can be easily re-established within 30 years, it is easy to recreate or replace, rendering it a low score in irreplaceability (Score 1). This habitat type is uncommon in Singapore (Score 2) due to increasing urbanisation.

With two criteria assessed to be medium (Score 2) and two criteria assessed to be low (Score 1), the overall score for the exotic-dominated secondary forest is 6, which translates to medium ecological values across all terrestrial habitats in Singapore and an A1 (Value) score of 2.

4.4.1.1.4 Scrubland/ Grassland

Scrubland/ grassland is open canopy vegetation dominated by shrubs, climbers, ferns, and/ or grasses. In the EIA Study Area, it occurs as patches or strips mostly along the forest edges. Generally, they were dominated by herbaceous plants such as *Nephrolepis biserrata*, *Dillenia suffruticosa*, and grasses. Scrubland/ grassland often has low flora and fauna species richness (Score 1) but are known to support some unique flora and fauna species (Score 2). As shrubs and grasses colonise rapidly with minimal human intervention, the habitat is easy to recreate or replace (Score 1). This habitat type is common in Singapore (Score 1).

With one criterion assessed to be medium (Score 2) and three criteria assessed to be low (Score 1), the overall score for the scrubland/ grassland is 5, which translates to low ecological values across all terrestrial habitats in Singapore and an A1 (Value) score of 1.

4.4.1.1.5 Urban Vegetation

Urban vegetation in the EIA Study Area consists mainly streetscape landscaping and trees and planted trees within private compounds. Urban vegetation often has low flora and fauna species richness (Score 1) and are not known to support any unique species (Score 0). This habitat type is easy to recreate and replace (Score 1) and is common in Singapore (Score 1).

With three criteria assessed to be low (Score 1) and one criterion assessed to be very low (Score 0), the overall score for urban vegetation is 3, which translates to low ecological values across all terrestrial habitats in Singapore and an A1 (Value) score of 1.

4.4.1.1.6 Forest Stream

The forest stream WQ2 flows through native-dominated secondary forest, abandoned-land forest, exotic-dominated secondary forest and scrubland/ grassland. The banks of the stream are well-vegetated. Forest streams often have complex hydrological, biological, and water quality requirements to reach an ecologically optimal structure and species composition. Such streams generally have high flora and fauna species richness (Score 3) although they are not known to support unique species (Score 0). The intricate requirements result in this habitat type being difficult to recreate or replace, giving it a medium score in irreplaceability (Score 2). Moreover, with increasing urbanisation, forest streams are uncommon in Singapore (Score 2).

With one criterion assessed to be high (Score 3), two criteria assessed to be medium (Score 2), and one criterion assessed to be very low (Score 0), the overall score for forest stream is 7, which translates to medium ecological values across all freshwater aquatic habitats in Singapore and an A1 (Value) score of 2.

4.4.1.1.7 Concrete Drain/Canal

The watercourses WQ1, WQ3, WQ4, and WQ5 are concrete-lined channels that enable drainage of water during high rainfall events but are otherwise periodically wet. Such drains/ canals generally have low flora and fauna species richness (Score 1) but are known to support unique species (Score 1). This habitat type is not ideal to

recreate/ replace for biodiversity, giving it a score of 0 for irreplaceability. Concrete drains/ canals are ubiquitous in Singapore (Score 0).

With two criteria assessed to be low (Score 1), and two criteria assessed to be very low (Score 0), the overall score for concrete drain/ canal is 2, which translates to low ecological values across all freshwater aquatic habitats in Singapore and an A1 (Value) score of 1.

4.4.1.2 Flora

The ecological value of 281 plant species was assessed. Twelve species and species groups from the initial 293 species were excluded from the assessment, as 10 species were not listed in the flora databases referenced, and the remaining two (*Pandanus* cultivar and *Renanthera* cultivar) could not be identified to the species level.

Species were initially flagged as having high ecological value if they met one or more of the following criteria: (1) species of conservation significance; (2) keystone species of the genus *Ficus*; and (3) common native trees with restricted national distribution. This initial screening identified 82 species, including cultivated specimens.

The list was then refined by excluding: (1) species without precise location data; (2) species of conservation significance determined to be planted or escapees from cultivation; and (3) herbaceous *Ficus* species. Following these exclusions, 29 species were identified as high priority species for the impact assessment.

Table 4-15 summarises the 281 species and species groups assessed. Altogether, 14 species had their ecological values increased after assessment. These include 10 keystone species of the genus *Ficus* (low/ medium initial ecological value), 3 native species with restricted national distribution (medium initial ecological value), and the Rain tree, *Samanea saman* (low initial ecological value).

Table 4-15: Assessment of Ecological Value for Selected Flora Species

	High Value	Medium Value	Low Value	Excluded	Total
Final Assessment and Number of Species (%)	29 (10.3%)	25 (8.9%)	176 (62.6%)	51 (18.2%)	281 (100.0%)

4.4.1.3 Fauna

All recorded and probable faunal species were accorded an ecological value based on its conservation significance and species origin. A total of 83 fauna species of high ecological value was identified, comprising of recorded and probable CS species.

From the field surveys, this includes the 11 recorded CS species were of conservation significance, and 73 probable CS species were identified as probable within the EIA Study Area.

One species appears in both the recorded and probable species lists: the Bamboo bat (Tylonycteris sp.), which could only be identified to genus level from bioacoustic recordings. Accounting for this overlap, the total number of fauna species of high ecological value is 83.

4.4.2 Potential Impacts on Biodiversity

Impacts during the construction and post-construction/ operational phases were separated for habitat, flora, and fauna, as detailed in **Section 4.5**. These impacts fall into two main categories: (1) direct impacts – affecting habitats and species located within the worksites; and (2) indirect impacts – affecting habitats and species outside the worksites but within the designated impact zones.

The direct impact zone is defined as the area within the indicative boundary of future development area, excluding Telok Blangah Hill Park (**Figure 4-18**). The indirect impact zone is defined as a 30 meter buffer extending from the boundary of the direct impact zone. This buffer distance assumes that edge effects, environmental changes in habitats directly adjacent to construction areas, are most significant within 30 meters of the disturbance (**Figure 4-18**).

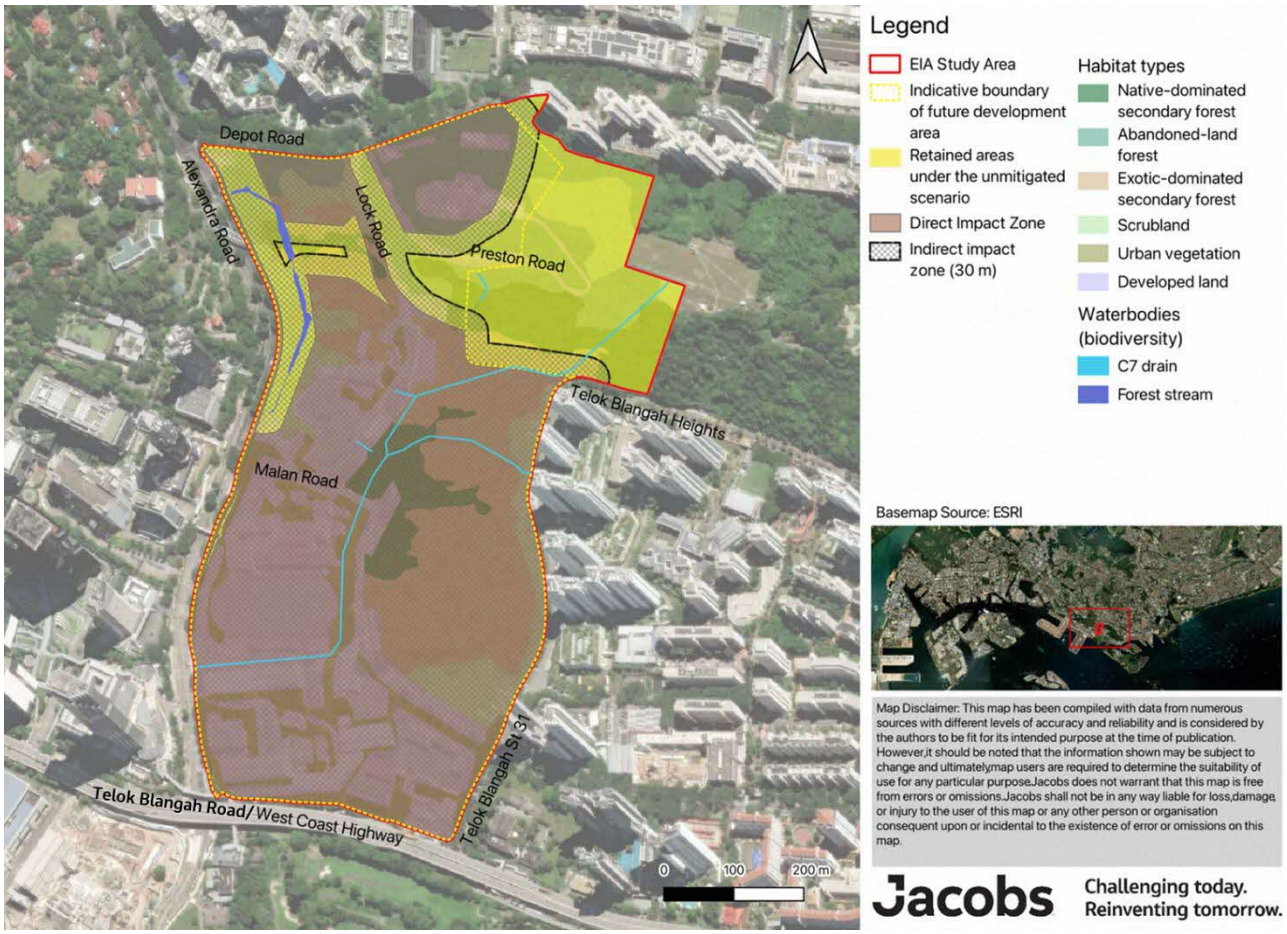


Figure 4-18: Direct and Indirect Impact Zones under the Unmitigated Scenario

Habitats and plants that fall within the impact zones of the future development were identified as biodiversity sensitive receptors (**Figure 4-19**). Fauna species that were recorded during the baseline study or deemed probable were also identified as biodiversity sensitive receptors.

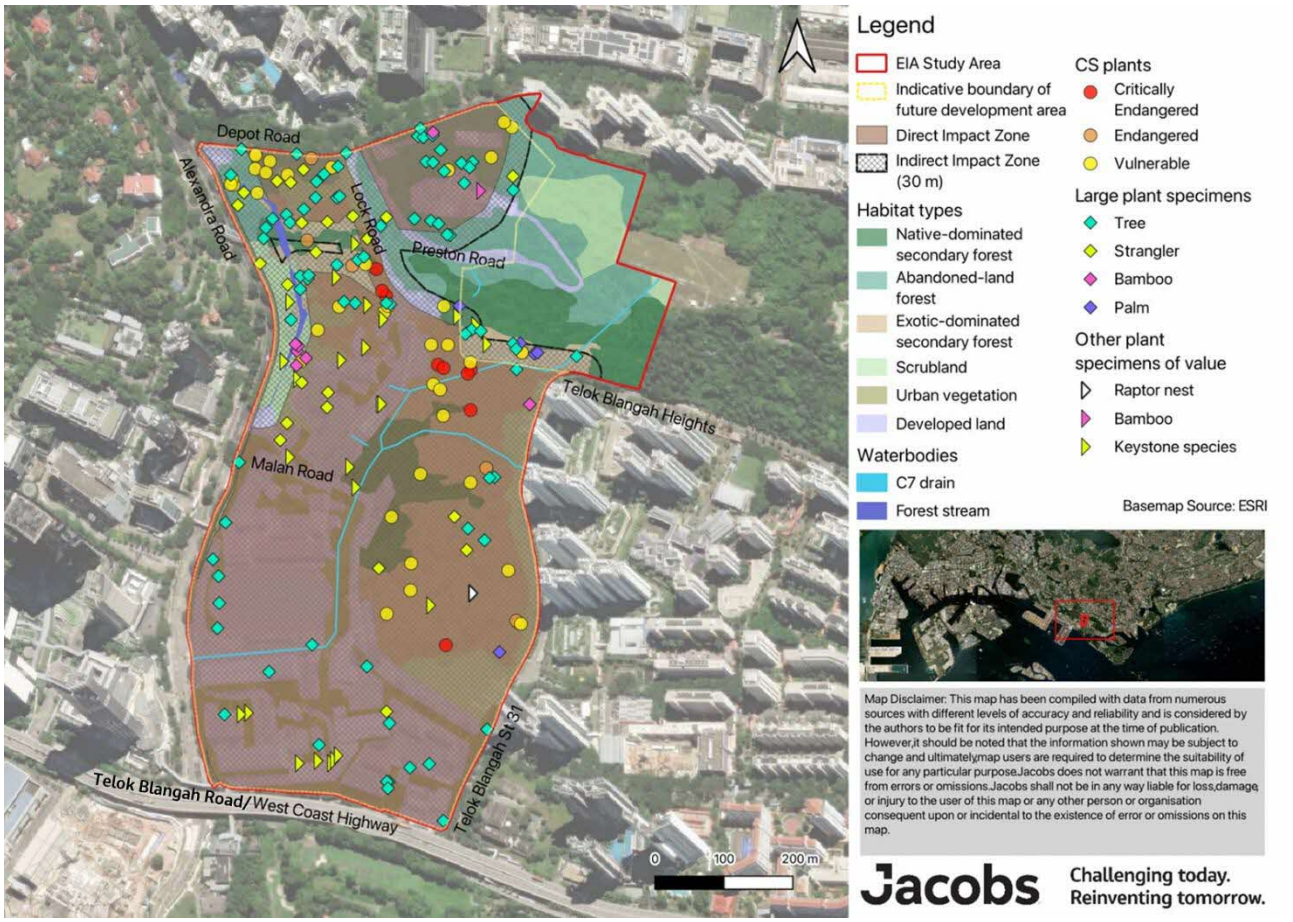


Figure 4-19: Habitat and Flora Receptors within the Direct and Indirect Impact Zones

4.4.3 Minimum Control Measures

Table 4-16 lists biodiversity-specific minimum controls commonly implemented in Singapore for similar construction and operational activities. These are assumed to be implemented for the impact assessment.

Table 4-16: Minimum Control Measures Assumed to be Implemented at the Construction and Operational Phases

Phase	Activities	Minimum Control Measures
Construction	General	• Install hoarding that is embedded at least 300 mm into the ground to delineate worksite. • Minimise fogging by implementing preventive measures for mosquito to remove sources of stagnant water or water-bearing receptacles (e.g., provide well-maintained pitched roof, clear discarded items daily, store materials appropriately, level up ground depression/ uneven surfaces, ensure effective drainage flow). • Practice due diligence in proper storage and handling of machinery to prevent release of chemicals, fuels or other potentially harmful materials. • Transfer of fuel shall be done over contaminant trays and mats to prevent spillage into the ground. • Ensure oil-containing equipment or machineries are inspected for leaks before being put into use.

Phase	Activities	Minimum Control Measures
		• Provide emergency spill kits on site in the event of any fuel spillages. The emergency response team shall also be competent in the use of these spill kits. • Chemical and fuel in drums, carboys, containers, etc shall be stored in a designated storage area within a building or covered shed with concrete floors and containment facilities to contain any leak or spillage. • A full containment should be provided for bulk storage oil tanks, including skid tanks. • Ensure all hazardous substances and chemical containers are labelled as per the Globally Harmonised System (GHS) requirement. • Ensure a chemical inventory is maintained to track the movement of all hazardous substance and chemicals. • Return the chemicals back to its designated storage areas when not in use. • Transfer of chemicals shall be done over contaminant trays and mats to prevent spillage into the ground. • All leaks and spillages in the storage area or construction site shall be collected and sent to a licensed toxic waste collector for proper disposal. • Ensure Toxic Industrial Waste (TIW) are stored in a designated storage area within a building or covered shed with concrete floors and containment facilities to contain any leak or spillage. • Maintain a TIW register, which is to be updated on a weekly basis. • TIW shall be collected regularly by a licensed TIW collector for off-site disposal. • Ensure leaks and spillages in the TIW storage area or construction site are collected and sent to a licensed toxic waste collector for proper disposal.
Construction	Vegetation clearance	• No felling or damaging of trees without prior approval under the Parks and Trees Act. • Set up Tree Protection Zones (TPZs) around trees or other plant specimens to be retained within the worksites, within which no construction works are allowed. This should be advised by certified arborists and in accordance with NParks' guidelines. • Conduct directional site clearance. • Conduct inspections of fauna prior to felling or removal of vegetation. This should be done by an ecologist who is able to identify wildlife and/ or active nesting structures, such as bird nests, tree hollows and/ or burrows, and bamboo clusters. • Implement soil erosion control measures prior to vegetation clearance. The ECM plan should be formulated by a Qualified Erosion Control Professional (QECP). • Use only fully biodegradable wildlife-friendly erosion control blankets (ECBs) to avoid trapping fossorial fauna such as snakes.
Construction	Earthworks and aboveground construction	• Implement soil erosion control measures. • Use only fully biodegradable wildlife-friendly ECBs to avoid trapping fossorial fauna such as snakes. • Proper storage of materials likely to leach harmful chemicals and fuel-powered equipment by storing them away from waterbodies and/or sensitive habitats. • Implement dust control measures. • Keep noise levels within approved limits, and to implement noise barriers where required.

Phase	Activities	Minimum Control Measures
Construction	Setting up of worksite, stockpiling	• Locate facilities other than the proposed construction worksites (e.g., site offices, storage. yards, rest areas, access route, etc.) within the worksite itself or on existing built-up areas/ agreed working spaces; ensure no clearing of additional habitats.
Post-construction/ Operation	General	• Minimise fogging by implementing preventive measures for mosquito to remove sources of stagnant water or water-bearing receptacles (e.g., provide well-maintained pitched roof, clear discarded items daily, store materials appropriately, level up ground depression/ uneven surfaces, ensure effective drainage flow). • No killing, trapping, taking or keeping any wildlife under the Wildlife Act.

4.4.4 Evaluation of Impact Significance

The Impact Assessment follows the RIAM method defined in **Section 3.3**.

For biodiversity receptors, **A2.2 Magnitude of Change** is calculated by multiplying two subcategories: **A2.2a Impact Intensity** and **A2.2b Impact Likelihood**. The scoring criteria for each subcategory (A2.2a and A2.2b) are shown in **Table 4-17**, and the conversion of the calculated score to the A2.2 Magnitude of Change (A2.2a × A2.2b) is shown in **Table 4-18**.

Table 4-17: Criteria of Scoring for A2.2a Impact Intensity and A2.2b Impact Likelihood for Biodiversity Receptors

Components of A2.2 Magnitude of Change for Biodiversity	Score/ General Criteria Considered	
A2.2a – Impact Intensity Impact intensity is defined by the characteristics of each receptor	**3:**	Major
	2:	Medium
	1:	Minor
	0:	No change/ status quo
A2.2b – Impact Likelihood Likelihood is defined largely based on extent of development works	**4:**	Almost certain/ continuous
	3:	Likely/ regular
	2:	Possible/ occasional
	1:	Less likely/ rare
	0:	Unlikely/ Remote

Table 4-18: A2.2 Magnitude of Change Scoring Categories based on Calculated Scores (A2.2a Impact Intensity × A2.2b Impact Likelihood)

A2.2 Magnitude of Change	A2.2 Score		Calculated Score Range (A2.2a × A2.2b)
Score scaling	**3:**	High impact/ changes	8-12
	2:	Medium impact/ changes	4-7
	1:	Low impact/ changes	1-3
	0:	No change/ status quo/ negligible	0

4.4.5 Construction Phase Impact

4.4.5.1 Habitat

The definitions for impact intensity and likelihood for habitat receptors are given in **Table 4-19** and **Table 4-20**. The values assigned for each criterion in RIAM as well as the resulting impact significance for all habitat receptors are provided in **Appendix 4I**.

Table 4-19: Definitions of Each Level of Impact Intensity for Impact Types During Construction Phase for Habitat Receptors

Impact Type	Negligible	Low	Medium	High
Loss of habitat	The habitat does not overlap with the worksites	< 10% of the habitat overlaps with the worksites	10–40% of the habitat overlaps with the worksites	> 40% of the habitat overlaps with the worksites Worksite overlaps with waterbody
Forest edge effects	Terrestrial habitats The habitat does not overlap with areas 30 m from the worksites Aquatic habitats The dominant terrestrial habitat adjacent to the aquatic habitat does not overlap with areas 30 m from the worksites	Terrestrial habitats < 10% of the habitat overlaps with areas 30 m from the worksites Aquatic habitats < 10% of the dominant terrestrial habitat adjacent to the aquatic habitat overlaps with areas 30 m from the worksites	Terrestrial habitats 10–40% of the habitat overlaps with areas 30 m from the worksites Aquatic habitats 10–40% of the dominant terrestrial habitat adjacent to the aquatic habitat overlaps with areas 30 m from the worksites	Terrestrial habitats > 40% of the habitat overlaps with areas 30 m from the worksites Aquatic habitats > 40% of the dominant terrestrial habitat adjacent to the aquatic habitat overlaps with areas 30 m from the worksites
Habitat degradation	Terrestrial habitats The habitat does not overlap with areas 30 m from the worksites Aquatic habitats No change in surface water quality	Terrestrial habitats < 10% of the habitat overlaps with areas 30 m from the worksites Aquatic habitats Some changes in surface water quality	Terrestrial habitats 10–40% of the habitat overlaps with areas 30 m from the worksites Aquatic habitats Considerable changes in surface water quality	Terrestrial habitats > 40% of the habitat overlaps with areas 30 m from the worksites Aquatic habitats Extensive changes in surface water quality

Table 4-20: Definitions of Each Level of Likelihood for all Impact Types During Construction for Habitat Receptors

Likelihood	Unlikely/ Remote	Less Likely/ Rare	Possible/ Occasional	Likely/ Regular	Almost Certain/ Continuous
Loss of habitat	The habitat does not overlap with the worksite	N.A.	N.A.	N.A.	The habitat overlaps with the worksite

Likelihood	Unlikely/ Remote	Less Likely/ Rare	Possible/ Occasional	Likely/ Regular	Almost Certain/ Continuous
Forest edge effects	The habitat does not overlap with the worksite	The worksites are small (e.g., trails, boardwalks) and/ or is not expected to change vegetation structure significantly to effect changes in microclimatic conditions (e.g., minimal tree or vegetation removal)	The worksites are of considerable size (e.g., single lane roads) and/ or is expected to change some vegetation structure significantly to effect changes in microclimatic condition (e.g., some tree or vegetation removal)	The worksites are large (e.g., buildings, multiple lane roads) and/ or is expected to change vegetation structure significantly to effect changes in microclimatic conditions (e.g., extensive tree or vegetation removal)	N.A.
Habitat degradation	N.A.	The likelihood of habitat degradation is presumed to be Less Likely for all habitat receptors, based on the assumption that all minimum controls are adequately and properly implemented	N.A.	N.A.	N.A.

Seven habitat types (i.e., all habitats excluding developed land) were assessed for the following impacts: (1) loss of habitat, (2) forest edge effects, and (3) habitat degradation. A summary of the results is given in **Table 4-21**, and the impacts with Slight Negative and above significance are briefly explained below.

Table 4-21: Summary of Construction Impacts to Habitat Receptors and Number of Habitat Types Affected

Impact Type	Major Negative	Moderate Negative	Minor Negative	Slight Negative	No Change
Loss of Habitat	1	3	3	0	0
Forest Edge Effects	0	0	3	0	4
Habitat Degradation	0	0	1	6	0

4.4.5.1.1 Loss of Habitat

Loss of habitat is defined as the direct removal of vegetation to create space for construction activities, as well as changes in waterbody due to backfilling, and/or changes in hydrology.

Vegetation clearance will occur in all terrestrial and aquatic habitat types: native-dominated secondary forest, abandoned-land forest, exotic-dominated secondary forest, scrubland/ grassland, urban vegetation, forest/ rural stream, and concrete drain/ canal. Based on the area of vegetation clearance, the impact intensity is "High" for exotic-dominated secondary forest, abandoned-land forest, scrubland/ grassland, urban vegetation, and concrete drain/ canal. The impact intensity is "Medium" for native-dominated secondary forest and abandoned-land forest. The impact intensity is "Low" for forest/ rural stream. The likelihood of occurrence is "Certain" for all habitat types. Overall, the impact significance of loss of habitat will be **Major Negative** for native-dominated secondary forest as it is of "High" ecological value. The impact significance will be **Moderate Negative** for abandoned-land forest, exotic-dominated secondary forest, and forest/ rural stream and **Minor Negative** for the remaining habitat types.

4.4.5.1.2 Forest Edge Effects

Forest edge effects refer to the changes in microclimatic conditions of forested habitats due to vegetation removal. This includes changes in the exposure of direct sunlight, temperature, humidity, wind exposure, etc. For aquatic habitats, the impact intensity will follow that of the dominant riparian vegetation.

Forest edge effects are "Likely" to occur in the native-dominated secondary forest, abandoned-land forest, and exotic-dominated secondary forest. Based on the proportion of each habitat type that falls within the 30 m impact zone adjacent to the proposed worksites, the impact intensity is "High" for exotic-dominated secondary forest and "Medium" for native-dominated secondary forest and abandoned-land forest. Overall, the impact significance is **Minor Negative** for these three habitat types.

4.4.5.1.3 Habitat Degradation

Habitat degradation refers to the disturbances to habitats as a result of construction activities (e.g., improper disposal of construction waste, accidental release of hazardous materials, etc.)

Habitat degradation is "Less Likely" to occur in all the terrestrial and aquatic habitat types, assuming all minimum controls are adequately and properly implemented (**Section 4.4.3**). Based on the proportion of each habitat type that falls within the 30 m impact zone adjacent to the proposed worksites, the impact intensity is "High" for all the habitat types except for native-dominated secondary forest, for which the impact intensity is "Medium". Overall, the impact significance of habitat degradation will be **Minor Negative** for native-dominated secondary forest as it is of "High" ecological value. The impact significance will be **Slight Negative** for the remaining habitat types.

The values assigned for each criterion in RIAM as well as the resulting impact significance for habitat receptors are provided in **Appendix 4I**.

4.4.5.2 Flora

The definitions for impact intensity and likelihood for flora species receptors are presented in **Table 4-22** and **Table 4-23**, respectively. The values assigned for each criterion in RIAM as well as the resulting impact significance for all flora receptors are provided in **Appendix 4J**.

The 29 flora species of high ecological value were assessed for the following impacts: (1) Mortality and (2) Decline in Plant Health and Survival. A summary of the impacts on flora receptors is given in **Table 4-24**, with the numbers indicating the number of species in each impact significance category.

Table 4-22: Impact Intensity During Construction Phase for Flora Receptors

Impact Type	Negligible	Low	Medium	High
Mortality	No plant specimens of this species are within the worksites	< 50% of all plant specimens of this species are within the worksites	≥ 50% of all plant specimens of this species are within the worksites	All plant specimens of this species are within the worksites
Decline in plant health and survival	No specimens of this species are within 30 m from the worksites	< 50% of all specimens of this species are within 30 m from the worksites	≥ 50% of all specimens of this species are within 30 m from the worksites	All specimens of this species are within 30 m from the worksites

Table 4-23: Impact Likelihood During Construction Phase for Flora Receptors

Likelihood	Mortality	Decline in Plant Health and Survival
Unlikely/ Remote	No plant specimens of this species are within the worksites	No formation of forest edges (i.e., construction activities are fully underground and/ or in existing built-up areas outside the forest) that changes the existing microclimate conditions
Less Likely/ Rare	Plants specimens of this species located in the worksite is less likely to be inflicted with mechanical injuries during construction	Formation of scrubland edges in scrubland areas only
Possible/ Occasional	No count data and/ or locations of specimens of this species is available, but specimens could possibly be within the worksites	Formation of some forest and scrubland edges in urban vegetation, scrubland and/ or forested areas
Likely/ Regular	N.A.	N.A.
Almost Certain/ Continuous	Plant specimens of this species located within the worksite are cleared	Formation of new forest edges (i.e., complete clearance within forested areas)

Table 4-24: Summary of Construction Impacts to Flora Receptors and Number of Species Affected

Impact Type	Major Negative	Moderate Negative	Minor Negative	No Change	N.A.
Mortality	12	3	6	8	0
Decline in Plant Health and Survival	0	6	3	14	18

4.4.5.2.1 Mortality

Mortality refers to the direct removal of vegetation to create space for construction activities.

Of the 29 species assessed during the construction phase pre-mitigation, 12 were assessed to an impact significance of **Major Negative** because of "Medium" and "High" impacts on mortality, combined with the threatened status of the taxon and an "Almost Certain" likelihood of clearance. These include all recorded specimens of the critically endangered *Antiaris toxicaria* and *Ficus sinuata*, and endangered *Symplocos adenophylla* and *Ficus apiocarpa*.

Three vulnerable species–*Endospermum peltatum*, *Goniphlebium percussum,* and *Macaranga griffithiana*–were assessed to face an impact significance of **Moderate Negative**. Thirty-three per cent (33%) of *E. peltatum* and *M. griffithiana* and 50% of *G. percussum* specimens fall within the worksite, resulting in "Low" and "Medium" impact intensity on mortality, respectively.

Six keystone species of the genus *Ficus* were assessed to an impact significance of **Minor Negative** with "Low" to "High" impacts on mortality. The reduction in overall impact significance is attributed to the non-threatened status of the species, and reduced impact extent of clearance relative to species of conservation significance. Finally, eight species, *Archidendron contortum*, *Burmannia coelestis*, *Linostoma pauciflorum*, *Litsea* cf. *castanea*, *Litsea umbrellata*, *Olea brachiata*, *Pittosporum ridleyi,* and *Trema tomentosum*, were assessed to an impact significance of **No Change**, as all recorded specimens fall within the retained areas of Telok Blangah Hill Park.

4.4.5.2.2 Decline in Plant Health and Survival

Decline in plant health and survival may arise from changes in microclimatic conditions (i.e., dust, noise, light, temperature, and humidity), or changes in hydrology and/or surface water quality.

Six species were assessed to an impact significance of **Moderate Negative** with "Low" to "Medium" impact intensities. These include a single specimen of the endangered *Litsea* cf. *castanea*, which falls approximately 16m from the worksite, making it likely to face edge effects from forest clearance and a resultant possible decline in health during the construction phase.

Three keystone species – *Ficus benjamina*, *Ficus microcarpa* and *Ficus variegata* – were assessed to an impact significance of "**Minor Negative**". Nine specimens (82%) of *F. benjamina*, two specimens (40%) of *F. microcarpa*, and five specimens (36%) of *F. variegata* fall within 30m of the worksite, resulting in "Low" and "Medium" impact intensities, with "Possible/ Occasional" impact likelihood.

Six species – *Archidendron contortum*, *Goniophlebium percussum, Linostoma pauciflorum*, *Macaranga griffithiana*, *Pittosporum ridleyi,* and *Trema tomentosum* – were assessed to have an impact significance of **No Change**, as all recorded specimens fall more than 30 m from the worksite, and are not expected to face edge effects as a result of forest clearance.

Finally, the remaining 18 species were not assessed (impact significance of **N.A.**) for decline in health and survival as they are presumed to be cleared pre-mitigation, and therefore not on site during the construction phase.

4.4.5.3 Fauna

The definitions for impact intensity and likelihood for fauna species receptors of conservation significance are presented in **Table 4-25** and **Table 4-26**, respectively.

Table 4-25: Definitions of Level of Impact Intensity for all Impact Types During Construction Phase for Fauna Species

Impact Type	Negligible	Low	Medium	High
Loss of/ reduction in habitats and food sources	Loss of/ reduction in habitats and food sources	Loss of/ reduction in habitats and food sources	Loss of/ reduction in habitats and food sources	Loss of/ reduction in habitats and food sources

Impact Type	Negligible	Low	Medium	High
Accidental injury or mortality	Species with negligible susceptibility to accidental injury/ mortality from construction activities (large vehicles, excavation, piling, etc.) and roadkills	Species with low susceptibility to accidental injury/ mortality from construction activities (large vehicles, excavation, piling, etc.) and roadkills: ▪ Volant species (e.g., odonates, butterflies, highly volant birds, most bats)	Species that are mobile but possibly susceptible to accidental injury/ mortality from construction activities (large vehicles, excavation, piling, etc.) and roadkills: ▪ Less volant birds ▪ All amphibians ▪ Some mammals (e.g., squirrels, shrews)	Species with high susceptibility to accidental injury/ mortality from construction activities (large vehicles, excavation, piling, etc.) and roadkills: ▪ Reptiles ▪ Some mammals (e.g., Sunda pangolin, Long-tailed macaque, Smooth-coated otter)
Human-wildlife conflict	Species that are not perceived as nuisance or threats by construction personnel: ▪ Odonates ▪ Butterflies ▪ Most birds ▪ Bats ▪ Amphibians	Species that are possibly perceived as both nuisance and threats by construction personnel, less tolerant of human presence and urban environments: ▪ Some reptiles	Species that are typically perceived as nuisance and possibly as threats by construction personnel, highly tolerant of human presence and urban environments, and frequently implicated in human-wildlife conflict: ▪ Smooth-coated otter ▪ Aculeate hymenopterans	Species that are typically perceived as both nuisance and threats by construction personnel, highly tolerant of human presence and urban environments, and are frequently implicated in human-wildlife conflict: ▪ Long-tailed macaque ▪ Some snakes
Loss of/ reduction in of ecological connectivity for fauna movement (within region)	Not dependent on connected habitats for dispersal and able to traverse urban infrastructure	Slightly dependent on connected habitats for dispersal and adaptable to traverse urban infrastructures if needed	Dependent on connected habitats for dispersal	Highly dependent on connected habitats for dispersal
Light disturbance	Species that are not sensitive to changes in light levels: aculeate hymenopterans, most aquatic species	Species that are slightly sensitive to changes in light levels: odonates, butterflies	Species that are sensitive to changes in light levels: diurnal birds, reptiles, and mammals	Species that are highly sensitive to changes in light levels: nocturnal, crepuscular fauna
Human disturbance	Species that are not sensitive to human presence	Species that are slightly sensitive to human presence	Species that are sensitive to human presence	Species that are extremely sensitive to human presence, and nesting birds

Table 4-26: Definitions of Each Level of Likelihood for all Impact Types During Construction Phase for Fauna Species Receptors

Likelihood	Definition
Unlikely/ Remote	Impact is not expected to happen during the construction phase.
Less Likely/ Rare	Impact is not likely to happen during the construction phase.
Possible/ Occasional	Impact could possibly happen or known to occur during the construction phase.
Likely/ Regular	Impact is a common occurrence during the construction phase.
Almost Certain/ Continuous	Impact is a continual or repeated process during the construction phase.

Five construction phase impact types were identified and assessed for the pre-mitigated fauna receptors: (1) Loss of/ reduction in habitats and food sources; (2) loss of/ reduction of ecological connectivity for fauna movement; (3) accidental injury or mortality; (4) light disturbance; (5) human-wildlife conflict; and (6) human disturbance.

A total of 83 species of high ecological value were assessed. The impact significance ranged from **No Change** to **Major Negative** with minimum control measures in place. The more substantial impact arising from each impact type are briefly explained below. A summary of all the impact on fauna receptors is given in **Table 4-27**, with the numbers indicating the number of species in each impact significance category.

The list of species evaluated, and values assigned for each criterion in RIAM are provided in **Appendix 4K.**

Table 4-27: Summary of Construction Impacts to Fauna Receptors and Number of Species Affected

Impact Type	Major Negative	Moderate Negative	Minor Negative	No Change
Loss of/ reduction in habitats and food sources	60	23	0	0
Loss/ reduction of ecological connectivity for fauna movement	0	63	0	20
Accidental injury or mortality	2	10	34	37
Light disturbance	0	46	37	0
Human-wildlife conflict	0	2	4	77
Human disturbance	0	0	83	0

4.4.5.3.1 Loss of/ Reduction in Habitats and Food Sources

The loss of/ reduction in habitats and food sources for fauna arise from the direct removal of vegetation, nests or roost sites to create space for construction activities.

Under the unmitigated scenario, Telok Blangah Hill Park is retained while complete site clearance is assumed for the rest of the indicative boundary of future development area. This results in **Major Negative** impact for 61 species due to the "High" intensity and "Almost certain/ continuous" likelihood of habitat loss and reduction in food sources.

The retention of most of the forest stream as part of Telok Blangah Hill Park reduces the intensity of impacts on aquatic species. A **Moderate Negative** impact is expected for the remaining 23 species, primarily aquatic fauna. These include water-associated birds such as yellow bittern, great egret, and buffy fish owl, as well as odonates and reptiles like the Asian softshell turtle.

4.4.5.3.2 Loss/ Reduction of Ecological Connectivity for Fauna Movement

This assessment considers the potential loss or reduction of ecological connectivity for fauna movement within the EIA Study Area as well as with the surrounding parks (i.e. Telok Blangah Hill Park beyond the EIA Study Area; Berlayar Creek and Labrador Nature Reserve).

Moderate Negative impact is expected for 63 species, generally forest-associated species that are dependent on connected habitats for dispersal. These include forest-associated birds such as the Straw-headed bulbul, Thick-billed green pigeon, and Square-tailed drongo-cuckoo; forest butterflies such as the Singapore fourline blue and Grand imperial; mammals like the Sunda pangolin, which is particularly vulnerable to roadkill during forest-to-forest movement, and reptiles such as snake species.

No Change is expected for the remaining 20 species that do not require connected habitats for dispersal and are capable of traversing urban infrastructure. These include the Long-tailed macaque, Smooth-coated otter, urban-adapted or migratory bird species, and a few butterfly species that utilise scrubland and streetscapes.

4.4.5.3.3 Accidental Injury or Mortality

Accidental injury or mortality may arise from construction activities, such as collisions with machinery, entrapments in construction materials (e.g., non-biodegradable erosion control blankets) and structures (such as exposed pits or drains).

Major Negative impact is expected for two species of Bamboo bats, which roost in bamboo nodes and are highly susceptible to injury and mortality during bamboo clearance. **Moderate Negative** impact is expected for 10 species, including snakes, mammals such as Sunda pangolin and Smooth-coated otter, and ground-dwelling birds such as crakes. These species are susceptible to injury as they are ground-dwelling and inhabit dense ground vegetation and grasses. As a result, they tend to be less visible to machinery operator and are less likely to disperse quickly from clearing activities compared to more mobile and/or volant fauna.

Minor Negative impact is expected for 34 bird species, and **No Change** is expected for the one odonate and 36 butterfly species, as their flight capability allows them to readily disperse and therefore experience lower risk of mortality and injury during construction.

4.4.5.3.4 Light Disturbance

The increase in light levels from construction activities may cause disturbance to wildlife. **Moderate Negative** impact is expected for 46 species, including nocturnal animals such as bats, herpetofauna, and mammals, which are highly sensitive to artificial lighting which can disrupt their foraging and navigation behaviours. Birds are also affected due to their sensitivity to light, which can disrupt their roosting behaviour.

Minor Negative impact is expected for one odonate and 36 butterfly species.

4.4.5.3.5 Human-wildlife Conflict

Human-wildlife conflict refers to direct, negative human-wildlife interactions, such as the deliberate killing of species perceived as nuisances or threats by construction personnel.

Moderate Negative impact is expected for two species, the Long-tailed macaque and Smooth-coated otters, with an impact intensity of "High" and "Medium", respectively. Long-tailed macaques may be attracted to food waste within the worksite and are commonly perceived as a nuisance, leading to negative interactions with site personnel. Smooth-coated otters are not naturally aggressive, but may react defensively to human encounters, especially if site personnel lack knowledge on how to interact with wildlife safely.

Minor Negative impact is expected for four species: Sunda pangolin and three snake species (speckle-headed whip snake, keel-bellied whip snake, and red-tailed pipe snake). The impact intensity is "Low" due to the shy and reclusive nature of these species, which minimises the potential for serious conflict or harm during encounters.

No Change is expected for the remaining 77 species that are not perceived as nuisance or threats to construction personnel, such as butterflies, odonates, and birds that are highly mobile and can avoid human presence.

4.4.5.3.6 Human Disturbance

Human disturbance refers to the indirect negative impacts which may arise from the increase in human traffic (i.e., of construction personnel).

Minor negative impact is expected for all 83 species with the proper implementation of minimum control measures.

4.4.6 Post-Construction/ Operational Phase Impact

4.4.6.1 Habitat

The definitions for impact intensity and likelihood for habitat receptors are given in **Table 4-28** and **Table 4-29**. The values assigned for each criterion in RIAM as well as the resulting impact significance for all habitat receptors are provided in **Appendix 4I**.

Table 4-28: Definitions of Each Level of Impact Intensity for Impact Types During Post-Construction/ Operational Phase for Habitat Receptors

Impact Type	Negligible	Low	Medium	High
Habitat degradation	Terrestrial habitats The habitat does not overlap with areas 30 m from the development Aquatic habitats No change in surface water quality	Terrestrial habitats < 10% of the habitat overlaps with areas 30 m from the development Aquatic habitats Some changes in surface water quality	Terrestrial habitats 10–40% of the habitat overlaps with areas 30 m from the development Aquatic habitats Considerable changes in surface water quality	Terrestrial habitats > 40% of the habitat overlaps with areas 30 m from the development Aquatic habitats Extensive changes in surface water quality
Changes in microclimatic conditions	The habitat does not overlap with areas 30 m from the development	< 10% of the habitat overlaps with areas 30 m from the development	10–40% of the habitat overlaps with areas 30 m from the development	> 40% of the habitat overlaps with areas 30 m from the development

Impact Type	Negligible	Low	Medium	High
Introduction of exotic species	The habitat is already exotic-dominated such that introduction of exotic species has no impact on the habitat	The habitat is already exotic-dominated such that introduction of exotic species has some impact on the habitat	Introducing exotic species will change the balance of exotic versus native species within the habitat	Introducing exotic species will be detrimental to the native-dominated habitat

Table 4-29: Definitions of Each Level of Likelihood for all Impact Types During Post-Construction/ Operational Phase for Habitat Receptors

Likelihood	Unlikely/ Remote	Less Likely/ Rare	Possible/ Occasional	Likely/ Regular	Almost Certain/ Continuous
Habitat degradation	The development is not accessible to public; the surrounding natural habitats are not accessible to public	The development is designed for the public to use or visit; the surrounding natural habitats are accessible but public use is restricted/ controlled	The development is designed for the public to use or visit; the surrounding natural habitats are accessible and have infrastructure for the public to use, such as boardwalks (but people can still stray off-track)	The development and its surroundings are designed for large groups of people to live or work in the long-term; the surrounding natural habitats are easily accessible and do not have infrastructure for the public to use, such as boardwalks (thus people will be off-track)	N.A.
Changes in microclimatic conditions	The development is largely green, and human activity is limited (e.g., nature park)	The development involves the building of urban structures but will be heavily landscaped (e.g., urban park)	The development involves the building of urban structures that are designed to release heat (e.g., ventilation shafts)	The development involves the building of extensive hardscapes that absorb and retain heat (e.g., residential estate)	N.A.
Introduction of exotic species	The development is not accessible to public; aquatic habitats are not accessible to public	The development is designed for the public to use or visit; aquatic habitats are accessible but public use is restricted/ controlled	The development is designed for the public to use or visit; aquatic habitats are accessible	The development and its surroundings are designed for large groups of people to live or work in the long-term; aquatic habitats are easily accessible	N.A.

Seven habitat types (i.e., all habitats excluding developed land) were assessed for the following impacts: (1) loss of habitat; (2) forest edge effects; and (3) habitat degradation. A summary of the results is given in **Table 4-30**, and the impacts with **Slight Negative** and above impact significance are briefly explained below.

Table 4-30: Summary of Post-Construction/ Operational Phase Impacts to Habitat Receptors and Number of Habitat Types Affected

Impact Type	Major Negative	Moderate Negative	Minor Negative	Slight Negative	No Change	N.A.
Habitat Degradation	0	1	3	2	1	0
Changes in Microclimatic Conditions	0	3	1	1	1	1
Introduction of Exotic Species	0	1	1	1	3	1

4.4.6.1.1 Habitat Degradation

Habitat degradation refers to the indirect impacts resulting from increased human activities (e.g., trampling on vegetation, litter, changes in surface water quality).

Habitat degradation is "Less Likely" to occur in all the terrestrial and aquatic habitat types except for concrete drain/canal, which does not fall within the 30 m impact zone. Based on the proportion of the remainder of each habitat type that falls within the 30 m impact zone adjacent to the development, the impact intensity is "High" for exotic-dominated secondary forest, urban vegetation, and forest/rural stream. The impact intensity is "Medium" for native-dominated secondary forest, abandoned-land forest, and scrubland/grassland. Overall, the impact significance is **Moderate Negative** for the native-dominated secondary forest as it is of "High" ecological value. The impact significance will be **Minor Negative** for abandoned-land forest, exotic-dominated secondary forest, and forest stream. The impact significance will be **Slight Negative** for scrubland/grassland and urban vegetation.

4.4.6.1.2 Changes in Microclimatic Conditions

This impact refers to the changes in microclimatic conditions (i.e., temperature, light, humidity, etc.) of the habitat due to operational activities and/or micro urban heat island from the adjacent development.

It is "Possible" for changes in microclimatic conditions to occur in all the habitat types except for urban vegetation. Based on the proportion of the remainder of each habitat type that falls within the 30 m impact zone adjacent to the development, the impact intensity is "High" for exotic-dominated secondary forest and forest/ rural stream. The impact intensity is "Medium" for native-dominated secondary forest, abandoned-land forest, and scrubland/grassland. Overall, the impact significance is **Moderate Negative** for the native-dominated secondary forest, exotic-dominated secondary forest, and forest/ rural stream. The impact significance will be **Minor Negative** for abandoned-land forest and **Slight Negative** for scrubland/ grassland.

4.4.6.1.3 Introduction of Exotic Species

The introduction of exotic species refers to the accidental and/or intentional release of exotic animals by humans into waterbodies or terrestrial habitats.

It is "Likely" for introduction of exotic species to occur in the native-dominated secondary forest, forest/ rural stream, and concrete canal/ drain. Given the native-dominated condition of the native-dominated secondary forest, introduction of exotic species will be detrimental and the impact intensity is "High". On the other hand, the forest stream and concrete canal/drain are already exotic-dominated such that introduction of exotic species will have little impact on the habitats. Overall, the impact significance is **Moderate Negative** for native-dominated secondary forest, **Minor Negative** for forest/ rural stream, and **Slight Negative** for concrete canal/ drain.

4.4.6.2 Flora

The poaching of flora species is a potential post-construction/ operational phase impact, which is defined in **Table 4-31** below.

Table 4-31: Likelihood of Poaching During Post-Construction/ Operational Phase for Flora Receptors

Impact Type	Negligible	Low	Medium	High
Poaching	Plant specimens of this species are unlikely to be stolen (i.e., not charismatic, no ethnobotanical value), and/or are too big to remove (e.g., large trees)	Few plant specimens of this species could become stolen (i.e., most plant species are without any ethnobotanical value or are common ornamental plants), and are of small to medium sizes, which can be removed	Some plant specimens of this species could become stolen (i.e., plant species with ethnobotanical value and/or common ornamental plants), and are of small to medium sizes which can be removed	Most plant specimens of this species could become stolen (i.e., orchids, pitcher plants), and are of small to medium sizes, which can be removed

4.4.6.2.1 Poaching

Poaching refers to the stealing of plants by humans. The impact likelihood for all 29 flora species was assessed as "negligible", as they were not of ornamental or ethnobotanical value, and/or were too large to be easily removed, resulting in an impact significance of **No Change**.

4.4.6.3 Fauna

The impact intensity and likelihood of each impact type during the post-construction/ operational phase are defined for fauna species receptors in **Table 4-32** and **Table 4-33**, respectively.

Table 4-32: Definitions of Level of Impact Intensity for All Impact Types During Post-Construction/ Operational Phase for Fauna Receptors

Impact Type	Negligible	Low	Medium	High
Loss of/ reduction in of ecological connectivity for fauna movement	Not dependent on connected habitats for dispersal and able to traverse urban infrastructure	Slightly dependent on connected habitats for dispersal and adaptable to traverse urban infrastructures if needed	Dependent on connected habitats for dispersal	Highly dependent on connected habitats for dispersal
Light disturbances	Species that are not sensitive to changes in light levels: aculeate hymenopterans, aquatic species	Species that are slightly sensitive to changes in light levels: odonates, butterflies	Species that are sensitive to changes in light levels: diurnal birds, reptiles, and mammals	Species that are sensitive to changes in light levels: diurnal birds, reptiles, and mammals

Impact Type	Negligible	Low	Medium	High
Accidental injury or mortality	Species with negligible susceptibility to accidental injury/ mortality from human activities (i.e., residential, commercial, educational or recreational activities) , roadkill, and collision with buildings	Species with low susceptibility to accidental injury/ mortality from operation activities, roadkill, and collision with buildings: ▪ Birds with low susceptibility to collision with buildings ▪ Volant species (e.g., odonates, butterflies, raptors and frugivorous bats)	Species that are mobile but possibly susceptible to accidental injury/ mortality from operation activities and roadkill, and collision with buildings: ▪ Birds that are possibly susceptible to collision with buildings (e.g., resident species with known records of bird-building collision ▪ All amphibians ▪ Some mammals (e.g., squirrels, shrews) ▪ Insectivorous bats (susceptible to roadkill as they are attracted to insects that are attracted to street lamps)	Species with high susceptibility to accidental injury/ mortality from operation activities and roadkill, and collision with buildings: ▪ Birds with high susceptibility to collision with buildings (e.g., forest-edge frugivores, migratory species). ▪ Reptiles. ▪ Some mammals (e.g., Sunda pangolin, Long-tailed macaque, Smooth-coated otter).
Poaching	Species with negligible susceptibility to poaching	Species with low susceptibility to poaching; not commonly known to be traded as pets	Species that are possibly susceptible to poaching; commonly traded as pets	Species that are highly susceptible to poaching; listed on CITES Appendix I or II

Impact Type	Negligible	Low	Medium	High
Human-wildlife conflict	Species that are not perceived as nuisance or threats by construction personnel: ▪ Odonates ▪ Butterflies ▪ Most birds ▪ Bats ▪ Amphibians	Species that are possibly perceived as both nuisance and threats by construction personnel, less tolerant of human presence and urban environments: ▪ Some reptiles	Species that are typically perceived as nuisance and possibly as threats by construction personnel, highly tolerant of human presence and urban environments, and frequently implicated in human-wildlife conflict: ▪ Smooth-coated otter ▪ Aculeate hymenopterans	Species that are typically perceived as both nuisance and threats by construction personnel, highly tolerant of human presence and urban environments, and are frequently implicated in human-wildlife conflict: ▪ Long-tailed macaque ▪ Some snakes
Human disturbances	Species that are not sensitive to human presence	Species that are slightly sensitive to human presence	Species that are sensitive to human presence	Species that are extremely sensitive to human presence, and nesting birds

Table 4-33: Definitions of Each Level of Likelihood for all Impact Types During Post-Construction/ Operational Phase for Fauna Receptors

Likelihood	Definition
Unlikely/ Remote	Impact is not expected to happen during the post-construction/ operational phase.
Less Likely/ Rare	Impact is not likely to happen during the post-construction/ operational phase.
Possible/ Occasional	Impact could possibly happen or known to occur during the post-construction/ operational phase.
Likely/ Regular	Impact is a common occurrence during the post-construction/ operational phase.
Certain/ Continuous	Impact is a continual or repeated process during the post-construction/ operational phase.

Six post-construction/ operational phase impact types were identified and assessed for the pre-mitigated fauna receptors: (1) Loss/ reduction of ecological connectivity for fauna movement; (2) Light disturbance; (3) Accidental injury or mortality; (4) Poaching; (5) Human-wildlife conflict; (6) Human disturbance.

The impact significance ranged from **No Change** to **Minor Negative**. A summary of all the impact on fauna receptors is given in **Table 4-34**, with the numbers indicating the number of species that experience that magnitude of impact. The values assigned for each criterion in the RIAM as well as the resulting impact significance for each fauna receptor are provided in **Appendix 4K**.

Table 4-34: Summary of Post-Construction/ Operational Phase Impact to Fauna Receptors and Number of Species Affected

Impact Type	Major Negative	Moderate Negative	Minor Negative	No Change
Loss/ reduction in ecological connectivity for faunal movement	0	63	0	20
Light disturbance	0	46	37	0
Accidental injury or mortality	0	27	9	47
Poaching	0	17	60	6
Human-wildlife conflict	0	2	4	77
Human disturbance	0	0	83	0

4.4.6.3.1 Loss/ Reduction of Ecological Connectivity for Fauna Movement

This impact is defined as impediments to faunal movement by presence of buildings, infrastructure, and human activity. The impact significance for the loss/ reduction of ecological connectivity follows from the Construction Phase (see **Section 4.4.5.3.2**), on the assumption that minimum control measures are fully implemented.

Moderate Negative impact is expected for 63 species, generally forest-associated species that are dependent on connected habitats for dispersal. These include forest-associated birds such as the Straw-headed bulbul, Thick-billed green pigeon and Square-tailed drongo-cuckoo; forest butterflies such as the Singapore fourline blue and Grand imperial; mammals like the Sunda pangolin, which is particularly vulnerable to roadkill during forest-to-forest movement, and reptiles such as the Speckle-headed whip snake.

No Change is expected for the remaining 20 species that do not require connected habitats for dispersal and are capable of traversing urban infrastructure. These include the Long-tailed macaque, Smooth-coated otter, urban-adapted or migratory bird species, and a few butterfly species that utilise scrubland and streetscapes.

4.4.6.3.2 Light Disturbance

The Increase in light levels from the development may result in disturbance to wildlife.

During the operational phase, urban lighting is expected to result in **Moderate Negative** impact for 46 species, including nocturnal animals such as bats, herpetofauna, and mammals, which are highly sensitive to artificial lighting which can disrupt their foraging and navigation behaviours. Birds are also affected due to their sensitivity to light, which can disrupt their roosting behaviour.

Minor Negative impact is expected for one odonate and 36 butterfly species.

4.4.6.3.3 Accidental Injury or Mortality

The development of new road infrastructure and high-rise residential buildings is expected to increase the risk of roadkill and bird collisions during the operational phase, resulting in an impact likelihood of "Possible/ Occasional (3)".

Moderate Negative impact is expected for two ground-dwelling mammal species and 25 species of birds.

Two species prone to roadkill, the Sunda pangolin and Smooth-coated otter, and likely to traverse roads while foraging or move between habitat patches, resulting in an impact significance of **Moderate Negative**.

Meanwhile, birds that are highly susceptible to collision with glass facades include forest-edge frugivores, migratory species, and resident species with known records of collisions. The 25 species identified in these categories were assigned an impact intensity of "Moderate (2)" or "High (3)", resulting in an impact significance of **Moderate Negative**.

The remaining nine bird species are less susceptible to glass collisions and were assigned an impact intensity of "Low (1)", resulting in an impact significance of **Minor Negative**.

4.4.6.3.4 Poaching

Poaching refers to the trafficking of wildlife by humans. Due to increased site accessibility and human presence during the operational phase, **Moderate Negative** impact is expected for 17 species. This includes species that are vulnerable to the pet trade and illegal wildlife trade, which were assigned an impact intensity of "Medium (2)" or "High (3)". Despite Singapore's stance of zero-tolerance towards illegal wildlife trade, the likelihood is still "Possible (2)" given known occurrences of such activities.

Mammals such as the Sunda pangolin are also highly susceptible, being highly prized in the illegal wildlife trade. Songbirds such as the Straw-headed bulbul, and other charismatic species such as the Jambu fruit dove, Spotted wood owl, and Crested serpent eagle; and turtles such as the Malayan box terrapin and Asian softshell turtle may also be targeted for the exotic pet market.

Minor Negative impact is expected for 60 species, including butterflies and the three species of snakes assessed, which are less frequently targeted by collectors. **No Change** is expected for six highly volant species such as bats and Plume-toed swiftlet, which are unlikely to be targeted and difficult to capture.

4.4.6.3.5 Human-wildlife Conflict

Human-wildlife conflict refers to direct, negative human-wildlife interactions, such as the deliberate killing of species perceived as nuisances or threats by members of the public. The impact significance of human-wildlife conflict during the operational phase is similar to that of the construction phase:

Moderate Negative impact is expected for two species, the Long-tailed macaque and Smooth-coated otter. Long-tailed macaques may be attracted to food waste, leading to negative interactions with residents. Smooth-coated otters are not naturally aggressive but may react defensively to human encounters especially if residents lack knowledge on how to interact with wildlife safely.

Minor Negative impact is expected for four species: Sunda pangolin and three snake species (Speckle-headed whip snake, Keel-bellied whip snake, and Red-tailed pipe snake). The impact intensity is "Low (1)" due to the shy and reclusive nature of these species, which minimises the potential for serious conflict or harm during encounters.

No Change is expected for the remaining 77 species that are not perceived as nuisance or threats to construction personnel, such as butterflies, odonates, and birds that are highly mobile and can avoid human presence.

4.4.6.3.6 Human Disturbance

Human disturbance refers to the indirect negative impacts which may arise from the increase in human traffic.

All 83 species are expected to experience **Minor Negative** impact from increased human presence during the operational phase, with an impact likelihood of "Possible/ Occasional (2)".

4.5 Recommendation of Preventive and Mitigation Measures

This section discusses mitigation measures for future residential developments, which are implemented based on the mitigation hierarchy in the following order: (1) avoid; (2) minimise; (3) restore; and (4) compensate. Avoidance of the impact is first attempted. If avoidance is not possible, efforts are made to minimise construction impacts. Finally, if habitat loss is inevitable, suggestions for compensation and enhancement/rehabilitation of remaining and/ or nearby habitats are proposed as a form of impact mitigation.

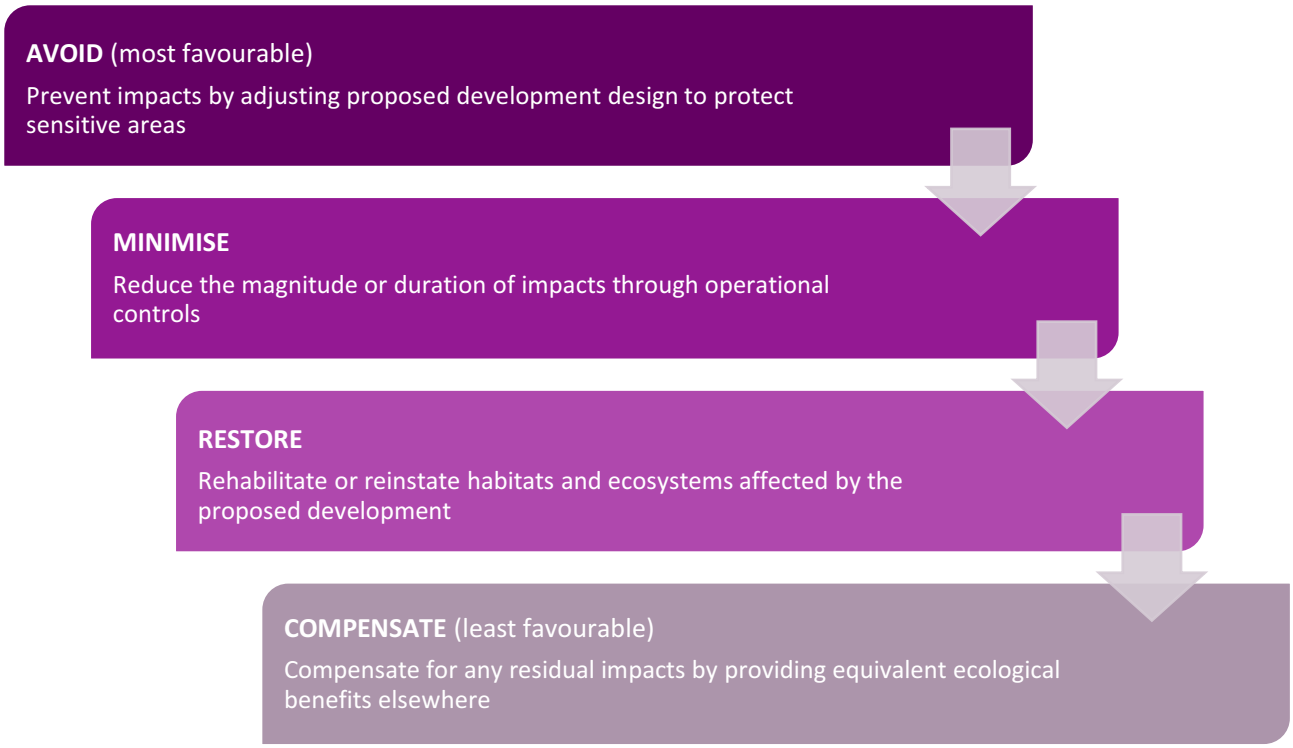


Figure 4-20: The Mitigation Hierarchy

4.5.1 Avoid

The first priority in the mitigation hierarchy is to avoid impacts to biodiversity. Avoidance is preferred because it prevents impacts from occurring in the first place, thereby eliminating the need for subsequent mitigation measures.

4.5.1.1 Proposed Retained Area and Area of Habitat Creation

Based on the findings of the baseline study, a 14.6 ha Proposed Retained Area and Area of Habitat Creation was identified (**Figure 4-21**), which includes Telok Blangah Hill Park. These areas should be retained where possible and integrated in the proposed development as park spaces where light structures such as footpaths/ boardwalks may be constructed for public use. Large/ heavy structures should be avoided as far as possible to ensure seamless connectivity for fauna.

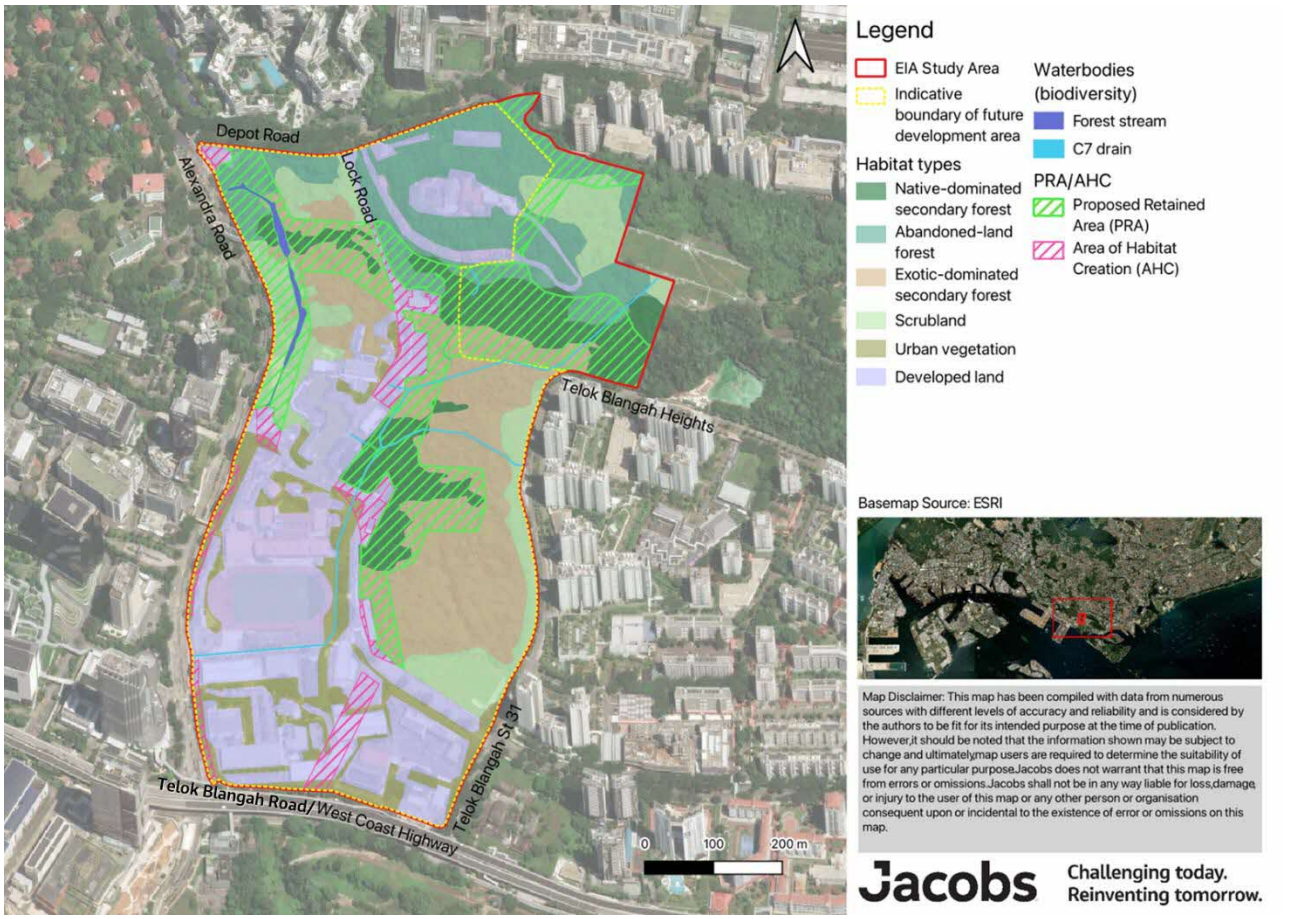


Figure 4-21: Proposed Retained Area and Area of Habitat Creation

These areas include the following existing ecological features of high value and potential habitat enhancement/ creation opportunities.

(a) Native-dominated secondary forest: Majority of the native-dominated secondary forest found in the EIA Study Area is proposed to be retained. Native-dominated secondary forest is of high ecological value because it is able to support high flora and fauna species richness, including unique species that are typically not found in other terrestrial habitat types. Such forests are mature and are irreplaceable and rare in Singapore because of increasing urbanisation.

(b) Forest stream: The interface of terrestrial and aquatic habitats has formed a diverse ecosystem for stream-dependent flora and fauna to persist. Stream-dependent fauna species of conservation that were identified of probable occurrence are likely to utilise the forest stream (WQ2). Some examples of these species include the nationally Vulnerable Yellow bittern (*Ixobrychus sinensis*), Cinnamon bittern (*Ixobrychus cinnamomeus)*, Green-eyed percher (*Chalybiothemis fluviatilis*), and Asian softshell turtle (*Amyda cartilaginea*). The stream currently also serves an important role in flood control. During the detailed design stage, hydrology studies should be undertaken to accurately determine how the development and any land grade changes around the stream will affect the existing volume of water flowing within the catchment of the stream. In planning the drainage, some surface flow could be diverted from the proposed development into the stream to ensure a constant basal volume of water flow. Care should also be taken not to drain too much additional surface flow into the stream so as not to overburden it.

(c) Flora species of conservation significance: A concentration of flora species of conservation significance can be found within the Proposed Retained Area. Notably, all three specimens of the Vulnerable *Endospermum peltatum* and the only specimen of the Vulnerable *Pittosporum* cf. *ridleyi* were found in the Proposed Retained Area. Most of the specimens of the Critically Endangered *Ficus sinuata*, Vulnerable *Ficus vasculosa*, Vulnerable *Horsfieldia polyspherula* were also found in the Proposed Retained Area.

(d) Large plant specimens: Of the 176 large plant specimens recorded, 67 were found within the Proposed Retained Area and Area of Habitat Creation. These include more than half of the large bamboo specimens recorded within the EIA Study Area. These large bamboo specimens provide ample roosting opportunities for the nationally Vulnerable Bamboo bats (*Tylonycteris* sp.). The Proposed Retained Area also includes several specimens of Strangling figs (*Ficus benjamina* and *Ficus microcarpa*), the largest of which cover a spread of 20 m. Many mature specimens of streetscape trees such as *Pterocarpus indicus*, *Samanea saman*, and *Khaya senegalensis* also fall within the Area of Habitat Creation. Retaining these trees can greatly help in maintaining the microclimate of the habitats, buffering them against edge effects. These large specimens are also extremely difficult to transplant and are highly recommended to be retained *in-situ*.

(e) Other plant specimens of value: The Proposed Retained Area contains nine plant specimens of value, which are mainly keystone species such as *Ficus fistulosa* and *Ficus variegata*.

(f) Part of existing Telok Blangah Hill Park: The Proposed Retained Area and Area of Habitat Creation consists of area zoned Park in URA Master Plan 2025, which is made up of a portion of the existing Telok Blangah Hill Park. This strip of park serves as a key ecological corridor facilitating the east-west movement of avian and arboreal fauna between the existing Telok Blangah Hill Park and HortPark.

(g) Ecological corridor connecting surrounding green spaces: Further to the east-west ecological corridor mentioned above, a north-south ecological corridor is proposed as the spine of the Proposed Retained Area and Area of Habitat Creation. The alignment of this corridor is such that it provides the path of least resistance to volant fauna moving between the EIA Study Area and existing or future ecological corridors in Berlayar Creek or Berlayar (former Keppel Club site) in the south. Furthermore, literature review indicates the importance of the former Keppel Club site as a nesting and foraging ground for birds and an important ecological corridor between Labrador Nature Reserve and the Southern Ridges (which includes Mount Faber Park, Telok Blangah Hill Park, and Kent Ridge Park). For example, forest-dependent birds such as the Straw-headed bulbul (*Pycnonotus zeylanicus*) and Changeable hawk-eagle (*Nisaetus cirrhatus*) were recorded in this EIA Study Area as well as former Keppel Club site (AECOM, 2022), suggesting that these birds could belong to the same metapopulation utilising this ecological corridor. This path has also been identified by NParks in the Ecological Profiling Exercise. At the areas currently occupied by developed land, creation of a rewilded urban park should be implemented to ensure the continuity and effectiveness of this corridor. The recommended width of this corridor is 60 m, based on a literature review on corridor sizes and surrounding land uses. The United States Department of Agriculture (USDA) National Agroforestry Centre recommends as a guideline that a corridor will generally need to be wider in landscapes that provide limited habitat or that are dominated by human use. The considerations for the proposed corridor width include:

- **Target species**: In general, the larger the target species, the wider the corridor needed. In the context of the EIA Study Area, the target species are birds (including forest interior species) and arboreal mammals. The recommended width for such species is 30 m to 60 m (National Agroforestry Centre, ND).

- **Edge effects**: Changes in temperature, light intensity, and soil moisture happens between 20 and 30 m from the forest edge, and at least 32 m of heavily forested vegetation is required to buffer for noise (Beschta et al., 1987; Johnson & Ryba, 1992; Matlack, 1993; Murphy, 1995; The Environment Law Institute, 2003). Therefore, the proposed corridor width of 60 m would be a minimum requirement to ensure the habitat core of the corridor is protected against edge effects.

- **Ecological corridor widths in the surrounding landscape**: The former Keppel Club site adopted green corridors that were 30 m- and 60 m-wide. A 30 m-wide corridor was adopted along Berlayar Creek, as the development was only on one side of the habitat (AECOM, 2022). Meanwhile, a Central Green Corridor of 60-m wide was implemented for areas with development on both sides of the forest, to account for double edge effects. Given the proximity and similar ecological context of the former Keppel Club site, the considerations for this study are similar. Maintaining corridor continuity across the landscape would provide synergies for ecological connectivity within the broader Labrador Nature Park Network.

The Proposed Retained Area features varied corridor widths, achieving a minimum of 30 m throughout, and expanding to approximately 200-m within the native-dominated secondary forest. Although its narrower sections may experience some edge effects, the wider retained areas compensate by providing habitat for shelter and foraging. Overall, the Proposed Retained Area is expected to adequately facilitate fauna movement across the landscape.

4.5.2 Minimise

Secondly, the mitigation hierarchy seeks to minimise impacts by reducing the magnitude or duration of impacts through operational controls. The goal is to ensure that impacts which cannot be avoided are reduced to the lowest practicable level.

(a) Transplantation or salvaging of flora species of conservation significance

Species of conservation significance of girth 0.3 m and less that fall within the construction zone can be salvaged prior to site clearance, transplanted to retained areas of native-dominated forest, or used in habitat creation and enhancement works within the EIA Study Area. Site visits shall be conducted to identify suitable specimens for salvaging together with and under the discretion of the National Biodiversity Centre and Pasir Panjang Nursery (NParks). Specimens are selected for salvaging based on national status, health, size and survival rates post-transplantation.

Figure 4-22 shows the specimens recommended for salvaging. Notable species include the critically endangered *Antiaris toxicaria* (1 specimen; <0.05 m girth, 0.1 m height) and *Ficus sinuata* (3 specimens; <0.05 m girth, 0.7-1.4 m height).

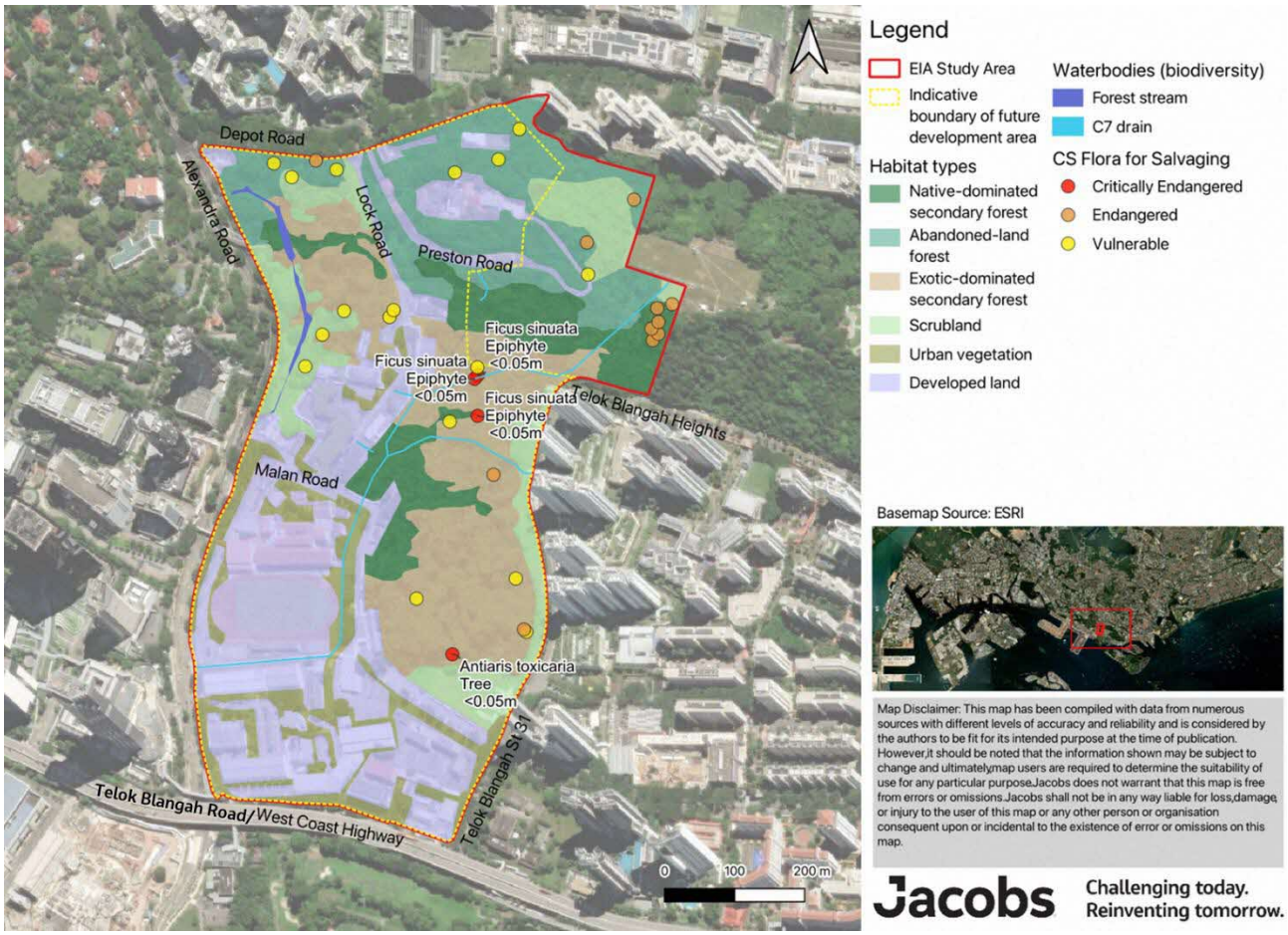


Figure 4-22: Flora Specimens Identified for Transplantation or Salvaging

(b) Conduct regular inspections in habitats adjacent to the worksite

During the construction phase, regular inspections shall be conducted by a Flora Specialist in the habitats adjacent to the worksite to identify any signs of habitat degradation and forest edge effects. Measures shall then be implemented to remediate such effects. The inspections shall also identify any excessive vegetation clearance beyond the agreed working boundaries.

(c) Implement dense landscaping and in-fill planting along the new forest edges

During the construction phase, in-fill planting shall be implemented along the new forest edges to minimise forest edge effects. In-fill planting involves planting of native plants, particularly pioneer trees to jump start forest succession. It makes use of the existing framework of forest canopy and emergent, while selectively removing undesirable exotic species. Plant species of various other habits should also be planted (i.e., shrubs, ground cover, etc.), Ideally, forest edges should be deliberately tiered with shrubs at the outer edges followed by tree species of different mature heights. This would produce a graded canopy line that is shape-optimised to buffer against wind and rain to reduce tree failure at the forest edges.

(d) Conduct regular site inspections to ensure contractor compliance with the EMMP

During the construction phase, regular site inspections should be conducted to verify that the contractor adheres to the clauses within the EMMP, such as proper pollution control measures related to water, air, food waste, and toxic waste.

Inspections should also ensure the implementation of fauna protection measures, including directional site clearance, and compliance with restrictions on night works. Where night works are unavoidable, a light

management plan must be in place to minimise disturbance to nocturnal species. Additionally, inspections should confirm that biodiversity awareness training has been conducted for all site personnel to reduce accidental injury, mortality, and human-wildlife conflict. Specialised measures such as Bamboo bat rescue and translocation protocols should be conducted in line with the EMMP (see **Section 8.5**).

(e) Put up signages with guidelines for visitors

During the post-construction/ operational phase, signages should be in place to remind visitors not to stray off-trail, litter, or release exotic animals. The signages should also clearly establish the penalties involved in committing such offences. This can reduce the likelihood of habitat degradation and introduction of exotic species occurring.

Additionally, signage providing guidelines for safe wildlife interaction, such as maintaining distance and not feeding animals, can minimise human-wildlife conflict. Information on the Wildlife Act and penalties should also be displayed prominently to deter harm to protected fauna species.

(f) Conduct regular removal of undesirable exotic species

During the post-construction/ operational phase, regular removal of the undesirable exotic flora and fauna species should be implemented to minimise the uncontrolled spread of such species.

(g) Carry out regular maintenance of the retained habitats

During the post-construction/ operational phase, regular maintenance (e.g., removal of litter, emptying of trash, ensure integrity of railings along trails and boardwalks) should be conducted to minimise habitat degradation.

(h) Restrict entry of retained forest at night (1900h – 0700h)

Access to retained forest areas should be restricted between 1900h and 0700h to minimise disturbance to wildlife. Physical barriers such as fencing, combined with clear signage, can be installed at access points to prevent unauthorised entry during sensitive hours.

(i) Integrate bird-friendly building design

Building design should incorporate bird-friendly features to reduce collision risk with glass and reflective surfaces. Measures include the use of glass decals, treated glass, or external screens. These design elements increase visibility of barriers to birds and minimise the risk of collision.

(j) Implement road calming measures

Road calming measures should be implemented along internal roads adjacent to retained habitats to reduce vehicle speeds and roadkill risk. Measures may include speed bumps, raised crossings, narrowed road widths, and clear speed limit signage. Wildlife crossing signs should also be installed at identified movement corridors to alert drivers to areas of high fauna activity.

(k) Adopt light management strategies to prevent light spill

Light shielding (e.g., directional fixtures or hoods, etc.) and the use of warm lighting (<3,000K colour temperature) should be implemented to minimise disruption to nocturnal wildlife and reduce sky glow. Fixtures should be directed downward and away from sensitive ecological areas.

4.5.3 Restore

Third in the mitigation hierarchy is to restore affected habitats and ecosystems. Restoration measures are implemented after construction is complete to rehabilitate areas that have been temporarily disturbed or degraded.

The goal of restoration is to return ecological functions and biodiversity values to conditions as close as possible to their pre-impact state. However, restoration can never fully replicate the complexity of mature, undisturbed ecosystems, which reinforces why avoidance and minimisation remain the preferred approaches in the mitigation hierarchy.

(a) Carry out habitat enhancement in retained areas

Assisted natural regeneration can be carried out for the following habitats: abandoned-land forest, exotic-dominated secondary forest, and scrubland/ grassland. Within these habitat types, undesirable and storm-vulnerable exotic trees are abundant. These species are fast-growing and compete for resources with native trees. Storm-vulnerable exotic tree species including *Acacia auriculiformis*, *Falcataria moluccana*, and *Spathodea campanulata* also pose a safety risk to visitors. These species should be phased out and in-fill planting of native plants as described above, should be carried out. Storm-vulnerable specimens near (future) areas of human activity should be removed unless they bear other important ecological features such as raptor nests. The assisted natural regeneration should consider the planting of native riparian plants with reference to floral assemblages within the proposed retained areas and along the retained/ enhanced waterbodies.

These habitat enhancement measures can help to partially offset the loss of habitats.

4.5.4 Compensate

Last in the mitigation hierarchy is to offset residual impacts by compensating for biodiversity loss through the provision of ecological benefits elsewhere.

(a) Carry out habitat creation

For the retained areas that are currently occupied by developed land, habitat creation should be carried out to bolster the ecological connectivity and to partially compensate for the loss of habitats. The habitat creation should cater primarily to birds, small mammals, and other arboreal animals.

The priority shall be to create or maintain a continuous tree canopy to facilitate fauna movement across the site. A multi-layered forest structure should be established, comprising understorey shrubs and groundcover, mid-layer trees, and canopy trees. This vertical stratification is essential for arboreal mammals, providing access points from ground level to the canopy layer. The retention of large existing plant specimens can help expedite canopy establishment.

A native planting palette should be used, based on species currently present within specific habitat types on site. This includes, but is not limited to the following:

- Native-dominated secondary forest: Wild cinnamon (*Cinnamomum iners*), Sea almond (*Terminalia catappa*), Tembusu (*Cyrtophyllum fragrans*), Malayan teak (*Vitex pinnata*), Medang (*Litsea elliptica*).
- Forest stream: Pulai (*Alstonia angustiloba*), Sea almond (*Terminalia catappa*), Red-stem fig (*Ficus variegata*), Sea apple (*Syzygium grande*).

The planting palette should also incorporate bird and butterfly-attracting species. The implementation of NParks' Nature Ways planting scheme should be considered, as this approach simulates natural forest conditions, and supports diverse wildlife.

(b) Creation of Active, Beautiful, Clean Waters (ABC) features in the AHC

ABC features such as rain gardens or bioswales could be considered for the proposed development to provide ecological benefits while managing stormwater runoff. ABC features planted with native vegetation can provide supplementary habitat and stepping-stone connectivity for urban-adapted fauna species, enhancing the overall ecological value of the development.

4.6 Residual Impact

4.6.1 Habitat Residual Impact Assessment

The assessment of residual impacts took into consideration the mitigation measures for habitats provided in **Section 4.5**. It also assumes minimum controls are properly implemented and enforced. A summary of the significant pre-mitigation impacts and the corresponding residual impact significance for habitat receptors is shown in **Table 4-35**. The detailed evaluation for each habitat is provided in **Appendix 4I**.

Table 4-35: Summary of Impact Significance for Habitat Receptors (Pre-mitigation vs Residual Impact)

Habitat Receptor	Significant Pre-mitigation Impacts (Environmental Score)	Residual Impact Significance (Environmental Score)
Construction Phase – Loss of Habitat		
Native-dominated secondary forest	Major Negative (-351)	Moderate Negative (-234)
Abandoned-land forest	Moderate Negative (-234)	Moderate Negative (-234)
Exotic-dominated secondary forest	Moderate Negative (-234)	Moderate Negative (-234)
Scrubland/grassland	Minor Negative (-117)	Minor Negative (-117)
Urban vegetation	Minor Negative (-117)	Minor Negative (-117)
Forest stream	Moderate Negative (-156)	No Change/ Status Quo (0)
Concrete drain/canal	Minor Negative (-117)	Minor Negative (-117)
Post-Construction/ Operational Phase – Habitat Degradation		
Native-dominated secondary forest	Moderate Negative (-132)	Minor Negative (-66)
Abandoned-land forest	Minor Negative (-88)	Slight Negative (-44)
Exotic-dominated secondary forest	Minor Negative (-88)	Slight Negative (-44)
Scrubland/grassland	Slight Negative (-44)	Slight Negative (-22)
Urban vegetation	Slight Negative (-44)	Slight Negative (-22)
Forest stream	Minor Negative (-88)	Slight Negative (-44)
Concrete drain/canal	No Change/ Status Quo (0)	Slight Negative (-22)
Post-Construction/ Operational Phase – Changes in Microclimatic Conditions		
Native-dominated secondary forest	Moderate Negative (-144)	Moderate Negative (-144)
Abandoned-land forest	Minor Negative (-96)	Minor Negative (-96)
Exotic-dominated secondary forest	Moderate Negative (-144)	Minor Negative (-96)
Scrubland/grassland	Slight Negative (-44)	Slight Negative (-22)
Urban vegetation	N.A.	N.A.
Forest stream	Moderate Negative (-144)	Minor Negative (-96)
Concrete drain/canal	No Change/ Status Quo (0)	Slight Negative (-48)

Habitat Receptor	Significant Pre-mitigation Impacts (Environmental Score)	Residual Impact Significance (Environmental Score)
Post-Construction/ Operational Phase – Introduction of Exotic Species		
Native-dominated secondary forest	Moderate Negative (-198)	Moderate Negative (-198)
Abandoned-land forest	No Change/ Status Quo (0)	No Change/ Status Quo (0)
Exotic-dominated secondary forest	No Change/ Status Quo (0)	No Change/ Status Quo (0)
Scrubland/grassland	No Change/ Status Quo (0)	No Change/ Status Quo (0)
Urban vegetation	N.A.	N.A.
Forest stream	Minor Negative (-88)	Slight Negative (-44)
Concrete drain/canal	Slight Negative (-44)	Slight Negative (-22)

4.6.1.1 Construction Phase – Loss of Habitat

As most (97.26%) of the native-dominated secondary forest is located within the Proposed Retained Area identified in **Section 4.5.1.1**, the **Major Negative** impact arising from the loss of this habitat type can be reduced to **Moderate Negative** with the retention of the Proposed Retained Area.

For the forest stream, the habitat type would be fully retained within the Proposed Retained Area. Hence, the **Moderate Negative** impact can be reduced to **No Change/ Status Quo**.

For abandoned-land forest and exotic-dominated secondary forest, although less of the habitat types would be cleared if the Proposed Retained Area were to be retained, the impact significance would remain in the **Moderate Negative** range.

4.6.1.2 Post-Construction/ Operational Phase – Habitat Degradation

For the native-dominated secondary forest, the installation of signages to remind visitors not to stray off-trail or litter, as well as implementation of regular maintenance of the park (e.g., removal of litter, emptying of trash, ensure integrity of railings along trails and boardwalks) can reduce the likelihood of habitat degradation occurring. The **Moderate Negative** impact can therefore be reduced to **Minor Negative** impact. The impact significance for concrete drain/canal increases from **No Change** to **Slight Negative** as a larger proportion of it will fall within the 30 m indirect impact zone, instead of being cleared, under the post-mitigation scenario.

4.6.1.3 Post-Construction/ Operational Phase – Changes in Microclimatic Conditions

For native-dominated secondary forest, exotic-dominated secondary forest, and forest stream, "High" intensity of forest edge effects is expected but the implementation of in-fill planting would help to buffer against microclimatic changes and reduce the likelihood of occurrence from "Likely" to "Possible". The **Moderate Negative** impact can be reduced to **Minor Negative** for exotic-dominated secondary forest and forest stream. For native-dominated secondary forest, the impact significance remains in the **Moderate Negative** range despite reduction in likelihood of occurrence as it is of "High" ecological value. The impact significance for concrete drain/canal increases from **No Change** to **Slight Negative** as a larger proportion of it will fall within the 30 m indirect impact zone, instead of being cleared, under the post-mitigation scenario.

4.6.1.4 Post-Construction/ Operational Phase – Introduction of Exotic Species

For the native-dominated secondary forest, the installation of signages to remind visitors not to release exotic animals, as well as implementation of regular removal of undesirable exotic species can reduce the likelihood of introduction of exotic species and minimise their uncontrolled spread. The impact significance remains in

the **Moderate Negative** range despite reduction in likelihood of occurrence as the habitat type is of "High" ecological value.

4.6.2 Flora Residual Impact Assessment

The assessment of flora residual impacts took into consideration the mitigation measures provided in **Section 4.5**. It also assumes minimum controls are properly implemented and enforced. A summary of the significant pre-mitigation impacts and the corresponding residual impact significance is shown in **Table 4-36**. A detailed evaluation for each flora receptor is provided in **Appendix 4J**.

Table 4-36: Summary of Impact Significance for Flora Impacts (Pre-mitigation vs Residual Impact)

Impact Type		Major Negative	Moderate Negative	Minor Negative	No Change	N.A. (Salvaged)
Mortality (Construction Phase)	Unmitigated Impact	12	3	6	8	0
	Residual Impact	1	0	6	7	15
Decline in Plant Health and Survival (Construction Phase)	Unmitigated Impact	0	6	3	6	14
	Residual Impact	0	9	7	5	8

4.6.2.1 Mortality

The impact assessment on flora mortality illustrates the effect of mitigation measures on the assessed species at the pre-construction phase. The mitigation measure at this stage is the transplantation or salvaging of affected individual(s) if they are of 0.3 m girth or less. Salvaged individuals above 0.3 m in girth have low survival rates post-transplantation (Struve, 2009).

The critically endangered *Symplocos adenophylla* faces **Major Negative** residual impact. At the time of survey, the girth and height of the single specimen was 0.3 m and 5 m, respectively. Accounting for time and growth of the specimen between the survey and any initial attempts at salvation of species of conservation significance, it is very unlikely that the single specimen can be salvaged and will instead be felled.

Six specimens of *Palaquium obovatum* ranging <0.05-0.05m in girth shall be salvaged, while one specimen of 0.3 m in girth will likely be felled, resulting in an impact significance of **Minor Negative** with an environmental score of -117. The nine remaining specimens all fall within Telok Blangah Park, unlikely to be affected by indirect construction impacts.

The vulnerable *Endospermum peltatum* is distributed only within the native-dominated secondary forest habitat within the EIA Study Area. Initially affected by a pre-mitigation score of -351 (Major Negative), the retention of the habitat as a mitigation measure drops the score to 0 (No Change), with all three specimens located more than 30 m from a forest edge.

4.6.2.2 Decline in Plant Health and Survival

The impact assessment on the decline in plant health and survival illustrates the effect of mitigation measures on the assessed species during the construction phase. The mitigation measure at this stage is the provision of dense planting along the new forest margins, which alleviates microclimatic fluctuations caused by loss of habitat and construction work.

Nine species may decline in health post-mitigation (**Moderate Negative**, with an environmental score of -180). These can be attributed to indirect effects of construction, which either deteriorate microclimatic conditions or cause significant fluctuations in essential parameters such as humidity, light exposure, siltation and disturbances to subterranean hydrology. *Litsea* cf. *castanea* for example, falls approximately 16 m from a new

forest edge and may decline in health during the construction phase, warranting regular monitoring. The specimen, as with others in similar predicaments, may be marked for salvation or transplantation during the environmental monitoring and management phase, though not initially identified for salvation or transplantation pre-construction.

Two species, *Archidendron contortum* and *Macaranga griffithiana*, have a pre-mitigation impact environmental score of "**No Change**" because all individuals fall outside but close to the development boundary. This falls to a residual impact environmental score of "**Moderate Negative**" because at least 50% of the individuals are within 30m of the new forest margin and construction zone during the construction phase.

Similarly, five other species, *Ficus sinuata, Archidendron jiringa*, *Ficus vasculosa*, *Horsfieldia polyspherula* and *Pittosporum* cf. *ridleyi*, have a pre-mitigation impact environmental score of "**N.A. (salvaged)**" because suitable individuals were assumed to be salvaged in the prior pre-construction phase (**Section 4.6.2.1**). This again falls to a residual impact environmental score of "**Moderate Negative**" because at least 50% of the remaining individuals from all five species are within 30 m of the new forest margin and construction zone.

4.6.3 Fauna Residual Impact Assessment

The assessment of residual impacts took into consideration the mitigation measures outlined in **Section 4.5** and assumes minimum controls are properly implemented and enforced. The detailed evaluation for each species is provided in **Appendix 4K**.

4.6.3.1 Fauna Residual Impact for Construction Phase

A summary of the significant pre-mitigation impacts and the corresponding residual impact significance for fauna receptors during construction phase is shown in **Table 4-37**.

Table 4-37: Summary of Construction Phase Impact Significance for Fauna Receptors (Pre-mitigation vs Residual Impact)

Impact Type		Major Negative	Moderate Negative	Minor Negative	No Change
Loss of/ reduction in habitats and food sources	Unmitigated Impact	60	**23**	0	0
	Residual Impact	58	**19**	0	**6**
Loss/ reduction of ecological connectivity for fauna movement	Unmitigated Impact	0	**63**	0	20
	Residual Impact	0	**49**	**14**	20
Accidental injury or mortality	Unmitigated Impact	**2**	**10**	**34**	37
	Residual Impact	0	**2**	**44**	37
Light disturbance	Unmitigated Impact	0	**46**	**37**	0
	Residual Impact	0	0	**83**	0
Human-wildlife conflict	Unmitigated Impact	0	**2**	**4**	77
	Residual Impact	0	0	**6**	77
Human disturbance	Unmitigated Impact	0	0	**83**	0
	Residual Impact	0	0	0	**83**

4.6.3.1.1 Loss of/Reduction in Habitats and Food Sources

Under the mitigated scenario, the Proposed Retained Area is implemented to reduce habitat loss. The forest stream is fully retained within this area, resulting in the impact significance for six stream habitat specialist species, such as the Malayan box terrapin, reducing from Moderate Negative to **No Change**.

While a larger proportion of terrestrial habitats are also retained compared to the unmitigated scenario, the extent of retention only results in a categorical change in impact significance for two species, reducing the residual impact from Major Negative to **Moderate Negative** for the Square-tailed drongo-cuckoo and keel-bellied whipsnake. The residual impact for 58 species continues to fall under **Major Negative**, while 19 species fall under **Moderate Negative**.

4.6.3.1.2 Loss/Reduction of Ecological Connectivity for Fauna Movement

With the implementation of the Proposed Retained Area and Area of Habitat Creation, along with connectivity measures like culverts, the impact likelihood reduces from "Almost Certain/Continuous" to "Less Likely/Rare".

Of the 63 species with **Moderate Negative** unmitigated impacts, 49 species remain at **Moderate Negative** post-mitigation, but with an improved environmental score (i.e., from -216 to -144). For the remaining 14 species, the impact significance after mitigation is reduced categorically to **Minor Negative**. These 14 species include those are better able to traverse urban matrices such as the Oriental magpie-robin and Spotted wood owl.

No Change is expected for 20 species that do not require connected habitats and are capable of traversing urban infrastructure, including the Long-tailed macaque, Smooth-coated otter, and bird species that are particularly urban-adapted.

4.6.3.1.3 Accidental Injury or Mortality

The implementation of Bamboo bat roost emergence surveys and translocation reduces the impact significance for the two Bamboo bat species from Major Negative to **Moderate Negative**. While these species remain susceptible to injury and mortality during bamboo clearance due to their roosting behaviour in bamboo nodes, the specialised rescue measures reduce the likelihood of casualties.

The impact likelihood is reduced for all other affected species with the implementation of comprehensive fauna protection measures outlined in the EMMP (e.g., regular site inspections, directional site clearance, and biodiversity awareness training), leading to 44 species under **Minor Negative**. The one odonate and 36 butterfly species remain at **No Change**.

4.6.3.1.4 Light Disturbance

With the avoidance of night works and light management measures in place, the residual impact significance for all species is reduced to **Minor Negative**.

4.6.3.1.5 Human-wildlife Conflict

The adoption of mitigation measures listed in **Section 4.5** reduces the likelihood of human-wildlife conflict from "Possible/ Occasional" to "Less Likely/ Rare".

Two species, the Long-tailed macaque and Smooth-coated otters, have a reduced Impact Significance, dropping to **Minor Negative**. Four species, including three species of snakes and the Sunda pangolin, remain at **Minor Negative** with an improved environmental score (i.e., from -90 to -60). **No Change** is expected for the remaining 77 species.

4.6.3.1.6 Human Disturbance

Biodiversity awareness training for construction personnel is expected to reduce the likelihood of human disturbance to wildlife to "Unlikely/ Remote", resulting in an Impact Significance of **No Change** for all 83 species.

4.6.3.2 Fauna Residual Impact for Post-Construction/ Operation Phase

A summary of the significant pre-mitigation impacts and the corresponding residual impact significance for fauna receptors during post-construction/ operational phase is shown in **Table 4-38**.

Table 4-38: Summary of Post-Construction/ Operational Phase Impact Significance for Fauna Receptors (Pre-mitigation vs Residual Impact)

Impact Type		Major Negative	Moderate Negative	Minor Negative	No Change
Loss of/ reduction in ecological connectivity for faunal movement	Unmitigated Impact	0	**63**	0	20
	Residual Impact	0	**49**	**14**	20
Light disturbance	Unmitigated Impact	0	**46**	**37**	0
	Residual Impact	0	0	**83**	0
Accidental injury or mortality	Unmitigated Impact	0	**27**	**9**	47
	Residual Impact	0	0	**36**	47
Poaching	Unmitigated Impact	0	**17**	**60**	6
	Residual Impact	0	0	**77**	6
Human-wildlife conflict	Unmitigated Impact	0	**2**	**4**	77
	Residual Impact	0	0	**2**	81
Human disturbance	Unmitigated Impact	0	0	83	0
	Residual Impact	0	0	83	0

4.6.3.2.1 Loss/ Reduction of Ecological Connectivity for Fauna Movement

The residual impact significance for the loss/ reduction of ecological connectivity follows from the Construction Phase (see above).

4.6.3.2.2 Light Disturbance

With the recommended light management measures in place, the residual impact significance for all species is reduced to **Minor Negative**.

4.6.3.2.3 Accidental Injury or Mortality

Road-calming measures reduces the impact significance for two ground-dwelling species, the Sunda pangolin and Smooth-coated otter, from Moderate Negative to **Minor Negative**.

Bird-friendly building design measures, in addition to the retention of ecological corridors that improve connectivity pathways for birds, reduces the impact likelihood from "Less Likely/Rare (1)" to "Unlikely/Remote

(0)", resulting in an impact significance of all 34 bird species of **No Change**. All remaining 47 species remain at **No Change**.

4.6.3.2.4 Poaching

The implementation of deterrence measures, including restrictions on human entry to retained forest areas, prominent signage detailing the Wildlife Act and penalties for wildlife offences, and regular patrols, reduces the impact likelihood for all affected species. The impact significance of the 17 species that vulnerable to the illegal wildlife trade and pet trade falls from Moderate Negative to **Minor Negative**.

The sixty species previously assessed as Minor Negative retain this classification, and the most highly volant species (e.g., bats, Plume-toed swiftlet, and Green-eyed percher) continue to fall under **No Change**.

4.6.3.2.5 Human-wildlife Conflict

The impact significance of two species, the Long-tailed macaque and Smooth-coated otter, is reduced from Moderate Negative to **Minor Negative**.

The retention of habitats within Telok Blangah Hill Park provides natural foraging resources for macaques, reducing their incentive to enter residential areas. However, some level of human-macaque interaction is expected during the post-construction/ operational phase. Resident education and proper waste management will be necessary to minimise conflict.

No Change is expected for the remaining 81 species post-mitigation.

4.6.3.2.6 Human Disturbance

Mitigation measures are expected to reduce human traffic in sensitive areas (i.e., within the Proposed Retained Area), thus reducing the impact likelihood for all species from "Possible/ Occasional" to "Less likely/ Rare". However, the impact significance for all species remains at **Minor Negative**, but with an improved environmental score (i.e., from -108 to -54) for species that are more sensitive to human disturbance.

5. Assessment of Geomorphology

5.1 Applicable Legislation Standards

In Singapore, there is no specific legislation or standard that prescribes impact assessment requirements for geomorphology and soil erosion associated with development activities. The Environmental Protection and Management Act (EPMA) and the Code of Practice (COP) on Surface Water Drainage are typically referenced for such assessments. Both EPMA and COP emphasise the need to prevent alterations to the natural baseline drainage morphology and require the implementation of monitoring measures for surface water resources, focusing on parameters such as flow, discharge rates, and water quality.

5.2 Methodology for Assessment of Geomorphology

5.2.1 Baseline Data Analysis

Desktop research was conducted to review the historical land use, existing available geologic, topographic and soil data regarding the EIA Study Area. Information reviewed include existing baseline data obtained from public sources, literature review, as well as satellite images from online sources.

A Singapore Land Authority (SLA) Licensed Surveyor, YJP Surveyors Pte Ltd, was engaged to conduct a comprehensive topographical survey within the EIA Study Area between 19 November 2024 and 11 April 2025. The topographic survey map including spot level mapping of grid size 5 x 5 m prepared and endorsed by the SLA's licensed surveyor (see **Appendix 5A**) was assessed and processed to generate a Digital Elevation Model (DEM). The DEM enables the visualization of slopes with the indicative boundary of future development area. A generalised terrain analysis is made upon this DEM to evaluate the potential changes in terrain and its implication to the proposed development.

The geological characteristics of the EIA Study Area were examined based on information obtained from the Building and Construction Authority (BCA) (2021). The geological data derived from the shapefiles was utilised to analyse stratigraphy and bedrock distribution within the EIA Study Area.

Desktop literature review was conducted to assess the baseline soil condition within the EIA Study Area. Borehole information was obtained from SLA Singapore Integrated Land Information Service (INLIS).

5.2.2 Soil Erosion Assessment

The information of topographical survey and desktop analysis of geological and soil characteristic of the EIA Study Area was used as input to the soil erosion assessment for the EIA Study Area.

The Universal Soil Loss Equation (USLE) was developed to estimate soil erosion over extended periods under various land management practices. It predicts the long-term average annual soil loss from specific slopes. By integrating empirical data with process-based erosion modeling, the USLE provides a reliable measure of how land management influences erosion rates. For soil loss estimation for the indicative boundary of future development area, the Modified Universal Soil Loss Equation (MUSLE) is applied. MUSLE is an adaptation of the original USLE, where the rainfall-runoff erosivity factor is replaced by the storm runoff volume and peak discharge. This modification enables MUSLE to more accurately predict soil erosion from individual storm events, providing a better representation of local hydrological conditions.

To establish a theoretical basis for calculating potential sediment yield within the EIA Study Area under varying conditions, a worst-case scenario can be modeled by assuming the entire area is cleared of vegetation and no erosion control measures are implemented. The MUSLE for the EIA Study Area is expressed as:

$Y = 89.6(VQp)0.56.K.LS.C.P$

Where:

Y	=	Sediment yield per storm event, tons.
V	=	Storm runoff volume (m^3) per storm event, derived from hydrology runoff study.
Qp	=	Peak runoff rate (m^3/s), derived from hydrology runoff study.
K	=	Soil erodibility factor, tons/ha/ (MJ.mm/ha/h), computed by using the equation for the standard soil erodibility nomograph. Subfactors are determined through borehole data.
LS	=	Topographic factor (dimensionless), combination of the Slope Length (L) and Slope Steepness (S), which is calculated from the height and length of the slope. Values are derived from the DEM of the EIA Study Area.
C	=	Cover management factor (dimensionless), reflects the effect of vegetation, crop cover, and management practices on erosion.
P	=	Support practice factor (dimensionless), accounts for erosion control practices (e.g., contouring, terracing).

5.3 Baseline

5.3.1 Topography

Surface topographic relief is rolling within the EIA Study Area and its vicinity. According to Singapore 1:50,000 Topographical Map, 2010 (published by SO Publication, Ministry of Defence, Singapore), the EIA Study Area is between a 19.0 m above datum benchmark located northwest of the EIA Study Area along Alexandra Road and 4.02 m above Singapore Height Datum (SHD) benchmark near the junction of West Coast Highway and Henderson Road at the southeast.

Figure 5-1 provides the DEM of the EIA Study based on the topographical survey for the EIA. The highest elevation within the EIA Study Area, marked in dark red in **Figure 5-1**, reaches 75.90 metres (m) SHD and is located primarily in the northeastern section along Depot Road. This high point gradually transitions south into lower elevations, where the lowest elevation of 1.69 m SHD, represented in blue, is located in the southwestern corner of the EIA Study Area. There is slight undulation found in the central region of the EIA Study Area, which may affect drainage patterns in the area, where low-lying areas may have a higher susceptibility to water accumulation.

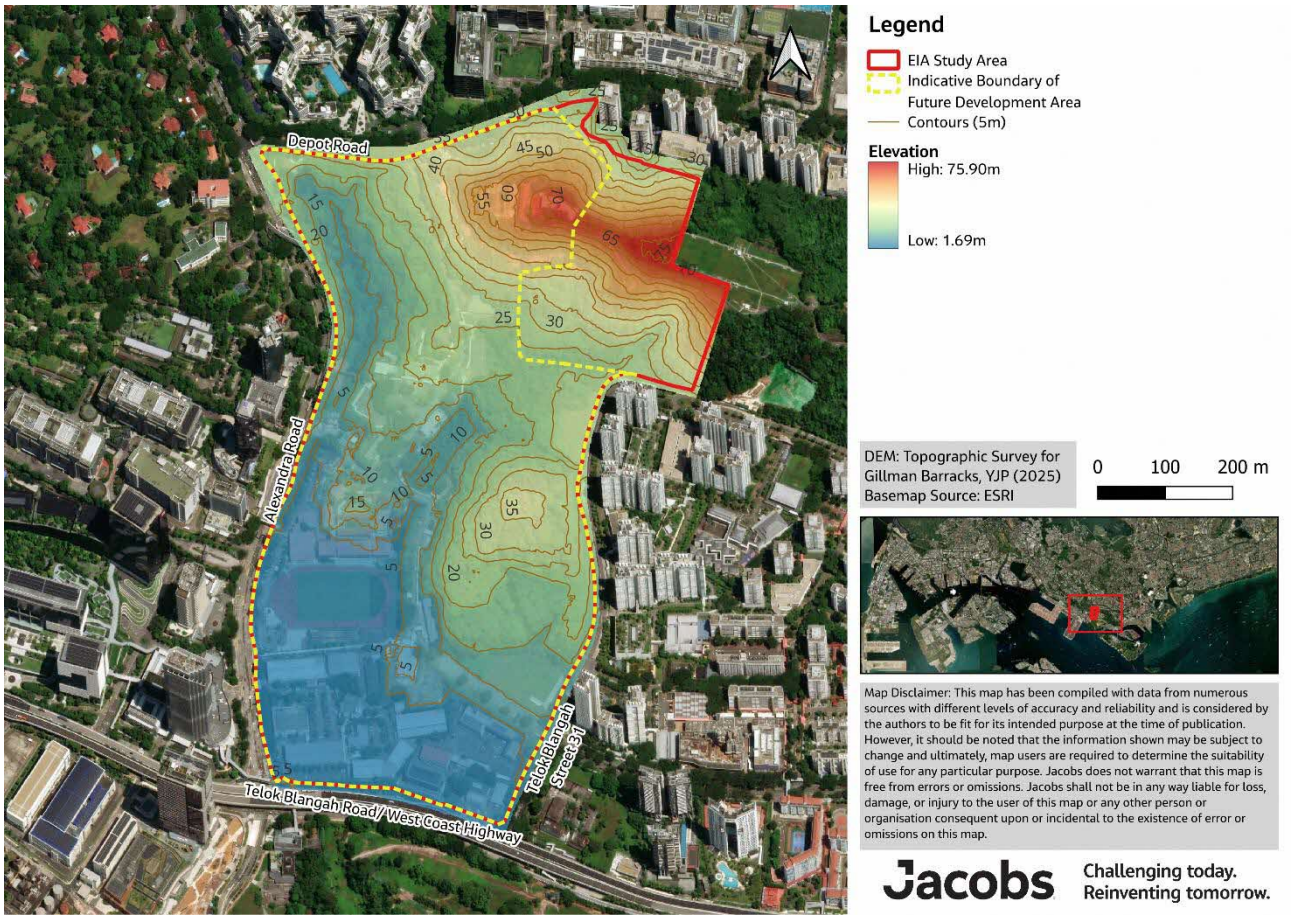


Figure 5-1: Digital Elevation Model (DEM) of the EIA Study Area

5.3.2 Slope

The EIA Study Area footprint is segmented into zones, each corresponding to a specific slope range based on the slope classification system outlined by Pamela et al. (2018) with reference to the United States Department of Agriculture (USDA, 2018) (**Table 5-1**). The zone categories for the EIA Study Area are shown in **Table 5-2** and **Figure 5-2**.

Table 5-1: USDA 2018 Slope Classification Table

Description	Slope Gradient Classes	
	Slope Range Percentage (%)	Degree
Flat	0 – 3	<2
Undulating	3 – 8	2 – 5
Moderately sloping	8 – 15	5 – 8
Hilly	15 – 30	8 – 17
Moderately steep	30 – 45	17 – 24
Steep	45 – 65	24 – 33
Very steep	>65	>33

Table 5-2: Zones and Average Slope Identified for the EIA Study Area as Per USDA 2018 Slope Classification

Zone	Average Slope (%)	Description	Vegetation Cover
1A	30	Hilly and moderately steep	Abandoned-land forest
1B	30	Hilly and moderately steep	Abandoned-land forest
2A	22.5	Hilly	Native-dominated secondary forest
2B	22.5	Hilly	Native-dominated secondary forest
3	7.5	Undulating	Exotic-dominated secondary forest
4	15	Moderately sloping	Exotic-dominated secondary forest
5	3	Flat	Developed land
6	7.5	Undulating	Developed land
7	15	Moderately sloping	Exotic-dominated secondary forest and scrubland

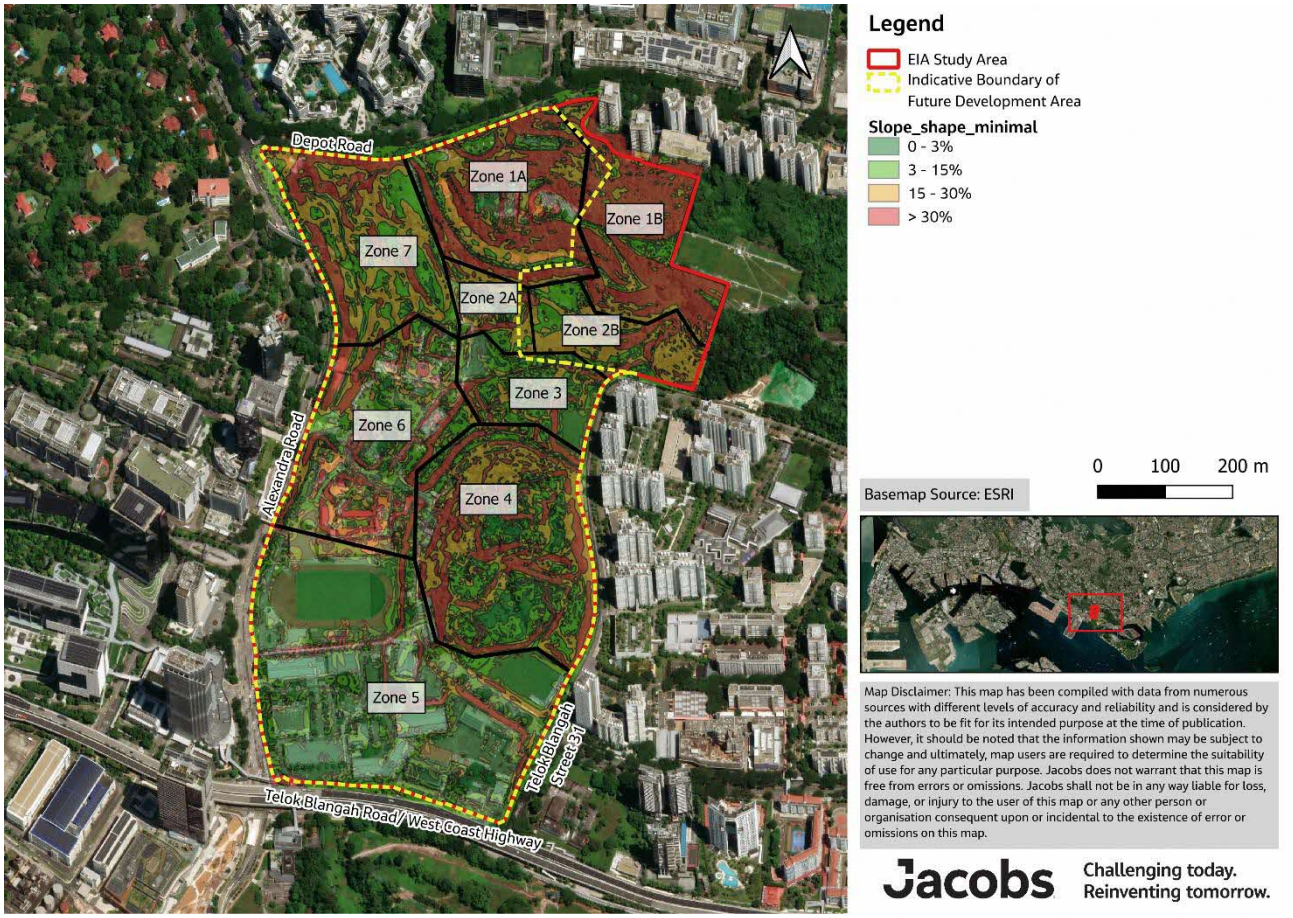


Figure 5-2: Slope Map and Zoning for the EIA Study Area

5.3.3 Geology

The analysis from Singapore Geological Map derived from BCA (2021) revealed that the Study Area is characterised by a diverse geological composition comprising of multiple types of bedrock and superficial layers. This may be critical in understanding the current geological conditions which include land stability, groundwater flow, and construction feasibility.

Figure 5-3 illustrates the geological map of the EIA Study Area, generated using the shapefiles provided by the BCA (2021), while each geological type with its composition and characteristics are described in **Table 5-3**.

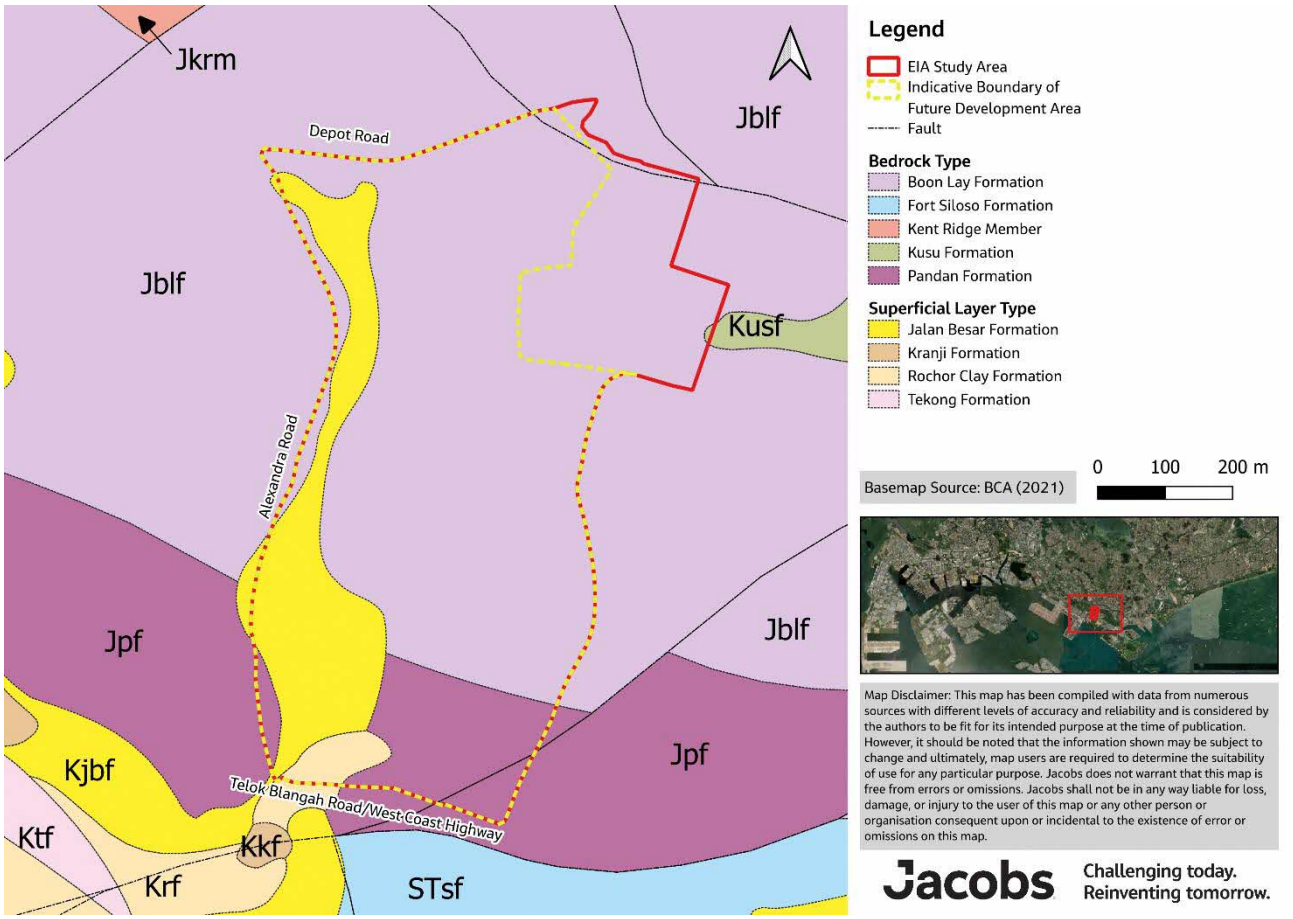


Figure 5-3: Geological Formations in the EIA Study Area

Table 5-3: Geological Formations and Characteristics in the EIA Study Area

Geological Type	Formation	Composition	Characteristics
Bedrock	**Boon Lay Formation (Jblf)**	Sandstone; subordinate interbedded mudstone pyroclastic rock and volcaniclastic rock	The Boon Lay formation is mainly composed of sandstone, a sedimentary rock made up of sand-sized grains. The inclusion of multiple rock types suggests a complex depositional environment.

Geological Type	Formation	Composition	Characteristics
Bedrock	**Pandan Formation (Jpf)**	Limestone; subsidiary beds of carbonate-cemented sandstone and mudstone	The Pandan Formation is primarily composed of limestone. The presence of carbonate-cemented sandstone and mudstone suggests variations in depositional conditions, including periods of higher energy environments where sand was deposited and calmer conditions where mud settled.
	Kusu Formation (Kusf)	White, quartz-rich sandstone and subordinate conglomerate	The Kusu Formation is quartz-rich. Thick layers of sandstone found in this granite type vary from rounded to well-rounded, medium to coarse-grained quartz grains.
Superficial Layer	**Jalan Besar Formation (Kjbf)**	Silt to coarse sand	The Jalan Besar formation consists of grain sizes that range from fine silt to coarse sand, indicating a varied depositional environment. The sediments are typically loose and unlithified, indicating that they haven't been compacted into solid rock. This formation is often associated with fluvial deposits.
	Rocher Clay Formation (Krf)	Mud (clay and silt) with thin beds of sand and peat	This formation usually consists of high organic content, with peat-rich clay and silt, suggesting a depositional environment with accumulation of organic matter. The presence of peat may indicate that the land use was once covered by dense vegetation that has since decomposed. The sediment type is typically soft and may pose a challenge for construction.

Source: *Dodd et al., 2019; and BCA, 2021.*

5.3.4 Soil

Desktop literature review was conducted to assess the baseline soil condition within the EIA Study Area. Information of soil characteristic of the EIA Study Area was obtained from SLA INLIS. **Figure 5-4** indicates the locations of previously drilled boreholes from various soil investigation studies, and the summary of the soil investigation are presented in **Table 5-4**.

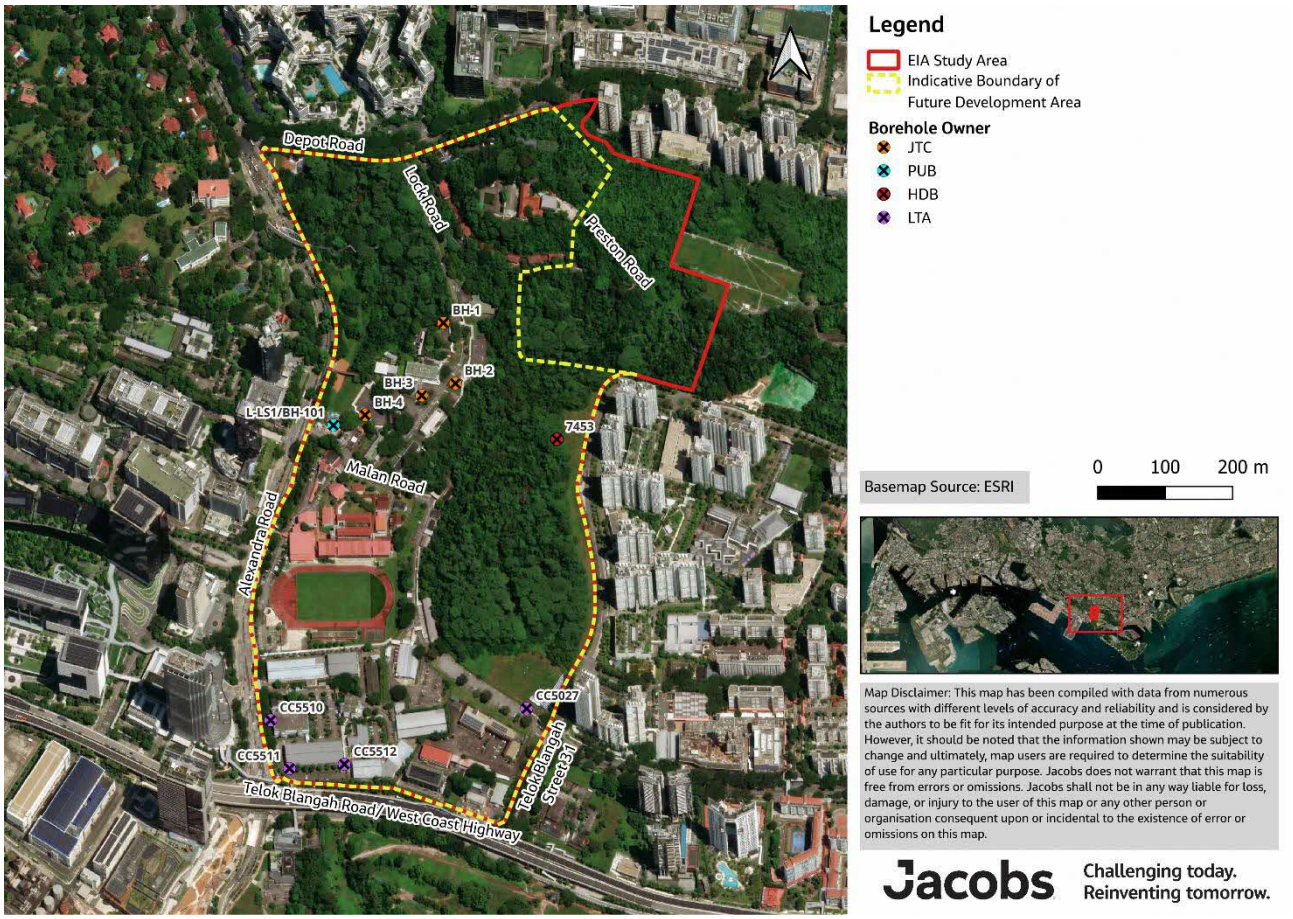


Figure 5-4: Borehole Location of Various Soil Investigations within the EIA Study Area

Table 5-4: Soil Investigation Findings from Literature Review

Literature Review	Borehole ID	Subsoil Type	Chemical Content
Soil Investigation works at Gillman Barracks for JTC Corporation (20 April 2016, JTC)	▪ BH-1 ▪ BH-2 ▪ BH-3 ▪ BH-4	▪ Fill layer was found in all boreholes with soil thickness ranging from 2.0 m to 4.5 m ▪ Residual soil (Jurong Formation) (JF) layer was found in all boreholes with soil thickness ranging from 6.0 m to 13.00 m ▪ Completely weathered (JF) layer was found in all boreholes with thickness ranging from 3.0 m to 36.30 m	▪ pH: 4.9 to 7.8 ▪ Chloride: Below the detection limit for all boreholes ▪ Organic matter: <0.1 to 0.2 (% of dry weight)
Soil Investigation works for DTSS Phase 2 Project - Part 3 (20 July 2015, PUB)	L-LS1/BH-101	▪ Fill layer was found from 0 m to 3.6 m. ▪ Residual soil (JF) layer was found from 3.6 m to 8.0 m ▪ Moderately weathered (JF) layer was found from 8.0 m to 12.0 m and 22.0 m to 48.0 m ▪ Completely weathered (JF) layer was found from 12.0 m to 22.0 m	▪ pH: 4.78 ▪ Sulfate: 0.27 (g/l) ▪ Chloride: 0.01 (% of dry weight) ▪ Organic matter: <0.01 (% of dry weight)

Literature Review	Borehole ID	Subsoil Type	Chemical Content
Site Investigation at Gillman Barracks for M/S HDB **(1997, HDB)**	7453	▪ Loose sandy/clayey silt was found from 0m to 2.0 m ▪ Loose clayey sand was found from 2.0 m to 5.0 m ▪ Very dense clayey sand and sandy/clayey silt was found from 5.0 m to 15.27 m	No test was done
LTA Contract 8227 Site Investigation Works from Pasir Panjang Road to Telok Blangah Road **(12 Sep 2003, LTA)**	CC5510 CC5511 CC5512 (no chemical test done)	▪ Fill layer was found in all boreholes with soil thickness ranging from surface to 4.6 m ▪ Kallang Formation layer was found in all boreholes with soil thickness ranging from 2.5 m to 9.0 m ▪ Residual soil (JF) layer was found in all boreholes with soil thickness ranging from 5.5 m to 12.2 m ▪ Completely weathered (JF) layer was found in all boreholes with soil thickness ranging from 9.0 m to 15.0 m ▪ Highly weathered (JF) layer was found in all boreholes with soil thickness ranging from 14.0 m to 26.3 m	▪ pH: 4.39 to 6.81 ▪ Sulfate: <0.02 to 0.10 (% of dry weight) ▪ Chloride: <0.01 to 0.54 (% of dry weight) ▪ Organic matter: 1.11 to 19.3 (% of dry weight)
LTA Contract 4905 Site Investigation Works from National University Hospital to Harbor Front Station (2) Final Report **(8 May 2002, LTA)**	CC5027	▪ Fill layer was found from 0 m to 1.5 m ▪ Residual soil layer was found from 1.5 m to 12.1 m ▪ Moderate to highly weathered rock – siltstone layer was found from 12.1 m to 24.2 m ▪ Moderately weathered rock – sandstone layer was found from 24.2 m to 35.4 m	No test was done

5.3.5 Groundwater

Desktop literature review was conducted to assess the baseline subsurface condition within the EIA Study Area. Soil investigation information was obtained from Singapore Integrated Land Information Service (INLIS) and the summary of the groundwater findings are presented in **Table 5-5**.

Table 5-5: Groundwater Table Findings from Literature Review

Literature Review	Borehole ID	Groundwater Table	Chemical Content
Soil Investigation works at Gillman Barracks for JTC Corporation **(20 April 2016, JTC)**	▪ BH-1 ▪ BH-2 ▪ BH-3 ▪ BH-4	▪ No groundwater was detected for BH-1 and BH-2 ▪ Groundwater was detected at: - 2.63 m below ground level for BH-3 - 0.70 m below ground level for BH-4	No test was done

Literature Review	Borehole ID	Groundwater Table	Chemical Content
Soil Investigation works for DTSS Phase 2 Project - Part 3 **(20 July 2015, PUB)**	L-LS1/BH-101	Groundwater was detected at 0.60 m below ground level	▪ pH: 6.43 ▪ Sulfate: 0.26 (g/l) ▪ Chloride: 0.03 (g/l)
Site Investigation at Gillman Barracks for M/S HDB **(1997, HDB)**	7453	Groundwater was detected at 3.1 m below ground level	No test was done
LTA Contract 8227 Site Investigation Works from Pasir Panjang Road to Telok Blangah Road **(12 Sep 2003, LTA)**	CC5510 CC5511 CC5512	▪ Groundwater was detected at: - 1.80 m below ground level for CC5510 - 0.30 m below ground level for CC5511 - 0.80 m below ground level for CC5512	No test was done
LTA Contract 4905 Site Investigation Works from National University Hospital to Harbor Front Station (2) Final Report **(8 May 2002, LTA)**	CC5027	Groundwater was detected at 1.3 m below ground level	No test was done

5.4 Impact Assessment

5.4.1 Evaluation of Geomorphology Impact

As per proposed development works described in **Section 2.4**, the construction works at the indicative boundary of future development area may include one or more of the following activities:

- Stripping or removal of the existing soil cover.
- Ground or subsurface excavation, including cut and fill operations.
- Earthmoving and handling of excavated materials.
- Temporary stockpiling of soils and spoil materials.
- Ground compaction and surface sealing.

These activities can significantly affect soil infiltration capacity, contribute to soil loss and erosion, and alter hydrogeological conditions. The specific impact evaluation are described below.

5.4.2 Changes to Soil Infiltration Capacity

Soil compaction is expected as a result of one or more of the construction activities outlined in **Section 5.4.1**, as well as from the use of temporary work areas within the EIA Study Area. This compaction may cause a temporary or permanent reduction in soil infiltration capacity.

In locations where pavement or ground sealing is applied for buildings, infrastructure, and amenities such as roads and drainage lines, the soil and underlying subsurface are anticipated to permanently lose infiltration capacity. The degree of compaction may also influence lateral hydraulic conductivity in the subsurface, potentially affecting groundwater movement.

As noted in **Section 5.3.3**, based on literature review, the predominant soil type across the EIA Study Area is loose sandy/ clayey silt sand which shall be the soil types and their corresponding permeability values shall be confirmed through soil investigation (S.I.) during the detailed design stage. During ground preparation and construction, a reduction in permeability below the baseline value is anticipated within working areas. A near-permanent loss of infiltration capacity (i.e., infiltration rate reduced to near zero) is expected in areas where permanent removal of soil and subsurface materials occurs. For the impact assessment purpose, the magnitude of change (A2.2) is classified as follows:

- **Low**: Reduction in infiltration rate is ≤10% of the measured pre-construction rate.
- **Medium**: Reduction in infiltration rate is >10% but ≤50% of the measured pre-construction rate.
- **High**: Reduction in infiltration rate is >50% of the measured pre-construction rate.

The evaluation of the impact significances for changes of soil infiltration capacity is given in **Table 5-6** with the RIAM specific calculation tool available in **Appendix 5B**.

Table 5-6: Impact Significance of Changes to Soil Infiltration Capacity

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	1: Local	Changes in infiltration capacity are limited to areas of local interest within the indicative boundary of future development area, but outside of the Proposed Retained Area (PRA).
A2.1: Impact Nature	-1: Negative	Loss or reduction of infiltration capacity in the work areas of for permanent structures is a negative impact which may lead to waterlogging issues and groundwater movement.
A2.2: Magnitude of Changes	2: Medium	Changes in infiltration capacity in working areas within indicative boundary of future development area are predicted to be more than 10% but equal or less than 50%.
A2.3: Impact Extent	1: Local	Impact is limited within the disturbance areas where temporary and permanent earthworks are expected to take place.
B1: Permanence	2: Short-term	Alterations to soil infiltration capacity are site-specific and temporary, occurring exclusively during earth-moving activities associated with proposed development.
B2: Impact Pathway	3: Direct	Ground disturbance is expected to have direct impact on soil infiltration.
B3: Reversibility	3: Irreversible	Once disturbed or altered due to land use changes, original soil materials and profiles cannot be restored to their natural state. Stripping or excavation of surfaces results in a permanent loss or significant reduction of infiltration capacity.

Assessment Criterion	Score Rating	Rating Justification/ Definition
B4: Cumulative	2: Non-cumulative	Changes in soil infiltration capacity are localised and non-cumulative, occurring only during earth-moving activities at specific sites as part of proposed development.
Environmental Score (ES)	(-2) x (10) = -20	
Range Bands ES/ Impact Significance	Minor Negative	

5.4.3 Soil Erosion and Sediment Yield

5.4.3.1 Sediment Yield Determination

The MUSLE applied to assess erosion risk for proposed land use parcellation within the indicative boundary of future development area (**Figure 5-5**) under three development conditions:

- **Condition A: Existing/ Undisturbed Condition** – Represents the baseline scenario with no site works or disturbance.
- **Condition B: Uncontrolled/ Unmitigated Condition** – A worst-case scenario assuming site clearance following the land use parcellation, excluding Proposed Retained Area (PRA) as per **Figure 4-21**, without any erosion control measures.
- **Condition C: Controlled/ Mitigated Condition** – Assumes site clearance and earthworks for Condition B are managed through the implementation of minimum control measures supplemented by recommended mitigation measures and best practices.

Sediment yield (Y) from the three development conditions was calculated using the MUSLE formula outlined in **Section 5.2.2**, following the steps detailed below:

(a) Step 1: Determination of Zones based on Slope Classification

The slope classifications for each zone within the indicative boundary of future development area are presented in **Table 5-7** and illustrated in **Figure 5-5**.

Table 5-7: Zones and Average Slope Identified for Indicative Boundary of Future Development Area under Condition A as Per USDA 2018 Slope Classification

Zone	Average Slope (%)	Description	Vegetation Cover
1	30.0	Hilly and moderately steep	Abandoned-land forest
2	22.5	Hilly and moderately steep	Abandoned-land forest
3	15.0	Moderately sloping	Developed land
4	15.0	Moderately sloping	Exotic-dominated secondary forest and Developed land
5	22.5	Hilly	Exotic-dominated secondary forest
6	3.0	Flat	Developed land
Retained Zone 1	30.0	Hilly and moderately steep	Abandoned-land forest
Retained Zone 2	15.0	Moderately sloping	Exotic- and Native-dominated secondary forest

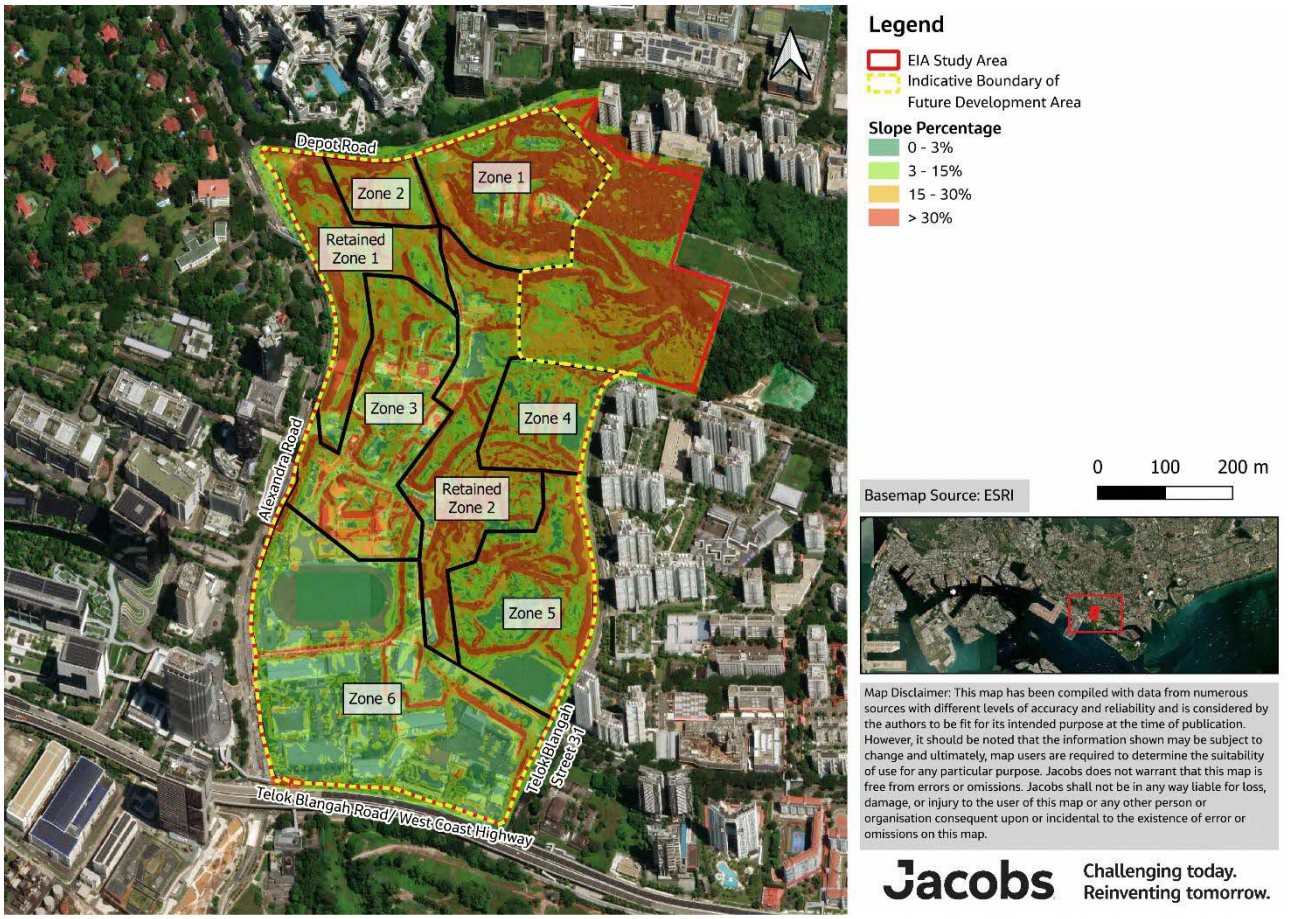


Figure 5-5: Slope Map and Zoning for HDB's Land Use Plan for Gillman Barracks

(b) Step 2: Determination of Rainfall Erosivity Factor

The factor rainfall erosivity was calculated using the equation $\boldsymbol{\psi_2(V \times Q_\rho)^{0.56}}$, where:

ψ_2= 89.6 for SI units

V = Runoff volume (m^3) per storm event

Qp = Peak Flow (m^3/s)

The runoff volume (V) was calculated using equation, $\boldsymbol{V = \alpha \times I \times T \times A}$, where:

V = Runoff volume (m^3)

α = constant value of 89.6 in SI units

I = rainfall intensity

T = duration of storm

A = area in m^2

The peak flow (Qp), the value was derived by the equation: $\boldsymbol{Q_p = \frac{V}{T}}$

Qp = Peak Flow (m^3/s)

V = Runoff volume (m^3)

T = duration of storm

The values of I and T are 147 mm/hour and 60 minutes, respectively, from the historical extreme rainfall data of the Meteorological Service Singapore.

(c) Step 3: Determination of Soil Erodibility Factor, K Factor

K Factor is determined as 0.045 with reference to soil investigation data within the vicinity of Telok Blangah from available sources described in **Section 5.3.3** and the soil erodibility chart defined in USDA-Natural Resources Conservation Service (NRCS) soil survey manual.

(d) Step 4: Determination of LS Factor

Slope length and gradient were derived using the DEM and also calculated manually based on the data provided in the topographical map. The values are listed in **Table 5-8**.

Table 5-8: LS Factor Value by Zone

Zone	LS Value (Existing Slope)	LS Value (Future Platform Level)
1	6.494	2.539
2	1.870	1.799
3	2.413	0.157
4	1.511	0.567
5	2.234	1.223
6	0.338	0.638
Retained Zone 1	1.781	1.781
Retained Zone 2	1.282	1.282

(e) Step 5: Determination of CP Factor

The cover management factor, C Factor, for different land use cover is described in **Table 5-9**.

Table 5-9: LS Factor Value by Zone

Cover Management Type	C Factor
Native-dominated secondary forest/ Exotic-dominated secondary forest/ Abandoned-land forest/ scrubland	0.03
Developed land	0.25
Newly cleared land	1.00
Controlled clearing with mitigation measures (assumed 60% turfing/ grass cover)	0.05

The support practice factor (P) is assigned as follow:

- Condition A (Existing undisturbed condition) – 0.6 (existing with reasonable management support practice).
- Condition B (Uncontrolled without mitigation measures) – 1.0 (no management support practice provided, except for Retained Zone 1 and Retained Zone 2).
- Condition C (Controlled with mitigation measures) – 0.5 (sediment containment system).

5.4.3.2 Sediment Yield for the Proposed Land Use Development Scenario

Based on the MUSLE formula determination, the sediment yield as per zones for the proposed development parcellation within the indicative boundary of future development area under Conditions A and B are given in **Table 5-10** and **Table 5-11,** respectively.

Table 5-10: Sediment Yield for Condition A (Existing Undisturbed Condition)

Zone	Parameters					Sediment Yield
	$89.6(VQ_p)^{0.56}$	K	LS	C	P	T (tonnes/storm)
1	8,437	0.045	6.494	0.03	0.60	44.4
2	2,015	0.045	1.870	0.03	0.60	3.1
3	11,312	0.045	2.413	0.25	0.60	184.3
4	4,665	0.045	1.511	0.25	0.60	47.6
5	9,775	0.045	2.234	0.25	0.60	147.4
6	26,000	0.045	0.338	0.25	0.60	59.3
Retained Zone 1	7,236	0.045	1.781	0.03	0.60	10.4
Retained Zone 2	10,867	0.045	1.282	0.03	0.60	11.3
					Total	507.7

Table 5-11: Sediment Yield for Condition B (Uncontrolled)

Zone	Parameters					Sediment Yield
	$89.6(VQ_p)^{0.56}$	K	LS	C	P	T (tonnes/storm)
1	8,437	0.045	2.539	1.00	1.00	964.0
2	2,015	0.045	1.799	1.00	1.00	163.1
3	11,312	0.045	0.157	1.00	1.00	79.9
4	4,665	0.045	0.567	1.00	1.00	119.0
5	9,775	0.045	1.223	1.00	1.00	538.0
6	26,000	0.045	0.638	1.00	1.00	746.5
Retained Zone 1	7,236	0.045	1.781	0.03	0.60	10.4
Retained Zone 2	10,867	0.045	1.282	0.03	0.60	11.3
					Total	2,632

5.4.3.3 Evaluation of Impact Significance of Soil Loss

The sediment yield estimated using MUSLE for the proposed land use parcellation scenario within the indicative boundary of future development area represents a conservative rate, assuming complete clearance of the designated development area without phased site clearance and under a worst-case storm event. Sediment yield is expected to reduce to zero upon completion of all site clearance and earthworks, as erodible material is assumed to be fully removed and previously exposed subsurface permanently covered with concrete or other

materials within the work site. The evaluation of impact significance of soil loss under unmitigated conditions is given in **Table 5-12**, with the magnitude changes (A2.2) defined on the sediment yield derived from uncontrolled conditions as below:

- Rating "zero": no change/ status quo for exceedances compared with *in-situ* (existing condition).
- Rating 1: Low impact for exceedance ≤ 5 times of *in-situ* (existing condition).
- Rating 2: Medium impact for exceedance > 5 times but ≤ 10 times of *in-situ* (existing condition).
- Rating 3: High impact for exceedance >10 times of *in-situ* (existing condition).

Table 5-12: Impact Significance for Soil Loss of the Proposed Land Use Parcellation within the Indicative Boundary of Future Development Area

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	1: Local	Soil loss is limited to local areas of interest within the indicative boundary of future development area.
A2.1: Impact Nature	-1: Negative	Site clearance will remove soil cover within the working zones designated for permanent structures. This may lead to increased sediment yield per storm event and elevate soil erodibility in adjacent areas if no control measures are implemented. Under uncontrolled conditions, soil loss can contribute to downstream siltation, particularly during heavy storm events.
A2.2: Magnitude of Changes	2: Medium	Based on the sediment yield calculated under Condition B (2,632 tonnes/storm) compared to Condition A (508 tonnes/storm), the magnitude of changes is evaluated as Medium, exceedance > 5 times but ≤ 10 times of *in-situ* (existing condition).
A2.3: Impact Extent	3: Impact extends beyond EIA Study Area	Impact, although more localised within the disturbed work areas, may eventually lead to sedimentation at downstream areas beyond the EIA Study Area under uncontrolled conditions.
B1: Permanence	2: Short-term	Construction activities that have impact on soil loss, including site clearance, earthworks, and ground disturbance, are estimated to last less than three years (short-term).
B2: Impact Pathway	3: Direct	Ground disturbance is anticipated to directly affect soil loss and sedimentation, as it may remove the protective soil cover.
B3: Reversibility	3: Irreversible	Original soil materials and profiles cannot be restored to their pre-disturbance state following land use changes. Permanent loss of soil cover is anticipated in areas designated for the construction of permanent structures.
B4: Cumulative	2: Non-cumulative	The impact of soil loss from surface stripping is expected to be non-cumulative, occurring only during site clearance and earthwork activities at specific locations associated with the proposed development.
Environmental Score (ES)	(-6) x (10) = -60	
Range Bands ES/ Impact Significance	**Minor Negative**	

5.5 Minimum Control Measures

Table 5-13 outlines the sedimentation and erosion-specific minimum controls commonly adopted in Singapore for similar construction activities. These controls form the basis for developing, implementing, and monitoring Earth Control Measures (ECM) at construction sites, in compliance with Regulation 4 of the *Sewerage and Drainage (Surface Water Drainage) Regulations*. These controls also align with the COP for Environmental Control Officer (ECO) issued by NEA, the COP on Surface Water Drainage as well as the Guidebook on Erosion and Sediment Control at Construction Sites and the Guidebook for QECP issued by PUB. These measures are assumed to be incorporated by future developer/ developing agency as embedded requirements or minimum controls mandated under the relevant regulations and COPs.

Table 5-13: Minimum Control Measures of Sedimentation and Soil Erosion Adhered to Applicable Regulations and COP

Stage	Minimum Controls Adhered to Applicable Regulations and COP
Prior to Construction Phase	▪ Submit a detailed ECM proposal duly endorsed by a QECP to PUB and copied to future developer/ developing agency indicating: - Plans to minimise exposed surfaces. - Implementation of effective sediment control facilities (including storage and treatment facilities). - ECM systems that shall be put in place prior to the commencement of physical works. • A PUB's approval that is obtained prior to the commencement of physical works. - Revisions or updates to the ECM systems during construction to control silty discharge, where necessary. - ECM shall not be removed prior to the completion of physical works. Relevant approvals from PUB shall be obtained for removal of ECM upon the completion of physical works. - Condition of ECM shall be inspected regularly and during/ after every rain event. - QECP shall carry out regular audits/ reviews for every stage of the construction works and revise the ECM on-site accordingly.
Construction Phase	• Earth surfaces or slopes adjacent to any drain shall be turfed, paved or covered with appropriate materials. ▪ Bare surfaces shall be covered up with appropriate materials before rain and daily works should be halted to reduce the volume of silty water to be contained and treated. ▪ The treatment of silty water shall be closely monitored, and the treatment shall be halted immediately if silty water is being discharged to public drains.

5.6 Recommendation of Preventive and Mitigation Measures

In addition to the minimum control measures outlined in **Section 5.5**, a suite of supplementary mitigation measures is recommended to minimise, and where practicable, eliminate geomorphological changes that may adversely affect soil infiltration capacity and increase the risk of soil erosion. These measures shall be implemented either individually or in combination, based on site-specific conditions and applicable regulatory requirements.

- Carry out site clearance and earthworks in stages following a programmatic excavation, cut-and-fill, and earthmoving plan to minimise the extent of disturbed areas at any given time. Limiting excavation and earthworks to only essential areas will help to reduce potential erosion and topsoil loss by minimising the overall disturbance footprint.
- Appoint a Qualified Person (QP) or Professional Engineer to undertake slope stability and soil compaction assessments within and adjacent to the areas of concern prior to any site clearance or earthworks. The

findings from these assessments should be integrated into the operational manual to guide excavation and earth-moving activities, ensuring safe and compliant implementation.

- Apply the approved ECM plan, including all minimum control measures and best management practices (BMPs) throughout the construction phase. This includes, but is not limited to covering stockpiles, protecting exposed soil surfaces after work, isolating bare earth areas with silt fences, and paving access paths and roads to reduce sediment transport.
- Reuse the excavated topsoil to backfill low-lying areas to establish the platform for the development. Any excess soil material shall be transported off-site for reuse in other projects, where feasible. Unsuitable materials are recommended to be stockpiled separately and disposed of at approved off-site facilities in accordance with regulatory requirements.
- Rehabilitate temporary construction areas, including staging and stockpiling zones, to conditions as close as practicable to their original pre-construction state upon completion of works. This shall include regrading, soil stabilisation, and re-vegetation where appropriate to restore site functionality and minimise long-term environmental impacts.

With reference to **Table 5-14**, implementation of the minimum control measures, supplemented by the additional mitigation measures, can reduce sediment yield to approximately 87 tonnes/storm, significantly lower than the estimated 508 tonnes/storm under existing conditions.

The reduction of sediment yield with the minimum control measures and recommended mitigation measures can likewise reduce the magnitude of impact from "Medium" to "Low". The detailed of the RIAM is given in **Appendix 5B**.

Table 5-14: Sediment Yield for Condition C (Controlled)

Zone	Parameters					Sediment Yield
	$89.6(VQ_P)^{0.56}$	K	LS	C	P	T (tonnes/storm)
1	8,437	0.045	2.539	0.05	0.50	24.1
2	2,015	0.045	1.799	0.05	0.50	4.1
3	11,312	0.045	0.157	0.05	0.50	2.0
4	4,665	0.045	0.567	0.05	0.50	3.0
5	9,775	0.045	1.223	0.05	0.50	13.4
6	26,000	0.045	0.638	0.05	0.50	18.7
Retained Zone 1	7,236	0.045	1.781	0.03	0.60	10.4
Retained Zone 2	10,867	0.045	1.282	0.03	0.60	11.3
					Total	87.0

5.7 Residual Impact

The significances of residual impacts from changes in soil infiltration and soil erosion are summarised in **Table 5-15**. The significance of impacts is assessed as **Slight Negative** following the adoption of embedded control measures and recommended mitigation measures. These measures help restore or maintain soil porosity, reduce compaction, and enhance water retention, thereby improving infiltration rates compared to untreated disturbed soils.

Table 5-15: Summary of Evaluation of Residual Impact Significance for Geomorphology Impact

Impact Register	Before Mitigation Measures		Post-Mitigation Measures	
	Environmental Score (ES)	Range Bands of ES	Environmental Score (ES)	Range Bands of ES
Soil Infiltration Capacity	-20	Minor Negative	-10	Slight Negative
Soil Loss	-60	Minor Negative	-10	Slight Negative

6. Assessment of Hydrology and Water Quality

6.1 Applicable Legislation Standards

The Sewerage and Drainage Act (SDA) in Singapore is a key piece of legislation that governs construction, maintenance, and improvement of sewerage and land drainage systems; operation and use of these systems; and discharge of sewage and trade effluent, ensuring compliance with environmental and public health standards. The Act empowers the Public Utilities Board (PUB) to enforce these regulations. It also sets out requirements for permits, standards for discharge, penalties for non-compliance, and provisions for stormwater management to prevent flooding.

Code of Practice on Surface Water Drainage (COPSWD) is issued by PUB under the SDA to provide planning, design and procedural requirement for surface water drainage system. The COPSWD specifies minimum engineering standards for stormwater management and flood protection. The latest version (Seventh Edition, Dec 2018) with Addendum No.3 (April 2025) introducing the maintenance regime for flood protection measures, annual declarations for pumped detention tanks and flood barriers as well as updated platform levels.

For water quality, the National Environment Agency (NEA) administers the Environmental Protection and Management Act (EPMA) and the Environmental Protection and Management (Trade Effluent) Regulations, which govern the discharge of wastewater into open drains, canals and rivers. These regulations specify the permissible limits for trade effluent discharged into various types of watercourses. Prior approval from NEA is required for the nature and type of trade effluent before any discharge into a watercourse. All effluent must be treated to meet the water quality standards stipulated in the regulations before discharge.

Given that the waterbodies of the EIA Study Area are not discharging into any PUB reservoirs, these waterbodies are not strictly classified as trade effluent channels, they are considered uncontrolled watercourses where existing users may discharge trade effluent. For the purpose of this assessment, the report will reference the EPM Trade Effluent guidelines and allowable limits for evaluating water quality. For parameters not covered under the EPM Trade Effluent guidelines, NEA's Water Quality Guidelines for Popular Recreational Beaches for Enterococcus were adopted as the reference standard. In addition, this report also references the ASEAN Marine Water Quality Management Guidelines (AMWQC) (ASEAN, 2008) and the United States Environmental Protection Agency (US EPA) Water Quality Criteria for Aquatic Life (US EPA, 2017), as the streams within the largest catchment ultimately discharge into Berlayar Creek. For the AMQQC values that differentiate between coastal and estuarine values, this report assesses against the estuarine values due to the habitat nature of Berlayar Creek and Labrador Nature Reserve.

6.2 Methodology for Hydrology and Water Quality Assessment

6.2.1 Hydrology

Currently, there is no legislation or standard in Singapore that specifies the methodology for conducting surface hydrology baseline and impact assessments. For the hydrology impact assessment in this EIA, the SDA, the COPSWD and Biodiversity Impact Assessment (BIA) Guidelines (Revised Version May 2024, NParks) and best practices are referenced as guidelines. The method approach include the following:

(a) Baseline establishment for catchment delineation and hydrological pattern based on combination of desktop analysis of historical maps and present-day satellite images, gathering information from the following sources, and supplementing it through field hydrological mapping by appointed surveyor.

- Existing drainage map provided by NParks via email on 15 August 2024.
- Historical maps on the National University of Singapore (NUS) library portals dating back from 1914 (Geographical Section, 1914), historical maps dated in 1958 (Assistant Directed of Survey, 1958), 1983 (Mapping Unit, 1983), and 2010 (Mapping Unit, 2010).
- Screening of potential waterbodies (i.e., streams, ponds, canals) within the EIA Study Area from satellite imagery Environmental Systems Research Institute (ESRI), etc.
- Site reconnaissance was conducted in August 2025.
- Field hydrological mapping surveys conducted by our appointed hydrology surveyor, YJP Surveyors Pte Ltd (an SLA licensed surveyor), from 19 November 2024 to 23 January 2025. Streams and drains were characterised at 20-metre intervals, detailing stream cross-sections, pool length and depth, substrate type, riparian vegetation composition, wetted width, and estimated flow velocity.
- Meteorological data (i.e., rainfall intensity) from Meteorological Services Singapore NEA.

(b) Impact assessment using simplified hydrological calculation (rational method) combined with qualitative interpretation of drainage adequacy to estimate the change in peak runoff due to increased impervious surfaces from the proposed development and assess the risk of localised flooding if drainage capacity is inadequate.

(c) Recommending mitigation measures to minimise any identified adverse impacts and identifying appropriate monitoring requirements.

6.2.2 Water Quality

This EIA focuses on assessing potential water quality impacts during the construction phase. Given the nature of the proposed development, primarily housing estates where sanitary wastewater will be collected via property sewer lines and discharged into the public sewer system managed by PUB, adverse impacts on water quality during the post-construction/operational phase are considered unlikely.

Currently, there is no legislation or standard in Singapore that prescribes a methodology for water quality impact assessment. Therefore, this study adopts the Technical Memorandum Annex 14: Guidelines for Assessment of Water Pollution, published by Hong Kong's Environmental Protection Department (HK EPD), and adapts it to the Singapore context. This guideline was selected because it provides a comprehensive framework for identifying potential water pollution sources associated with proposed development, as well as predicting and assessing potential water pollution impacts.

The assessment of potential water quality impacts during the construction phase is undertaken qualitatively, as specific discharge quantities and discharge points are not yet known. The assessment involves the following:

- Identifying watercourses within the EIA Study Area.
- Establishing baseline water quality conditions at receiving watercourses, based on specifications and methodologies approved in the EIA Inception Report.
- Specifying construction activities that may affect water quality and assessing their potential impacts.
- Recommending mitigation measures to minimise any identified adverse impacts on water quality and identifying appropriate monitoring requirements during the construction phase.

6.3 Baseline

6.3.1 General Climate in Singapore

Singapore lies north of the Equator at Latitude 1.3 degree north and Longitude 103.8-degree east. Because of its geographical location and maritime exposure, its climate is characterised by uniform temperature and pressure, high humidity, and abundant rainfall. The climate of Singapore can be divided into two main seasons, the northeast monsoon, and the southwest monsoon season, separated by two relatively short inter-monsoon periods (MSS, 2024a).

- Northeast monsoon season (December to early March): Northerly to northeasterly winds prevail, sometimes reaching 25 – 35 km/h winds in the first half of the season. Cloudy conditions in December and January with frequent afternoon and early evening showers. Relatively drier in late January till early March.
- Pre-southwest monsoon/ Inter-monsoon (late March to May): Light and variable winds with afternoon and early evening showers often with thunder. Hot afternoons are common, where temperatures can be above 32°C.
- Southwest monsoon season (June to September): Southeasterly and southerly winds. Isolated to scattered late morning and early afternoon showers. Early morning "Sumatra" line squalls are common.
- Pre-northeast monsoon/ Inter-monsoon (October to November): Light and variable winds. Sea breezes in the afternoon. Scattered showers with thunder in the late afternoon and early evening.

6.3.1.1 Rainfall

The annual total rainfall across all stations in 2024 was 2,739.8mm, 8.1% above the long-term average of 2,534.3 mm. The monthly rainfall in 2024 was highly variable, where island-wide rainfall in November (419mm) recorded the highest rainfall in November since 1980, where it was 47.4% above its long-term average. In December the island-wide average rainfall (221.3 mm) was 30% below its long-term average (MSS, 2024b).

6.3.1.2 Air Temperature

Over the last decade from 2015 to 2024, the mean temperature in Singapore recorded a new high of 28.11°C, with 6 of the 10 warmest years being recorded within this decade. In 2024, the annual mean daily minimum and maximum temperatures were 25.9°C (highest on record) and 32.1°C (third highest on record). All months during 2024 recorded temperatures that were equal or above their long-term average temperatures with April recording the warmest month in Singapore (MSS, 2024a).

6.3.1.3 Relative Humidity

Relative humidity in Singapore is fairly uniform throughout the year and does not vary much from month to month, although it generally remains high. During days where there is no rain, the daily relative humidity varies from more than 90% in the morning just before sunrise and falls to around 60% in the mid-afternoon. The mean annual relative humidity in 2024 was 77.9%, with a decade average of 78.23%. Relative humidity can reach up to 100% during prolonged periods of rain (MSS, 2024b).

6.3.2 Site Specific Rainfall within the EIA Study Area

There is one rainfall weather station located with the EIA Study Area (**Figure 6-1**). Malan Road rainfall station (S226) is located at 1.27472 N, 103.80389E.

Data on the total daily rainfall was collected between November 2024 and March 2025 (5 months) and obtained from publicly available platforms hosted by NEA's Meteorological Service Singapore (MSS) division and presented in **Figure 6-2**. The 120-minute rainfall (mm) prior to sampling collection was used in **Figure 6-2.**

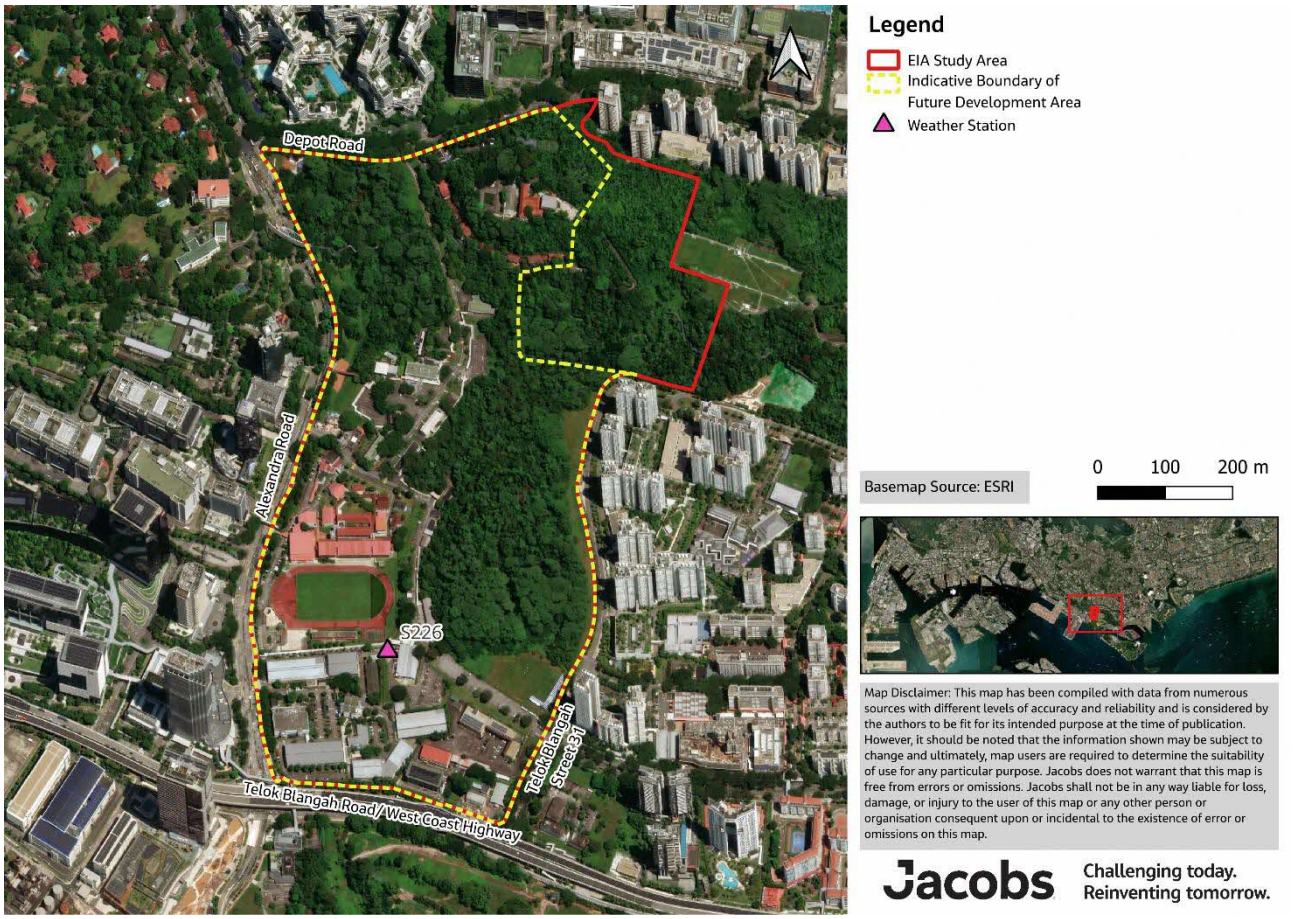


Figure 6-1: Location of Weather Stations within the EIA Study Area

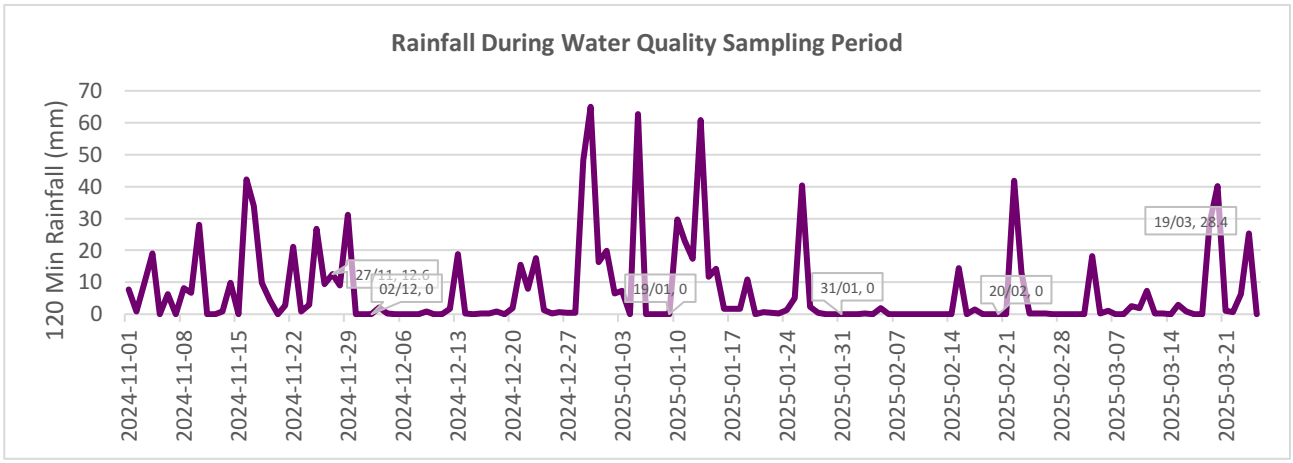


Figure 6-2: Daily Rainfall Data During the Water Quality Sampling Period

6.3.3 Hydrology

6.3.3.1 Waterbodies of the EIA Study Area

The EIA Study Area and its surrounding area was formerly a swamp area, where the development of infrastructure and network of roads most likely redirected and disrupted the area's natural hydrology over time.

The comprehensive field survey of streams and drains surveyed by YJP Surveyors Pte Ltd is given in **Figure 6-3**. The map presents the covered drains, open drains and earth drains in the EIA Study Area. The earth drains that were dry and/ or filled with debris are labelled as earth drain (dry) in the figure.

Appendix 5A presents the hydrological mapping, while the pictorial view of the various waterbodies types within the EIA Study Area from site reconnaissance is given in **Appendix 6A**.

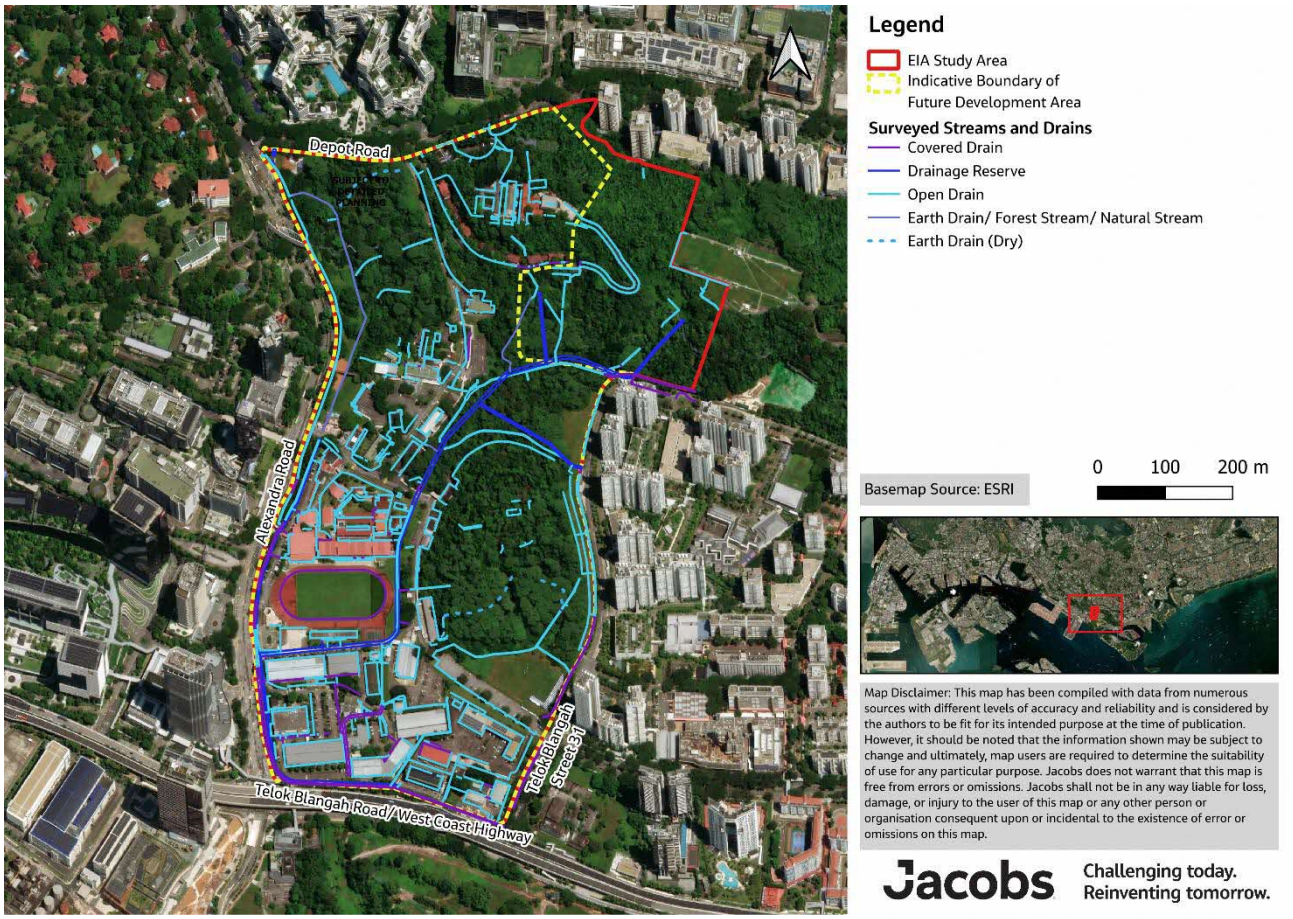


Figure 6-3: Identified Streams and Drains within the EIA Study Area from Hydrological Survey

6.3.3.2 Determination of Catchment Basins

The EIA Study Area, outlined in red in **Figure 6-4** spans across two primary catchment basins: the Pandan catchment (in light blue) and the Singapore River catchment (in dark blue), as shown in part (b) of **Figure 6-4**. Within the EIA Study Area boundary, a total of three sub-catchments (named as "Sub-catchment E1, E2 and E3") are delineated (part (c) of **Figure 6-4**), each contributing to the overall drainage flow via delineated channels. The formation and boundaries of these sub-catchments are highly influenced by topography, as variations in elevation and land contours dictate the direction and accumulation of surface runoff.

The EIA Study Area significantly overlaps with the Pandan catchment, particularly in the southern region where the largest sub-catchment, E1, is located. This sub-catchment contains the majority of the drainage channels,

which are directed toward the southern part of the EIA Study Area. Due to the area's topography, surface runoff and flow accumulation are expected to be more prominent in the south, eventually discharging through an outlet along the Telok Blangah Road/ West Coast Highway before draining into Belayar Creek. In contrast, surface runoff and flow accumulation from sub-catchments E2 and E3 are directed towards the north, into the Singapore River catchment.

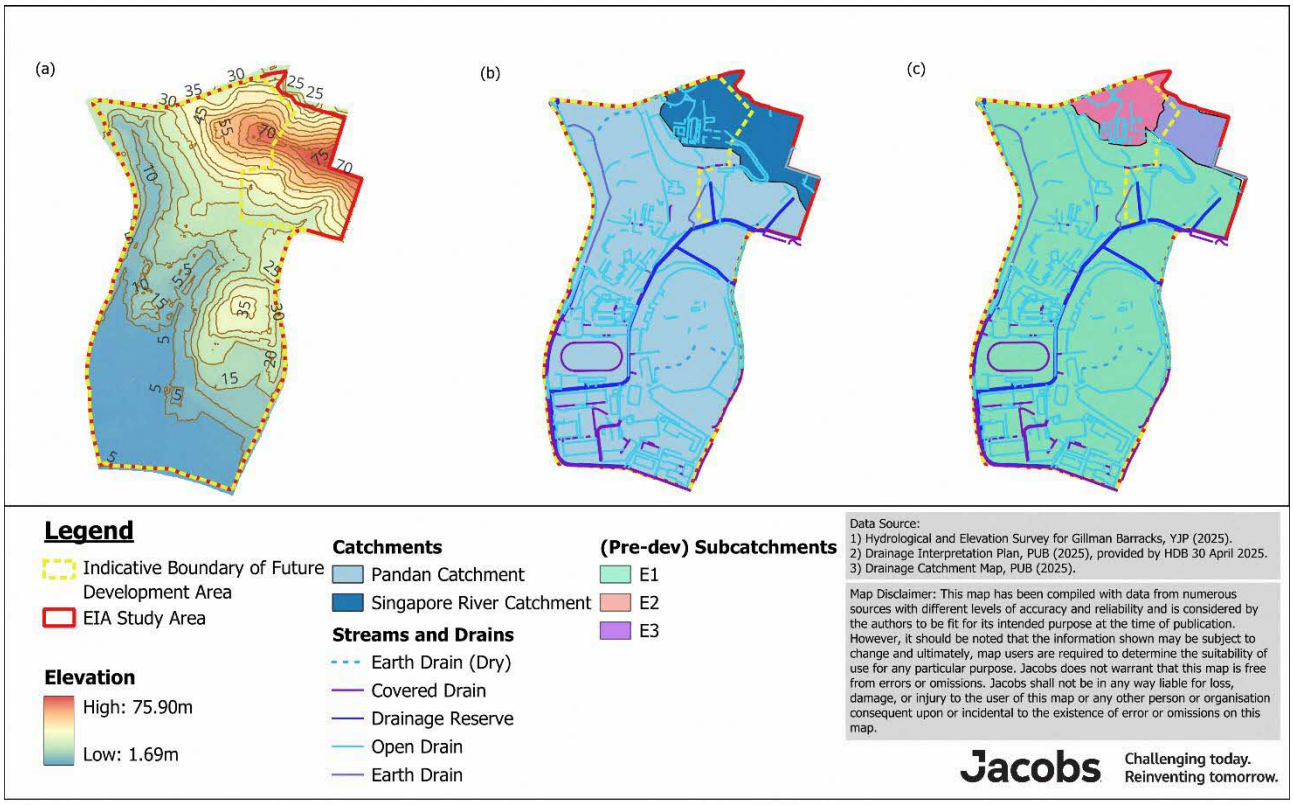


Figure 6-4: Water Catchments with Sub-Catchments within the EIA Study Area a) Elevation Map b) Singapore Catchments in the EIA Study Area c) Sub-Catchments in the EIA Study Area

6.3.3.3 Pre-Development Peak Flow

Table 6-1 shows the pre-development peak flows (Qpre) for 10 years Average Recurrence Interval (ARI) ($^{10}Q_{tc}$) calculated for the three sub-catchments of the EIA Study Area using equations provided in PUB's COPSWD (Seventh Edition, Dec 2018; Addendum No.3 – April 2025) by applying weighted runoff coefficient value (C value) and specific rainfall duration (Tc). The full calculation of the pre-development peak flow is given in **Appendix 6B**. The catchment delineation with its total area size, existing land use characteristic and location of peak flow outlet are illustrated in **Figure 6-5**.

Table 6-1: Calculated Pre-Development Peak Flow for the EIA Study Area

Sub-Catchment	Catchment Area Size (ha)	Discharge Outlet	Pre-Development Peak Flow (Qpre) $^{10}Q_{tc}$ (m3/s)	Weighted Runoff Coefficient Applied (C_{avg})
Area 1	42.4	E1	9.5	0.60
Area 2	2.9	E2	1.0	0.60
Area 3	2.0	E3	0.5	0.45

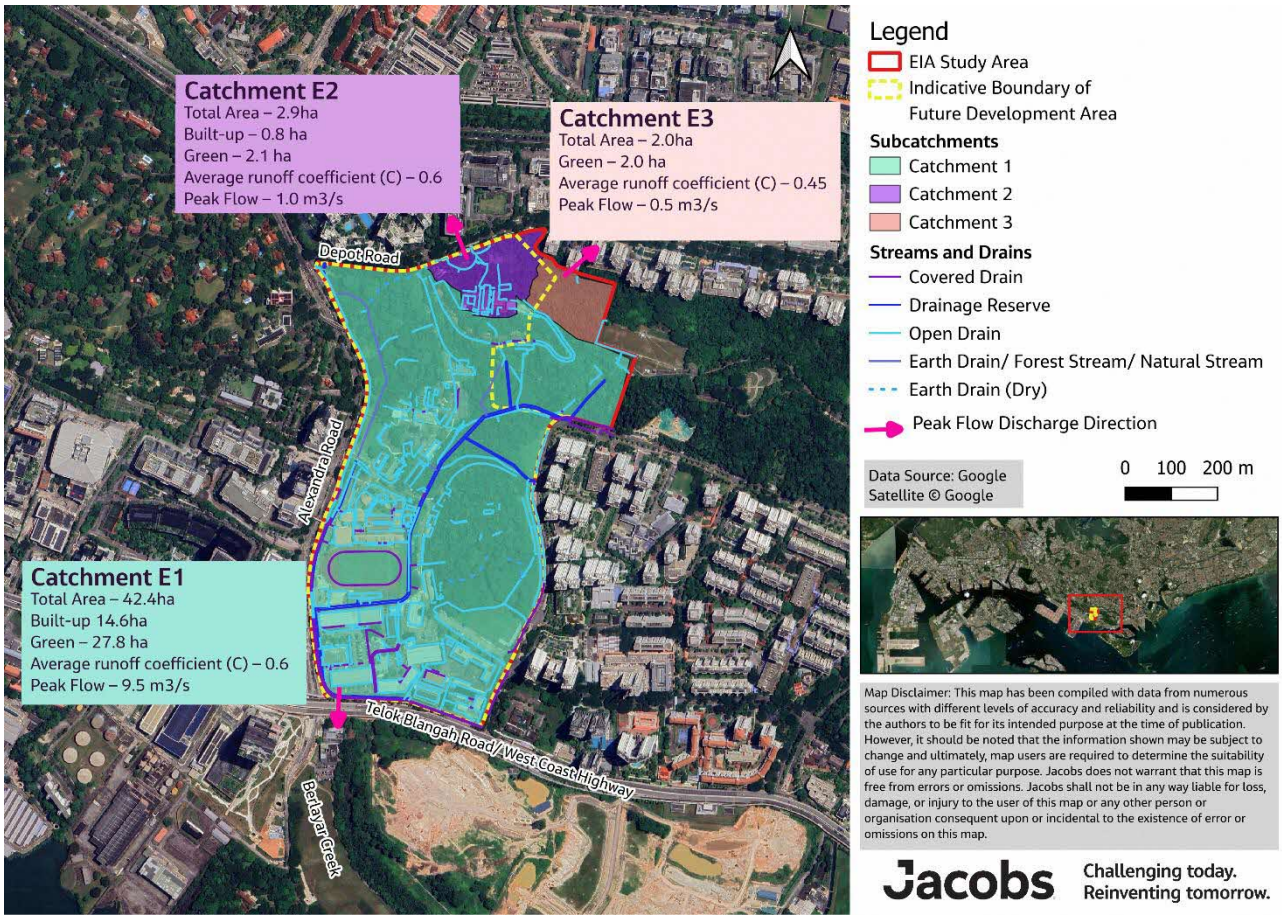


Figure 6-5: Pre-Development Peak Flow for the EIA Study Area

6.3.4 Surface Water Quality

6.3.4.1 Sampling Locations and Sample Size

Water quality baseline sampling was carried out at the start, middle, confluence points and points just before entering closed drains along accessible inland natural streams/ open drains/ naturalised streams/ earth streams within the EIA Study Area. A total of six streams have been identified and sampled within the EIA Study Area, where water quality baseline sampling was carried out from each sampling point. The sampling points are shown in **Figure 6-6**. WQ2 and WQ3 are earth drains while WQ1, WQ4, WQ5, and WQ6 are open drains.

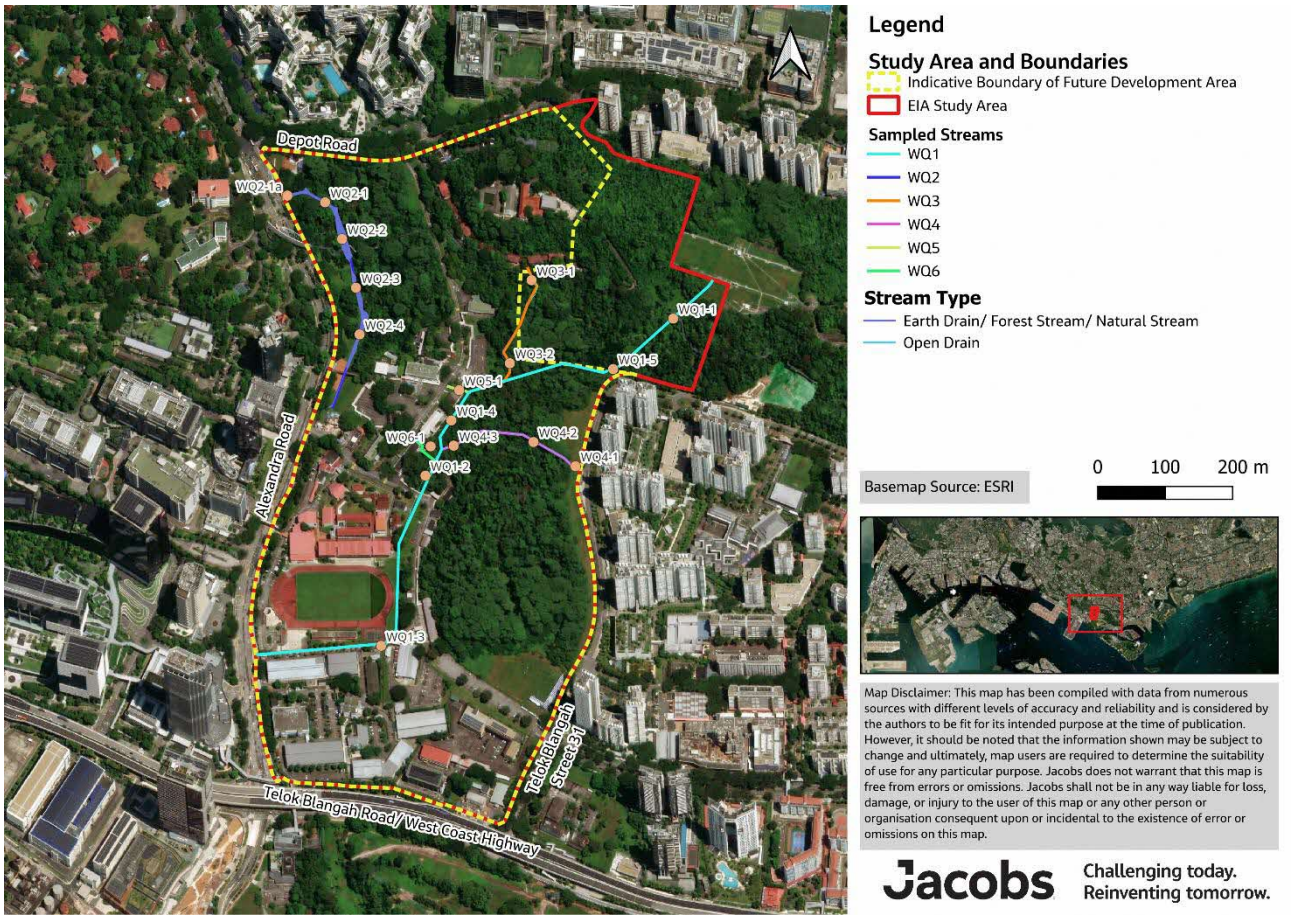


Figure 6-6: Sampled Streams and Water Quality Monitoring Locations within the EIA Study Area

Collection of water samples from the identified six waterbodies were conducted over three replicates. Two replicates were conducted over dry weather (no rain event in the preceding 48 hours) while one replicate was conducted over wet weather (within 3 hours after rainfall >10mm). Details on the sampling point, dates, and weather conditions are given in **Table 6-2.** Photographic documentation of each sampling event at each point is presented in **Appendix 6C**.

Table 6-2: Details of Surface Water Baseline Weather Events

Stream	Monitoring Point	Wet Weather Event		Dry Weather Event 1		Dry Weather Event 2	
		Sampling Date	Weather Condition	Sampling Date	Weather Condition	Sampling Date	Weather Condition
WQ1	WQ1-1	19-Mar-2025	Total rainfall of 26.8 mm within 3 hours of sampling *WQ1-1 was dry during sampling (no sample collected)*	31-Jan-2025	No rain for 48 hours before sampling. *WQ1-1 was dry during sampling (no sample collected)*	20-Feb-2025	No rain for 48 hours before sampling *WQ1-1 was dry during sampling (no sample collected)*
	WQ1-2	19-Mar-2025	Total rainfall of 26.8 mm within 3 hours of sampling	31-Jan-2025	No rain for 48 hours before sampling	20-Feb-2025	No rain for 48 hours before sampling

Stream	Monitoring Point	Wet Weather Event		Dry Weather Event 1		Dry Weather Event 2	
		Sampling Date	Weather Condition	Sampling Date	Weather Condition	Sampling Date	Weather Condition
	WQ1-3	19-Mar-2025	Total rainfall of 26.8 mm within 3 hours of sampling	31-Jan-2025	No rain for 48 hours before sampling	20-Feb-2025	No rain for 48 hours before sampling
	WQ1-4	19-Mar-2025	Total rainfall of 26.8 mm within 3 hours of sampling	31-Jan-2025	No rain for 48 hours before sampling	20-Feb-2025	No rain for 48 hours before sampling
	WQ1-5	19-Mar-2025	Total rainfall of 26.8 mm within 3 hours of sampling	31-Jan-2025	No rain for 48 hours before sampling	20-Feb-2025	No rain for 48 hours before sampling
WQ2	WQ2-1a	27-Nov-2024	Total rainfall of 12.6 mm within 3 hours of sampling	2-Dec-2024	No rain for 48 hours before sampling	9-Jan-2025	No rain for 48 hours before sampling
	WQ2-1	27-Nov-2024	Total rainfall of 12.6 mm within 3 hours of sampling	2-Dec-2024	No rain for 48 hours before sampling	9-Jan-2025	No rain for 48 hours before sampling
	WQ2-2	27-Nov-2024	Total rainfall of 12.6 mm within 3 hours of sampling	2-Dec-2024	No rain for 48 hours before sampling	9-Jan-2025	No rain for 48 hours before sampling
	WQ2-3	27-Nov-2024	Total rainfall of 12.6 mm within 3 hours of sampling	2-Dec-2024	No rain for 48 hours before sampling	9-Jan-2025	No rain for 48 hours before sampling
	WQ2-4	27-Nov-2024	Total rainfall of 12.6 mm within 3 hours of sampling	2-Dec-2024	No rain for 48 hours before sampling	9-Jan-2025	No rain for 48 hours before sampling
WQ3	WQ3-1	27-Nov-2024	Total rainfall of 12.6 mm within 3 hours of sampling	2-Dec-2024	No rain for 48 hours before sampling *WQ3-1 was dry during sampling (no sample collected)*	9-Jan-2025	No rain for 48 hours before sampling *WQ3-1 was dry during sampling (no sample collected)*
	WQ3-2	27-Nov-2024	Total rainfall of 12.6 mm within 3 hours of sampling	2-Dec-2024	No rain for 48 hours before sampling	9-Jan-2025	No rain for 48 hours before sampling
WQ4	WQ4-1	19-Mar-2025	Total rainfall of 26.8 mm within 3 hours of sampling	31-Jan-2025	No rain for 48 hours before sampling	20-Feb-2025	No rain for 48 hours before sampling
	WQ4-2	19-Mar-2025	Total rainfall of 26.8 mm within 3 hours of sampling	31-Jan-2025	No rain for 48 hours before sampling	20-Feb-2025	No rain for 48 hours before sampling

Stream	Monitoring Point	Wet Weather Event		Dry Weather Event 1		Dry Weather Event 2	
		Sampling Date	Weather Condition	Sampling Date	Weather Condition	Sampling Date	Weather Condition
	WQ4-3	19-Mar-2025	Total rainfall of 26.8 mm within 3 hours of sampling	31-Jan-2025	No rain for 48 hours before sampling	20-Feb-2025	No rain for 48 hours before sampling
WQ5	WQ5-1	27-Nov-2024	Total rainfall of 12.6 mm within 3 hours of sampling	2-Dec-2024	No rain for 48 hours before sampling *WQ5-1 was dry during sampling (no sample collected)*	9-Jan-2025	No rain for 48 hours before sampling *WQ5-1 was dry during sampling (no sample collected)*
WQ6	WQ6-1	27-Nov-2024	Total rainfall of 12.6 mm within 3 hours of sampling	2-Dec-2024	No rain for 48 hours before sampling *WQ6-1 was dry during sampling (no sample collected)*	9-Jan-2205	No rain for 48 hours before sampling *WQ6-1 was dry during sampling (no sample collected)*

6.3.4.2 Evaluation of Analytical Results

NEA administers the *Environmental Protection and Management Act* (EPMA) and the E*nvironmental Protection and Management (EPM) (Trade Effluent) Regulations* which regulates the discharge of wastewater into open drains, canals, and rivers, and specifies the allowable limits for trade effluent discharge to various types of watercourses. The nature or type of trade effluent discharge must be approved by NEA prior to discharge into any watercourse. The effluent must be treated before discharge and comply with the water quality limits specified in the regulations.

The streams where the baseline water samples taken are all within the sub-catchment of E1, drain from the north to the south and not towards any PUB's reservoirs. Although the streams are not strictly categorised as trade effluent but rather an uncontrolled watercourse that existing users may discharge trade effluent into, the report applied the EPM Trade Effluent guidelines and allowable limits (**Table 6-3**) as a reference for the water quality assessment. For parameters not listed in the EPM Trade Effluent, *NEA's Water Quality Guidelines for Popular Recreational Beaches* for Enterococcus is adopted as reference guidelines.

In addition to the aforementioned water quality parameters, this report references the ASEAN Marine Water Quality Management Guidelines (AMWQC) (ASEAN, 2008) and the US EPA Water Quality Criteria for Aquatic Life (US EPA, 2017) given streams of the largest catchment E1 discharge into Berlayar Creek. For the AMQQC values that differentiate between coastal and estuarine values, this report assesses against the estuarine values due to the habitat nature of Berlayar Creek and Labrador Nature Reserve. The values must not exceed the criteria set out in **Table 6-3**, unless otherwise specified.

Table 6-3: *In-situ* and *Ex-situ* Parameters Analysed for Water Quality Sampling and Reference Limits

	Item of Analysis	Units	Test Method	NEA Trade Effluent Discharge Limit to Watercourse, mg/L	Criteria for Aquatic Life	
					AMWQC	US EPA
In-situ Parameters	Temperature	°C	MLS-SOP-ES-004 using multi-parameter	45°C	Increase not more than 2C above the max ambient temperature	-
	pH	-	MLS-SOP-ES-004 using multi-parameter	6-9	-	6.5 – 9 (chronic)
	Conductivity	µS/cm	MLS-SOP-ES-004 using multi-parameter	-	-	-
	Salinity	ppt	MLS-SOP-ES-004 using multi-parameter	-	-	-
	Dissolved Oxygen	mg/l	MLS-SOP-ES-004 using multi-parameter	-	4[1]	-
	Turbidity	NTU	MLS-SOP-ES-004 using multi-parameter	-	-	-
Ex-situ Parameters	Biochemical Oxygen Demand (BOD)	mg/l	APHA 5210B	50	-	-
	Chemical Oxygen Demand (COD)	mg/l	HACH Method 8000 (Jul 2021)	100	-	-
	Total alkalinity	mg/L CaC03	APHA 2320B	-	-	20[1] (chronic)
	Total Phosphorus (TP)	mg/l	APHA 4500-P (J)	-	-	-
	Total Nitrogen (TN)	mg/l	APHA 4500-P (J)	-	-	-
	Total Organic Carbon (TOC)	mg/l	APHA 5310B	-	-	-
	Nitrate (NO3-N)	mg/l	APHA 4500- NO3 (I)	-	0.06	-
	Ammoniacal Nitrogen (NH4-N)	mg/l	APHA 4500- NH3 (H)	-	0.07	-

	Item of Analysis	Units	Test Method	NEA Trade Effluent Discharge Limit to Watercourse, mg/L	Criteria for Aquatic Life	
					AMWQC	US EPA
	Orthophosphate (PO4-P)	mg/l	APHA 4500-P (G)	5	0.015 (coastal) 0.045 (estuarine)	-
	Total Dissolved Solids (TDS)	mg/l	APHA 2540C	-	-	-
	Total Suspended Solids (TSS)	mg/l	APHA 2540D	50	Permissible 10% maximum increase over seasonal average concentration	-
	Arsenic as As	mg/l	APHA 3500B	0.1	-	0.34 (acute) 0.15 (chronic)
	Barium as B	mg/l	APHA 3500B	2	-	-
	Tin as Sn	mg/l	APHA 3500B	-	-	-
	Beryllium as Be	mg/l	APHA 3500B	-	-	-
	Boron as B	mg/l	APHA 3500B	5	-	-
	Manganese as Mn	mg/l	APHA 3500B	5	-	-
	Iron as Fe	mg/l	APHA 3500B	10	-	1 (chronic)
	*Lead	mg/l	APHA 3500B	0.1	0.0085	0.065 (acute) 0.025 (chronic)
	*Zinc	mg/l	APHA 3500B	1	-	0.12 (acute & chronic)
	*Mercury	mg/l	USEPA 245.1 (FIMS) (1994)	0.05	0.00016	0.0014 (acute) 0.00077(chronic)
	*Cadmium	mg/l	APHA 3500B	0.1	0.01	0.0018 (acute)
	*Chromium	mg/l	APHA 3500B	1	-	III: 0.57 (acute). 0.016 (chronic) IV: 0.074 (acute), 0.011 (chronic)[2]
	*Copper	mg/l	APHA 3500B	0.1	0.05	-
	*Nickel	mg/l	APHA 3500B	1	-	0.47 (acute) 0.52 (chronic)
	*Selenium	mg/l	APHA 3500B	0.5	-	-
	*Silver	mg/l	APHA 3500B	0.1	-	0.0032 (acute)
	*Metals in Total	mg/l	By Calculation	1	-	-

	Item of Analysis	Units	Test Method	NEA Trade Effluent Discharge Limit to Watercourse, mg/L	Criteria for Aquatic Life	
					AMWQC	US EPA
	Grease and Oil [total]	mg/l	Accredited In-house Method MLS-SOP-WQ-033 Rev 0 (adapted from APHA 5520C)	10	0.14	-
	Oil and grease (hydrocarbon)	mg/l	APHA 5520F	10	-	-
	Bacteria (Enterococcus, etc.)	cfu/100ml	APHA 9230C	200[3]	-	-

Notes:
[1]Parameters should be higher than indicated value
[2]The criteria for Chromium IV is used for reference for higher stringency
[3]Taken from NEA's Water Quality Guidelines for Popular Recreational Beaches for Enterococcus

The *Sewerage and Drainage Act (SDA)* authorises PUB to construct, maintain and improve sewerage and drainage systems, to regulate the discharge into these systems, and to issue codes of practice or specifications. It mandates the supervision of works requiring a clearance certificate under this Act by a Qualified Person. The Act also confers PUB with enforcement powers. The Codes of Practice (COPs) and guidelines that are relevant to discharges into waterbodies are listed below:

- COP for Environmental Control Officer (ECO) issued by NEA.
- COP on Surface Water Drainage (revised 2007) issued by PUB.
- Guidebook on Erosion and Sediment Control at Construction Sites, issued by PUB.
- Guidebook for Qualified Erosion Control Professional (QECP), issued by PUB.

6.3.4.3 Surface Water Quality Baseline Results

Dry weather surface water quality baseline sampling was carried out on 2 December 2024, 9 January 2025, 31 January 2025, and 20 February 2025 where no rain had occurred for the preceding 48 hours of each sample collection day. Wet weather surface water quality monitoring was carried out on 27 November 2024 and 19 March 2025 where sampling was carried out within 3 hours of rain with intensity of more than 10mm/hr. A total of 51 water surveys were conducted at 17 sampling locations, where only 42 samples were collected and submitted for laboratory analysis as some locations were dry or had insufficient water for sampling.

The analytical results for water surface water quality reported that pH value, dissolved oxygen (DO), biochemical oxygen demand (BOD5), chemical oxygen demand (COD), total organic carbon (TOC), total alkalinity, nitrate (NO_3-N), ammonia (NH_4-N), phosphate (PO_4-P), total suspended solids (TSS), iron, grease and oil (total), and enterococcus had exceeded any of the reference limits set out in **Table 6-3** in at least one of the water samples.

The complete surface water quality analytical results (detects and non-detects) and comparison with the limits described in **Table 6-3** are presented in **Appendix 6D** while the laboratory reports are shown in **Appendix 6E**. The water analytical results of parameters with exceedances of any of the referenced guidelines is given in **Table 6-4**.

Table 6-4: Surface Water Quality Results

		WQ1					WQ2					WQ3		WQ4			WQ5	WQ6
Test Parameter		WQ1-1	WQ1-2	WQ1-3	WQ1-4	WQ1-5	WQ2-1a	WQ2-1	WQ2-2	WQ2-3	WQ2-4	WQ3-1	WQ3-2	WQ4-1	WQ4-2	WQ4-3	WQ5-1	WQ6-1
Temperature (°C)	WWS	-	25.9	25.9	26.2	26.1	27.2	27.0	27.1	27.0	27.0	26.4	26.9	26.5	26.4	26.2	27.9	27.3
	DWS1	-	26.1	26.3	26.1	26.6	29.2	29.0	29.0	29.0	28.6	-	28.3	26.9	27.1	25.8	-	-
	DWS2	-	28.0	28.8	28.8	27.8	28.6	28.3	28.6	29.0	29.0	-	28.2	28.7	28.9	27.9	-	-
pH	WWS	-	7.52	7.63	7.77	6.64	8.40	7.16	6.88	7.06	7.10	7.58	7.87	7.86	7.81	7.53	8.75	7.86
	DWS1	-	6.59	7.29	7.34	6.12	8.39	6.67	6.69	6.93	6.93	-	7.03	8.8	8.70	7.18	-	-
	DWS2	-	6.17	7.06	6.75	6.29	8.19	6.61	6.66	6.92	7.14	-	7.21	8.7	10.13	7.62	-	-
Conductivity (µS/cm)	WWS	-	75	67	128	134	250	229	243	295	259	81.40	168	44	48	46	171	9
	DWS1	-	155	2901	167	115	317	380	392	437	407	-	158	19	344	198	-	-
	DWS2	-	118	257	127	115	270	243	317	348	423	-	148	251	222	171	-	-
Dissolved Oxygen as DO	WWS	-	7.72	7.97	7.85	7.39	7.82	6.88	6.31	5.53	5.91	7.92	7.60	8.03	8.03	8.08	7.68	7.62
	DWS1	-	6.91	5.82	7.85	6.86	7.42	6.01	6.02	4.87	5.21	-	6.84	7.9	7.80	7.64	-	-
	DWS2	-	6.99	**3.34**	6.56	7.27	7.46	4.67	4.57	**3.36**	4.27	-	7.39	7.7	7.38	7.55	-	-
Turbidity (NTU)	WWS	-	186	9.02	214	26.2	26	28.96	117	132	87	351	69.76	13.94	12.03	13.79	23.12	8.84
	DWS1	-	11.76	11.07	14.86	8.73	16.04	12.09	13.75	14.36	9.76	-	17.85	5.0	4.18	11.25	-	-
	DWS2	-	6.52	33.43	19.69	5.90	15.37	10.06	12.65	6.01	10.42	-	8.09	8.5	4.61	38.66	-	-
Salinity (PSU)	WWS	-	0.03	0.03	0.06	0.06	0.12	0.11	0.12	0.14	0.12	0.04	0.08	0.02	0.02	0.02	0.08	0.04
	DWS1	-	0.07	1.49	0.08	0.05	0.15	0.18	0.19	0.21	0.20	-	0.07	0.0	0.16	0.09	-	-
	DWS2	-	0.05	0.12	0.06	0.05	0.12	0.12	0.15	0.17	0.20	-	0.07	0.1	0.10	0.08	-	-
Biochemical Oxygen Demand, BOD5 (mg/L)"	WWS	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.33	ND	ND	ND	ND	ND	2.57
	DWS1	-	ND	3.16	ND	ND	5.45	ND	ND	ND	ND	-	ND	ND	ND	ND	-	-
	DWS2	-	ND	99.97	ND	ND	3.99	5.33	5.40	2.28	2.70	-	ND	ND	3.04	ND	-	-
Chemical Oxygen Demand, COD (mg O2/L)"	WWS	-	ND	ND	24	ND	ND	ND	ND	ND	26	27.00	ND	ND	ND	ND	ND	ND
	DWS1	-	ND	24.00	ND	ND	27.00	ND	ND	ND	ND	-	ND	ND	ND	ND	-	-
	DWS2	-	ND	174	ND	ND	ND	ND	ND	ND	ND	-	ND	ND	22.00	ND	-	-
Total Alkalinity as CaCO3 (mg/L)	WWS	-	31	27	40	21	56	54	72	112	92.00	ND	62	ND	20	ND	72	20
	DWS1	-	44	147	52	23	53	52	104	163	116	-	52	223	134	67	-	
	DWS2	-	28	78	33	21	48	56	117	231	139	-	51	80	62	55	-	

		WQ1					WQ2					WQ3		WQ4			WQ5	WQ6
Test Parameter		WQ1-1	WQ1-2	WQ1-3	WQ1-4	WQ1-5	WQ2-1a	WQ2-1	WQ2-2	WQ2-3	WQ2-4	WQ3-1	WQ3-2	WQ4-1	WQ4-2	WQ4-3	WQ5-1	WQ6-1
Total Phosphorus as TP (mg/L)	WWS	-	0.098	0.09	0.094	0.031	0.116	0.079	0.090	0.076	0.04	0.135	0.02	0.031	0.034	0.026	0.033	0.02
	DWS1	-	ND	0.10	ND	ND	0.171	0.08	0.051	0.047	0.05	-	0.02	0.0	0.026	0.013	-	-
	DWS2	-	ND	0.268	ND	ND	0.152	0.177	0.135	0.036	0.03	-	ND	0.1	0.075	0.029	-	-
Total Nitrogen as TN (mg/L)	WWS	-	0.64	0.62	1.05	1.04	1.9517	1.91	1.63	1.36	1.24	1.94	0.96	0.43	0.5	0.4	0.56	0.62
	DWS1	-	0.91	0.83	0.91	1.02	2.9436	2.50	1.54	1.11	1.58	-	1.24	0.6	0.6	0.7	-	-
	DWS2	-	1.01	2.24	0.91	1.14	1.1495	0.5	0.45	0.29	0.39	-	0.87	2.3	1.6	0.65	-	-
Total Organic Carbon, TOC (mg/L)	WWS	-	3.08	1.82	4.95	3.67	5.0420	3.72	3.51	6.80	3.37	5.46	6.31	2.29	3.12	2.46	5.07	4.65
	DWS1	-	1.65	7.32	1.85	1.45	6.07	3.57	2.65	2.43	3.94	-	2.60	2.6	2.67	1.63	-	-
	DWS2	-	1.48	37.18	1.6	1.21	2.87	3.95	4.55	2.26	2.86	-	2.30	3.1	3.78	1.72	-	-
Nitrate as NO3-N (mg/L)	WWS	-	**0.31**	**0.40**	**0.56**	**0.80**	**1.49**	**1.37**	**1.10**	**0.62**	**0.87**	**1.4**	**0.72**	**0.18**	**0.22**	**0.22**	**0.28**	**0.45**
	DWS1	-	**0.78**	**0.13**	**0.77**	**0.98**	**1.45**	**1.43**	**0.91**	**0.54**	**0.83**	-	**0.75**	**0.6**	**0.51**	**0.58**	-	-
	DWS2	-	**0.91**	ND	**0.76**	**1.10**	**0.76**	**0.23**	**0.25**	**0.13**	**0.26**	-	**0.76**	**1.6**	**1.035**	**0.58**	-	-
Ammonia as NH4-N (mg/L)	WWS	-	ND	0.02	0.0290	ND	**0.11**	0.12	**0.22**	**0.21**	**0.17**	0.02	0.05	ND	ND	ND	ND	ND
	DWS1	-	**0.10**	**0.12**	**0.12**	0.02	0.04	0.18	0.17	0.21	**0.09**	-	0.12	ND	0.015	0.11	-	-
	DWS2	-	**0.08**	ND	0.13	0.01	ND	ND	ND	**0.09**	0.05	-	**0.07**	0.1	**0.08**	0.04	-	-
Phosphate as PO4-P (mg/L) 0.045 (estuarine)"	WWS	-	ND	0.05	ND	ND	**0.07**	ND	ND	ND	ND	**0.06**	ND	ND	ND	ND	ND	ND
	DWS1	-	ND	ND	ND	ND	0.041	ND	ND	ND	ND	-	ND	ND	ND	ND	-	-
	DWS2	-	ND	ND	ND	ND	**0.07**	ND	ND	ND	ND	-	ND	ND	ND	ND	-	-
Total Dissolved Solids, TDS (mg/L)	WWS	-	49	44	80	84	165	157	163	186	169	45	109	26	30	28	114	57
	DWS1	-	86	1968	92	69	214	267	275	287	271	-	106	257	217	115	-	-
	DWS2	-	65	163	74	63	242	159	205	278	242	-	101	157	129	96	-	-
Total Suspended Solids, TSS (mg/L)	WWS	-	105	ND	101	ND	ND	ND	30.80	43.60	20.20	202.4	32	ND	ND	ND	ND	11.67
	DWS1	-	ND	20.00	ND	ND	ND	ND	11.60	10.40	ND	-	ND	ND	ND	22	-	-
	DWS2	-	ND	ND	43.40	ND	ND	ND	ND	ND	ND	-	ND	ND	ND	10	-	-
Lead as Pb (mg/L) 0.025 (chronic)	WWS	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.01	ND	ND	ND	ND	ND	ND
	DWS1	-	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND	ND	ND	ND		
	DWS2	-	ND	ND	ND	ND	ND	ND	ND	ND	ND		ND	ND	ND	ND		
Zinc as Zn (mg/L)	WWS	-	0.02	0.02	0.02	0.01	0.04	0.03	0.02	0.02	0.02	0.04	0.02	0.05	0.05	0.05	0.08	0.11
	DWS1	-	0.01	0.01	ND	0.01	0.04	0.02	0.01	0.01	0.01	-	0.01	0.0	0.01	0.01	-	-
	DWS2	-	0.02	0.03	0.01	0.01	0.01	0.02	0.01	ND	0.01	-	0.02	0.0	0.02	0.01	-	-

		WQ1					WQ2					WQ3		WQ4			WQ5	WQ6
Test Parameter		**WQ1-1**	**WQ1-2**	**WQ1-3**	**WQ1-4**	**WQ1-5**	**WQ2-1a**	**WQ2-1**	**WQ2-2**	**WQ2-3**	**WQ2-4**	**WQ3-1**	**WQ3-2**	**WQ4-1**	**WQ4-2**	**WQ4-3**	**WQ5-1**	**WQ6-1**
Mercury as Hg (mg/L)	WWS	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	DWS1	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	ND	ND	ND	ND	-	-
	DWS2	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	ND	ND	ND	ND	-	-
Arsenic as As (mg/L)	WWS	-	ND	ND	ND	ND	ND	ND	ND	0.01	ND	0.02	ND	ND	ND	ND	ND	ND
	DWS1	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	ND	ND	ND	ND	-	-
	DWS2	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	ND	ND	ND	ND	-	-
Barium as Ba (mg/L)	WWS	-	0.04	0.01	0.04	0.03	0.03	0.03	0.04	0.05	0.04	0.10	0.04	0.01	0.01	0.01	0.02	0.01
	DWS1	-	0.03	0.06	0.04	0.03	0.04	0.03	0.04	0.04	0.04	-	0.04	0.0	0.03	0.01	-	-
	DWS2	-	0.03	0.05	0.03	0.03	0.02	0.02	0.04	0.04	0.04	-	0.03	0.0	0.02	0.01	-	-
Tin as Sn (mg/L)	WWS	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	DWS1	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	ND	ND	ND	ND	-	-
	DWS2	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	ND	ND	ND	ND	-	-
Iron as Fe (mg/L)	WWS	-	1.75	0.10	2.59	0.54	0.51	0.71	1.33	2.16	1.14	6.42	2.10	0.07	0.09	0.14	0.42	0.04
	DWS1	-	1.39	0.88	1.67	0.44	0.09	0.55	1.00	1.24	0.75		2.16	0.2	0.07	0.59	-	-
	DWS2	-	0.82	0.41	1.23	0.98	0.23	0.70	1.03	0.88	0.60		2.09	0.1	0.05	0.48	-	-
Boron as B (mg/L)	WWS	-	0.02	0.01	0.03	0.04	0.01	ND	0.01	0.01	0.01	ND	ND	0.01	0.01	0.01	ND	ND
	DWS1	-	0.02	0.24	0.02	0.02	0.04	0.03	0.03	0.02	0.02	-	0.02	0.0	0.04	0.02	-	-
	DWS2	-	0.02	0.03	0.02	0.03	0.02	0.03	0.02	0.02	0.02	-	0.02	0.0	0.03	0.01	-	-
Manganese as Mn (mg/L)	WWS	-	0.0152	ND	0.02	0.03	ND	0.01	0.04	0.06	0.04	0.01	0.04	ND	ND	0.006	ND	ND
	DWS1	-	0.11	0.09	0.11	0.06	ND	0.03	0.09	0.07	0.07	-	0.08	ND	ND	0.21	-	-
	DWS2	-	0.09	0.05	0.09	0.05	ND	0.03	0.04	0.06	0.07	-	0.08	ND	ND	0.11	-	-
Cadmium as Cd (mg/L)	WWS	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	DWS1	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	ND	ND	ND	ND	-	-
	DWS2	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	ND	ND	ND	ND	-	-
Chromium as Cr (trivalent and hexavalent) (mg/L)	WWS	-	0.0074	ND	0.0066	ND	ND	ND	ND	ND	ND	0.01	ND	ND	ND	ND	ND	ND
	DWS1	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	ND	ND	ND	ND	-	-
	DWS2	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	ND	ND	ND	ND	-	-
Copper as Cu (mg/L)	WWS	-	ND	ND	ND	ND	0.02	0.01	0.01	ND	ND	0.01	ND	ND	ND	ND	ND	ND
	DWS1	-	ND	0.01	ND	ND	0.01	0.02	0.01	0.01	0.01		ND	ND	0.01	ND		
	DWS2	-	ND	0.02	ND	ND	0.01	0.01	0.01	ND	ND		ND	ND	0.01	ND		

		WQ1					WQ2					WQ3		WQ4			WQ5	WQ6
Test Parameter		**WQ1-1**	**WQ1-2**	**WQ1-3**	**WQ1-4**	**WQ1-5**	**WQ2-1a**	**WQ2-1**	**WQ2-2**	**WQ2-3**	**WQ2-4**	**WQ3-1**	**WQ3-2**	**WQ4-1**	**WQ4-2**	**WQ4-3**	**WQ5-1**	**WQ6-1**
Nickel as Ni (mg/L) 0.52 (chronic)	WWS	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	DWS1	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	ND	ND	ND	ND	-	-
	DWS2	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	ND	ND	ND	ND	-	-
Silver as Ag (mg/L)	WWS	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	DWS1	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	ND	ND	ND	ND	-	-
	DWS2	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	ND	ND	ND	ND	-	-
Beryllium as Be (mg/L)	WWS	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	DWS1	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	ND	ND	ND	ND	-	-
	DWS2	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	ND	ND	ND	ND	-	-
Selenium as Se (mg/L)	WWS	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	DWS1	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	ND	ND	ND	ND	-	-
	DWS2	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	ND	ND	ND	ND	-	-
Metals in Total (mg/L)	WWS	-	0.031	0.025	0.024	0.006	0.059	0.037	0.028	0.015	0.016	0.073	0.018	0.053	0.055	0.050	0.081	0.110
	DWS1	-	0.011	0.013	ND	0.010	0.057	0.040	0.022	0.016	0.015	-	0.01	0.010	0.019	0.007	-	-
	DWS2	-	0.016	0.051	0.006	0.008	0.014	0.025	0.018	ND	0.009	-	0.015	0.029	0.027	0.009	-	-
Grease and Oil (Total) (mg/L)	WWS	-	**0.21**	ND	**0.21**	**0.19**	**0.61**	ND	ND	**1.16**	ND	**0.98**	**0.43**	**0.32**	**0.26**	**0.22**	**0.41**	**0.38**
	DWS1	-	ND	**0.25**	ND	ND	0.37	ND	ND	ND	ND	-	ND	ND	ND	ND	-	-
	DWS2	-	ND	**7.27**	ND	ND	0.11	**0.14**	**0.28**	ND	ND	-	ND	ND	ND	ND	-	-
Grease and Oil (Hydrocarbon) (mg/L)	WWS	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.12	ND	ND	ND	ND
	DWS1	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	ND	ND	ND	ND	-	-
	DWS2	-	ND	0.45	ND	ND	ND	ND	ND	ND	ND	-	ND	ND	ND	ND	-	-
Enterococci (cfu/100mL)	WWS	-	1600	1000	1700	1500	10	360	730	880	720	750	640	1100	7300	900	720	230
	DWS1	-	29	1000	150	31	580	80	59	620	140	-	350	160	1400	480	-	-
	DWS2	-	14	4400	80	16	128.	210	132	230	290	-	16	310	5800	900	-	-

Note:
ND – Non-detect
Values in red indicate exceedance of NEA trade effluent discharge for watercourse
*Values in **bold** indicate exceedance of AMWQC*
Values underlined indicate exceedance of US EPA
Values in blue indicate exceedance of NEA's water quality guideline for enterococcus

In general, elevated concentrations of enterococcus were reported in all streams across the EIA Study Area, having been recorded during all sampling locations during the wet weather sampling event and in at least one dry weather event in all locations with sufficient water supply for sampling. Enterococcus is an indicator of the presence of fecal matter in the water. Elevated levels of enterococcus may be attributed to stormwater runoff from heavy rainfall in the area, malfunction or overflow from sewerage systems within the EIA Study Area, or wildlife and pets in the vicinity of the EIA Study Area that may be washed into streams.

6.3.4.3.1 Baseline Results Analysis for WQ1

WQ1 – The WQ1 C7 drain is the longest stream in the EIA Study Area, with an approximate length of 1 km. Sampling details of WQ1 are given in **Figure 6-7**. Exceedances of grease and oil was recorded in the three midstream locations during the wet weather sampling event and downstream at WQ1-3 in both dry weather events. Exceedance of ammonia was reported in both dry weather events between WQ1-2 and WQ1-4 (midstream to downstream). Iron was recorded in all three weather events between the two midstream points (WQ1-2 and WQ1-4) and nitrate in all locations except upstream. Exceedances may be attributed to decomposition of organic matter from the surrounding forest patch, anthropogenic inputs from fertilizers, industrial discharge, or wastewater effluent. Exceedance of TSS was reported at the two midstream points of WQ1 (WQ1-2: 105 mg/L; WQ1-4: 101 mg/L) during wet weather. This may be explained by the points WQ1-2 and WQ1-4 being located in an area of lower elevation compared to the surrounding areas, allowing sediment to accumulate in these sections of the stream. The downstream sampling point WQ1-3 reported exceedances of BOD5 (100 mg/L), COD (174 mg/L), and TOC (37.2 mg/L) during one of the dry weather sampling events, and phosphate (0.045 mg/L) in the wet weather sampling event. WQ1-3 also recorded DO below the minimum requirement of 4.00 mg/L at one of the dry weather sampling events, coinciding with the elevated levels of BOD5, COD, and TOC, suggesting a temporary but potentially significant oxygen depletion event. Elevated levels of oxygen demand may be attributed to decomposing vegetation and microbial activity from warm temperatures and stagnant water, while TOC and COD could be explained by sediment runoff or disturbances of contaminated soil layers from previous site clearance and development activities. pH was recorded to be below the minimum of 6.5 at WQ1-2 and WQ1-5 during at least one of the dry weather events, describing potentially anaerobic conditions from low DO levels in the stream.

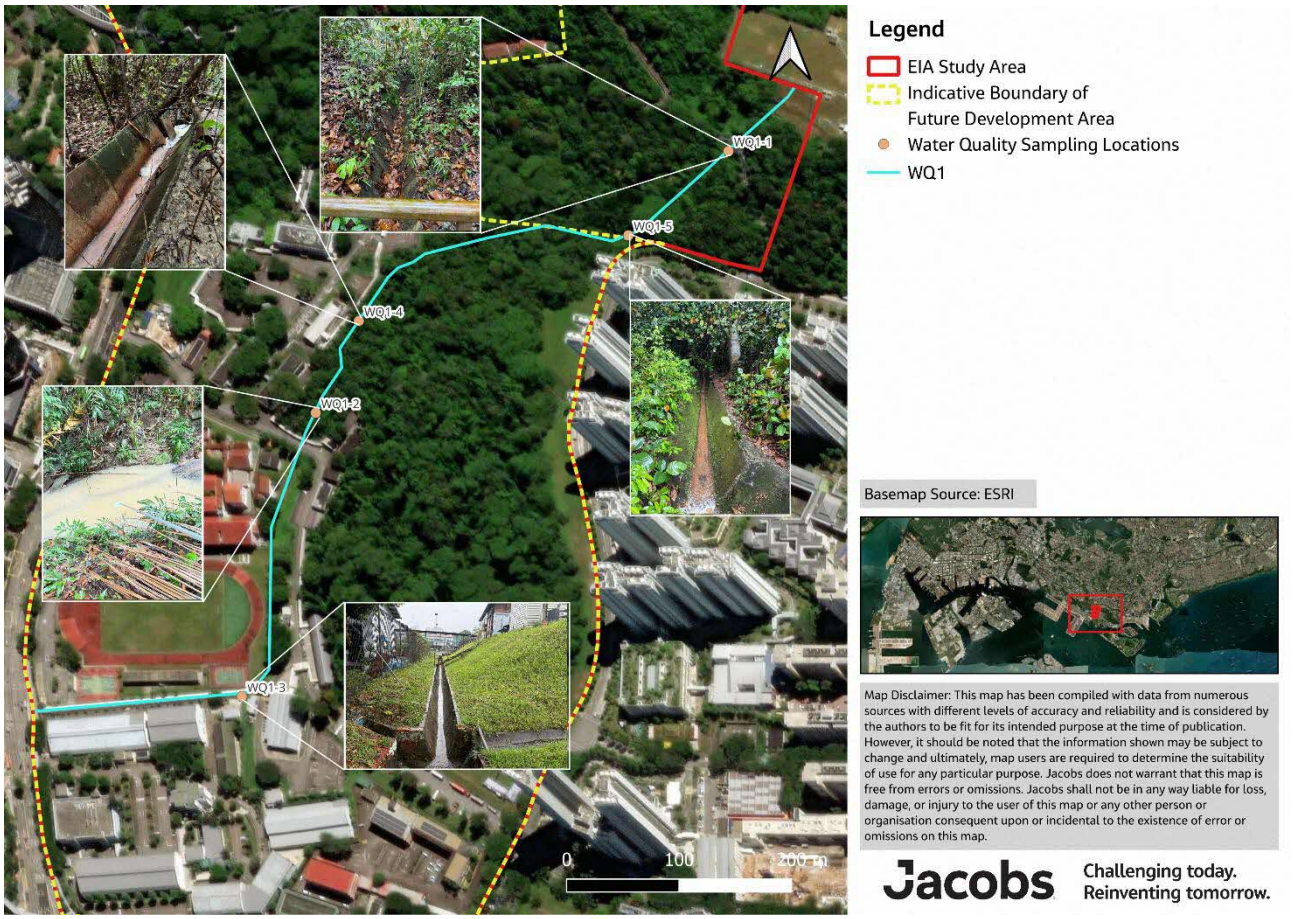


Figure 6-7: Water Quality Sampling in Stream WQ1

6.3.4.3.2 Baseline Results Analysis for WQ2

WQ2 – WQ2 is an earth drain approximately 389 m long (**Figure 6-8**). Sampling was not conducted in the most downstream point of WQ2 as access was limited due to ongoing but unrelated construction works. Exceedances of ammonia were recorded in all sampling locations during the wet weather event, and in all sampling locations except for WQ2-1a in at least one dry weather event. This suggests a persistent source driven by non-point source pollution and surface runoff, from various sources including runoff from fertilizers, animal waste, soil leaching, low flow/ stagnation, or decomposition of organic matter. Similar to WQ1, WQ2 is surrounded by a forested patch, where ammonia may be affected by the decomposition of organic matter. Grease and oil exceedances were reported in the upstream portions of the stream during the wet weather event and both dry weather events, indicating a pollutive source upstream along Alexandra Road. Exceedances of iron were recorded in the midstream portions of the stream during the wet weather event and at least one of the dry weather events. Nitrate had exceeded the limits set out in the AMWQC in all sampling locations in all three weather events. Phosphate exceedances were also recorded at the upstream point in the wet weather event and one dry weather event.

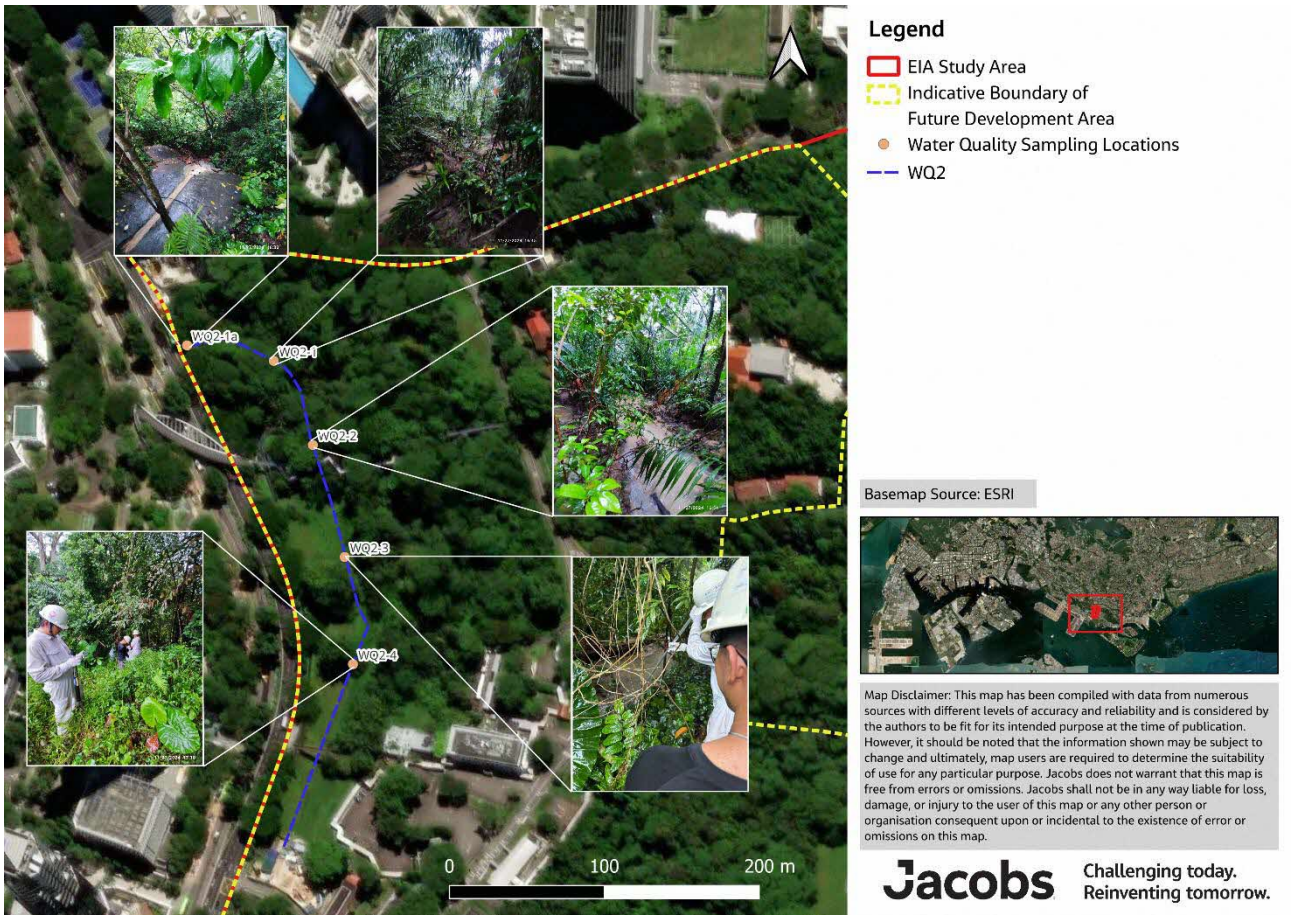


Figure 6-8: Water Quality Sampling in Stream WQ2

6.3.4.3.3 Baseline Results Analysis for WQ3

WQ3 – WQ3 is a combination of an earth drain and a C7 drain 193 m long, where approximately 43 m of the upstream is an open drain, with the remaining 150 m being an earth drain (**Figure 6-9**). Sampling point WQ3-1, located at the upstream, recorded exceedances of alkalinity, chromium, grease and oil, iron, nitrate, phosphate, and TSS during the wet weather event. Grease and oil, iron, and nitrate were also recorded in the downstream location WQ3-2. These exceedances suggest that the upstream section is likely receiving direct runoff from urban sources (including the row of houses and Preston Road, or the school slightly higher up the hill). The sources may include surface runoff from impervious surfaces (e.g., roads, pavements) carrying oils, grease, and heavy metals, nutrient loading from fertilizers or organic waste, and high TSS from sediment runoff. The reduction in the number of exceeded parameters downstream may suggest that the earth drain may be providing some natural attenuation or filtration through dilution from additional inflows, and adsorption and updated from soil and vegetation along the earth drain. During dry weather sampling, no samples were collected at WQ3-1 due to insufficient water levels. Iron and nitrate were also recorded at WQ3-2 during both dry weather events. The presence of ammonia at WQ3-2 during both dry weather events may be explained by decomposition of organic matter and lack of water flow or dilution.

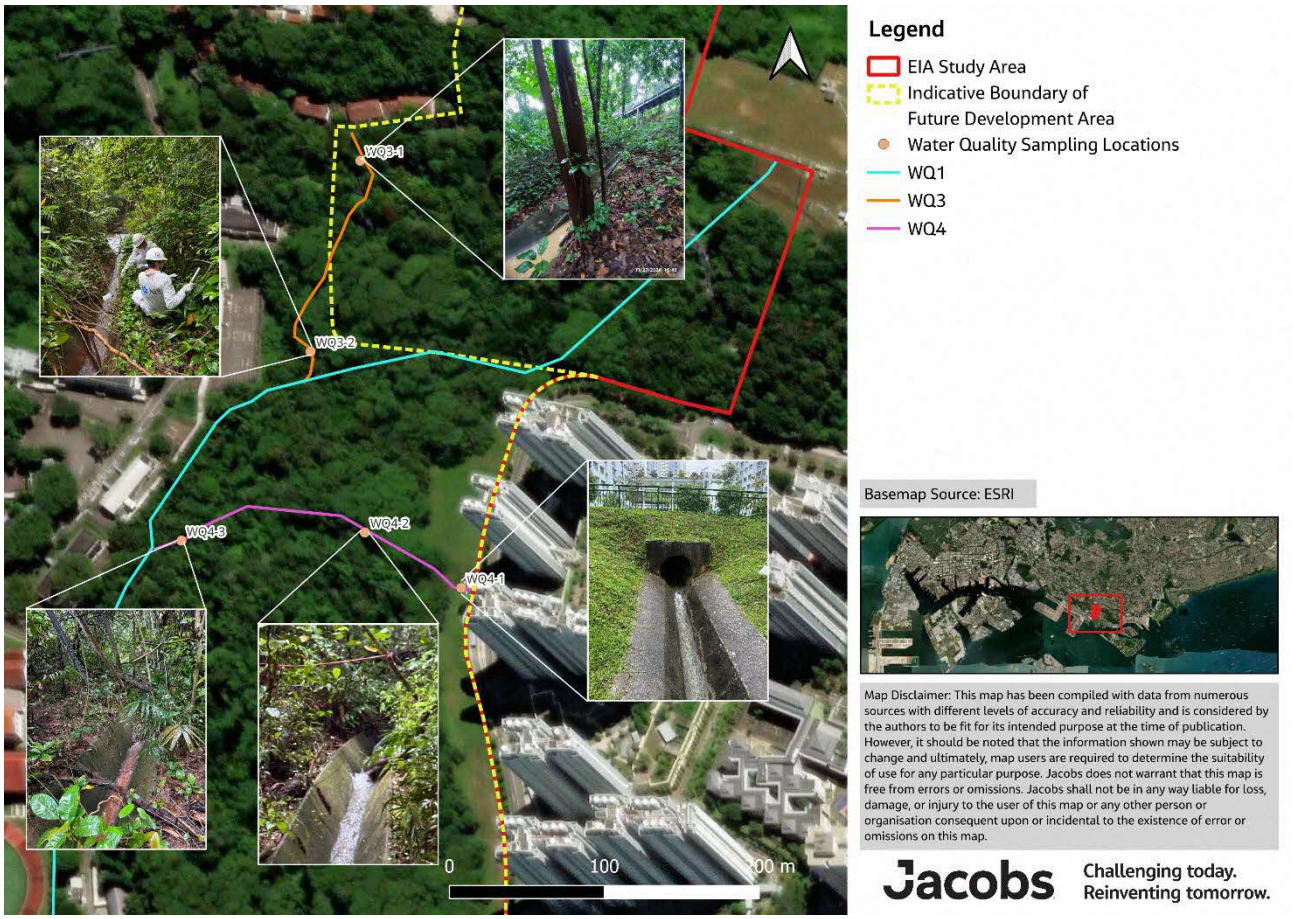


Figure 6-9: Water Quality Sampling in Stream WQ3 & WQ4

6.3.4.3.4 Baseline Results Analysis for WQ4

WQ4 – WQ4 is a 223 m long C7 drain running from east to west and discharging into WQ1 (**Figure 6-9**). During wet weather sampling, alkalinity, grease and oil, and nitrate were recorded in all three sampling locations, likely from urban runoff and/ or organic waste. The presence of nitrate in all three sampling locations for both dry weather events indicate persistent chronic contamination. Ammonia was recorded in the downstream sampling location during one dry weather event, while high pH (10.1) was recorded at the midstream location during the second dry weather event. During the other dry weather sampling event, pH was under the limit of 9, although the reading was slightly elevated (8.70). At the upstream of WQ4, pH was recorded to be under the limit but also sampled to be slightly high during dry weather (8.75 and 8.67). Elevated levels of pH may be attributed to natural weathering processes of the concrete drain, where high pH material could have potentially leached from the drain substrate into the water, increasing the alkalinity of the water.

6.3.4.3.5 Baseline Results Analysis for WQ5

WQ5 – WQ5 is a C7 drain of 32 m discharging into WQ1 (**Figure 6-10**). Samples were only collected during the wet weather event in WQ5 as there were insufficient water levels during both dry weather events. The wet weather event recorded exceedances of grease and oil, and nitrate in WQ5-1.

6.3.4.3.6 Baseline Results Analysis for WQ6

WQ6 – WQ6 is a C7 drain of 45 m discharging into WQ1 (**Figure 6-10**). Samples were only collected during the wet weather event in WQ6 as there were insufficient water levels during both dry weather events. The wet weather event recorded exceedances of grease and oil, and nitrate in WQ6-1. Alkalinity levels were reported to

be below the minimum detection threshold, with concentrations falling below 20 mg/L, the analytical detection limit for the sampling method used.

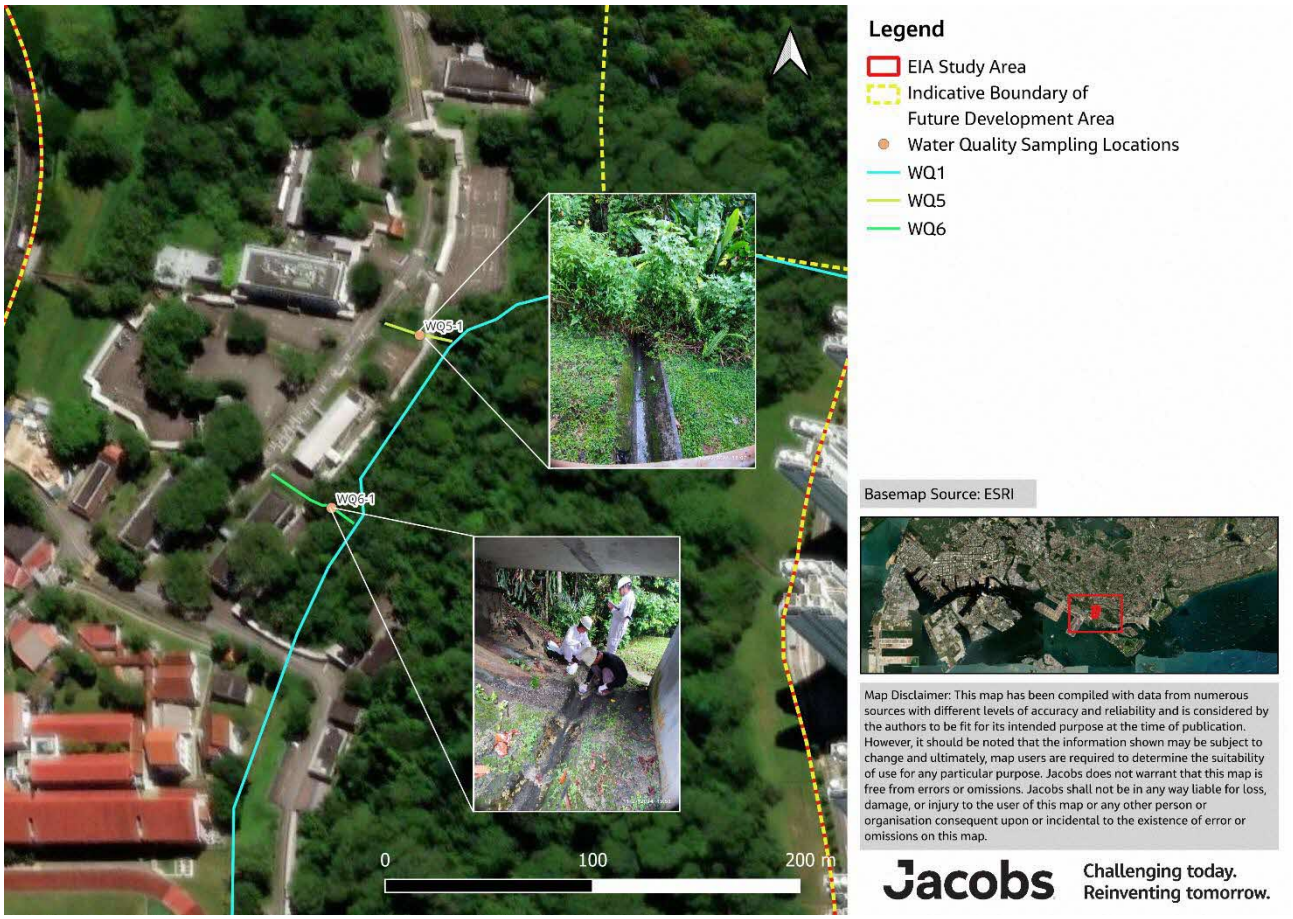


Figure 6-10: Water Quality Sampling in Stream WQ5 & WQ6

6.3.4.4 Evaluation of Results against Soil and Groundwater Quality

Surface water quality is closely linked to soil and groundwater quality as any water pollution from runoff, construction activities, or wastewater discharge can contaminate soil, and subsequently groundwater, with harmful chemicals and heavy metals.

Dutch Intervention Values (DIV) are environmental standards used to estimate the extent of remediation required from soil or groundwater contamination. The values are part of the Dutch Soil Protection Act and is published in documents such as the Soil Remediation Circular 2013. The DIV describes target values and intervention values for both soil (mg/kg dry matter), and groundwater (µg/l in solution). Target values for groundwater are also provided for both shallow and deep groundwater. The surface water quality results obtained from the baseline conducted for this EIA have been evaluated against the DIV for shallow groundwater. While the DIV are not directly intended for surface water assessments, they are used here as a conservative benchmark to provide a preliminary indication of potential environmental concern. Evaluation against soil quality standards (typically expressed in mg/kg) is not appropriate in this context, as those values are based on solid-phase concentrations and are not directly comparable to the dissolved concentrations measured in surface water (expressed in mg/L or µg/L). Therefore, groundwater target values (which are also expressed in mg/L) provide a more suitable reference point for preliminary assessment, while acknowledging the limitations of this comparison due to the differing environmental and regulatory contexts of surface water and groundwater.

Table 6-5 gives the target values and intervention values for groundwater for the metals evaluated in this EIA. Comparing the concentration of corresponding metals (**Appendix 6D**) analysed for the EIA against the DIV, the results indicate that surface water quality in the EIA Study Area did not exceed groundwater thresholds, suggesting no adverse impact to groundwater or soil quality.

Table 6-5: Target Values and Soil Remediation Intervention Values in Groundwater for Metals

Parameter	Groundwater (mg/l in solution)		
	Target Value (shallow)	Target Value (deep)	Intervention Value
Arsenic	0.01	0.0072	0.06
Barium	0.04	0.2	0.625
Cadmium	0.0004	0.00006	0.006
Chromium	0.001	0.0025	0.03
Cobalt	0.02	0.0007	0.1
Copper	0.015	0.0013	0.075
Mercury	0.00005	0.00001	0.0003
Lead	0.015	0.0017	0.075
Nickel	0.015	0.0021	0.075
Zinc	0.065	0.024	0.8

6.4 Impact Assessment

6.4.1 Evaluation of Hydrology Impact

Alteration of drainage patterns with temporary diversion, excavation and site grading has the potential to change surface runoff flow direction and concentration of runoff may cause erosion or affect downstream watercourses. Given that no major drainage diversion flow is planned for the proposed development, the impact on surface runoff flow direction will not be assessed for this EIA.

Key construction activities within the indicative boundary of future development area, such as land clearing and removal of vegetation are expected to reduce the infiltration and increase impervious surfaces, eventually may cause higher peak runoff, particular during rainfall events, which can lead to localised flooding if drainage capacity is inadequate.

6.4.1.1 Determination of Post-Development Peak Flows

As indicated in **Section 6.2.1** and **Section 6.3.3.3**, simplified hydrological calculation using the rational method, as outlined in PUB's COPSWD, was applied to predict the pre-development peak flows (Qpre) and post-development peak flows for a 10-year ARI ($^{10}Q_{tc}$) across the three sub-catchments. **Table 6-6** shows the summary of the calculation. The full calculation is given in **Appendix 6B**. The catchment delineation with its total area size, future land use characteristic and location of peak flow outlet are illustrated in **Figure 6-11**.

Table 6-6: Summary of Calculated Pre-Development and Post-Development Runoff Peak Flow

Sub-Catchment	Catchment Area Size (ha)	Discharge Outlet ID	Pre-Development		Post-Development	
			Peak Flow (Qpre) $^{10}Q_{tc}$ (m3/s)	Weighted Runoff Coefficient Applied (C_{avg})	Peak Flow (Qpost) $^{10}Q_{tc}$ (m3/s)	Weighted Runoff Coefficient Applied (C_{avg})
Area 1	42.4	E1/P1	9.5	0.60	14.1	0.75
Area 2	2.9	E2/P2	1.0	0.60	1.5	0.85
Area 3	2.0	E3/P2	0.5	0.45	0.6	0.50

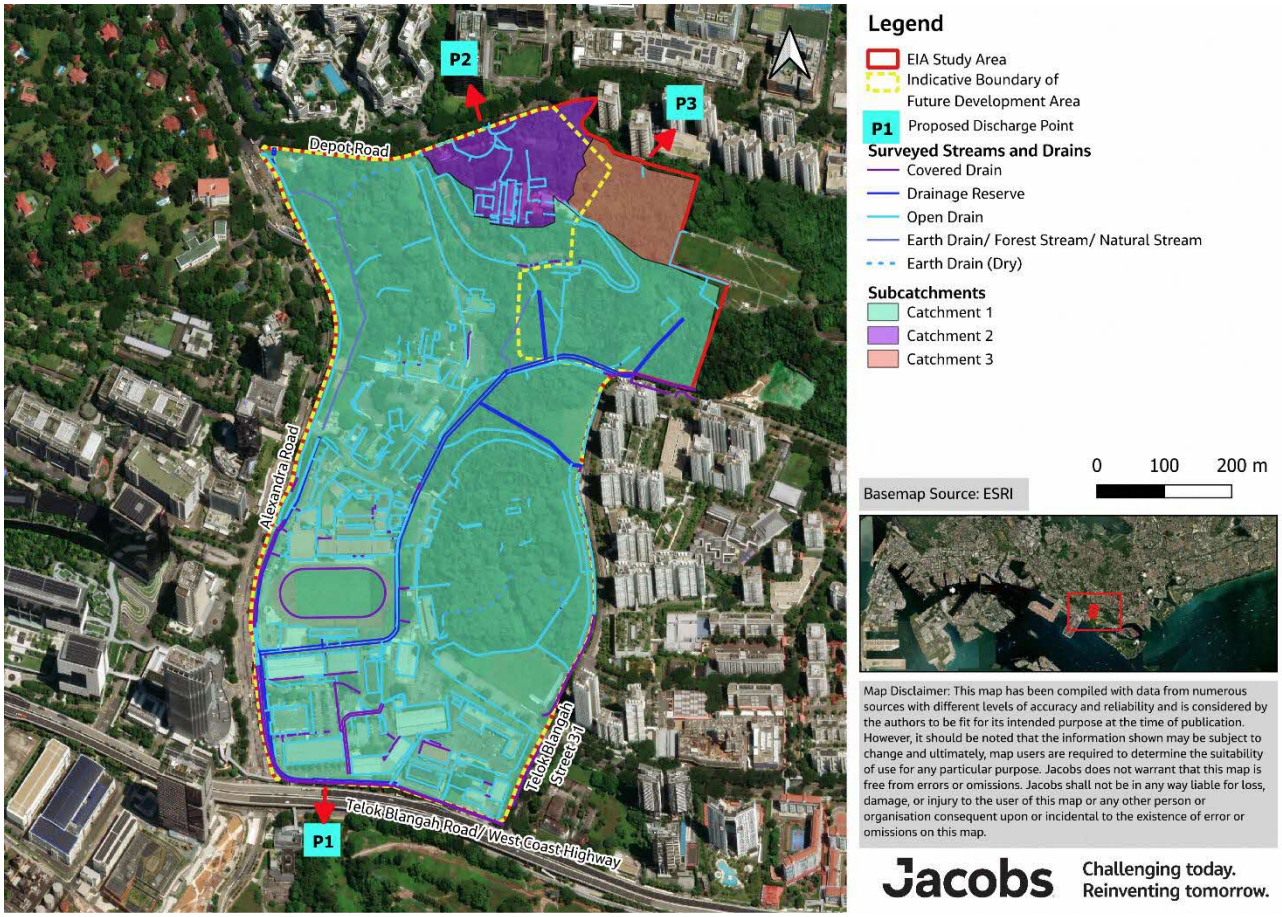


Figure 6-11: Post-Development Peak Flow Catchment Area and Discharge Outlet

6.4.1.2 Evaluation of Impact Significance for Runoff Peak Flow Changes

Table 6-7 presents the changes in runoff peak flow between pre-development and post-development conditions for each sub-catchment. Among them, Sub-catchment P2 exhibits the highest increase in peak flow, followed by sub-catchments P1 and P3.

Table 6-7: Summary of Changes of Runoff Peak Flows between Pre-Development and Post-Development

Sub-Catchment	Catchment Area Size (ha)	Discharge Outlet ID	Pre-Development Peak Flow (Qpre) $^{10}Q_{tc}$ (m3/s)	Post-Development Peak Flow (Qpost) $^{10}Q_{tc}$ (m3/s)	Percentage Increased Qpost vs Qpre
Area 1	42.4	E1/P1	9.5	14.1	48%
Area 2	2.9	E2/P2	1.0	1.5	50%
Area 3	2.0	E3/P2	0.5	0.6	20%

Based on the future drainage plan for the proposed development, the majority of surface runoff will be directed to outlet of sub-catchment P1, which conveys flows downstream to Berlayar Creek, a sensitive mangrove ecosystem. High-velocity flows can erode stream banks and transport large amounts of sediment downstream; this may significantly impact the Proposed Retained Area (PRA) downstream and cumulatively impact the mangrove ecosystem further downstream. Excess sediment can smother tree/mangrove roots, reduce oxygen exchange, and impair seedling establishment. Large volumes of freshwater during storm events can dilute salinity of the mangrove and cause stress to sensitive mangrove species. In addition, strong flows may potentially uproot seedlings and damage root structures leading to long-term habitat degradation.

Evaluation of the significance of changes in runoff peak flows under unmitigated conditions is given in **Table 6-8**, with the magnitude changes (A2.2) defined below. The full RIAM for peak flow changes is given in **Appendix 6F**.

- Rating "zero": no change/ status quo for incremental flows compared with *in-situ* (existing condition).
- Rating 1: Low impact for less than 5% incremental flows.
- Rating 2: Medium impact for more than 5% but less than 20% incremental flows.
- Rating 3: High impact for more than 20% incremental flows.

Table 6-8: Impact Significance for Runoff Peak Flow Changes of the Proposed Development

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	3: National/ Regional	The value of the drainage system is rated as National/ Regional as the largest sub-catchment flows towards downstream into Berlayar Creek, beyond the EIA Study Area.
A2.1: Impact Nature	-1: Negative	High peak flows can significantly impact the PRA and mangrove ecosystems downstream, especially sensitive areas like Berlayar Creek.
A2.2: Magnitude of Changes	3: High	Based on the calculated changes in runoff peak flow, the largest catchment outlet, P1, is expected to experience an incremental flow increase of more than 20%, particularly during storm events. The magnitude of changes is evaluated as High.

Assessment Criterion	Score Rating	Rating Justification/ Definition
A2.3: Impact Extent	3: Impact extends beyond EIA Study Area	Impact may eventually lead to sedimentation, water quality changes and physical damages in downstream areas beyond the EIA Study Area under unmitigated conditions.
B1: Permanence	4: Long-term	Drainage planning and development activities are considered long-term impacts due to the permanent alteration of the drainage system.
B2: Impact Pathway	3: Direct	Change in runoff peak flows has a direct impact on sedimentation, localised ponding/ flooding and physical damages to waterbodies and ecosystem downstream.
B3: Reversibility	3: Irreversible	The change in runoff peak flows is permanent to accommodate the new land use, with flow rates and drainage capacity adjusted to suit the altered conditions.
B4: Cumulative	3: Cumulative	The impact of change in runoff peak flow is evaluated as cumulative impact with multiple development parcellation increases the impervious surface runoff, the combined effect can significantly alter hydrology, exceed the drainage capacity and affect downstream ecosystem.
Environmental Score (ES)	(-27) x (13) = -351	
Range Bands ES/ Impact Significance	Major Negative	

6.4.2 Evaluation of Water Quality Impact

6.4.2.1 Potential Impact on Water Quality

Construction activities have the potential to adversely affect water quality. These activities may generate wastewater containing silt, sediments, chemicals, and other contaminants, which can enter adjacent waterways and result in water pollution. These pollutants could potentially migrate into sensitive water receptors, such as Berlayar Creek and Labrador Nature Reserve, which have therefore been considered as part of the local environmental context. Potential sources of impact include:

- Surface runoff from exposed soil and stockpiles during vegetation clearance and earthworks.
- Sediment-laden water from excavation and pilling works.
- Accidental spillage of chemicals, fuels or lubricant used by construction machineries and tools.
- Discharge of trade effluent from the construction activities.
- Sewage discharge from sanitary facility at construction site.

Impacts on water quality of the streams resulting from discharges related to the proposed development have been assessed with reference to the EPM (Trade Effluent) Regulations. The assessment is based on available information regarding the construction phase activities. The identified potential sources of impacts include:

- Exposed areas of ground from earthworks and foundation activities with associated works such as site preparation, securing or formation of road access, vegetation clearance, temporary storage areas,

excavation, and piling works and from civil and structural works activities such as stockpiling and backfilling works.

- Land preparation for road access, earthworks and foundation works involved excavations and removal of surface vegetation and topsoil can lead to soil erosion, releasing high level of organic matters into adjacent watercourses during the wet season. Increased surface runoff with high suspended solids loading may also occur.
- Demolition of existing structures may cause water pollution due to accidental entry or spillage of waste materials into adjacent watercourses. Water spraying for dust suppression can generate surface runoff containing suspended solids and greases.
- Storage and use of diesel, hydraulic oil and chemicals at temporary storage and equipment maintenance areas pose risks of spillage. Stormwater runoff from laydown areas, if discharged untreated into nearby watercourses, can cause contamination.
- Construction activities near streams may result in sedimentation due to loss/ disturbance of topsoil.
- Washing trucks after concrete delivery produces wastewater with high pH, TSS, and COD if discharged over exposed ground.
- Washing wheels and undercarriages before leaving the site generates water containing suspended solids and possibly oils and grease.
- Due to site remoteness or inaccessibility, sewage may affect water quality by increasing *Escherichia coli* and BOD.

The qualitative assessment of potential water quality impact using the RIAM considers the construction activities of the proposed development and the applicable legislations, regulations and requirements mentioned in **Section 6.1** with key regulatory considerations listed in **Appendix 1A**. Impacts that are cumulative, unavoidable, or irreversible are also identified. The potential water quality impacts identified are also assessed to determine the significance of these impacts. The full RIAM can be found in **Appendix 6G**.

6.4.2.2 Impact Magnitude Definition

Criterion A2 of the assessment criteria for impact significance following the RIAM method (see **Section 3.3**) is a measure of the magnitude/ scale of the changes and whether the nature of impact is beneficial or dis-beneficial. Criterion A2.2 in particular assesses whether the magnitude of changes contributing to environmental deterioration attributed to the proposed works is high (3), medium (2), low (1), or negligible/ no change (0). The impact magnitude definition for water quality is outlined in **Table 6-9**.

Table 6-9: Impact Magnitude Definition for Water Quality

Criterion A2.2	Magnitude of Changes
3: High	A significant level of proposed activities contributing to environmental deterioration.
2: Medium	A moderate level of proposed activities contributing to environmental deterioration.
1: Low	A relatively minor level of proposed activities contributing to environmental deterioration.
0: Negligible	A negligible level of proposed activities contributing to environmental deterioration.

6.4.2.3 Impact Evaluation

6.4.2.3.1 Degradation of Water Quality due to Surface Runoff from Construction Activities

During site clearance, demolition, and construction of new roads and ramps, removal of vegetation and disturbance of topsoil can result in sedimentation. This may lead to increased silt and suspended solids entering nearby streams and drains, potentially affecting flow conditions. Sediment build-up can reduce the capacity of surface drainage systems and increase the risk of localised flooding, while also negatively impacting water quality.

Sediment introduced into waterways from construction activities via surface runoff can lead to water pollution and degrade the quality of receiving watercourses. Surface runoff may occur during rainfall events in areas with exposed earth, disturbed soils, and unprotected soil stockpiles.

Consequently, construction phase activities may result in increased loading of sediments and other pollutants into the receiving watercourses within the EIA Study Area.

Table 6-10: Impact Assessment for Surface Runoff During Construction Phase

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	3: National/ Regional	The Value is rated as National/ Regional as the largest sub-catchment of the EIA Study Area discharges south and flows into Berlayar Creek and Labrador Nature Reserve.
A2.1: Impact Nature	-1: Negative	Increased sedimentation due to surface runoff from construction activities is expected to have a negative impact.
A2.2: Magnitude of Changes	3: High	The construction activities are anticipated to generate surface runoff and sedimentation which may alter water quality parameters if released into the watercourse.
A2.3: Impact Extent	3: Impact extends beyond EIA Study Area	Impact can extend outside the EIA Study Area.
B1: Permanence	3: Medium-term	Impact will occur during the construction phase and will last between 3 and 15 years.
B2: Impact Pathway	3: Direct	Soil erosion and surface runoff have a direct impact on the water quality.
B3: Reversibility	2: Reversible	The water quality impact due to surface runoff is reversible when construction activities are completed. The impacted surface water may revert to the current conditions by natural water flow and surface water dilution.
B4: Cumulative	3: Cumulative	Presence of existing brownfield uses, active construction sites, as well as future developments located within the vicinity of Gillman Barracks (**see Section 2.5**), can cumulatively generate soil-driven runoffs to the same receiving watercourse.
Environmental Score (ES)	**(-27) x 11 = -297**	
Range Bands ES/ Impact Significance	**Moderate Negative**	

6.4.2.3.2 Degradation of Water Quality due to Accidental Spillage of Diesel, Oil, and other Pollutive Substances

Construction phase activities are expected to involve onsite storage and handling of diesel for drilling machines, lubrication oil for equipment maintenance, and polymer for bored piling works. If these substances are not properly stored or handled, such as in cases of accidental spills, poor handling practices, leaks, or inadequate safeguards, they could enter surrounding water streams either directly or indirectly. This may cause adverse impacts on the receiving watercourses and potentially harm existing aquatic species.

Diesel, lubrication oil, and bentonite or polymers, if discharged into watercourses, can significantly alter water quality parameters such as pH, COD, and dissolved oxygen (DO). Diesel, while biodegradable by naturally occurring microbes, requires time for complete degradation. Bentonite, when dispersed in water, swells and forms a gel-like substance; however, it can be effectively removed using appropriate clean-up methods.

Table 6-11: Impact Assessment for Accidental Spillage of Diesel, Oil, and other Pollutive Substances During Construction Phase

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	3: National/ Regional	The Value is rated as National/ Regional as the largest sub-catchment of the EIA Study Area discharges south and flows into Berlayar Creek and Labrador Nature Reserve.
A2.1: Impact Nature	-1: Negative	Water quality is expected to degrade due to diesel and other pollutive substances spill from construction activities.
A2.2: Magnitude of Changes	2: Medium	Construction works will require the storage and use of substances that, if released into watercourses, may alter water quality parameters. However, any potential spillage is anticipated to occur at moderate levels.
A2.3: Impact Extent	3: Impact extends beyond EIA Study Area	Impact can extend outside the EIA Study Area where watercourses are located.
B1: Permanence	3: Medium-term	Impact will occur across the construction activities and will persist for a period of 3 to 15 years.
B2: Impact Pathway	3: Direct	Pollutive substances spill is a direct impact on the water quality.
B3: Reversibility	2: Reversible	Water quality impacts resulting from diesel and other pollutive substances are considered reversible once earthworks and construction activities cease. Impacted surface water can gradually return to its natural condition through natural recovery processes or with the application of appropriate remediation measures and clean-up systems.
B4: Cumulative	3: Cumulative	Presence of active construction sites as well as future development located within the vicinity of the EIA Study Area with interconnecting watercourses and pollutive substances spill.
Environmental Score (ES)	**(-18) x 11 = -198**	
Range Bands ES/ Impact Significance	**Moderate Negative**	

6.4.2.3.3 Degradation of Water Quality due to Trade Effluent Discharge

The proposed development is anticipated to generate trade effluent from activities such as piling and concreting works. This trade effluent may include wastewater streams such as bentonite or polymer slurry, concrete washout, excess grouting materials, and wheel wash water. Such process wastewater is typically highly alkaline (with a pH of approximately 12), contains fine suspended particles, and may also include contaminants such as heavy metals, oil and grease.

The discharge of untreated trade effluent into watercourses, whether directly or indirectly, can significantly degrade the quality of the receiving waterbody. Such discharges may lead to elevated levels of pH, COD, TSS, turbidity, and metals, thereby adversely impacting water quality.

Trade effluent must not be discharged into any receiving watercourse without prior treatment and must be managed separately from surface runoff before discharge. Given the indicative boundary of future development area's proximity to Berlayar Creek and Labrador Nature Reserve, even treated trade effluent cannot be discharged without proper authorisation. The source of these impacts is expected to be medium-term, reversible, and limited to the duration of construction activities. Additionally, trade effluent from other nearby construction sites may have a cumulative effect if discharges enter the same watercourse network.

Table 6-12: Impact Assessment of Trade Effluent Discharge During Construction Phase

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	3: National/ Regional	The Value is rated as National as the largest catchment subarea of the EIA Study Area discharges south and flows into Berlayar Creek and Labrador Nature Reserve.
A2.1: Impact Nature	-1: Negative	Trade effluent discharge from Construction Activities is expected to have a negative impact on water quality.
A2.2: Magnitude of Changes	2: Medium	Construction Activities are anticipated to generate trade effluent which may moderately alter water quality parameters if released into receiving watercourses.
A2.3: Impact Extent	3: Impact extends beyond EIA Study Area	Impact can extend outside the EIA Study Area where watercourses are located.
B1: Permanence	3: Medium-term	Impact will occur across the construction activities and will persist for a period of 3 to 15 years.
B2: Impact Pathway	3: Direct	Trade effluent discharge has a direct impact on water quality.
B3: Reversibility	2: Reversible	Water quality impacts resulting from trade effluent discharge are considered reversible upon completion of construction activities. Impacted surface water can gradually return to baseline conditions through natural water flow and dilution processes.
B4: Cumulative	3: Cumulative	Presence of active construction sites and future development located within the vicinity of the proposed development, can cumulatively generate trade effluent discharge into the same receiving watercourse.
Environmental Score (ES)	**(-18) x 11 = -198**	
Range Bands ES/ Impact Significance	**Moderate Negative**	

6.4.2.3.4 Sewage from Construction Phase

Sewage is considered biohazardous as it may contain bacteria and pathogens that pose environmental and public health risks if released into the environment. Given that the construction site is located near natural open streams and connected to the water canal system, there is a potential risk of water contamination. Nevertheless, sewage can generally be well-managed on construction sites by adhering to the COP, including the provision of proper toilets equipped with sewage disposal and management systems. While the anticipated high volume of sewage and associated contamination risks are notable, the implementation of appropriate management measures would reduce the overall impact to a moderate level of significance.

Table 6-13: Impact Assessment of Sewage During Construction Phase

Assessment Criterion	Score Rating	Rating Justification/ Definition
A1: Value	3: National	The environmentally sensitive receiver includes waterbodies connected to the national network of water channels.
A2.1: Impact Nature	-1: Negative	Water quality is expected to degrade due to sewage from construction works.
A2.2: Magnitude of Changes	2: Medium	While a high volume is expected to be produced, only a medium magnitude is expected from leakage/ insufficient capacity.
A2.3: Impact Extent	3: Impact extends beyond EIA Study Area	Impact can extend outside the EIA Study Area where watercourses are located due to water movement.
B1: Permanence	3: Medium-term	Impact will occur across the construction activities and will persist for a period of 3 to 15 years.
B2: Impact Pathway	3: Direct	There is a direct impact on the water and soil quality.
B3: Reversibility	2: Reversible	The water quality impacts are reversible when construction activities stop. The impacted surface water may be reversed as the natural condition by surface water clean-up. The appropriate system of remediation might be applied.
B4: Cumulative	3: Cumulative	Presence of active construction sites as well as future development located within the vicinity of the proposed development with interconnecting watercourses can lead to cumulative impacts.
Environmental Score (ES)	**(-18) x 11 = -198**	
Range Bands ES/ Impact Significance	**Moderate Negative**	

6.5 Minimum Control Measures

This section outlines surface water-specific minimum controls commonly implemented in Singapore for similar construction activities. These controls form the basis for developing, implementing, and monitoring ECM at construction sites, as required under Regulation 4 of the Sewerage and Drainage (Surface Water Drainage) Regulations. They also align with the COP for ECO issued by NEA, the COP on Surface Water Drainage issued by PUB, as well as the Guidebook on Erosion and Sediment Control at Construction Sites and the Guidebook for QECP.

These measures are assumed to be implemented by future developer/ developing agency as embedded measures or minimum control measures, in accordance with applicable regulations and COPs (**Table 6-14**).

Table 6-14: Minimum Control Measures for Surface Water Pollution Implemented at Construction Phase

Impact	Minimum Controls Adhered to Applicable Regulations and COP
Sedimentation/ Soil Erosion	▪ Before work commences, submit a detailed ECM proposal duly endorsed by a QECP to PUB and copied to future developer/developing agency indicating: - Plans to minimise exposed surfaces. - Implementation of effective sediment control facilities (including storage and treatment facilities). - ECM systems that shall be put in place prior to the commencement of physical works. • A PUB's approval that is obtained prior to the commencement of physical works. - Revisions or updates to the ECM systems during construction to control silty discharge, where necessary. - ECM shall not be removed prior to the completion of physical works. Relevant approvals from PUB shall be obtained for removal of ECM upon the completion of physical works. - Condition of ECM shall be inspected regularly and during/ after every rain event. - QECP shall carry out regular audit/reviews for every stage of the construction works and revise the ECM on-site accordingly. ▪ Earth surfaces or slopes adjacent to any drain shall be close turfed, paved or covered with appropriate materials. ▪ Bare surfaces shall be covered up with appropriate materials before rain and daily works should be halted to reduce the volume of silty water to be contained and treated. ▪ The treatment of silty water shall be closely monitored, and the treatment shall be halted immediately if silty water is being discharged to the public drain.
Water Pollution/ Trade Effluent Discharge	▪ Discharge from the site into public drains shall not contain TSS in concentrations greater than the prescribed legal limits for an uncontrolled watercourse, i.e., 50 mg/L. ▪ All wastewater generated at the site must be properly treated and disposed of. No discharge of untreated wastewater into public drains or land is allowed. ▪ Oil and chemicals in drums, carboys, containers, etc. shall be stored in a designated storage area within a building or covered shed with concrete floors and facilities to contain any accidental leak or spillage. ▪ Waste oil and chemicals generated from site activities, as well as all leaks and spillage, shall only be sent to a licensed toxic industrial waste collector for proper disposal. ▪ Bunds of stockpiled materials such as earth from trench work shall not be longer than 10 m. Gaps of at least 1 m width shall be provided between the bunds to allow the free flow of surface runoff. ▪ Material from any stockpile shall not be allowed to fall or be washed into the drain. Adequate preventive measures, including the provision of proper and stable barricades or screens where necessary, should be provided. ▪ All used water discharged from temporary toilets, sanitary appliances and washing facilities at the site must be collected and disposed of via temporary sanitary facilities. The design shall be in accordance with the General Requirements for temporary sanitary facilities for Construction Site and obtain NEA's Clearance Certificate on Environmental Health.

6.6 Recommendation of Preventive and Mitigation Measures

6.6.1 Recommended Measures to Reduce Change in Runoff Peak Flow

The objective of these mitigation measures is to minimise the increase in runoff peak flows resulting from the proposed development, thereby reducing the risk of localised flooding and protecting sensitive downstream ecosystems such as Berlayar Creek mangroves.

(a) Drainage system optimisation

Based on the high-level Rational Method calculation and the existing drain profile within the EIA Study Area, as referenced in COPSWD, and assuming all drains have a design depth of 2 m, engineering solutions such as widening the drainage system appear feasible to accommodate the excess volume of approximately 4,724 m^3. It is recommended that the proposed drainage system be designed to increase its storage capacity to accommodate this excess volume to allow zero or minimal increase in runoff peak flows compared to pre-development levels or within the acceptable allowable limit imposed by PUB.

Given the information available at this EIA stage, it is recommended that a detailed dynamic hydraulic assessment be conducted during the detailed design phase to confirm the required additional storage requirement, identify feasible engineering solutions in alignment with land use planning and PUB's requirement as well as to establish an appropriate flow control strategy.

(b) Green infrastructure

The implementation of green roofs and the use of permeable materials for walkways and car parks are recommended to enhance infiltration and reduce surface runoff. Additionally, incorporating vegetated swales along roads and open spaces is advised to slow down stormwater flow and improve filtration.

(c) Construction phase control

During the construction phase, staged land clearing and controlled ground disturbance are recommended to minimise large-scale exposure of impervious surfaces at any given time. This approach helps reduce peak runoff, erosion and sediment transport risks.

6.6.2 Recommended Mitigation Measures to Reduce Impacts on Water Quality

The following recommended mitigation measures for each potential impact on water quality are assumed to be additional mitigation measures apart from applicable embedded control measures in the COPs outlined in **Section 6.5** that need to be adhered to prior to applying these additional measures.

(a) Mitigation measures recommended to control sediment-laden runoff:

- Construction works such as ground preparation, vegetation clearing, topsoil removal, excavation and concreting should be carried out in a phased manner to minimise the extent of disturbed areas at any given time. This approach reduces erosion potential and mitigates sediment-laden runoff into adjacent watercourses.
- Install hoarding along the site boundary with silt fences embedded at the base to create a fully enclosed construction area, effectively containing any silty runoff from construction activities.
- Place sandbags along the edges of existing earth drains to prevent soil and silt from entering the drainage system.
- Cover all exposed soil surfaces with fully biodegradable earth control blankets (ECB) or other approved erosion control methods.

- Cover cleared vegetation, especially on sloped areas, with fully biodegradable ECB to prevent erosion of exposed soil. Re-vegetate exposed ground promptly to stabilise surfaces and minimise soil erosion into watercourses.

(b) Mitigation measures recommended to control accidental leaks or spills:

- Provide spill containment at all discharge points.
- Develop and implement a spill response plan to address accidental discharges into any watercourse. The plan shall be clearly communicated to all on-site personnel, and comprehensive training on spill response procedures shall be provided to all staff.
- Regularly maintain all spill containment facilities and spill trays to ensure they remain effective and prevent rainwater from washing out pollutive substances.
- Clean spills within the same day or immediately under wet weather conditions.
- Compile Safety Data Sheets (SDS) for all hazardous materials used or stored on site, and maintain them on site in a central, accessible location for viewing by all personnel at site.
- Provide spill management kits at all worksites, tailored to the types of hazardous materials in use. Kits shall include, but not be limited to, absorbent rags, sand, eyewash solution, protective gloves, and other appropriate items. Position these kits at locations where hazardous materials, equipment, and machinery are stored or operated.
- Store all hazardous materials in bunded and covered areas, strictly following the manufacturer's safety requirements. On-site storage shall be limited to the minimum quantities necessary to reduce the risk of spillage and mitigate potential containment failures.

(c) Mitigation measures recommended to control trade effluent discharge:

- Divert wheel wash wastewater into ECM facilities for reuse as wheel washing.
- Provide designated concrete washout containers and position them well away from any streams or watercourses.
- Collect all washout water for off-site disposal through licensed waste treatment contractors.

(d) Mitigation measures recommended to control sewage discharge:

- Provide temporary sanitary facilities for on-site workers throughout the construction phase.
- Conduct training and awareness sessions to emphasise the importance of using portable sanitary facilities to maintain hygiene and prevent environmental contamination.
- Conduct regular clearance of domestic waste from temporary sanitary facilities. Position these facilities in locations accessible to NEA-licensed portable toilet service providers for scheduled servicing, including sewage collection and disposal.

6.7 Residual Impact

The significances of residual impacts from impacts to hydrology and water quality are summarised in **Table 6-15**. The significance of residual impacts is assessed under the assumption that all embedded control measures and recommended mitigation measures are fully implemented.

Table 6-15: Evaluation of Residual Impact Significance for Hydrology and Water Quality Impact

Impact Register	Before Mitigation Measures		Post-Mitigation Measures	
	Environmental Score (ES)	Range Bands of ES	Environmental Score (ES)	Range Bands of ES
Change in Runoff Peak Flow	-351	Major Negative	-78	Minor Negative
Degradation of water quality from surface runoff	-297	Moderate Negative	-66	Minor Negative
Degradation of water quality from diesel, oil, and other pollutive substances	-198	Moderate Negative	-33	Slight Negative
Degradation of water quality from trade effluent discharge	-198	Moderate Negative	-33	Slight Negative
Sewage from construction phase	-198	Moderate Negative	-33	Slight Negative

7. Ambient Noise

This section describes the regulations and standards for noise pollution control that are applicable to the proposed development during construction activities, discusses the baseline ambient noise data obtained and assesses the potential noise impacts associated with the construction activities of the proposed development to the Noise Sensitive Receivers (NSR).

7.1 Applicable Legislation and Standards

7.1.1 Noise Assessment Criteria for Human Noise Sensitive Receivers (NSR)

In Singapore, construction sites are required to adhere to the permissible noise limits established by the National Environment Agency (NEA) under the Environmental Protection and Management (Control of Noise at Construction Sites) Regulations. These regulations specify maximum permissible noise levels, which vary depending on the time of day and proximity to human noise sensitive premises such as residential buildings, hospitals and schools (**Table 7-1**).

Table 7-1: Maximum Permissible Noise Levels

Period	Types of Affected Buildings	Maximum Permissible Noise Levels in A-weighted decibels (dBA)		
		7 a.m. – 7 p.m.	7 p.m. – 10 p.m.	10 p.m. – 7 a.m.
Monday to Saturday	(a) Hospitals, schools, institutions of higher learning, homes for the sick aged etc.	60 (L_{Aeq} 12 hour)	50 (L_{Aeq} 12 hour)	
		75 (L_{Aeq} 5 mins)	55 (L_{Aeq} 5 mins)	
	(b) Residential buildings located less than 150 m from the construction site	75 (L_{Aeq} 12 hour)	65 (L_{Aeq} 12 hour)	55 (L_{Aeq} 12 hour)
		90 (L_{Aeq} 5 mins)	70 (L_{Aeq} 5 mins)	55 (L_{Aeq} 5 mins)
	(c) Buildings other than those in (a) and (b) above	75 (L_{Aeq} 12 hour)	65 (L_{Aeq} 12 hour)	
		90 (L_{Aeq} 5 mins)	70 (L_{Aeq} 5 mins)	
Sunday and Public Holidays	(a) Hospitals, schools, institutions of higher learning, homes for the aged, sick etc.	60 (L_{Aeq} 12 hour)	50 (L_{Aeq} 12 hour)	
		75 (L_{Aeq} 5 mins)	55 (L_{Aeq} 5 mins)	
	b) Residential buildings located less than 150 m from the construction site	75 (L_{Aeq} 12 hour)	-*	
		75 (L_{Aeq} 5 mins)	55 (L_{Aeq} 5 mins)	
	(c) Buildings other than those in (a) and (b) above	75 (L_{Aeq} 12 hour)	65 (L_{Aeq} 12 hour)	

7.1.2 Noise Assessment Criteria for Fauna Noise Sensitive Receivers (NSR)

There is currently no specific legislation, standard or widely accepted guidelines in Singapore and internationally that prescribes the noise levels or threshold limit for fauna. Humans and faunas have different hearing abilities and acoustic behaviours, and it is not appropriate to directly extrapolate from human standards to fauna. For instance, the range of frequencies that fauna can hear differ greatly from humans and amongst themselves. Humans have a hearing range of approximately 64 to 23,000 hertz (Hz) while dogs can hear between 67 and 45,000 Hz, owls between 200 and 12,000 Hz and bats between 2,000 and 110,000 Hz. Fauna also has different sound sensitivities, with some able to hear very low or very high frequencies once crossing a certain threshold of sound intensity (Strain, 2017).

It has been recognised that amongst and within different fauna taxon, there is substantial variation of auditory capabilities and behaviours which translate to a wide range of physiological and behavioural reactions to sound that current literature has limited coverage over. Fauna that relies on vocal communication for a range of functions such as mating courtship, prey location, threat detection and navigation are more severely affected by noise pollution. There are a few known fauna exceptions where current research point towards a greater tolerance to noise due to lower hearing capabilities such as odonates (Robert, 2005) and snakes (Christensen et al., 2012) who depend on other sensory faculties. It is also noted for bats that acoustic interference with the bat calls based on frequencies rather than the specific noise levels have a larger impact on their response to noise pollution (Bunkley et al., 2015).

In general, the main impacts which are noted in most research are avoidance, behavioural changes, psychological impacts, auditory damage and masking of auditory signals. A brief summary of selected laboratory and field research which broadly investigate road and construction noise is shown on **Table 7-2** to highlight the broad range of noise levels and their impacts on different taxon.

Table 7-2: Summary of Noise Levels and Impacts on Fauna Biological Responses

Taxon	Noise level	Biological Responses
Non-volant Mammals	≥ 43 dBA[(1)]	▪ Behavioural and psychological responses of fear such as vocalisations and movement away from noise
	≥ 52 dBA[(2)]	▪ Increase in physiological stress ▪ Decreased reproductive efficiency
Bats	≥ 80 dBA[(1)]	▪ Reduced the foraging efficiency
Birds	≥ 45 dBA[(3)]	▪ Changes in song frequency and length
	≥ 48 – 55 dBA[(3)]	▪ Decline in occupancy and abundance
	≥ 52 dBA[(2)]	▪ Increase in physiological stress levels
	≥ 68 dBA[(2)]	▪ Reduced breeding success
	≥ 50 – 60 dBA[(2)]	▪ Changes in community and species interactions
Amphibians (frogs)	60 dBA[(4)]	▪ Increased minimum frequency of vocalisations
	72 dBA[(2)]	▪ Impact to vocal behaviour/ reduction in chorus tenure in male frogs
Reptiles	74 dBA[(1)]	▪ Freezing (fear or stress reactions) in lizards/ geckos
Invertebrates	81 dBA[(4)]	▪ Higher frequency components in courtship signal

Source: Shannon et al., 2016; Simmons & Narins, 2018

Note:

[(1)] Studies simply reported sound pressure level (SPL), while others in this category also reported the square root of the mean of the pressures squared (rms) in a given time interval.

[(2)] Studies calculated an acoustic metric (e.g. SPL, L_{eq}) in a given time interval over a specific duration and then calculated an average or median of these values.

[(3)] Equivalent continuous sound level (L_{eq} or L_{Aeq}).

[(4)] Studies reported 'dB' without any information on the specific metrics (SPL, SEL, etc.).

Table 7-2 shows that noise affects species and taxonomic groups very differently, with some impacts occurring even at low noise levels. Regarding these noise level sensitivities and conservation status, fauna found during the baseline study can be divided into three categories as described in **Table 7-3**. Fauna that are considered sensitive to sound include those which utilise auditory cues and communication for survival, while non-noise sensitive fauna tends to rely less, or not at all, on auditory means for survival. We take the reasonable assumption that fauna in the EIA Study Area have since adapted to current baseline ambient noise levels, using that as the threshold limit for fauna receiver assessment, even if these levels may differ from what literature suggests.

The EIA Study Area supports arboreal and avifaunal species that primarily utilise the upper vegetation strata. Although these receptors are typically located above the effective height of conventional ground-based noise barriers, a conservative approach has been adopted at the EIA stage whereby arboreal fauna have been explicitly in the preliminary construction noise impact assessment and in the formulation of mitigation measures, recognising that this group constitutes the predominant fauna assemblage within the EIA Study Area. Given their elevated habitat use, standard noise barriers may have limited effectiveness; however, arboreal and avifaunal species are generally more mobile than ground-dwelling fauna and are therefore better able to temporarily relocate away from noise sources during periods of active construction. As such, they are considered to have comparatively lower vulnerability to short-term construction noise impacts. Notwithstanding this, the height, extent, and placement of noise barriers and other relevant mitigation measures will be reviewed and, where appropriate, refined in consultation with relevant agencies such as NParks during the Environmental Management and Monitoring Plan (EMMP) stage, such that mitigation measures remain appropriate, practicable, and proportionate to site-specific conditions.

The full list of fauna recorded during the baseline study can be found in **Appendices F** and **G**.

Table 7-3: Noise-Sensitivity and Conservation Significance of Fauna on Site

Fauna	General Taxon	Fauna Identified from Baseline Survey
Fauna of conservation significance (i.e. threatened species) who are sensitive to noise	▪ Aculeate hymenopterans ▪ Birds ▪ Amphibians ▪ Reptiles (geckos/ lizards) ▪ Mammals	▪ Cinnamon Bittern ▪ Square-tailed drongo-cuckoo ▪ Changeable hawk-eagle ▪ Straw-headed bulbul ▪ Swinhoe's white-eye ▪ Long-tailed parakeet ▪ Yellow-crested cockatoo ▪ Yellow Bittern ▪ Large-billed crow ▪ Citron-crested cockatoo ▪ Unidentified Bamboo bat (*Tylonycteris sp.*)
Fauna of non-conservation significance (i.e. common species) who are sensitive to noise	▪ Aculeate hymenopterans ▪ Birds ▪ Amphibians ▪ Reptiles (geckos/ lizards) ▪ Mammals	▪ Four-lined tree frog ▪ Dark-sided chorus frog ▪ Sumatran palm civet ▪ Greater racket-tailed drongo ▪ White-throated kingfisher ▪ Crested honey-buzzard ▪ Scarlet-backed flowerpecker ▪ Common flameback ▪ Yellow-vented bulbul

Fauna	General Taxon	Fauna Identified from Baseline Survey
Fauna who have lower sensitivity to noise	▪ Odonates ▪ Reptiles (snakes)	▪ Variable wisp ▪ Oriental whip snake ▪ Painted bronzeback ▪ Spine-tufted skimmer ▪ Variable wisp ▪ Scarlet grenadier ▪ White-barred duskhawk

7.2 Existing Pre-Construction Conditions

7.2.1 Determination of Noise Sensitive Receivers (NSR)

Fauna NSR were identified based on the existing forested area within the indicative boundary of future development area or adjacent to it. Human NSR were identified according to the criteria in the EPM (Control of Noise at Construction Sites) Regulation as listed below:

- Hospitals, schools, institutions of higher learning, homes for the aged sick, etc.
- Residential buildings are located less than 150 m from the construction site where the noise is being emitted.
- Buildings other than the two categories mentioned above.

Based on the criteria discussed above, and desktop assessment (i.e., review of publicly available street directory and satellite map), site reconnaissance, and the assumption that existing buildings will be maintained and no new developments will be placed within the forested area, a preliminary list of NSRs within the EIA Study Area and its 150 m buffer that may be affected by the proposed development is listed in **Table 7-4**.

Table 7-4: Identified Noise Sensitive Receivers for Baseline Measurement

NSR Cluster	Location	Type of Receivers	Number of Storeys	Approximate Distance to the Indicative Boundary of Future Development Area
NSR Cluster 1	The Interlace	Residential	24	50 m (northwestern side)
NSR Cluster 2	ISS International School	School	3	Within Indicative Boundary of Future Development Area (northeastern side)
	Preston Road Colonial Houses	Residential	2	
NSR Cluster 3	Depot Heights HDB (Block 114)	Residential	25	130 m (northeastern side)
	Depot Heights HDB (Block 113)		25	
	Depot Heights HDB (Block 112B)		25	
	Depot Heights HDB (Block 112C)		25	
	Depot Heights HDB (Block 111A)		25	
NSR Cluster 4	Telok Blangah HDB Block 85	Residential	30	90 m (eastern side)
	Telok Blangah HDB Block 86		30	
	Telok Blangah HDB Block 87		30	

NSR Cluster	Location	Type of Receivers	Number of Storeys	Approximate Distance to the Indicative Boundary of Future Development Area
	Telok Blangah HDB Block 88		30	
	Telok Blangah HDB Block 90A		30	
	Telok Blangah HDB Block 90B		30	
	Telok Blangah HDB Block 91A		30	
	Telok Blangah HDB Block 92A		30	
	Telok Blangah HDB Block 92B		30	
	Telok Blangah HDB Block 93A		30	
	Telok Blangah HDB Block 93B		30	
NSR Cluster 5	Hokkien Yeo See Association	Commercial	3	40 m (southeastern side)
NSR Cluster 6	SP Jain School of Global Management	School	5	120 m (western side)
NSR Cluster 7	Forested area	Fauna	NA	40 m (northeastern side)
NSR Cluster 8	Forested area	Fauna	NA	Within Indicative Boundary of Future Development Area (northwestern side)
NSR Cluster 9	Forested area	Fauna	NA	125 m (eastern side)
NSR Cluster 10	Forested area	Fauna	NA	Within Indicative Boundary of Future Development Area (southeastern side)
NSR Cluster 11[1]	UOB Alexandra	Commercial	110	45 m (western side)
	Alexandra Point		25	55 m (western side)
	UE Bizhub West		12	40 m (western side)
	Fragrance Empire Building		26	50 m (western side)
	Alexandra Retail Centre		3	45 m (western side)
	mTower		42	45 m (western side)

*Note: 1) [1]NSR Cluster 11 – baseline ambient noise not monitored; 2) Distance between NSR cluster and indicative boundary of future development area was calculated from the noise measurement points and the indicative boundary of future development shown in **Figure 7-1**; and 3) Aside from the future residential uses with supporting facilities, no elevated structure such as highways are assumed to be constructed within the indicative boundary of future development area.*

7.2.2 Baseline Ambient Noise Measurements Location

Figure 7-1 shows the ten baseline ambient noise measurement locations, selected based on the methodology detailed in **Section 7.2.1**.

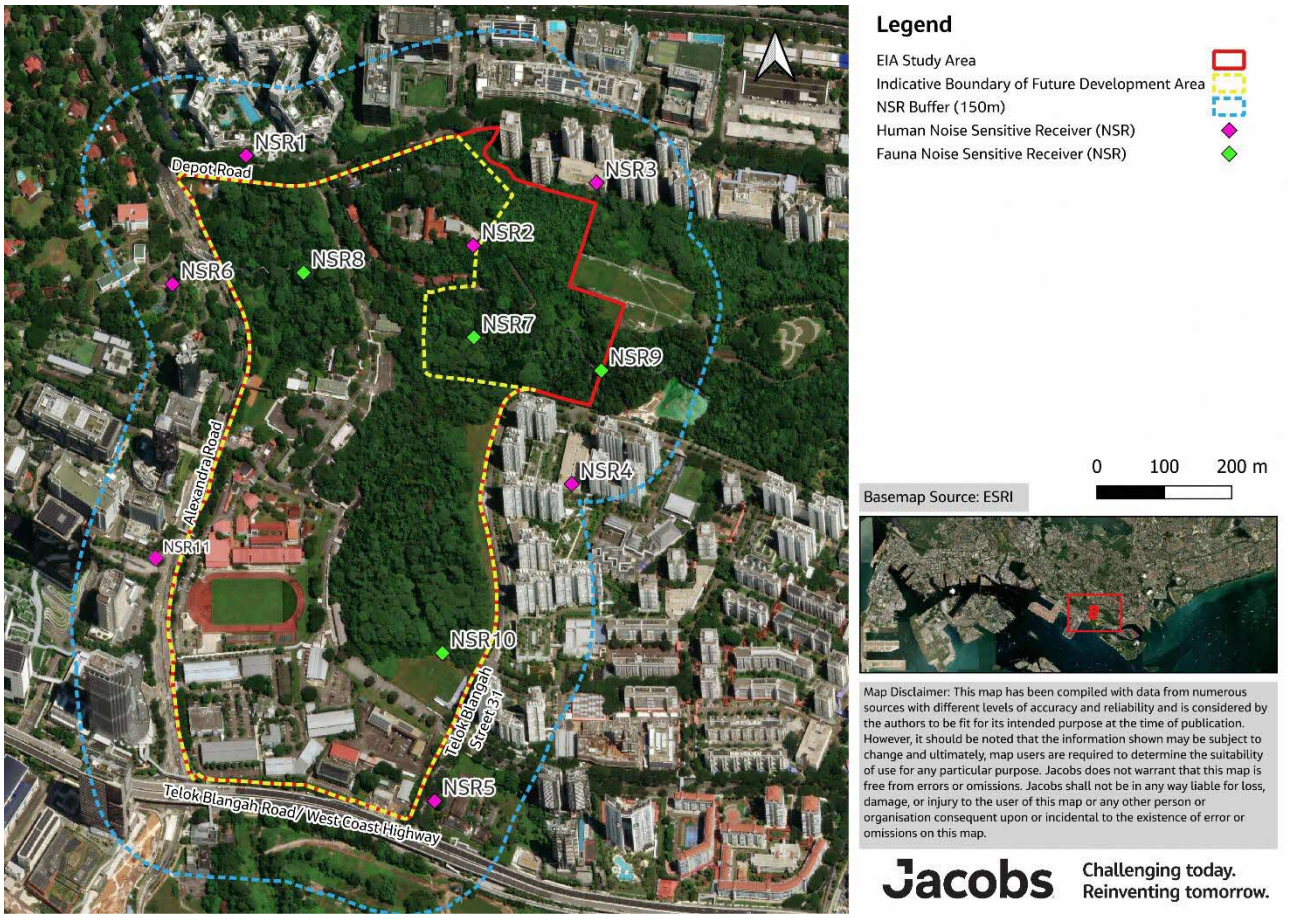


Figure 7-1: Baseline Ambient Noise Measurement Locations

Note: Baseline ambient noise measurement was not conducted at NSR11

7.2.3 Baseline Ambient Noise Measurement

The baseline ambient noise levels were measured using Type 1 sound level meter at five-minutes interval over three different periods of time, i.e., daytime (7 am – 7 pm), evening-time (7 pm – 10 pm), and night-time (10 pm – 7 am) for one week on a continuous basis to present a representative baseline of the existing environment. The parameters measured were A-weighted equivalent continuous noise level (L_{Aeq}) 5-minute, L_{Aeq} 1-hour and L_{Aeq} 12-hour. The purpose of the baseline measure is to establish baseline noise levels at the identified noise sensitive receiver locations. The baseline data serve as reference point for the subsequent noise impact assessment and guide the formulation of appropriate mitigation measures to address potential impacts arising from the proposed development.

Noise level measurements were conducted at ground level/ floor level (noise meters placed 1.5 m above ground/ floor).

7.2.4 Baseline Results and Discussion

The baseline ambient noise measurement was conducted for a week (or 7 days) continuously from 14 January to 20 January 2025 and 11 February to 17 February 2025. Baseline ambient noise result and photographic logs are provided in **Appendix 7A** and summary results are tabulated in **Table 7-5** and **Table 7-6**.

7.2.4.1 Human NSR

Baseline ambient noise levels for human NSR were measured and compared with the Second Schedule (Maximum Permissible Noise Levels for Construction Work Commenced on or after 1 October 2007) of the EPM (Control of Noise at Construction Sites) Regulations across different time periods of the day and for various types of human receivers. The baseline ambient noise levels at each human receiver are presented in **Table 7-5**.

Day time noise levels were generally found to follow the maximum permissible noise levels, particularly at residential and commercial receivers such as NSR1, NSR3, NSR4, and NSR5. However, exceedances were observed during the evening time and night time periods at several receivers, notably NSR1, NSR2, NSR5, and NSR6. These exceedances were most prominently reflected in the L_{Aeq} 5 mins measurements, indicating that short-term noise level spikes.

Across all receivers, the highest noise levels were consistently recorded during the day time, particularly in the L_{Aeq} 5 mins and L_{Aeq} 12 hours measurements. This pattern was aligned with typical human activity, including traffic, school operations, and commercial activities.

At most residential receivers (e.g., NSR3, NSR4), noise levels were observed to decrease from day time to evening, especially in the L_{Aeq} 1-hour values. However, elevated evening levels were maintained at NSR1 and NSR5, suggesting that persistent activity or traffic near these receivers from day time up to evening time.

Night time noise levels generally decreased from the evening and daytime levels across all receivers, particularly in residential areas such as NSR3 and NSR4. However, nighttime L_{Aeq} 5 mins values above 60 dBA were recorded at NSR1, NSR5, and NSR6.

Night time noise levels generally decreased from the evening time and day time across all receivers, particularly in residential areas such as NSR3 and NSR4. NSR1, NSR5, and NSR6, however, recorded night-time L_{Aeq} 5 mins values above 60 dBA, indicating that short-term noise level spikes during resting period.

Weekday noise levels were generally found to be higher, especially at school receivers (NSR2, NSR6), reflecting their operational periods. Reduced noise levels were observed on Sundays and public holidays in most areas imply reduced traffic or activities, though elevated L_{Aeq} 5 mins values were still recorded at NSR1 and NSR2.

Table 7-5: Noise Baseline Result for Human Noise Sensitive Receivers (NSR)

Measurement Point	Type of Affected Premises	Period	Parameter	Maximum Baseline Noise Level (dBA)[1]			Maximum Permissible Noise Level (dBA)[2]			Correction Factor			Maximum Adjusted Permissible Noise Level (dBA)[3]		
				D	E	N	D	E	N	D	E	N	D	E	N
NSR1	Residential	Weekday	L_{Aeq} 5 mins	75.8	70.8	65.6	90.0	70.0	55.0	0.0	3.0	0.0	90.0	73.8	65.6
			L_{Aeq} 1 hour	-	63.3	60.7	-	65.0	55.0	-	3.0	1.0	-	68.0	61.7
			L_{Aeq} 12 hours	62.4	-	-	75.0	-	-	0.0	-	-	75.0	-	-
		Sunday/ public holiday	L_{Aeq} 5 mins	68.7	66.1	66.2	75.0	55.0	55.0	1.0	0.0	0.0	76.0	66.1	66.2
			L_{Aeq} 1 hour	-	-	-	-	-	-	-	-	-	-	-	-
			L_{Aeq} 12 hours	58.4	-	-	75.0	-	-	0.0	-	-	75.0	-	-
NSR2[4]	Residential	Weekday	L_{Aeq} 5 mins	75.4	61.3	62.3	90.0	70.0	55.0	0.0	1.0	1.0	90.0	71.0	63.3
			L_{Aeq} 1 hour	-	54.8	52.9	-	65.0	55.0	-	0.0	2.0	-	65.0	57.0
			L_{Aeq} 12 hours	61.7	-	-	75.0	-	-	0.0	-	-	75.0	-	-
		Sunday/ public holiday	L_{Aeq} 5 mins	72.6	48.6	67.0	75.0	55.0	55.0	2.0	1.0	0.0	77.0	56.0	67.0
			L_{Aeq} 1 hour	-	-	-	-	-	-	-	-	-	-	-	-
			L_{Aeq} 12 hours	56.8	-	-	75.0	-	-	0.0	-	-	75.0	-	-
NSR3	Residential	Weekday	L_{Aeq} 5 mins	68.0	61.6	52.6	90.0	70.0	55.0	0.0	1.0	2.0	90.0	71.0	57.0
			L_{Aeq} 1 hour	-	54.7	50.9	-	65.0	55.0	-	0.0	1.0	-	65.0	56.0
			L_{Aeq} 12 hours	55.8	-	-	75.0	-	-	0.0	-	-	75.0	-	-

Measurement Point	Type of Affected Premises	Period	Parameter	Maximum Baseline Noise Level (dBA)[1]			Maximum Permissible Noise Level (dBA)[2]			Correction Factor			Maximum Adjusted Permissible Noise Level (dBA)[3]		
				D	E	N	D	E	N	D	E	N	D	E	N
NSR3	Residential	Sunday/ public holiday	L_{Aeq} 5 mins	54.9	51.1	50.4	75.0	55.0	55.0	0.0	2.0	1.0	75.0	57.0	56.0
			L_{Aeq} 1 hour	-	-	-	-	-	-	-	-	-	-	-	-
			L_{Aeq} 12 hours	51.2	-	-	75.0	-	-	0.0	-	-	75.0	-	-
NSR4	Residential	Weekday	L_{Aeq} 5 mins	68.0	61.8	53.7	90.0	70.0	55.0	0.0	1.0	3.0	90.0	71.0	58.0
			L_{Aeq} 1 hour	-	53.8	51.6	-	65.0	55.0	-	0.0	2.0	-	65.0	57.0
			L_{Aeq} 12 hours	55.0	-	-	75.0	-	-	0.0	-	-	75.0	-	-
		Sunday/ public holiday	L_{Aeq} 5 mins	55.0	53.2	50.4	75.0	55.0	55.0	0.0	3.0	1.0	75.0	58.0	56.0
			L_{Aeq} 1 hour	-	-	-	-	-	-	-	-	-	-	-	-
			L_{Aeq} 12 hours	49.3	-	-	75.0	-	-	0.0	-	-	75.0	-	-
NSR5	Commercial	Weekday	L_{Aeq} 5 mins	78.6	63.8	71.0	90.0	70.0	70.0	0.0	1.0	3.0	90.0	71.0	74.0
			L_{Aeq} 1 hour	-	-	-	-	-	-	-	-	-	-	-	-
			L_{Aeq} 12 hours	66.0	-	59.7	75.0	-	65.0	1.0	-	1.0	76.0	-	66.0
		Sunday/ public holiday	L_{Aeq} 5 mins	61.5	59.2	61.0	90.0	70.0	70.0	0.0	0.0	1.0	90.0	70.0	71.0
			L_{Aeq} 1 hour	-	-	-	-	-	-	-	-	-	-	-	-
			L_{Aeq} 12 hours	58.3	-	56.6	75.0	-	65.0	0.0	-	1.0	75.0	-	66.0

Measurement Point	Type of Affected Premises	Period	Parameter	Maximum Baseline Noise Level (dBA)[1]			Maximum Permissible Noise Level (dBA)[2]			Correction Factor			Maximum Adjusted Permissible Noise Level (dBA)[3]		
				D	E	N	D	E	N	D	E	N	D	E	N
NSR6	School	Weekday	L_{Aeq} 5 mins	**78.9**	**62.3**	**62.1**	75.0	55.0	55.0	2.0	1.0	1.0	80.9	63.3	63.1
			L_{Aeq} 1 hour	-	-	-	-	-	-	-	-	-	-	-	-
			L_{Aeq} 12 hours	**62.4**	-	**53.1**	60.0	-	50.0	2.0	-	2.0	64.4	-	55.1
		Sunday/ public holiday	L_{Aeq} 5 mins	63.9	**56.7**	**57.4**	75.0	55.0	55.0	0.0	3.0	2.0	75.0	59.7	59.4
			L_{Aeq} 1 hour	-	-	-	-	-	-	-	-	-	-	-	-
			L_{Aeq} 12 hours	55.9	-	**53.1**	60.0	-	50.0	1.0	-	2.0	61.0	-	55.1

Notes:

***Bold red**: measured noise level exceeds the maximum permissible noise level stipulated by EPM (Control of Noise at Construction Sites) Regulations, Second Schedule*

[1] Maximum equivalent continuous noise level over specific period from noise baseline measurement [D = day time 7 am – 7 pm; E = evening time 7 pm -10 pm; N = night time 10 pm – 7 am).

[2] Based on EPM (Control of Noise at Construction Sites) Regulations, Second Schedule.

[3] Based on EPM (Control of Noise at Construction Sites) Regulations, Third Schedule.

[4] Affected premises of NSR2 is categorised as residential receiver as ISS International School is expected to cease operation prior to construction work commencement.

7.2.4.2 Fauna NSR

Baseline ambient noise levels at NSR7 to NSR10, designated as fauna NSR, were analysed across day, evening, and night time periods. These areas are expected to maintain low ambient noise to support ecological integrity. The values were compared against published noise thresholds (**Table 7-2**) for various taxa to assess potential biological responses. The baseline ambient noise levels at each fauna receiver are tabulated in **Table 7-6**.

NSR7 to NSR10 are located near or within forested areas, where ambient noise levels were consistently elevated beyond thresholds (43 dBA to 81 dBA) known to affect fauna biological response. The sources of these elevated levels are likely to include nearby vehicular traffic and fauna noise.

Day time L_{Aeq} 5 mins noise levels exceeded 68 dBA at all four NSRs, with maximum noise level of above 80 dBA recorded at NSR7, NSR8, and NSR10. These levels surpass the biological thresholds for various fauna, indicating potential impacts such as:

- Stress responses, fear behaviour, and reduced reproductive efficiency in non-volant mammals.
- Altered vocalisation patterns, reduced occupancy of the area, increase in stress, reduced breeding success and changes in species interactions in birds.
- Reduced foraging efficiency in bats.
- Disruption of vocal behaviour and reduced chorus tenure in amphibians.
- Stress-induced freezing behaviour in reptiles.
- Altered courtship signalling in invertebrates.

A general trend of higher noise levels during the day-time (59.2 dBA – 85.2 dBA) compared to evening and night (48.7 dBA – 80.4 dBA) was observed, consistent with typical human activity patterns. Given the baseline ambient noise levels recorded ranging from approximately 48.7 to 85.2 dBA, the identified fauna groups (non-volant mammals, birds, bats, amphibians, reptiles, and invertebrates) are assumed to most likely adapt to the existing noise environment. These groups are already exposed to noise levels that exceed established biological response thresholds, and any additional increase due to future construction activities could further exacerbate impacts on their behaviour, physiology, and reproductive success.

Table 7-6: Noise Baseline Result for Fauna NSR

Measurement Point	Period	Parameter	Maximum Baseline Noise Level (dBA)		
			D	E	N
NSR7	Weekday	L_{Aeq} 5 mins	82.9	63.8	57.5
		L_{Aeq} 1 hour	72.5	58.0	52.8
		L_{Aeq} 12 hours	62.1	61.4	
	Sunday/ public holiday	L_{Aeq} 5 mins	76.3	75.5	52.3
		L_{Aeq} 1 hour	73.7	69.2	48.8
		L_{Aeq} 12 hours	63.4	61.4	

Measurement Point	Period	Parameter	Maximum Baseline Noise Level (dBA)		
			D	E	N
NSR8	Weekday	L_{Aeq} 5 mins	71.8	80.4	68.2
		L_{Aeq} 1 hour	64.9	78.5	66.0
		L_{Aeq} 12 hours	59.5	71.8	
	Sunday/ public holiday	L_{Aeq} 5 mins	76.7	76.1	79.6
		L_{Aeq} 1 hour	74.2	70.4	77.4
		L_{Aeq} 12 hours	64.7	71.8	
NSR9	Weekday	L_{Aeq} 5 mins	79.5	64.5	54.1
		L_{Aeq} 1 hour	69.3	60.5	49.7
		L_{Aeq} 12 hours	59.2	61.2	
	Sunday/ public holiday	L_{Aeq} 5 mins	76.1	74.7	52.2
		L_{Aeq} 1 hour	73.6	69.2	48.7
		L_{Aeq} 12 hours	63.3	61.2	
NSR10	Weekday	L_{Aeq} 5 mins	69.1	67.9	69.8
		L_{Aeq} 1 hour	63.1	65.1	64.7
		L_{Aeq} 12 hours	59.2	61.6	
	Sunday/ public holiday	L_{Aeq} 5 mins	85.2	57.4	63.1
		L_{Aeq} 1 hour	76.6	56.6	61.5
		L_{Aeq} 12 hours	68.8	59.5	

7.3 Impact Assessment

The quantitative assessment of potential noise impact distinguishes between those that are positive or negative in nature; major, moderate or minor magnitude of changes; transboundary, national, or local extents; long or short-term; direct or indirect; reversible or irreversible; cumulative and non-cumulative.

The prediction of the potential noise levels generated by the construction activities is simulated using noise modelling software CadnaA version 2025 (CadnaA), developed by DataKustik.

The assessment of potential noise impact distinguishes high, medium, or low magnitudes of changes as defined in **Table 7-7**. The impact magnitude of the exceedance in noise limits is based on the subjective perception of noise levels by humans. **Table 7-7** describes human responses to changes in noise levels and are taken as a guide to the impact magnitude on the fauna NSR when noise exceeds the maximum baseline noise level. Although fauna is likely to respond differently to these changes in noise levels, there are no known studies that have investigated responses to varying changes, and the same impact magnitude criteria is therefore adopted.

Table 7-7: Noise Impact Magnitude Definition Table

Exceedance Level (dBA)	Subjective Response	Impact Magnitude
> 0 to < 5	Just perceptible	Low
≥ 5 to < 10	Clearly perceptible	Medium
> 10	More than twice as loud	High

Source: Adapted from (Murphy & King, 2014)

7.3.1 Noise Emission Sources from the Proposed Construction Activities

Noise is expected to be mainly generated from the following sources during construction:

- Operation of fuel burning equipment (e.g., generator) and handheld tools (e.g., electric drilling, nail gun, welding, grinder, gas cutter, chainsaw).
- Operation and movement of heavy vehicles or machinery (e.g., excavators, piling machines, dozers, drilling machines, cranes, asphalt pavers, rollers, lorry cranes, transit mixers, and dump trucks).

Noise levels generated by construction equipment can exhibit significant variability, influenced by multiple factors including construction stage, nature of construction activities, adopted methodology, equipment type and model, equipment condition, as well as the quantity and duration of operation. Additional determinants include the distance from the source, source mobility (stationary or mobile), variations in equipment power output, and the inherent noise characteristics of the equipment, such as whether emissions are continuous or intermittent and whether they predominantly comprise low- or high-frequency components.

At the time of this EIA, detailed construction methodology and specifications for power mechanical equipment (PME) have not been finalised and will only be confirmed upon appointment of contractor(s). Consequently, modelling assumptions pertaining to the construction methodology, equipment type, quantities and operational duration have been derived based on established industry practices, precedent from HDB projects experience, and Jacobs' experience with comparable developments.

Table 7-8 summarises the PME emission sources and their corresponding sound power level (SWL), referenced from SS 602: 2014 Code of Practice for Noise Control on Construction and Demolition Sites and the British Standards BS 5228-1: 2009 Code of Practice for Noise and Vibration Control on Construction or Open Sites – Part 1: Noise. These values are adopted as representative industry standards for this assessment. Where a range of noise level was provided, the upper bound has been applied in the modelling as a conservative approach. A detailed description of the construction phases and the PMEs utilised in each phase is presented in **Appendix 7B**.

Table 7-8: Summary of the List of Emission Sources and Their Respective Sound Power Level (SWL)

Emission Sources	Sound Power Level (SWL, dBA)	Source
Air compressor	107	SS602:2014
Asphalt paver	119	SS602:2014
Boom lift	105	BS5228-1
Bored piling	124	SS602:2014
Chainsaw	126	SS602:2014
Concrete discharging and pumping	107	SS602:2014
Concrete/ rock drilling	129	SS602:2014

Emission Sources	Sound Power Level (SWL, dBA)	Source
Crawler crane	115	SS602:2014
Dozer	110	BS5228-1
Drilling machine	102	BS5228-1
Dump truck	114	SS602:2014
Electric drill	94	SS602:2014
Excavator	118	SS602:2014
Gas cutter	94	SS602:2014
Generator	119	SS602:2014
Grinding	106	SS602:2014
Loader	118	SS602:2014
Lorry crane	120	SS602:2014
Mobile crane	98	BS5228-1
Nail gun	101	BS5228-1
Poker vibrator	112	SS602:2014
Pre-cast concrete piling	128	SS602:2014
Pump	108	SS602:2014
Roller	104	SS602:2014
Saw	109	SS602:2014
Scissor lift	101	BS5228-1
Tower crane	108	SS602:2014
Transit mixer	116	SS602:2014
Vibratory piling	130	SS602:2014
Welding	96	SS602:2014

7.3.2 Noise Modelling Approach

In developing the noise modelling scenarios, the overall construction timeline has been broadly divided into four stages, as outlined in **Table 7-9**. These stages correspond to the noise modelling Scenario 1, 2, 3 and 4. Construction activities and their associated noise sources have been categorised and modelled accordingly, as presented in **Table 7-9**.

Table 7-9: Estimated Noise Modelling Scenario and List of Construction Activities in the Day that Modelled in Each Scenario

Scenario	Stage of Construction	Construction Activities	Estimated Duration
Scenario 1: Demolition Works	Demolition Phase – Demolition Works	▪ Erection of perimeter hoarding ▪ Site preparation e.g. entrance and access road, temporary facilities (e.g., site office, ECM facilities, noise barriers) ▪ Building structure and foundation demolition ▪ Debris transportation ▪ General works (e.g., machinery maintenance, construction materials delivery, waste management, storage and handling, electricity supply) ▪ Services diversion	18 months
Scenario 2: Pre-Construction Works	Construction Phase – Advance Works	▪ Wildlife shepherding ▪ Erection of perimeter hoarding ▪ Erection of tree protection zone (TPZ) (if any) ▪ Tree felling and land/ vegetation clearance ▪ Vegetation and debris transportation ▪ Site preparation (e.g. entrance and access road, temporary facilities) (e.g. site office, ECM facilities, noise barriers) ▪ Installation of mitigation measures (if any) ▪ Soil and geotechnical investigation ▪ Trial trenching works ▪ General works (e.g. machinery maintenance, construction materials delivery, waste management, storage and handling, electricity supply, instrumentation and monitoring	6 months
Scenario 3: Infrastructure Works	Construction Phase – Earthworks and Site Clearance	▪ Cut and fill/ regrading/ levelling/ platforming/ excavation ▪ Installing sheet pile/soldier pile/soil nail ▪ Services diversion works (i.e., cables, outlet drain, sewers encumbering the site) ▪ General works, e.g. machinery maintenance, construction materials delivery, waste management, storage and handling, electricity supply, instrumentation & monitoring ▪ Turfing and landscaping works	≤ 5 years

Scenario	Stage of Construction	Construction Activities	Estimated Duration
Scenario 3: Infrastructure Works	Construction Phase – Infrastructure	▪ Road works layering (e.g., spreading, rolling, compaction, paving) ▪ Excavation ▪ Drainage and drainage related work (box culverts, sumps, etc.) ▪ Sewerage and sewerage related work(sewer pipe laying, manhole construction etc.) ▪ Mechanical and Electrical works ▪ Road-related facilities works (i.e., bus shelter, pedestrian crossing, zebra crossing, covered linkways. Pedestrian overhead bridge, etc.) ▪ General works (e.g., machinery maintenance, construction materials delivery, waste management, storage and handling, services laying, instrumentation & monitoring) ▪ Turfing and landscaping works	≤ 5 years
Scenario 4: Building Works	Construction Phase – Building	▪ Bottom-up construction – substructure building foundation works and base slab casting ▪ Bottom-up construction – superstructure prefabrication and structure installation ▪ Architectural works (e.g., window, painting, door, railing, etc.) ▪ Pavement construction works ▪ General works, e.g. machinery maintenance, construction materials delivery, waste management, storage and handling, electricity supply	≤ 5 years

7.3.3 Noise Modelling Assumptions

The following assumptions were adopted for the noise modelling assessment:

- Construction activities are conducted during the day (7am – 7 pm) from Monday to Saturday excluding Sunday and public holidays.
- The sound power levels are obtained from the SS 602: 2014 Code of Practice for Noise Control on Construction and Demolition Sites or the British Standards BS 5228-1: 2009 Code of Practice for Noise and Vibration Control on Construction and Open Sites – Part 1: Noise.
- All equipment is cumulatively modelled as an area source in CadnaA.
- Singapore's annual average ambient temperature of 28.11˚C[1], relative humidity of 77.9%[2], and wind speed of 3 m/s was used in the noise modelling.

[1] Meteorological Service Singapore Annual Climate Assessment Report (2024)

[2] Singapore Department of Statistics. (2024). Air Temperature And Sunshine, Relative Humidity And Rainfall, Annual (2025) [Dataset]. data.gov.sg. Retrieved July 28, 2025 from https://data.gov.sg/datasets/d_19c6ce4509e0bddde2062298aa8ce9ab/view

- Fauna NSRs were assessed against the maximum baseline levels recorded during the baseline measurement. The assessment was undertaken under the assumption that these NSRs have since adapted to the prevailing baseline noise conditions, even if such levels exceed those typically reported in literature, as explained in **Section 7.1**.
- Noise levels generated by construction activities for NSRs have been estimated using receiver points positioned at a height of 0.5 m, 1.5 m and 15 m, representing ground-dwelling fauna, human and arboreal fauna respectively.
- Noise modelling was conducted using a horizontal grid spacing of 10 m x 10 m, with vertical grid spacing at 1.5 m for human NSR as well as 0.5 m and 1.5 m for fauna NSR.
- Predicted noise levels at NSR were derived by summing up the maximum background noise levels recorded during the baseline measurement with the maximum modelled noise as shown below:

  Predicted noise (dBA) = Maximum background noise (dBA) + Maximum modelled noise (dBA).

7.3.4 Noise Modelling Results

The summary of the predicted noise levels during the construction phases in the day generated over 12 hours (L_{Aeq} 12 hours) and over 5 mins (L_{Aeq} 5 mins), in the absence of any mitigation measures, are presented in **Table 7-10** and **Table 7-11**, respectively. Modelled noise contours are provided in **Appendix 7C**.

Human NSRs (L_{Aeq} 12 hours)

The predicted daytime noise levels over a 12-hour period (L_{Aeq} 12 hours) indicate that in the absence of mitigation measures within and along with the proposed development footprint, widespread exceedances of the adjusted permissible limits are anticipated across all construction phases.

- Predicted noise levels at residential NSRs (NSR1 – NSR4) range from 74.2 dBA to 84.5 dBA, with the majority exceeding the permissible limit of 75 dBA.
- Predicted noise levels at commercial NSRs (NSR5, NSR11) range between 79.4 dBA and 86.4 dBA, exceeding the permissible limits of 75 and 76 dBA.
- Predicted noise levels at school NSR (NSR6) range between 70.9 and 75.6 dBA, exceeding the permissible limit of 64.4 dBA.
- Impact magnitude for residential (NSR1-NSR4) and commercial (NSR5) NSRs is consistently High, while the school (NSR6) ranges from Medium to High.

Human NSRs (L_{Aeq} 5 minutes)

The predicted daytime noise levels over a 5-minute period (L_{Aeq} 5 minutes) indicate that in the absence of mitigation measures within and along with the proposed development footprint, short-term exposure remains within permissible limits but still results in noticeable impacts across all construction phases.

- Predicted noise levels at residential NSRs (NSR1 – NSR4) range from 74.3 dBA to 85.4 dBA, remaining below the permissible limit of 90 dBA with impact magnitude varying from Low to High.
- Predicted noise levels at commercial NSRs (NSR5, NSR11) range between 79.9 dBA and 84.6 dBA, also below the permissible limit of 90 dBA, with impact magnitude generally Low to Medium for NSR5.
- Predicted noise levels at school NSR (NSR6) range between 79.7 and 80.8 dBA, close to the permissible limit of 80.9 dBA, resulting in Low impact.
- Although regulatory compliance is achieved for short-term exposure, the variability in impact magnitude, particularly at residential NSRs suggests that sensitive receptors may still be perceptible disturbance.

Fauna NSRs (L_{Aeq} 12 hours)

The predicted daytime noise levels over a 12-hour period (L_{Aeq} 12 hours) indicate that in the absence of mitigation measures within and along with the proposed development footprint, substantial exceedances above baseline levels are anticipated across all construction phases for fauna NSRs. The impact magnitude for all fauna NSRs are generally assessed as High, underscoring the severity of potential ecological impacts.

Fauna NSRs (L_{Aeq} 5 minutes)

The predicted short-term daytime noise levels over a 5-minute period (L_{Aeq} 5 minutes) indicate that in the absence of mitigation measures within and along with the proposed development footprint, noticeable exceedances above baseline levels are expected for fauna NSRs across all construction phases. The impact magnitude for fauna NSRs is generally assessed as Low, with occasional instances of Medium to High impact.

NSR11, identified as in **Section 7.2.1**, was assessed using predicted construction noise level benchmarked against the Environmental Protection and Management (Control of Noise at Construction Sites) Regulations.

Table 7-10: Predicted Unmitigated Noise Levels for Day (L_{Aeq} 12 hours)

NSR Cluster	Type of NSR	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities[1] (dBA)	Predicted Noise Level[2] (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Demolition Works						
NSR1	Residential	62.4	76.4	76.6	75.0	High
NSR2	Residential	61.7	78.2	78.3	75.0	High
NSR3	Residential	55.8	79.3	79.3	75.0	High
NSR4	Residential	55.0	74.1	74.2	75.0	High
NSR5	Commercial	66.0	79.9	80.1	76.0	High
NSR6	School	62.4	70.8	71.4	64.4	Medium
NSR7	Fauna	62.1	73.8 – 75.9	74.1 – 76.1	-	High
NSR8	Fauna	59.5	72.4 – 76.8	72.6 – 76.9	-	High
NSR9	Fauna	59.2	68.7 – 71.0	69.2 – 71.3	-	Medium – High
NSR10	Fauna	59.2	71.0 – 75.8	71.3 – 75.9	-	High
NSR11	Commercial	-	83.9	-	75.0	-
Pre-Construction Works						
NSR1	Residential	62.4	78.2	78.3	75.0	High
NSR2	Residential	61.7	79.4	79.5	75.0	High
NSR3	Residential	55.8	79.6	79.6	75.0	High
NSR4	Residential	55.0	81.5	81.5	75.0	High
NSR5	Commercial	66.0	80.4	80.6	76.0	High
NSR6	School	62.4	72.6	73.0	64.4	High
NSR7	Fauna	62.1	79.1 – 77.1	77.2 – 79.2	-	High
NSR8	Fauna	59.5	74.3 – 78.6	74.4 – 78.7	-	High

NSR Cluster	Type of NSR	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities[1] (dBA)	Predicted Noise Level[2] (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
NSR9	Fauna	59.2	70.8 – 73.2	71.1 – 73.4	-	High
NSR10	Fauna	59.2	74.8 – 79.4	74.9 – 79.4	-	High
NSR11	Commercial	-	83.4	-	75.0	-
Infrastructure Works						
NSR1	Residential	62.4	80.7	80.8	75.0	High
NSR2	Residential	61.7	81.8	81.8	75.0	High
NSR3	Residential	55.8	81.7	81.7	75.0	High
NSR4	Residential	55.0	84.5	84.5	75.0	High
NSR5	Commercial	66.0	83.4	83.5	76.0	High
NSR6	School	62.4	75.4	75.6	64.4	High
NSR7	Fauna	62.1	79.9 – 81.9	80.0 – 81.9	-	High
NSR8	Fauna	59.5	77.2 – 81.4	77.3 – 81.4	-	High
NSR9	Fauna	59.2	73.5 – 75.9	73.7 – 76.0	-	High
NSR10	Fauna	59.2	77.8 – 82.4	77.9 – 82.4	-	High
NSR11	Commercial	-	86.4	-	75.0	-
Building Works						
NSR1	Residential	62.4	81.3	81.4	75.0	High
NSR2	Residential	61.7	81.2	81.2	75.0	High
NSR3	Residential	55.8	79.3	79.3	75.0	High
NSR4	Residential	55.0	81.9	81.9	75.0	High
NSR5	Commercial	66.0	79.2	79.4	76.0	High
NSR6	School	62.4	70.2	70.9	64.4	Medium
NSR7	Fauna	62.1	78.3 – 80.3	78.4 – 80.4	-	High
NSR8	Fauna	59.5	76.9 – 81.1	77.0 – 81.1	-	High
NSR9	Fauna	59.2	72.0 – 74.4	72.2 – 74.5	-	High
NSR10	Fauna	59.2	75.7 – 80.4	75.8 – 80.4	-	High
NSR11	Commercial	-	81.6	-	75.0	-

Note:

Red indicates exceedance of maximum baseline noise level

Noise levels and impact magnitudes for NSR4 – NSR10 accounts for both ground-dwelling and arboreal fauna

[1] Noise modelling output. Noise level is from construction activities only, without background noise

[2] Addition of background noise to modelling output

Table 7-11: Predicted Unmitigated Noise Levels for Day (L_{Aeq} 5 mins)

NSR Cluster	Type of NSR	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities[1] (dBA)	Predicted Noise Level[2] (dBA)	Max Adjusted Permissible Level (dBA)	Impact Magnitude
Demolition Works						
NSR1	Residential	75.8	76.5	79.2	90.0	Low
NSR2	Residential	75.4	80	81.3	90.0	Medium
NSR3	Residential	68.0	80.1	80.4	90.0	High
NSR4	Residential	68.0	73.2	74.3	90.0	Medium
NSR5	Commercial	78.6	79.9	82.3	90.0	Low
NSR6	School	78.9	72.2	79.7	80.9	Low
NSR7	Fauna	82.9	75.3 – 77.5	83.6 – 84.0	-	Low
NSR8	Fauna	71.8	73.6 – 78.0	75.8 – 78.9	-	Low – Medium
NSR9	Fauna	79.5	70.2 – 72.6	80.0 – 80.3	-	Low
NSR10	Fauna	69.1	72.0 – 76.9	73.8 – 77.6	-	Low – Medium
NSR11	Commercial	-	81.4	-	90.0	-
Pre-Construction Works						
NSR1	Residential	75.8	77.1	79.5	90.0	Low
NSR2	Residential	75.4	80.1	81.4	90.0	Medium
NSR3	Residential	68.0	79.2	79.5	90.0	High
NSR4	Residential	68.0	78.4	78.8	90.0	High
NSR5	Commercial	78.6	79.3	82.0	90.0	Low
NSR6	School	78.9	72.8	79.9	80.9	Low
NSR7	Fauna	82.9	77.4 – 79.4	84.0 – 84.5	-	Low
NSR8	Fauna	71.8	74.4 – 78.7	76.3 – 79.5	-	Low – Medium
NSR9	Fauna	79.5	71.1 – 73.5	80.1 – 80.5	-	Low
NSR10	Fauna	69.1	74.8 – 79.4	75.8 – 79.8	-	Medium – High
NSR11	Commercial	-	79.9	-	90.0	-
Infrastructure Works						
NSR1	Residential	75.8	80.1	81.5	90.0	Medium
NSR2	Residential	75.4	82.8	83.5	90.0	Medium

NSR Cluster	Type of NSR	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities[1] (dBA)	Predicted Noise Level[2] (dBA)	Max Adjusted Permissible Level (dBA)	Impact Magnitude
NSR3	Residential	68.0	81.4	81.6	90.0	High
NSR4	Residential	68.0	82.4	82.6	90.0	High
NSR5	Commercial	78.6	83.3	84.6	90.0	Medium
NSR6	School	78.9	76.4	80.8	80.9	Low
NSR7	Fauna	82.9	80.9 – 82.9	85.0 – 85.9	-	Low
NSR8	Fauna	71.8	78.2 – 82.4	79.1 – 82.8	-	Medium – High
NSR9	Fauna	79.5	74.5 – 76.9	80.7 – 81.4	-	Low
NSR10	Fauna	69.1	78.8 – 83.4	79.2 – 83.6	-	High
NSR11	Commercial	-	83.9	-	90.0	-
Building Works						
NSR1	Residential	75.8	82.3	83.2	90.0	Medium
NSR2	Residential	75.4	82.2	83.0	90.0	Medium
NSR3	Residential	68.0	80.4	80.6	90.0	High
NSR4	Residential	68.0	85.3	85.4	90.0	High
NSR5	Commercial	78.6	80.2	82.5	90.0	Low
NSR6	School	78.9	72.2	79.7	80.9	Low
NSR7	Fauna	82.9	79.3 – 81.3	84.5 – 85.2	-	Low
NSR8	Fauna	71.8	77.9 – 82.1	78.9 – 82.5	-	Medium – High
NSR9	Fauna	79.5	73.0 – 75.4	80.4 – 80.9	-	Low
NSR10	Fauna	69.1	76.7 – 81.4	77.4 – 81.6	-	Medium – High
NSR11	Commercial	-	82.5	-	90.0	-

Note:

Red indicates exceedance of max baseline noise level

Noise levels and impact magnitudes for NSR4 – NSR10 accounts for both ground-dwelling and arboreal fauna

[1] Noise modelling output. Noise level is from construction activities only, without background noise

[2] Addition of background noise to modelling output

7.3.5 Evaluation of Impact for Construction Phase

The impact permanence is anticipated to be short-term for demolition and pre-construction works as the construction activities are expected to last less than three years (i.e., 18 months and 6 months), and medium-term for infrastructure and building works, with an anticipated duration of three to 10 years. All impacts are considered reversible, as construction-related noise will cease upon completion of the works. The geographical extent of noise impact extends beyond indicative boundary of future development area for NSR NSR1 to NSR6 and beyond EIA Study Area for NSR7 to NSR10, with both non-cumulative impacts (NSR1 – NSR3 and NSR6 – NSR9) and cumulative impact (NSR4, NSR5 and NSR10) identified due to concurrent construction activities occurring near these NSRs.

The impact significance of unmitigated noise generated over 12 hours and 5 mins (L_{Aeq} 12 hours and L_{Aeq} 5 mins) during day time is presented in **Table 7-12** (L_{Aeq} 12 hours) and

Table 7-13 (L_{Aeq} 5 mins). The detailed assessment of noise impact for each particular construction stage can be found in **Appendix 7D**.

Table 7-12: Impact Significance for Predicted Unmitigated Noise (L_{Aeq} 12 hours)

Assessment Criterion	Score Rating	Rating Justification/ Definition
Demolition Works		
A1: Value	2: EIA Study Area & 150 m NSR	Important to area immediately outside local conditions (i.e., EIA Study Area and the150 m NSR buffer).
A2.1: Impact Nature	-1: Negative	Noise levels are expected to increase due to the construction activities.
A2.2: Magnitude of Changes	2: Medium 3: High	Predicted noise levels for increased from baseline noise levels (refer to **Table 7-5** and **Table 7-6**). ▪ Medium: 5 dBA to 10 dBA above baseline levels (NSR6). ▪ High: more than 10 dBA above baseline levels (NSR1-NSR5 and NSR7-NSR10).
A2.3: Impact Extent	2: Beyond indicative boundary of development area 3: EIA Study Area	Noise impact is anticipated to extend beyond the indicative boundary of future development area (NSR1 – NSR6) and beyond EIA Study Area (NSR7 – NSR10).
B1: Permanence	2: Short-term	Noise impact for the entire demolition works will be less than 3 years and will cease when construction works stop.
B2: Impact Pathway	3: Direct	Noise impact results in direct impact to the NSR.
B3: Reversibility	2: Reversible	The noise impacts are reversible when construction activities stop.
B4: Cumulative	2: Non-Cumulative	There are no known developments in proximity to NSR1-NSR3 and NSR6-NSR9 that would contribute to cumulative noise impacts associated with the proposed development.
	3: Cumulative	Cumulative impact on local noise levels are anticipated at NSR4, NSR5 and NSR10 due to concurrent noise emissions from other construction projects occurring in the vicinity.
Range Bands of ES/ Impact Significance & Environmental Score (ES)	**Minor Negative**	NSR1: (-12) x (9) = -108
		NSR2: (-12) x (9) = -108
		NSR3: (-12) x (9) = -108
		NSR4: (-12) x (10) = -120
		NSR5: (-12) x (10) = -120
		NSR6: (-8) x (9) = -72
	Moderate Negative	NSR7: (-18) x (9) = -162
		NSR8: (-18) x (9) = -162
		NSR9: (-12 to -18) x (9) = -108 to -162
		NSR10: (-18) x (10) = -180

Assessment Criterion	Score Rating	Rating Justification/ Definition
Pre-Construction Works		
A1: Value	2: EIA Study Area & 150 m NSR	Important to area immediately outside local conditions (i.e., EIA Study Area and the150 m buffer).
A2.1: Impact Nature	-1: Negative	Noise levels are expected to increase due to the construction activities.
A2.2: Magnitude of Changes	3: High	Predicted noise levels represent an increase over the baseline noise levels (refer to **Table 7-5** and **Table 7-6**). ▪ High: more than 10 dBA above baseline levels (NSR1-NSR10).
A2.3: Impact Extent	2: Beyond indicative boundary of future development area 3: EIA Study Area	Noise impact is anticipated to extend beyond the indicative boundary of future development area (NSR1 – NSR6) and beyond EIA Study Area (NSR7 – NSR10).
B1: Permanence	2: Short-term	Noise impact for the entire pre-construction works will be less than 3 years and will cease when construction works stop.
B2: Impact Pathway	3: Direct	Noise impact results in direct impact to the NSR.
B3: Reversibility	2: Reversible	The noise impacts are reversible when construction activities stop.
B4: Cumulative	2: Non-Cumulative	There are no known developments in proximity to NSR1-NSR3 and NSR6-NSR9 that would contribute to cumulative noise impacts associated with the proposed development.
	3: Cumulative	Cumulative impact on local noise levels are anticipated at NSR4, NSR5 and NSR10 due to concurrent noise emissions from other construction projects occurring in the vicinity.
Range Bands of ES/ Impact Significance & Environmental Score (ES)	**Minor Negative**	NSR1: (-12) x (9) = -108
		NSR2: (-12) x (9) = -108
		NSR3: (-12) x (9) = -108
		NSR4: (-12) x (10) = -120
		NSR5: (-12) x (10) = -120
		NSR6: (-12) x (9) = -108
Range Bands of ES/ Impact Significance & Environmental Score (ES)	**Moderate Negative**	NSR7: (-18) x (9) = -162
		NSR8: (-18) x (9) = -162
		NSR9: (-18) x (9) = -162
		NSR10: (-18) x (10) = -180
Infrastructure Works		
A1: Value	2: EIA Study Area & 150 m NSR	Important to area immediately outside local conditions (i.e., EIA Study Area and the150 m NSR buffer).
A2.1: Impact Nature	-1: Negative	Noise levels are expected to increase due to the construction activities.

Assessment Criterion	Score Rating	Rating Justification/ Definition
A2.2: Magnitude of Changes	3: High	Predicted noise levels represent an increase over the baseline noise levels (refer to **Table 7-5** and **Table 7-6**). ▪ High: more than 10 dBA above baseline levels (NSR1-NSR10).
A2.3: Impact Extent	2: Beyond indicative boundary of future development area 3: EIA Study Area	Noise impact is anticipated to extend beyond the indicative boundary of future development area (NSR1 – NSR6) and beyond EIA Study Area (NSR7 – NSR10),
B1: Permanence	3: Medium-term	Noise impact for the entire infrastructure works will be between 3 and 5 years and will cease when construction works stop.
B2: Impact Pathway	3: Direct	Noise impact results in direct impact to the NSR.
B3: Reversibility	2: Reversible	The noise impacts are reversible when construction activities stop.
B4: Cumulative	2: Non-Cumulative 3: Cumulative	There are no known developments in proximity to NSR1-NSR3 and NSR6-NSR9 that would contribute to cumulative noise impacts associated with the proposed development. Cumulative impact on local noise levels are anticipated at NSR4, NSR5 and NSR10 due to concurrent noise emissions from other construction projects occurring in the vicinity.
Range Bands of ES/ Impact Significance & Environmental Score (ES)	**Minor Negative**	NSR1: (-12) x (10) = -120
		NSR2: (-12) x (10) = -120
		NSR3: (-12) x (10) = -120
	Moderate Negative	NSR4: (-12) x (11) = -132
		NSR5: (-12) x (11) = -132
	Minor Negative	NSR6: (-12) x (10) = -120
	Moderate Negative	NSR7: (-18) x (10) = -180
		NSR8: (-18) x (10) = -180
		NSR9: (-18) x (10) = -180
		NSR10: (-18) x (11) = -198
Building Works		
A1: Value	2: EIA Study Area & 150 m NSR	Important to area immediately outside local conditions (i.e., EIA Study Area and the150 m NSR buffer).
A2.1: Impact Nature	-1: Negative	Noise levels are expected to increase due to the construction activities.
A2.2: Magnitude of Changes	3: High	Predicted noise levels represent an increase over the baseline noise levels (refer to **Table 7-5** and **Table 7-6**). ▪ High: more than 10 dBA above baseline levels (NSR1-NSR10).

Assessment Criterion	Score Rating	Rating Justification/ Definition
A2.3: Impact Extent	2: Beyond indicative boundary of future development area 3: EIA Study Area	Noise impact is anticipated to extend beyond the indicative boundary of future development area (NSR1 – NSR6) and beyond EIA Study Area (NSR7 – NSR10).
B1: Permanence	3: Medium-term	Noise impact for the entire building works will be between 3 and 5 years and will cease when construction works stop.
B2: Impact Pathway	3: Direct	Noise impact results in direct impact to the NSR.
B3: Reversibility	2: Reversible	The noise impacts are reversible when construction activities stop.
B4: Cumulative	2: Non-Cumulative	There are no known developments in proximity to NSR1-NSR3 and NSR6-NSR9 that would contribute to cumulative noise impacts associated with the proposed development.
	3: Cumulative	Cumulative impact on local noise levels are anticipated at NSR4, NSR5 and NSR10 due to concurrent noise emissions from other construction projects occurring in the vicinity.
Range Bands of ES/ Impact Significance & Environmental Score (ES)	**Minor Negative**	NSR1: (-12) x (10) = -120
		NSR2: (-12) x (10) = -120
		NSR3: (-12) x (10) = -120
	Moderate Negative	NSR4: (-12) x (11) = -132
		NSR5: (-12) x (11) = -132
	Minor Negative	NSR6: (-12) x (10) = -120
	Moderate Negative	NSR7: (-18) x (10) = -180
		NSR8: (-18) x (10) = -180
		NSR9: (-18) x (10) = -180
		NSR10: (-18) x (11) = -198

Table 7-13: Impact Significance for Predicted Unmitigated Noise (L_{Aeq} 5 minutes)

Assessment Criterion	Score Rating	Rating Justification/ Definition
Demolition Works		
A1: Value	2: EIA Study Area & 150 m NSR	Important to area immediately outside local conditions (i.e., EIA Study Area and the150 m NSR buffer).
A2.1: Impact Nature	-1: Negative	Noise levels are expected to increase due to the construction activities.
A2.2: Magnitude of Changes	1: Low 2: Medium 3: High	Predicted noise levels represent an increase over the baseline noise levels (refer to **Table 7-5** and **Table 7-6**): ▪ Low: below 5 dBA above baseline levels (NSR1, NSR5 – NSR7 and NSR9). ▪ Medium: between 5 dBA and 10 dBA above baseline levels (NSR2, NSR4, NSR8 and NSR10). ▪ High: more than 10 dBA above baseline levels (NSR3).
A2.3: Impact Extent	2: Beyond indicative boundary of future development area 3: EIA Study Area	Noise impact is anticipated to extend beyond the indicative boundary of future development area (NSR1 – NSR6) and beyond EIA Study Area (NSR7 – NSR10).
B1: Permanence	2: Short-term	Noise impact for the entire demolition works will be less than 3 years and will cease when construction works stop.
B2: Impact Pathway	3: Direct	Noise impact results in direct impact to the NSR.
B3: Reversibility	2: Reversible	The noise impacts are reversible when construction activities stop.
B4: Cumulative	2: Non-Cumulative	There are no known developments in proximity to NSR1-NSR3 and NSR6-NSR9 that would contribute to cumulative noise impacts associated with the proposed development.
	3: Cumulative	Cumulative impact on local noise levels are anticipated at NSR4, NSR5 and NSR10 due to concurrent noise emissions from other construction projects occurring in the vicinity.
Range Bands of ES/ Impact Significance & Environmental Score (ES)	**Slight Negative**	NSR1: (-4) x (9) = -36
	Minor Negative	NSR2: (-8) x (9) = -72
		NSR3: (-12) x (9) = -108
		NSR4: (-8) x (10) = -80
	Slight Negative	NSR5: (-4) x (10) = -40
		NSR6: (-4) x (9) = -36
		NSR7: (-6) x (9) = -54
	Minor Negative	NSR8: (-12 to -6) x (9) = -54 to -108
	Slight Negative	NSR9: (-6) x (9) = -54
	Minor Negative	NSR10: (-6 to -12) x (10) = -60 to -120

Assessment Criterion	Score Rating	Rating Justification/ Definition
Pre-Construction Works		
A1: Value	2: EIA Study Area & 150 m NSR	Important to area immediately outside local conditions (i.e., EIA Study Area and the150 m NSR buffer).
A2.1: Impact Nature	-1: Negative	Noise levels are expected to increase due to the construction activities.
A2.2: Magnitude of Changes	1: Low 2: Medium 3: High	Predicted noise levels represent an increase over the baseline noise levels (refer to **Table 7-5** and **Table 7-6**): ▪ Low: below 5 dBA above baseline levels (NSR1, NSR5-NSR7 and NSR9). ▪ Medium: between 5 dBA and 10 dBA above baseline levels (NSR2 and NSR8). ▪ High: more than 10 dBA above baseline levels (NSR3, NSR4 and NSR10).
A2.3: Impact Extent	2: Beyond indicative boundary of future development area 3: EIA Study Area	Noise impact is anticipated to extend beyond the indicative boundary of future development area (NSR1 – NSR6) and beyond EIA Study Area (NSR7 – NSR10).
B1: Permanence	2: Short-term	Noise impact for the entire pre-construction works will be less than 3 years and will cease when construction works stop.
B2: Impact Pathway	3: Direct	Noise impact results in direct impact to the NSR.
B3: Reversibility	2: Reversible	The noise impacts are reversible when construction activities stop.
B4: Cumulative	2: Non-Cumulative	There are no known developments in proximity to NSR1-NSR3 and NSR6-NSR9 that would contribute to cumulative noise impacts associated with the proposed development.
	3: Cumulative	Cumulative impact on local noise levels are anticipated at NSR4, NSR5 and NSR10 due to concurrent noise emissions from other construction projects occurring in the vicinity.
Range Bands of ES/ Impact Significance & Environmental Score (ES)	**Slight Negative**	NSR1: (-4) x (9) = -36
	Minor Negative	NSR2: (-8) x (9) = -72
		NSR3: (-12) x (9) = -108
		NSR4: (-12) x (10) = -120
	Slight Negative	NSR5: (-4) x (10) = -40
		NSR6: (-4) x (9) = -36
		NSR7: (-6) x (9) = -54
	Minor Negative	NSR8: (-6 to -12) x (9) = -54 to -108
	Slight Negative	NSR9: (-6) x (9) = -54
	Moderate Negative	NSR10: (-12 to -18) x (10) = -120 to -180

Assessment Criterion	Score Rating	Rating Justification/ Definition
Infrastructure Works		
A1: Value	2: EIA Study Area & 150 m NSR	Important to area immediately outside local conditions (i.e., EIA Study Area and the150 m NSR buffer).
A2.1: Impact Nature	-1: Negative	Noise levels are expected to increase due to the construction activities.
A2.2: Magnitude of Changes	1: Low 2: Medium 3: High	Predicted noise levels represent an increase over the baseline noise levels (refer to **Table 7-5** and **Table 7-6**): ▪ Low: below 5 dBA above baseline levels (NSR6, NSR7 and NSR9) ▪ Medium: between 5 dBA and 10 dBA above baseline levels (NSR1, NSR2 and NSR5). ▪ High: more than 10 dBA above baseline levels (NSR3, NSR4, NSR8 and NSR10).
A2.3: Impact Extent	2: Beyond indicative boundary of future development area 3: EIA Study Area	Noise impact is anticipated to extend beyond the indicative boundary of future development area (NSR1 – NSR6) and beyond EIA Study Area (NSR7 – NSR10).
B1: Permanence	3: Medium-term	Noise impact for the entire infrastructure works will be between 3 and 5 years and will cease when construction works stop.
B2: Impact Pathway	3: Direct	Noise impact results in direct impact to the NSR.
B3: Reversibility	2: Reversible	The noise impacts are reversible when construction activities stop.
B4: Cumulative	2: Non-Cumulative	There are no known developments in proximity to NSR1-NSR3 and NSR6-NSR9 that would contribute to cumulative noise impacts associated with the proposed development.
	3: Cumulative	Cumulative impact on local noise levels are anticipated at NSR4, NSR5 and NSR10 due to concurrent noise emissions from other construction projects occurring in the vicinity.
Range Bands of ES/ Impact Significance & Environmental Score (ES)	**Minor Negative**	NSR1: (-8) x (10) = -80
		NSR2: (-8) x (10) = -80
		NSR3: (-12) x (10) = -120
	Moderate Negative	NSR4: (-12) x (11) = -132
	Minor Negative	NSR5: (-8) x (11) = -88
	Slight Negative	NSR6: (-4) x (10) = -40
		NSR7: (-6) x (10) = -60
	Moderate Negative	NSR8: (-12 to -18) x (10) = -120 to -180
	Slight Negative	NSR9: (-6) x (10) = -60
	Moderate Negative	NSR10: (-18) x (11) = -198

Assessment Criterion	Score Rating	Rating Justification/ Definition
Building Works		
A1: Value	2: EIA Study Area & 150 m NSR	Important to area immediately outside local conditions (i.e., EIA Study Area and the150 m NSR buffer).
A2.1: Impact Nature	-1: Negative	Noise levels are expected to increase due to the construction activities.
A2.2: Magnitude of Changes	1: Low 2: Medium 3: High	Predicted noise levels represent an increase over the baseline noise levels (refer to **Table 7-5** and **Table 7-6**): ▪ Low: below 5 dBA above baseline levels (NSR5 – NSR7 and NSR9). ▪ Medium: between 5 dBA and 10 dBA above baseline levels (NSR1 and NSR2). ▪ High: more than 10 dBA above baseline levels (NSR3, NSR4, NSR8 and NSR10).
A2.3: Impact Extent	2: Beyond indicative boundary of future development area 3: EIA Study Area	Noise impact is anticipated to extend beyond the indicative boundary of future development area (NSR1 – NSR6) and beyond EIA Study Area (NSR7 – NSR10).
B1: Permanence	3: Medium-term	Noise impact for the entire building works will be between 3 and 5 years and will cease when construction works stop.
B2: Impact Pathway	3: Direct	Noise impact results in direct impact to the NSR.
B3: Reversibility	2: Reversible	The noise impacts are reversible when construction activities stop.
B4: Cumulative	2: Non-Cumulative	There are no known developments in proximity to NSR1-NSR3 and NSR6-NSR9 that would contribute to cumulative noise impacts associated with the proposed development.
	3: Cumulative	Cumulative impact on local noise levels are anticipated at NSR4, NSR5 and NSR10 due to concurrent noise emissions from other construction projects occurring in the vicinity.
Range Bands of ES/ Impact Significance & Environmental Score (ES)	**Minor Negative**	NSR1: (-8) x (10) = -80
		NSR2: (-8) x (10) = -80
		NSR3: (-12) x (10) = -120
	Moderate Negative	NSR4: (-12) x (11) = -132
	Slight Negative	NSR5: (-4) x (11) = -44
		NSR6: (-4) x (10) = -40
		NSR7: (-6) x (10) = -60
	Moderate Negative	NSR8: (-12 to -18) x (10) = -120 to -180
	Slight Negative	NSR9: (-6) x (10) = -60
	Moderate Negative	NSR10: (-12 to -18) x (11) = -132 to -198

7.3.6 Evaluation of Impact for Post-Construction/ Operation Phase

During the post-construction/ operational phase of the proposed development, noise emissions are anticipated to be minimal and not significant. The primary sources of noise during this phase are expected to be limited to typical residential activities and vehicular traffic within and around the proposed development.

No commercial, industrial, or other high-noise-generating facilities are included in the proposed development plan. Consequently, projected increase in traffic-related noise is expected to be marginal and is not anticipated to result in a significant deviation from the existing baseline noise level.

7.4 Preventive and Administrative Noise Control Measures

Where applicable, the following good practices, including administrative measures, should be reviewed and implemented by the contractor to further reduce the potential construction noise impact to As Low As Reasonably Practicable (ALARP):

- Prepare a noise management plan (NMP) with the finalised construction method, schedule and equipment sound power levels to reconfirm the noise impact to fauna NSR are within acceptable ranges. The suggested NMP template is indicted in Annex H of SS 602: 2014.
- Use engineering methodology to control noise at source (examples provided in **Picture 7-1**), such as:
  - Quieter construction methodology such as silent pilers instead of vibratory piling, hydraulic splitter instead of concrete/ rock drilling.
  - Noise enclosures to cover stationary PME such as generators.
- Noise screens/ noise panels to partially shield noise generated from noisy PME such as generators and excavators.
  - Portable noise barriers for noisy construction activities e.g., soil investigation drilling activities, or road and drainage works which are close to the site boundary.
- Plan the construction works to minimise noise sources onsite through the optimisation of construction sequences and methods, such as:
  - Optimising vehicular access to minimise reversing of vehicles.
  - Making use of existing structures such as silos or site offices as noise shields to reduce noise transmission from noisy static equipment to the fauna NSR.
- Conduct continuous real time noise monitoring using a Type 1 sound level meter with data logging at the fauna NSR. When noise levels exceed the maximum adjusted noise level, the contractor should investigate and apply appropriate mitigation measures.

Noise meters are recommended to be located at the site boundary near adjacent forested areas.

- Implement industry best practices:
  - On-site PME should be well-maintained, i.e. serviced regularly during the construction period.
  - The number of PME should be reduced as far as practicable when construction works are carried out at areas close to the NSRs.
  - Alternative equipment with less noise emission can be considered, such as the use of rubber mallets instead of metal hammers.
  - Care shall be taken during loading or unloading, dismantling, or moving materials to reduce noise.

  - Silencers or mufflers on PME (e.g., generator sets) should be utilised and properly maintained during construction.
  - Mobile PME, if any, should be sited as far from fauna NSR as possible.
  - PME (such as trucks and cranes) that may be in intermittent use should be shut down between work periods or throttled down to a minimum where possible.
  - PME known to emit noise strongly in one direction should, whenever possible, be oriented so that the noise is directed away from the fauna NSR.

- Consider limiting heavy construction working hours to 8 am to 6 pm where it is possible to avoid the timings when crepuscular species may be active. Toolbox meetings and winding down of work can be done outside of these hours.
- Implement progressive start of loud construction activities to gradually increase noise levels for mobile fauna who have returned to roost during the night or are in the area to move away before noise levels get more intense.
- Where night works are conducted, the minimal amount of equipment should be used to reduce noise levels.
- Where night works are conducted, workers should refrain from shouting or using loud hailers aside from emergencies.

In the event of planned night work, additional assessment, i.e. noise, light impact should be conducted and submitted to NParks for approval prior to commencement.

7.5 Recommendation of Preventive and Mitigation Measures

To protect NSRs from excessive exposure to the construction noise, additional mitigation measures such as noise source controls and barriers to interrupt noise propagating pathways have been reviewed, evaluated and presented in this section for consideration and implementation during construction. The assumptions underlying the formulation of these measures and their practicality are based on the information available at the time of reporting. Accordingly, it is recommended that the contractor(s) prepare a contract-specific Environmental Monitoring and Management Plan (CEMMP). This plan should incorporate updated noise modelling based on the actual equipment inventory and noise emission levels, as well as detailed specifications for feasible source control measures and noise barriers to be implemented.

Modelling of source control, in conjunction with noise barriers, has been undertaken to demonstrate how the combined application of mitigation strategies can reduce the predicted noise impact to ALARP. This layered approach provides a clear illustration of the potential benefits to the NSRs.

7.5.1 Noise Barrier

Noise barriers are highly effective measures to reduce the noise level from construction activities. Noise Barriers include Permanent Noise Control Barriers (PNCB), Temporary Noise Control Barriers (TNCB), as well as Portable Noise Control Barriers and Noise Reduction Nets, also known as Sound Blankets.

A noise barrier should ideally be constructed such that it blocks the line of sight between NSRs and the noise source (ground-dwelling fauna is expected to have more noise reduction from noise barriers than arboreal fauna).

The deployment of noise barriers will be contingent upon specific construction site conditions, which cannot be fully determined until construction activities commence. Detailed specifications and positioning of the noise barriers should be established by the contractor in consultation with the barrier provider, either prior or during construction, based on actual noise emission levels and the proximity of construction equipment to NSRs. The

location and height of the barriers should be determined by using updated noise modelling to achieve the required noise reduction objectives.

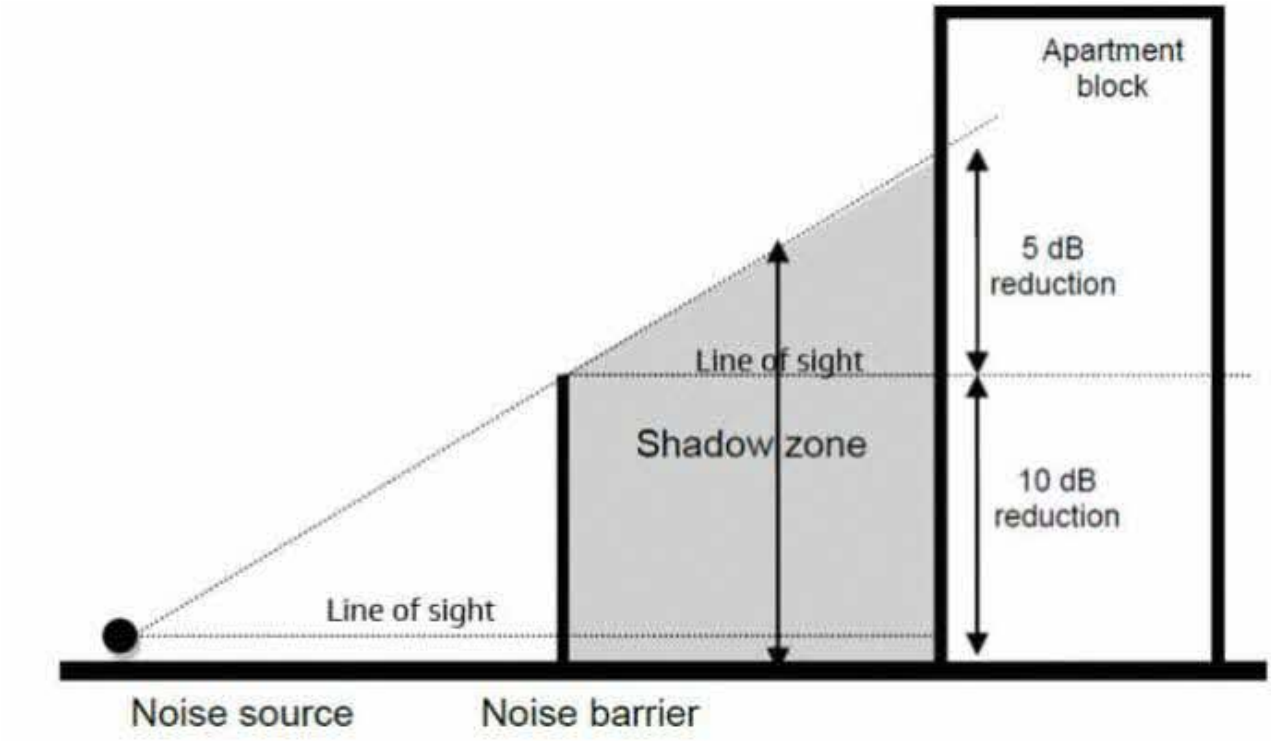


Figure 7-2: Effectiveness of a Noise Barrier

Source: Figure F.6 of SS 602: 2014

7.5.2 Control Measures of Emission Source

Source emission control measures include adoption of quieter construction methodologies, machinery, and equipment, as well as the use of enclosures, noise screen or noise panel, and portable noise barrier. It should be noted that, during construction, the contractor may utilise Powered Mechanical Equipment (PME) with sound power levels, quantities, and operating time that differ from those assumed in the modelling.

- Enclosure at PME with sufficient height and width to shield the noisy parts may achieve noise level reduction of up to 20 dBA (Table F.3 of SS 602: 2014).
- Noise screens or noise panels at PME of sufficient height and width to shield the noisy parts may achieve a noise level reduction of up to 15 dBA (Table F.3 of SS 602: 2014).
- Quieter construction methodology such as the use of diamond wire saw cutter can achieve up to 30 dBA of noise reduction.

The applicable engineering control measures at or near noise sources, along with their estimated noise reduction in decibels (dBA), are presented in **Table 7-14**.

Examples of mitigation measures at source are shown in **Picture 7-1**.

Table 7-14: Reduced Sound Power Level of Equipment with Additional Engineering Control Measures

Equipment	Initial Sound Power Level (dBA)	Type of Engineering Control Measures	Assumed Noise Reduction by Control Measures[1]	Reduced Sound Power Level at Source (dBA)
Asphalt paver	119	Noise reduction screen/ noise reduction panel	-15	104
Bored piling	124	Noise reduction screen/ noise reduction panel	-15	109
Chainsaw	126	Noise reduction screen/ noise reduction panel	-15	111
Concrete discharging and pump	107	Noise reduction screen/ noise reduction panel	-10	97
Concrete/rock drilling	129	Substitution by alternative process	-25	104
Crawler crane	115	Noise reduction screen/ noise reduction panel	-10	105
Dump truck	114	Noise reduction screen/ noise reduction panel	-15	99
Excavator	118	Noise reduction screen/ noise reduction panel	-15	103
Generator	119	Noise reduction screen/ noise reduction panel	-20	99
Grinding	106	Noise reduction screen/ noise reduction panel	-10	96
Loader	118	Noise reduction screen/ noise reduction panel	-10	108
Lorry crane	120	Noise reduction screen/ noise reduction panel	-15	105
Poker vibrator	112	Noise reduction screen/ noise reduction panel	-10	102
Pre-cast concrete piling	128	Substitution by alternative process & noise reduction screen/ noise reduction panel	-24	104
Pump	108	Noise reduction screen/ noise reduction panel	-10	98
Tower crane	108	Noise reduction screen/ noise reduction panel	-15	93
Transit mixer	116	Noise reduction screen/ noise reduction panel	-15	101
Vibratory piling	130	Substitution by alternative process	-36	94

Note:

[1]Noise reduction assumed according to SS 602: 2014 Code of Practice for Noise Control on Construction and Demolition Sites SS 602:2014

	
Noise proofing enclosure	Acoustic material installation for PME
	
Portable acoustic barrier for localised works	Noise panel fitted on noise emission outlet of bored piler

Picture 7-1: Examples of Noise Mitigation at Source

Source: LTA, Jacobs

7.5.3 Noise Modelling Results of Mitigation Measures

To determine the additional control measures that may be required to reduce the potential noise impact to the NSR, modelling trials were conducted as its results have exceedances at the NSR as presented in **Section 7.3.4**. Noise modelling trials are carried out for L_{Aeq} 12 hours and L_{Aeq} 5 mins. The predicted noise levels after mitigation measures are summarised below and presented in **Table 7-15** and **Table 7-16**.

Human NSR (L_{Aeq}, 12 hours)

Predicted daytime noise levels (L_{Aeq}, 12-hour) after implementing mitigation measures fully comply with the adjusted permissible limits across all construction phases.

- Residential NSRs (NSR1 – NSR4): Predicted levels range from 61.8 dBA to 69.3 dBA, well below the permissible limit of 75 dBA. Impact magnitude varies from Low to Medium, with occasional High impacts.
- Commercial NSRs (NSR5 and NSR11): Predicted levels range between 60.3 dBA and 70.8 dBA, below permissible limits of 75 – 76 dBA, resulting in Low impact for NSR5.
- School NSR (NSR6): Predicted levels range between 62.6 and 63.2 dBA, below the permissible limit of 64.4 dBA, with Low impact.

Overall: Mitigation measures effectively reduce noise levels to within compliance, significantly lowering impact magnitude compared to the unmitigated scenario.

Human NSR (L_{Aeq}, 5 mins)

Predicted short-term noise levels (L_{Aeq}, 5 minutes) after mitigation remain well below permissible limits across all phases.

- Residential NSRs (NSR1 – NSR4): Predicted levels range from 69.3 dBA to 76.3 dBA, below the permissible limit of 90 dBA, with impact magnitude consistently Low.
- Commercial NSRs (NSR5 and NSR11): Predicted levels range between 63.1 dBA and 78.9 dBA, below the permissible limit of 90 dBA, with Low impact for NSR5.
- School NSR (NSR6): Predicted levels remained at baseline level (78.9 dBA), just below the permissible limit of 80.9 dBA, resulting in Low impact.

Compliance is achieved for short-term exposure, and impact magnitude remains minimal.

Fauna NSR (L_{Aeq}, 12 hours)

Predicted noise levels for fauna NSRs (NSR7 – NSR10) after mitigation range between **59.8 dBA and 67.0 dBA**, close to or slightly above baseline but significantly reduced compared to unmitigated levels. Impact magnitude is consistently **Low to Medium**, indicating effective mitigation.

Fauna NSR (L_{Aeq}, 5 mins)

Predicted noise levels for fauna NSRs (NSR7 – NSR10) after mitigation range between **69.3 dBA and 83.0 dBA**, generally near baseline. Impact magnitude remains **Low**, confirming mitigation effectiveness.

Table 7-15: Predicted Mitigated Noise Levels for Day (L_{Aeq} 12 hours)

NSR Cluster	Type of NSR	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities[1] (dBA)	Predicted Noise Level[2] (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
Demolition Works						
NSR1	Residential	62.4	65.8	67.4	75.0	Medium
NSR2	Residential	61.7	62.0	64.8	75.0	Low
NSR3	Residential	55.8	69.1	69.3	75.0	High
NSR4	Residential	55.0	63.1	63.7	75.0	Medium
NSR5	Commercial	66.0	66.7	69.4	76.0	Low
NSR6	School	62.4	55.7	63.2	64.4	Low
NSR7	Fauna	62.1	60.4 – 63.1	64.3 – 65.6	-	Low
NSR8	Fauna	59.5	58.4 – 66.2	62.0 – 67.0	-	Low
NSR9	Fauna	59.2	56.5 – 57.3	61.1 – 61.4	-	Low
NSR10	Fauna	59.2	60.3 – 64.7	62.8 – 65.8	-	Low
NSR11	Commercial	-	70.8	-	75.0	-
Pre-Construction Works						
NSR1	Residential	62.4	63.1	65.8	75.0	Low
NSR2	Residential	61.7	58.9	63.5	75.0	Low
NSR3	Residential	55.8	65.1	65.6	75.0	Medium
NSR4	Residential	55.0	64.0	64.5	75.0	Medium
NSR5	Commercial	66.0	62.0	67.5	76.0	Low
NSR6	School	62.4	52.6	62.8	64.4	Low
NSR7	Fauna	62.1	55.7 – 61.6	63.0 – 64.9	-	Low
NSR8	Fauna	59.5	55.3 – 63.6	60.9 – 65.0	-	Low
NSR9	Fauna	59.2	52.2 – 54.5	60.0 – 60.5	-	Low
NSR10	Fauna	59.2	55.4 – 61.4	60.7 – 63.4	-	Low
NSR11	Commercial	-	65	-	75.0	-
Infrastructure Works						
NSR1	Residential	62.4	62.5	65.5	75.0	Low
NSR2	Residential	61.7	58.2	63.3	75.0	Low
NSR3	Residential	55.8	64.2	64.8	75.0	Medium

NSR Cluster	Type of NSR	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities[1] (dBA)	Predicted Noise Level[2] (dBA)	Max Adjusted Permissible Noise Level (dBA)	Impact Magnitude
NSR4	Residential	55.0	64.0	64.5	75.0	Medium
NSR5	Commercial	66.0	62.0	67.5	76.0	Low
NSR6	School	62.4	52.4	62.8	64.4	Low
NSR7	Fauna	62.1	55.4 – 61.3	62.9 – 64.7	-	Low
NSR8	Fauna	59.5	55.2 – 63.4	60.9 – 64.9	-	Low
NSR9	Fauna	59.2	51.7 – 54.1	59.9 – 60.4	-	Low
NSR10	Fauna	59.2	55.3 – 61.3	60.6 – 63.4	-	Low
NSR11	Commercial	-	65	-	75.0	-
Building Works						
NSR1	Residential	62.4	62.5	65.5	75.0	Low
NSR2	Residential	61.7	57.8	63.2	75.0	Low
NSR3	Residential	55.8	60.6	61.8	75.0	Medium
NSR4	Residential	55.0	62.9	63.5	75.0	Medium
NSR5	Commercial	66.0	60.6	67.1	76.0	Low
NSR6	School	62.4	50.7	62.6	64.4	Low
NSR7	Fauna	62.1	55.4 – 61.1	62.9 – 64.6	-	Low
NSR8	Fauna	59.5	55.7 – 64.3	61.0 – 65.5	-	Low
NSR9	Fauna	59.2	51.1 – 53.9	59.8 – 60.3	-	Low
NSR10	Fauna	59.2	55.7 – 61.7	60.8 – 63.6	-	Low
NSR11	Commercial	-	64.7	-	75.0	-

Note:

Red indicates exceedance of max baseline noise level

Noise levels and impact magnitudes for NSR7 – NSR10 accounts for both ground-dwelling and arboreal fauna

[1] Noise modelling output. Noise level is from construction activities only, without background noise

[2] Addition of background noise to modelling output

Table 7-16: Predicted Mitigated Noise Levels for Day (L_{Aeq} 5 mins)

NSR Cluster	Type of NSR	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities[1] (dBA)	Predicted Noise Level[2] (dBA)	Max Adjusted Permissible Level (dBA)	Impact Magnitude
Demolition Works						
NSR1	Residential	75.8	66.8	76.3	90.0	Low
NSR2	Residential	75.4	63.0	75.6	90.0	Low
NSR3	Residential	68.0	70.1	72.2	90.0	Low
NSR4	Residential	68.0	64.1	69.5	90.0	Low
NSR5	Commercial	78.6	67.7	78.9	90.0	Low
NSR6	School	78.9	56.7	78.9	80.9	Low
NSR7	Fauna	82.9	61.4 – 64.1	82.9 – 83.0	-	Low
NSR8	Fauna	71.8	59.4 – 67.2	72.0 – 73.1	-	Low
NSR9	Fauna	79.5	57.5 – 58.3	79.5	-	Low
NSR10	Fauna	69.1	61.3 – 65.7	69.8 – 70.7	-	Low
NSR11	Commercial	-	71.8	-	90.0	-
Pre-Construction Works						
NSR1	Residential	75.8	64.1	76.1	90.0	Low
NSR2	Residential	75.4	59.9	75.5	90.0	Low
NSR3	Residential	68.0	66.1	70.2	90.0	Low
NSR4	Residential	68.0	65.0	69.8	90.0	Low
NSR5	Commercial	78.6	63.0	78.7	90.0	Low
NSR6	School	78.9	53.6	78.9	80.9	Low
NSR7	Fauna	82.9	56.7 – 62.6	82.9	-	Low
NSR8	Fauna	71.8	56.3 – 64.6	71.9 – 72.6	-	Low
NSR9	Fauna	79.5	53.2 – 55.5	79.5	-	Low
NSR10	Fauna	69.1	56.4 – 62.4	69.3 – 69.9	-	Low
NSR11	Commercial	-	66.0	-	90.0	-

NSR Cluster	Type of NSR	Max Baseline Noise Level (dBA)	Noise Level from Construction Activities[1] (dBA)	Predicted Noise Level[2] (dBA)	Max Adjusted Permissible Level (dBA)	Impact Magnitude
Infrastructure Works						
NSR1	Residential	75.8	63.5	76.0	90.0	Low
NSR2	Residential	75.4	59.2	75.5	90.0	Low
NSR3	Residential	68.0	65.2	69.8	90.0	Low
NSR4	Residential	68.0	65.0	69.8	90.0	Low
NSR5	Commercial	78.6	63.0	78.7	90.0	Low
NSR6	School	78.9	53.4	78.9	80.9	Low
NSR7	Fauna	82.9	56.4 – 62.3	82.9	-	Low
NSR8	Fauna	71.8	56.2 – 64.4	71.9 – 72.5	-	Low
NSR9	Fauna	79.5	52.7 – 55.1	79.5	-	Low
NSR10	Fauna	69.1	56.3 – 62.3	69.3 – 69.9	-	Low
NSR11	Commercial	-	66.0	-	90.0	-
Building Works						
NSR1	Residential	75.8	63.4	76.0	90.0	Low
NSR2	Residential	75.4	58.6	75.5	90.0	Low
NSR3	Residential	68.0	63.5	69.3	90.0	Low
NSR4	Residential	68.0	65.4	69.9	90.0	Low
NSR5	Commercial	78.6	60.5	78.7	90.0	Low
NSR6	School	78.9	57.5	78.9	80.9	Low
NSR7	Fauna	82.9	55.6 – 61.4	82.9	-	Low
NSR8	Fauna	71.8	56.2 – 64.8	71.9 – 72.6	-	Low
NSR9	Fauna	79.5	51.6 – 54.2	79.5	-	Low
NSR10	Fauna	69.1	55.7 – 61.8	69.3 – 69.8	-	Low
NSR11	Commercial	-	63.1	-	90.0	-

Note:

Red indicates exceedance of maximum baseline noise level

Noise levels and impact magnitudes for NSR7 – NSR10 accounts for both ground-dwelling and arboreal fauna

[1] Noise modelling output. Noise level is from construction activities only, without background noise

[2] Addition of background noise to modelling output

7.5.4 Recommended Mitigation Measures

Based on modelling trials, the following measures are recommended:

- Noise barriers of varying heights positioned along designated construction site boundaries for different stages (**Scenario 1** to **Scenario 4**), illustrated in **Figure 7-3** to **Figure 7-5** and consideration for the barrier design listed below:
    - Strip footing of the noise barriers should be placed at designated work site and not within the PRA to avoid extensive vegetation clearance within the PRA.
    - At the steep zone along the eastern boundary between the PRA and future land use parcellation (refer to **Figure 7-4**), the noise barrier is recommended installed after site leveling.
    - Heights and locations of barriers and dimension of strip footing (typically 2m x 2m for a 12-m height noise barrier) shall be confirmed and refined during the detailed design and EMMP stages to ensure compliance with regulatory requirements and site-specific conditions (i.e., terrain, soil physical properties, etc.).
- Reduction of sound power levels at sources as specified in **Table 7-14**.

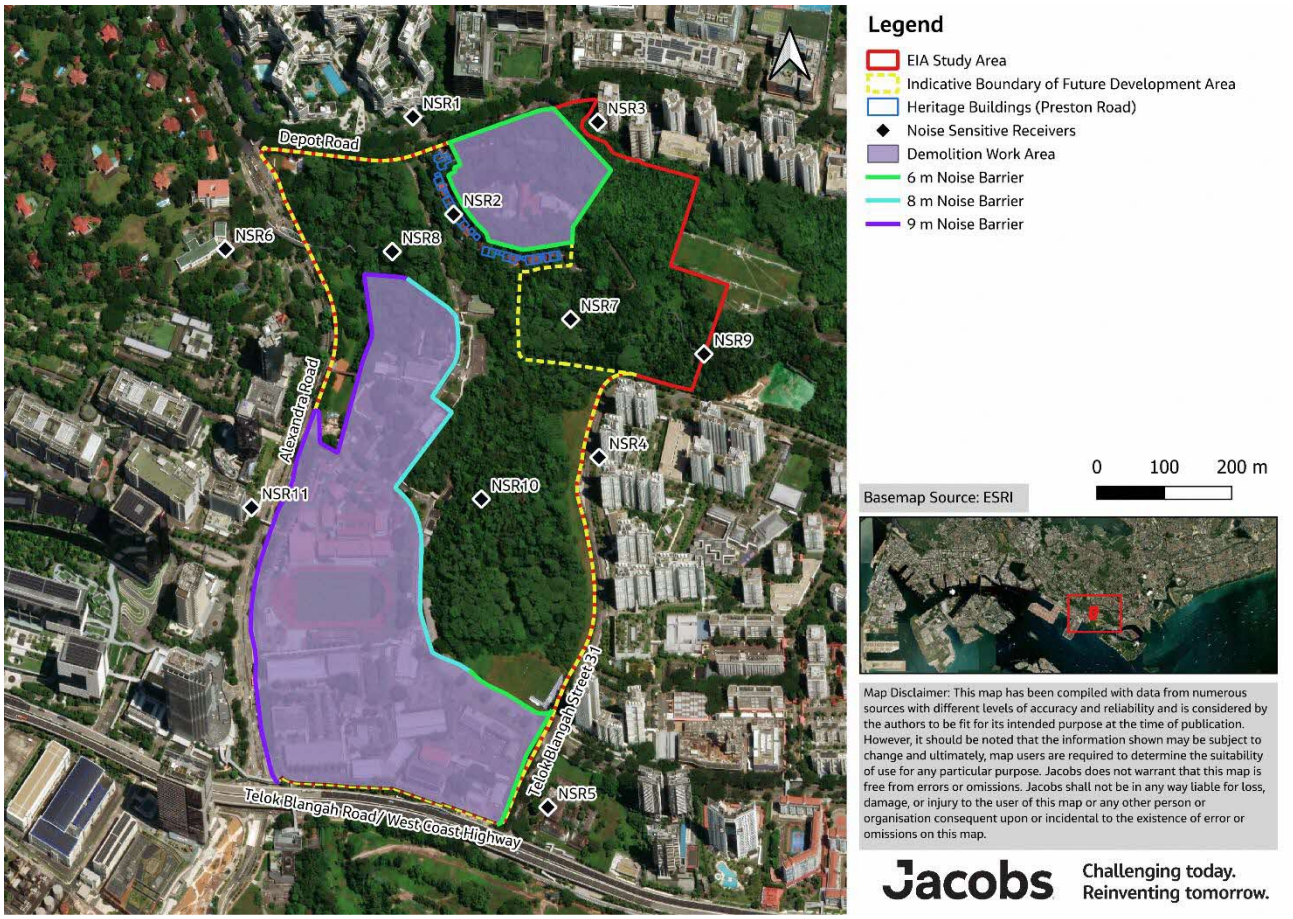


Figure 7-3: Recommended Location of Noise Barriers for Scenario 1: Demolition Works

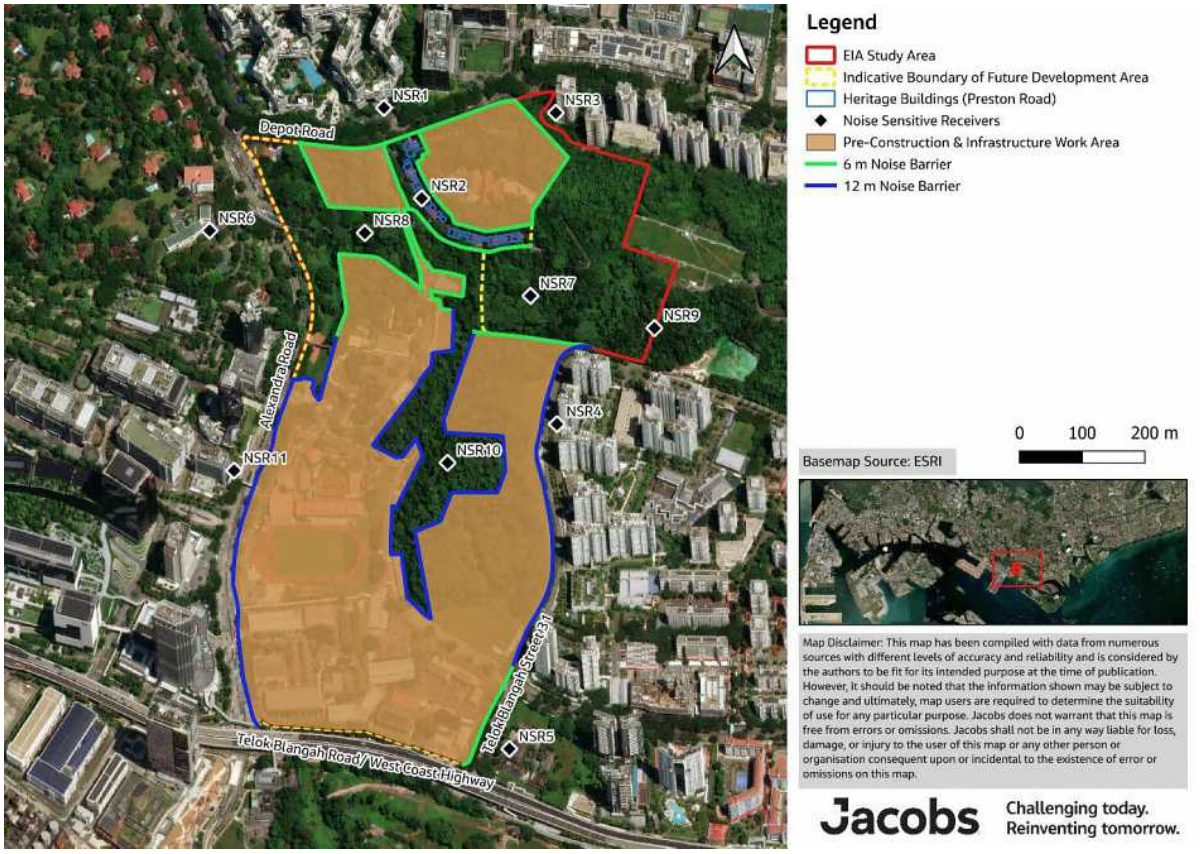


Figure 7-4: Recommended Location of Noise Barriers for Scenario 2 and 3: Pre-Construction (Land Preparation) and Infrastructure Work

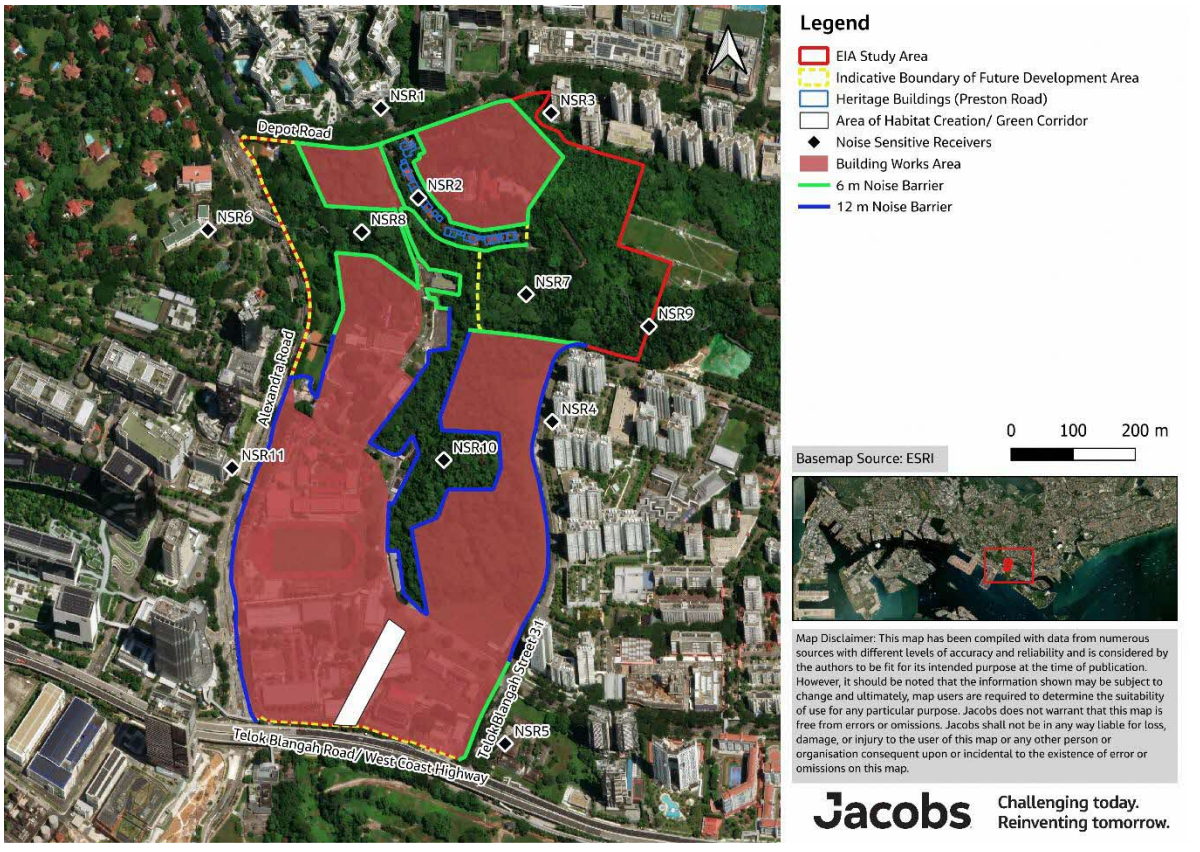


Figure 7-5: Recommended Location of Noise Barriers for Scenario 4: Building Works

7.6 Residual Impact

The recommended mitigation measures will help to reduce noise impacts during the construction phase of the proposed development. Following their implementation, the residual noise impact significance is expected to be **Slight Negative** to **Minor Negative**. A summary of the evaluated residual impacts is presented in **Table 7-17** and **Table 7-18**, while a detailed breakdown by specific receptors, construction stages, and associated residual impacts is provided in **Appendix 7D**.

Table 7-17: Summary of Evaluation of Residual Impacts (L_{Aeq} 12 hours)

Impact Register	Before Mitigation Measures		Post-Mitigation Measures	
	Environmental Score (ES)	Range Bands of ES/ Impact Significance	Environmental Score (ES)	Range Bands of ES/ Impact Significance
Demolition Works				
Noise emission from construction site to NSR1	-108	Minor Negative	-72	Minor Negative
Noise emission from construction site to NSR2	-108	Minor Negative	-36	Slight Negative
Noise emission from construction site to NSR3	-108	Minor Negative	-108	Minor Negative
Noise emission from construction site to NSR4	-120	Minor Negative	-80	Minor Negative
Noise emission from construction site to NSR5	-120	Minor Negative	-40	Slight Negative
Noise emission from construction site to NSR6	-72	Minor Negative	-36	Slight Negative
Noise emission from construction site to NSR7	-162	Moderate Negative	-54	Slight Negative
Noise emission from construction site to NSR8	-162	Moderate Negative	-54 to -108	Slight to Minor Negative
Noise emission from construction site to NSR9	-108 to -162	Minor to Moderate Negative	-54	Slight Negative
Noise emission from construction site to NSR10	-180	Moderate Negative	-60 to -120	Slight to Minor Negative
Pre-Construction Works				
Noise emission from construction site to NSR1	-108	Minor Negative	-36	Slight Negative
Noise emission from construction site to NSR2	-108	Minor Negative	-36	Slight Negative
Noise emission from construction site to NSR3	-108	Minor Negative	-72	Minor Negative

Impact Register	Before Mitigation Measures		Post-Mitigation Measures	
	Environmental Score (ES)	Range Bands of ES/ Impact Significance	Environmental Score (ES)	Range Bands of ES/ Impact Significance
Noise emission from construction site to NSR4	-120	Minor Negative	-80	Minor Negative
Noise emission from construction site to NSR5	-120	Minor Negative	-40	Slight Negative
Noise emission from construction site to NSR6	-108	Minor Negative	-36	Slight Negative
Noise emission from construction site to NSR7	-162	Moderate Negative	-54	Slight Negative
Noise emission from construction site to NSR8	-162	Moderate Negative	-54 to -108	Slight to Minor Negative
Noise emission from construction site to NSR9	-162	Moderate Negative	-54	Slight Negative
Noise emission from construction site to NSR10	-180	Moderate Negative	-60	Slight Negative
Infrastructure Works				
Noise emission from construction site to NSR1	-120	Minor Negative	-40	Slight Negative
Noise emission from construction site to NSR2	-120	Minor Negative	-40	Slight Negative
Noise emission from construction site to NSR3	-120	Minor Negative	-80	Minor Negative
Noise emission from construction site to NSR4	-132	Moderate Negative	-88	Minor Negative
Noise emission from construction site to NSR5	-132	Moderate Negative	-44	Slight Negative
Noise emission from construction site to NSR6	-120	Minor Negative	-40	Slight Negative
Noise emission from construction site to NSR7	-180	Moderate Negative	-60	Slight Negative
Noise emission from construction site to NSR8	-180	Moderate Negative	-60 to 120	Slight to Minor Negative
Noise emission from construction site to NSR9	-180	Moderate Negative	-60	Slight Negative
Noise emission from construction site to NSR10	-198	Moderate Negative	-66	Minor Negative

Impact Register	Before Mitigation Measures		Post-Mitigation Measures	
	Environmental Score (ES)	Range Bands of ES/ Impact Significance	Environmental Score (ES)	Range Bands of ES/ Impact Significance
Building Works				
Noise emission from construction site to NSR1	-120	Minor Negative	-40	Slight Negative
Noise emission from construction site to NSR2	-120	Minor Negative	-40	Slight Negative
Noise emission from construction site to NSR3	-120	Minor Negative	-80	Minor Negative
Noise emission from construction site to NSR4	-132	Moderate Negative	-88	Minor Negative
Noise emission from construction site to NSR5	-132	Moderate Negative	-44	Slight Negative
Noise emission from construction site to NSR6	-120	Minor Negative	-40	Slight Negative
Noise emission from construction site to NSR7	-180	Moderate Negative	-60	Slight Negative
Noise emission from construction site to NSR8	-180	Moderate Negative	-60 to -120	Slight to Minor Negative
Noise emission from construction site to NSR9	-180	Moderate Negative	-60	Slight Negative
Noise emission from construction site to NSR10	-198	Moderate Negative	-66	Minor Negative

Table 7-18: Summary of Evaluation of Residual Impacts (L_{Aeq} 5 mins)

Impact Register	Before Mitigation Measures		Post-Mitigation Measures	
	Environmental Score (ES)	Range Bands of ES/ Impact Significance	Environmental Score (ES)	Range Bands of ES/ Impact Significance
Demolition Works				
Noise emission from construction site to NSR1	-36	Slight Negative	-36	Slight Negative
Noise emission from construction site to NSR2	-72	Minor Negative	-36	Slight Negative
Noise emission from construction site to NSR3	-108	Minor Negative	-36	Slight Negative
Noise emission from construction site to NSR4	-80	Minor Negative	-40	Slight Negative

Impact Register	Before Mitigation Measures		Post-Mitigation Measures	
	Environmental Score (ES)	Range Bands of ES/ Impact Significance	Environmental Score (ES)	Range Bands of ES/ Impact Significance
Noise emission from construction site to NSR5	-40	Slight Negative	-40	Slight Negative
Noise emission from construction site to NSR6	-36	Slight Negative	-36	Slight Negative
Noise emission from construction site to NSR7	-54	Slight Negative	-54	Slight Negative
Noise emission from construction site to NSR8	-54 to -108	Slight to Minor Negative	-54	Slight Negative
Noise emission from construction site to NSR9	-54	Slight Negative	-54	Slight Negative
Noise emission from construction site to NSR10	-60 to -120	Slight to Minor Negative	-60	Slight Negative
Pre-Construction Works				
Noise emission from construction site to NSR1	-36	Slight Negative	-36	Slight Negative
Noise emission from construction site to NSR2	-72	Minor Negative	-36	Slight Negative
Noise emission from construction site to NSR3	-108	Minor Negative	-36	Slight Negative
Noise emission from construction site to NSR4	-120	Minor Negative	-40	Slight Negative
Noise emission from construction site to NSR5	-40	Slight Negative	-40	Slight Negative
Noise emission from construction site to NSR6	-36	Slight Negative	-36	Slight Negative
Noise emission from construction site to NSR7	-54	Slight Negative	-54	Slight Negative
Noise emission from construction site to NSR8	-54 to -108	Slight to Minor Negative	-54	Slight Negative
Noise emission from construction site to NSR9	-54	Slight Negative	-54	Slight Negative
Noise emission from construction site to NSR10	-120 to -180	Minor to Moderate Negative	-60	Slight Negative

Impact Register	Before Mitigation Measures		Post-Mitigation Measures	
	Environmental Score (ES)	Range Bands of ES/ Impact Significance	Environmental Score (ES)	Range Bands of ES/ Impact Significance
Infrastructure Works				
Noise emission from construction site to NSR1	-80	Minor Negative	-40	Slight Negative
Noise emission from construction site to NSR2	-80	Minor Negative	-40	Slight Negative
Noise emission from construction site to NSR3	-120	Minor Negative	-40	Slight Negative
Noise emission from construction site to NSR4	-132	Moderate Negative	-44	Slight Negative
Noise emission from construction site to NSR5	-88	Minor Negative	-44	Slight Negative
Noise emission from construction site to NSR6	-40	Slight Negative	-40	Slight Negative
Noise emission from construction site to NSR7	-60	Slight Negative	-60	Slight Negative
Noise emission from construction site to NSR8	-120 to -180	Minor to Moderate Negative	-60	Slight Negative
Noise emission from construction site to NSR9	-60	Slight Negative	-60	Slight Negative
Noise emission from construction site to NSR10	-198	Moderate Negative	-66	Minor Negative
Building Works				
Noise emission from construction site to NSR1	-80	Minor Negative	-40	Slight Negative
Noise emission from construction site to NSR2	-80	Minor Negative	-40	Slight Negative
Noise emission from construction site to NSR3	-120	Minor Negative	-40	Slight Negative
Noise emission from construction site to NSR4	-132	Moderate Negative	-44	Slight Negative
Noise emission from construction site to NSR5	-44	Slight Negative	-44	Slight Negative
Noise emission from construction site to NSR6	-40	Slight Negative	-40	Slight Negative

Impact Register	Before Mitigation Measures		Post-Mitigation Measures	
	Environmental Score (ES)	Range Bands of ES/ Impact Significance	Environmental Score (ES)	Range Bands of ES/ Impact Significance
Noise emission from construction site to NSR7	-60	Slight Negative	-60	Slight Negative
Noise emission from construction site to NSR8	-120 to -180	Minor to Moderate Negative	-60	Slight Negative
Noise emission from construction site to NSR9	-60	Slight Negative	-60	Slight Negative
Noise emission from construction site to NSR10	-132 to -198	Moderate Negative	-60	Minor Negative

7.7 Contract Specific Preventative and Mitigation Measures

At the time of preparing this EIA, detailed information on the actual construction equipment inventory, utilisation schedule, and site-specific mitigation measures is unavailable, as the appointed contractor has not yet been confirmed. Consequently, the noise modelling and recommended mitigation measures presented in this report are based on conservative assumptions and indicative equipment specifications.

To ensure effective management of noise impacts and maintain the practicality and relevance of mitigation measures under actual site conditions, the appointed contractor shall prepare a refined Noise Management Plan (NMP) as part of the Contract-Specific EMMP (CEMMP). This plan shall:

- Update Noise Modelling
  - Incorporate actual construction methodology, equipment list, and verified sound power levels.
  - Validate the EIA findings and confirm compliance with applicable noise criteria and ALARP principles.
- Refine Mitigation Measures
  - Review and optimise source control measures (e.g., quieter equipment, mufflers, enclosures).
  - Determine the specification, location, and height of noise barriers based on updated modelling and site utilisation layout.
  - Ensure barriers are installed at the earliest practicable stage of the project timeline.
- Monitoring and Verification
  - Include procedures for on-site noise monitoring during construction.
  - Establish trigger levels and corrective actions if noise exceeds predicted levels.

The contractor shall submit the refined NMP as part of the CEMMP workplan for approval by NParks and relevant agencies prior to construction works. The plan must clearly demonstrate how the proposed measures will achieve the required noise reduction objectives and minimise residual impacts on NSRs.

8. Environmental Management and Monitoring Plan

8.1 Overview

This Section outlines a preliminary broad Environmental Management and Monitoring Plan (EMMP) specification and its structure which consists of the requirement of policy statement, organisational structure with assigned roles and responsibilities, reporting and communication plans, management and monitoring measures, and training programme that will be put in place during the pre-construction, construction and post-construction/ operation phase of the proposed development for implementation of all the recommended prevention and mitigation measures in the preceding sections.

8.2 Purpose of EMMP

An EMMP for project-specific implementation during the pre-construction, construction and post-construction phases has the following purposes for:

- Commitment of compliance with mitigation and enhancement measures identified in this EIA as well as the relevant environmental legislation by responsible parties during various stages of development.
- Basis of guidance to the appointed Project Consultant and Main Contractor in developing an EMMP for implementing appropriate environmental controls and monitoring procedures.
- Basis of guidance to the future developer/developing agency in establishing impact registers and management protocols to minimise the identified environmental impact during the construction phase.
- Performance monitoring and auditing of the actual environmental impact of the proposed development during different stages of development.

8.3 Change Management and Review Process

The EIA has been prepared based on information available at the design stage of the proposed development. The EMMP may be updated once the detailed design is approved for the construction works. In particular, the recommended mitigation measures in this EIA may be revised in detail in parallel with the approved design for the proposed development.

For each of the issues identified as impact in the preceding sections, suitable mitigation measures have been proposed to reduce the significance of each impact type or to avoid the impact occurring at all. In tandem with the assessment and mitigation steps, the expected impact and their associated mitigation measures must be monitored to determine the effectiveness of mitigation and to revise relevant mitigation measures that are shown to be inadequate or unsuccessful based on monitoring.

As the EMMP functions as a "live document", it will be subject to periodic review and updates as additional project information becomes available and through continued consultation with relevant technical agencies. The change management review process will comprise the following key component:

- Identification of change triggers – new project design details of construction methodologies, updated regulatory requirements or guidelines, findings from ongoing monitoring and audits, etc.
- Environmental impact register evaluation – assessment of potential implications of proposed changes on environmental performance and determination of whether additional measures are required.
- Stakeholder consultation – engagement with technical agencies and relevant stakeholders to validate proposed revisions, documentation of feedback and integration into the EMMP.
- Formal endorsement of changes by the project environmental management team. Version control and record-keeping to maintain transparency and traceability.

8.4 Contract-Specific EMMP Structure

A Contract-Specific EMMP is required to be developed by the appointed Project Consultant and Contractors (this shall be referred to by all contractors for various stages of construction phase). The Contract-Specific EMMP shall include but not be limited to the following scopes where their respective specifications are described in the following subsections.

- Project description.
- Project environmental policy and objectives.
- EMMP organisation structure.
- EMMP roles and responsibilities.
- Reporting and communication plans.
- Training programme.
- Environmental impact register with identified sensitive receivers from the EIA findings (key aspect of concerns), potential impact with their respective mitigation and/or enhancement measures to be implemented, including the wildlife shepherding plan for wildlife migration out of the project construction boundary.
- Environmental performance inspection and monitoring regime for aspects such as noise, water quality and biodiversity to be conducted during the pre-construction, construction and post-construction/operation periods.
- Environmental audit programme.
- Contingency plan.
- Stakeholder engagement and management.

8.4.1 Project Description

The Contractor is required to include a description of the proposed development with the following key content:

- Overall site utilisation and layout plan.
- Construction method statements.
- Utilities and services plan.
- Access (e.g., vehicular entrances and vehicle movement to the work site).
- Construction material and chemical storages, soil stockpile area, etc.
- Hoarding and tree felling plan.
- Construction sequence.
- Waste handling and management.

8.4.2 Project Environmental Policy and Objectives

The Contractor is required to establish a project-specific environmental policy that affirms their commitment to EMMP implementation. The project-specific environmental policy should cover the following:

- Commitment from the company's management on environmental safeguarding for the proposed development.
- Compliance with all applicable environmental legislation and relevant requirements including mitigation measures from this EIA and industry best practices.
- Commitment to prevent pollution.
- Commitment to continually improve environmental performance by setting and reviewing environmental objectives and targets.
- Communication and education plans with all associated persons/ affected communities/ stakeholders to achieve environmental goals.

8.4.3 EMMP Organisation Structure

8.4.3.1 Pre-construction/ Construction Phase

The future developer/developing agency will be responsible for overseeing the Contractor, its subcontractors, and any third parties in implementing the EMMP during the pre-construction and construction phases of the proposed development for their respective land parcels within the indicative boundary of future development area. The Technical Agencies (i.e., NParks, NEA), along with relevant authorities and stakeholders (i.e., LTA, PUB) will provide guidance on requirements and coordinate with future developer/developing agency on issues related to interfacing works where cumulative impacts are identified. A recommended organisation structure for EMMP implementation during pre-construction/construction phase is presented in **Figure 8-1**.

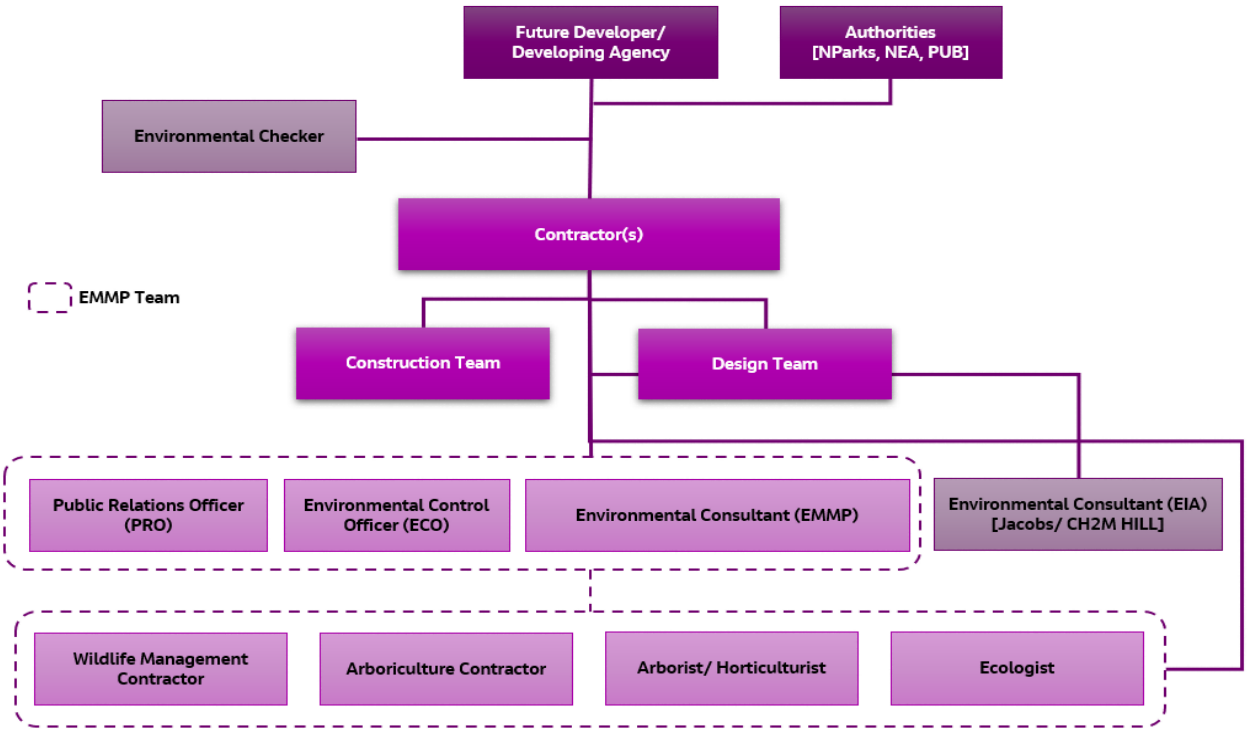


Figure 8-1: Recommended Organisation Chart and Line of Communication for EMMP Implementation during Pre-Construction/ Construction Phase

8.4.3.2 Post-construction/ Operation Phase

For the post-construction/ operational phases, any concerns related to environmental and ecological risk should be directed to the Environmental, Health and Safety Officer and/or Public Relation Officer or their equivalent from the respective developing agencies (e.g., HDB/ URA) and relevant agencies such as NParks, PUB, LTA and National Heritage Board (NHB) for the various development parcels within the EIA Study Area. The recommended lines of communication for environmental protection works involving the various parties responsible for implementing the EMMP during this phase are illustrated in **Figure 8-2**.

Figure 8-2: Recommended Organisation Chart and Line of Communication for EMMP Implementation during Post-construction/ Operation Phase Key Impact Assessment for Flora and Fauna

8.4.4 EMMP Roles and Responsibilities

8.4.4.1 Pre-construction/ Construction Phase

The roles and responsibilities for each key party in the recommended EMMP Organisation Structure during the pre-construction/ construction phase is given on **Table 8-1**.

Table 8-1: Roles and Responsibilities of Key Parties in Recommended EMMP Organisation Structure during Pre-Construction/ Construction Phase

Role	Party	Key Responsibilities
Developing Agency/ Project Owner	Future Developer/ Developing Agency	▪ Accountable for the overall environmental performance throughout the entire Project lifecycle. ▪ Assume ultimate ownership for project compliance and adherence to relevant environmental legislation, guidelines, and industry best practices.
Project Management and Construction Supervision	Future Developer/ Developing Agency QP (Supervision) Team	▪ Responsible for the overall management of proposed development, ensuring full commitment to the environmental policy and effective implementation of the EMMP. ▪ Review internal and external audit reports pertaining to environmental management for the respective developments. ▪ Communicate agency requirements and EIA obligations to the Contractors. ▪ Supervise and oversee construction works carried out by the Contractor(s) in compliance with contractual requirement, as well as the engineering, construction and EMMP specifications established by the Developing Agency and relevant Authorities. ▪ Monitor the implementation of the EMMP to ensure compliance with contract specifications and applicable environmental legislative requirements.

Role	Party	Key Responsibilities
		▪ Conduct audits to verify the accuracy, completeness, and compliance of environmental performance monitoring activities against established standards and contractual requirements. ▪ Initiate and implement the appropriate response plans promptly in the event of any environmental exceedances or incidents, ensuring mitigation measures are executed in accordance with regulatory and contractual requirements. ▪ Conduct investigations into environmentally-related complaints, where applicable, ensuring timely resolution and documentation in accordance with regulatory and contractual requirements.
Contractor	To be Appointed	▪ Responsible for executing the contract in full compliance with applicable environmental legislation, environmental policies, and the mitigation and enhancement measures recommended in the EIA, as stipulated by the relevant authorities and the Developing Agency. ▪ Employ and appoint an Environmental Monitoring and Management team, comprising the Consultant and adequately supported by specialist teams covering scopes such as water quality, noise control, wildlife shepherding, and flora and fauna monitoring. ▪ Appoint a Public Relation Officer (PRO) to assist the Superintending Officer (SO) in conducting complaint investigations. ▪ Establish method statements in accordance with the recommended mitigation measures, and provide the Contract-Specific EMMP Team with relevant information on potential activities that may result in adverse environmental conditions. ▪ Participate in site audits conducted by the independent third-party Environmental Performance Auditor and implement corrective actions as directed by the Auditor. ▪ Submit proposal for mitigation measures should there be an exceedances or incidents. ▪ Implement approved mitigation measures to reduce the potential impacts from exceedances or incidents. ▪ Submit periodic environmental performance monitoring reports to SO for review.
Environmental Consultant (EIA)	Jacobs	▪ Recommend environmental parameters to be managed and monitored in the EMMP. ▪ Recommend environmental performance monitoring and auditing scheme to be transform as part of Contract specification requirement.

Role	Party	Key Responsibilities
Environmental Consultant (EMMP)	TBA	▪ Prepare and develop a Contract-Specific EMMP based on the detailed construction method and the EMMP developed during the EIA. ▪ Submit to all relevant Authorities, including but not limited to NEA, NParks and the SO for approval prior to the commencement of the works.
Environmental Checker	TBA	▪ Support the SO as an environmental advisory role. ▪ Conduct environmental site inspections. ▪ Conduct environmental performance audits. ▪ Review environmental monitoring and management regime. ▪ Review implementation of environmental protection measures. ▪ Advise remediation actions for contingency scenarios.

8.4.4.2 Post-construction/ Operation Phase

The roles and responsibilities for each key party in the recommended EMMP Organisation Structure during the post-construction/operational phase is given on **Table 8-2**.

Table 8-2: Roles and Responsibilities of Key Parties in Recommended EMMP Organisation Structure during Post-Construction/ Operation Phase

Role	Party	Key Responsibilities
Developing Agency/ Project Owner (Operation/ Building Management Division)	Future Developer/ Developing Agency NParks/ LTA/ NHB	▪ Accountable for the comprehensive management of operation and building management, ensuring full adherence to the organisation' environmental policy and the effective implementation of the EMMP. ▪ Assume ultimate ownership for project compliance and adherence to relevant environmental legislation, guidelines, and industry best practices. ▪ Review internal and external audit reports pertaining to environmental management for the operation. ▪ Communicate agency requirements and EIA obligations to all appointed contractors during operational phases and building/ infrastructure/ utilities maintenance activities. ▪ Conduct audits to verify the accuracy, completeness, and compliance of environmental performance monitoring activities against established standards and contractual requirements. ▪ Initiate and implement the appropriate response plans promptly in the event of any environmental exceedances or incidents, ensuring mitigation measures are executed in accordance with regulatory and contractual requirements. ▪ Conduct investigations into environmentally-related complaints, where applicable, ensuring timely resolution and documentation in accordance with regulatory and contractual requirements.

Role	Party	Key Responsibilities
Environmental, Health and Safety (EHS) Officer/ Public Relation Officer (PRO) or equivalent	TBA	▪ Conduct environmental site inspections. ▪ Conduct environmental performance audits. ▪ Review environmental monitoring and management regime. ▪ Review implementation of environmental protection measures. ▪ Advise remediation actions for contingency scenarios.

8.4.5 Reporting and Communication Plan

All documentation throughout the construction contract period/ contract should exist in a written format and be filed in a traceable and systematic manner. The Contractor is to establish templates for reporting for approval by the Developing Agency prior to commencement of contract works. All documentation templates/ formats should be clearly communicated to potential users (i.e., Project Management Team, Project Consultants and Contract Specific EMMP Team). The documents shall include the following at a minimum:

- Minutes of records and attendance records for all meetings and trainings related to the environment.
- Special management plan and/or technical records.
- Method statement for construction approved by Developing Agency and SO.
- Environmental inspection reports.
- Environmental performance monitoring reports.
- Environmental audit reports.
- Non-compliance and remedial action plans.

All documents should be kept throughout the construction contract and defects-liability periods.

8.4.6 Specific Management and Monitoring Programme

The Environmental Impact Register outlined in **Section 9** is recommended as a management and monitoring tool. Continuous Compliance Monitoring is recommended throughout the various development phases by both the Developing Agencies and Contractor.

8.4.7 Training Programme

The appointed contractors shall be responsible for conducting induction sessions and providing appropriate environmental training to all workers employed on the construction site. The primary objectives are to effectively communicate the requirements of the EIA and EMMP, promote awareness of environmental responsibilities, and build capacity for the implementation of mitigation measures. The recommended training programmes are listed but not limited to:

- Tree protection management plan.
- Wildlife awareness and response procedures.
- Earth control measures management plan.
- Noise management plan.
- Environmental incident response and reporting procedures.

The Superintending Officer (SO) shall conduct periodic reviews and update the training program requirements to ensure alignment with any changes in project information, regulatory obligations, or environmental management objectives.

8.4.8 Environmental Audit Programme

8.4.8.1 Pre-construction/ Construction Phase

The objective of environmental auditing is to provide an independent verification that appropriate environmental management practices are being implemented in compliance with statutory requirements and the EIA/EMMP. The audit will also assess monitoring results obtained during the construction phase to determine whether additional environmental management actions or mitigation measures are required.

The audit shall encompass all environmental issues related to construction activities as identified in the EIA report and addressed by the EMMP. The Environmental Audit shall be carried out by the Developing Agency's appointed Environmental Checker, ensuring impartiality and adherence to established standards. The activities to be undertaken as part of an environmental audit include:

- Examination of the environmental incidents and complaints log.
- Examination of the environmental register, including results of monitoring.
- Interviews with the Contractor's Project Manager, Contract-Specific EMMP representative(s) and ECO and other site staff as required.
- Consultation with relevant statutory authorities, where appropriate.
- Visual examination of the construction site, to examine working practices, environmental effects, mitigation measures and monitoring activities.

For this proposed development, it is recommended that environmental auditing be carried out on a quarterly (i.e., every three months) basis throughout the pre-construction/ construction phase.

8.4.8.2 Post-construction/ Operation Phase

An annual environmental audit is recommended during the post-construction/ operational phase to verify compliance of all implemented measures against the Environmental Impact Register and to assess any potential changes in project conditions.

Documentation during this period such as maintenance procedures log/ complaint log, shall be kept by the Developing Agencies/ Project Owner.

8.4.9 Contingency Plan

To safeguard the environment and ensure the health and safety of workers, the Contractor shall develop and implement an Emergency Preparedness and Response Plan (EPRP) addressing potential emergencies, incidents, and accidents that may occur during construction according to the regulations/ guidelines (e.g. Environmental Protection and Management Act, Environmental Public Health Act, Building Control Act, Control of Vectors and Pesticides Act, Code of Practice on Surface Water Drainage, National Heritage Board Act, Parks and Trees Act and Sewerage and Drainage Act).

The plan should include environmental related emergency/ incidents (i.e., spillage, wildlife incidents), which should cover the following recommended specifications:

- Emergency contact personnel and contact details (internal and external contacts).
- Emergency contact organisation, include first and second point of contacts.

- Incident response notification procedures and action flow chart.
- Response reporting timeframe.
- Reporting requirement (date, time, location, incident encounter, reporting person and witness) and reporting timeframe (i.e., within 24 hours of an incident occurring).
- Reporting flow, i.e., report should be prepared by Contractor's appointed Ecologist/ EMMP Team and ultimately reporting to Developing Agency.

8.4.10 Stakeholder Engagement and Communication Plan

A dedicated Stakeholder Engagement Plan and Grievance Mechanism procedures shall be established and incorporated into the Contract-Specific EMMP, in accordance with the following specifications:

- Stakeholder identifications and analysis, i.e., nature groups (NG) engaged during the EIA stage.
- Information disclosure. The type of information should be on environmental impact and public safety concerns.
- Stakeholder consultation requirements.
- Communication channels where project information can be shared and communicated to affected communities and the public to provide greater transparency and help in allaying uncertainty or misconceptions about the proposed development.
- A grievance mechanism/ procedure to handle feedback and complaints to incorporate input from various stakeholders and the public.
- Organisation chart with roles and responsibilities for stakeholder engagement and grievance mechanism.
- Documentation and investigation procedures.
- Performance monitoring and evaluation of effectiveness of plan.

8.5 Biodiversity Monitoring Programme Requirement

As part of the CEMMP, a comprehensive Biodiversity Management and Monitoring Plan shall be developed prior to the start of any construction works. The plan shall detail measures to detect, minimise and manage anticipated impacts on biodiversity during both construction and early operation phases. In the following section, a recommended biodiversity monitoring programme is outlined, for implementation by the Contractor under the supervision of the Superintending Officer (SO) and representatives from future developer/ developing agency for their respective land parcels.

8.5.1 Pre-construction/ Construction Phase

8.5.1.1 Flora Management and Monitoring Plan

The recommended flora and arboriculture programme aims to assess and manage the impact of construction to retained vegetation and habitats (i.e., retained forest patch or adjacent forested areas), such as tree health, unauthorised vegetation removal, habitat degradation from soil erosion, and rubbish dumping.

This includes the reviewing of tree felling and site clearance plans (**Section 8.5.1.1.1**), establishment of tree protection zones (**Section 8.5.1.1.2**), verification and reviewing of site works (**Section 8.5.1.1.3**), transplantation of species of conservation significance (**Section 8.5.1.1.4)** and site inspections (**Section 8.5.1.1.5; Section 8.5.1.1.6**).

8.5.1.1.1 Review of Tree Felling and Site Clearance Plans

The Contractor shall appoint an International Society of Arboriculture (ISA) certified arborist(s) to review the tree felling and site clearance plans. The Arborist's role is to determine the trees to be retained or felled before the commencement of construction activities. This includes the assessment of tree physiological health, vigour, and structural stability, photographs, as well as the geographic locations of each specimen. This should apply to trees within the development footprint, including working spaces, construction access roads, and hoarding boundaries.

Any horticultural waste resulting from vegetation clearance should be disposed of on the same day to reduce the likelihood of fauna seeking shelter among the horticultural waste.

8.5.1.1.2 Establishment of Tree Protection Zones (TPZs)

Tree Protection Zones (TPZs) are to be erected for tree specimens recommended for retention by the Arborist, including the trees recommended for conservation from the EIA. These specimens could be within the development footprint and/or very close to but are outside the worksite boundary. Proper TPZs with a designated access for monitoring purposes should be established according to guidelines outlined in NParks' Guidelines on Greenery Provision and Tree Conservation for Developments (NParks, 2018). Measures should be proposed to ensure trees remain protected from damage from adjacent construction works including site access. This should be executed in consultation with the structural engineers and in accordance with the guidelines established by NParks. Construction works, such as tree felling and works in the 'no-go zone' for laying of footpaths/ roads, would require the Arborist to oversee the works.

In the event of observed damage to flora and trees, the Contractor shall carry out the following steps:

a) Take immediate action to avoid further damage to the surrounding flora and trees.

b) Notify future developer/developing agency for further assessment and determine the retention value of affected trees.

c) Implement the mitigation measures as per the approved Contract-Specific EMMP.

8.5.1.1.3 Verification and Review of Footprints for Hoarding, Worksite Boundaries, and Access Roads

Following the pegging of the hoarding alignment or worksite boundaries, as well as setting out for areas required for access roads, site offices, storage yards, etc., the alignment and footprints are to be verified by the contractor's Flora Specialist via ground-truthing. This is to be carried out with the aid of a Global Positioning System (GPS) receiver and cross-checked with the development footprint drawings. The Flora Specialist should ensure there is no excessive vegetation and/or tree removal within the site. The Flora Specialist shall also review the proposed locations for access roads, site offices, storage yards, etc., to ensure vegetation removal is kept to a minimum where feasible.

8.5.1.1.4 Transplantation of Plant Species of Conservation Significance

For affected plant species of conservation significance located within the worksite identified for salvaging, they should be transplanted prior to the start of hoarding installation and clearance works. The Flora Specialist appointed by the Contractor(s) should carry out consultations with NParks to determine the final list of specimens to be transplanted. See **Appendix 4L** for list of species suitable for salvaging.

8.5.1.1.5 Arboriculture Inspection

The Contractor appointed Arborist shall carry out the following during the monthly arboriculture inspections:

- Assess the conditions of retained trees and trees within and around the worksite, i.e., physiological health, vigour, and structural stability, and recommended mitigation measures where necessary.
    a. Ensure they have not deteriorated and that there are no mechanical damages.
    b. Carry out rehabilitation and remediation measures if the trees exhibit signs of stress (e.g., implement a watering schedule to prevent plants from drying out).
    c. Implement long-term mitigation solutions or recommend additional tree removal where necessary.
- Review method statements from builders for construction in close proximity to trees.
- Determine if more trees need to be removed after site clearance based on the construction activities happening in proximity to the retained trees and liaise with NParks for permission where necessary.
- Ensure that works are carried in alignment with NParks' standards.

8.5.1.1.6 Flora Inspection

The Flora Specialist appointed by the Contractor(s) is recommended to carry out the following during the monthly flora inspections:

- Assess the impact of operations on the overall health of vegetation at proximity to the development.
- Identify excessive and/or unauthorised removal of vegetation beyond the development boundary.
- Monitor and assess potential edge effects (e.g., predictable failures, accelerated growth of climbers on canopy, change in species composition at the edge) within vegetation adjacent to development.
- Identify unauthorised dumping of rubbish (e.g., food materials), construction debris and materials, oil/chemical leakage that may contaminate soil and waterbodies after construction.

8.5.1.2 Wildlife Management and Monitoring Plan

The recommended fauna programme consists of managing concerns related to fauna within and around all designated work areas. The objectives of the fauna management plan are as follows:

- Minimise negative impact to fauna, particularly to species of conservation significance.
- Minimise fauna entrapment on-site by inspecting features such as hoarding that may cause fauna entrapment as well as use of 100% biodegradable erosion control blankets.
- Monitor presence of trapped/injured/dead fauna inside hoarded areas.
- Minimise roadkill risk by inspecting hoarding, ensuring there are no gaps in hoarding. This will prevent animals from exiting into roadkill-prone areas.
- Prevent human-wildlife conflict.

It includes directional site clearance (**Section 8.5.1.2.1**), pre-felling tree inspections for fauna (**Section 8.5.1.2.2**), daily fauna inspections (**Section 8.5.1.2.3**), monthly fauna inspection (**Section 8.5.1.2.4**), regular biodiversity awareness training for the site team and workers (**Section 8.5.1.2.6**), fauna response plan in event of animal encounters (**Section 8.5.1.2.6**), as well as monthly fauna monitoring surveys in the retained areas (**Section 8.5.1.2.7**).

8.5.1.2.1 Directional Site Clearance

The worksite is bounded along the perimeter by roads and/or urban developments. It is recommended for site clearance to be carried out in a directional manner, to shepherd fauna towards the Proposed Retained Areas and adjacent forests (e.g., Telok Blangah Hill Park outside of the EIA Study Area) before construction works begin to prevent fauna entrapment, and injury and mortality. Directional site clearance also prevents incidents of fauna entrapment within isolated green patches, which may otherwise occur if site clearance were to be carried out in an unspecified manner.

Before commencing site clearance, hoardings must be fully installed along the perimeter of the site to prevent fauna from leaving the site during vegetation clearance. With Telok Blangah Hill Park and the Proposed Retained Area within the boundary, the worksite is split into two contiguous patches.

The general proposed sequence and details for directional site clearance is provided below. A detailed and contract-specific plan will have to be developed by the appointed EMMP consultant/ Ecologist, together with the Contractor.

(a) Hoarding installation

- **Figure 8-3** shows the suggested hoarding boundaries, as well as the recommended sequence of installation. In the northern portion, it is recommended for the hoarding to be first erected along Depot Road, as it has heavier traffic and pose the greatest risk of fauna injury. In the southern portion, the priority would be along the large patch of exotic-dominated secondary forest and scrubland, starting with the edge along Telok Blangah St 31.
- All site clearance zones shall be enclosed with hoarding installed from zinc sheets with a minimum 1.8 m height for the entire duration of the site clearance works.
- The hoarding plan shall be reviewed and updated based on recommendations from the appointed Contract-Specific EMMP consultants in consultation with relevant agencies (e.g., NParks and NEA). The final hoarding plan shall incorporate the proposed contract parcellation, recommended locations and specifications for noise mitigation measures (i.e., noise barriers) identified in the EIA as well as NEA's new requirement for mandatory minimum 6m-high perimeter noise barriers at selected construction sites.

(b) Directional site clearance

- Directional site clearance to be carried out in the directions indicated in **Figure 8-4**. The disturbance generated by site clearance activities is expected to encourage target fauna to move towards TBHP and the PRA through the wildlife exit points. Target fauna species include ground-dwelling mammals such as the Sunda pangolin (*Manis javanica*), as well as animals that may be implicated in human-wildlife conflicts (e.g. snakes).

(c) Post-site clearance fauna inspection

- After site clearance has been completed, the Ecologists will visually inspect the site for presence of target fauna species (i.e., ground-dwelling birds and snakes). If there are no remaining fauna on site, the site clearance is then completed. If there are remaining fauna on-site, the Ecologists will develop methods to remove them in consultation with the Contractor and relevant authorities (e.g., NParks).

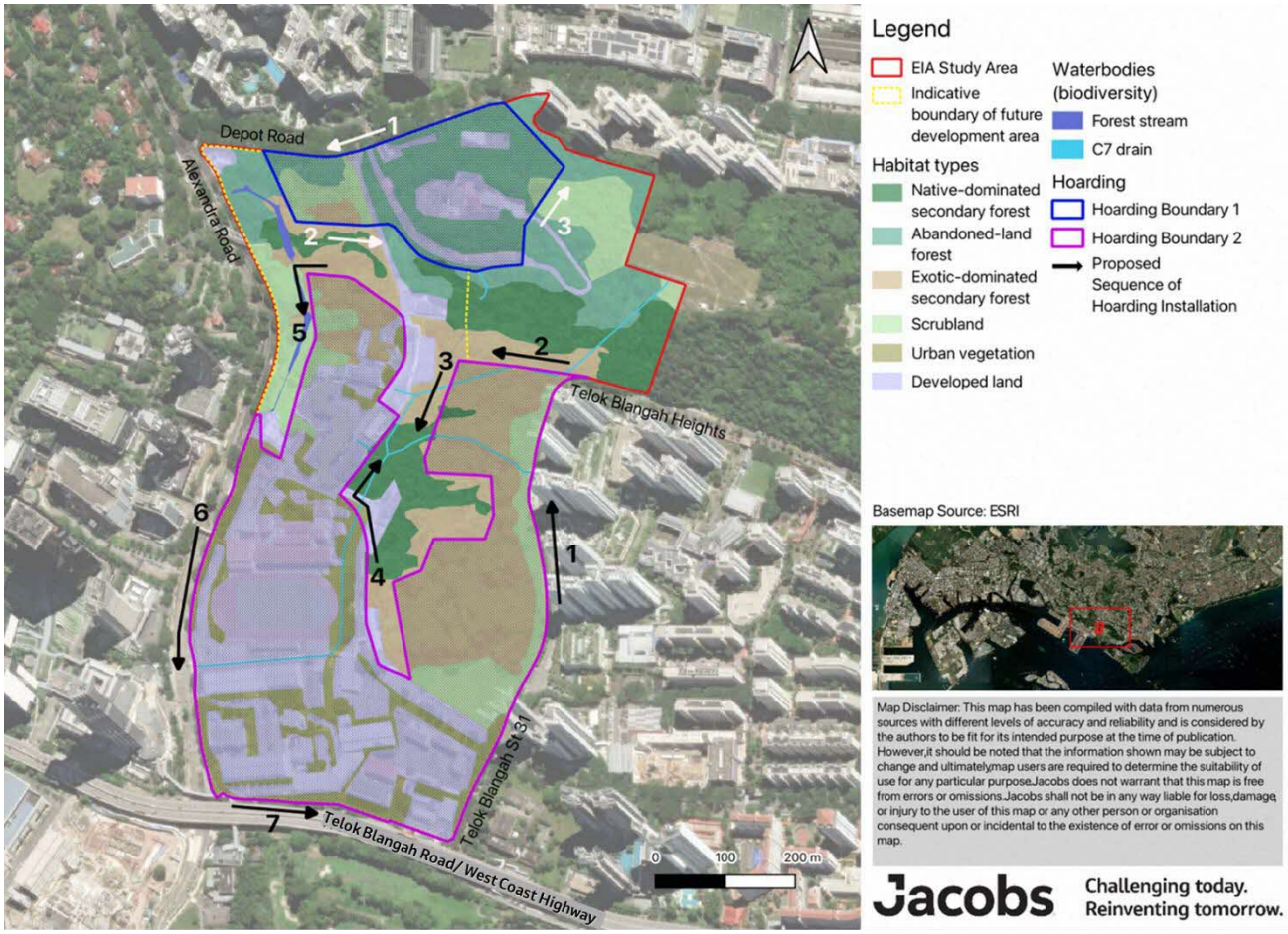


Figure 8-3: Recommended Hoarding Boundaries and Sequence of Installation for Directional Site Clearance

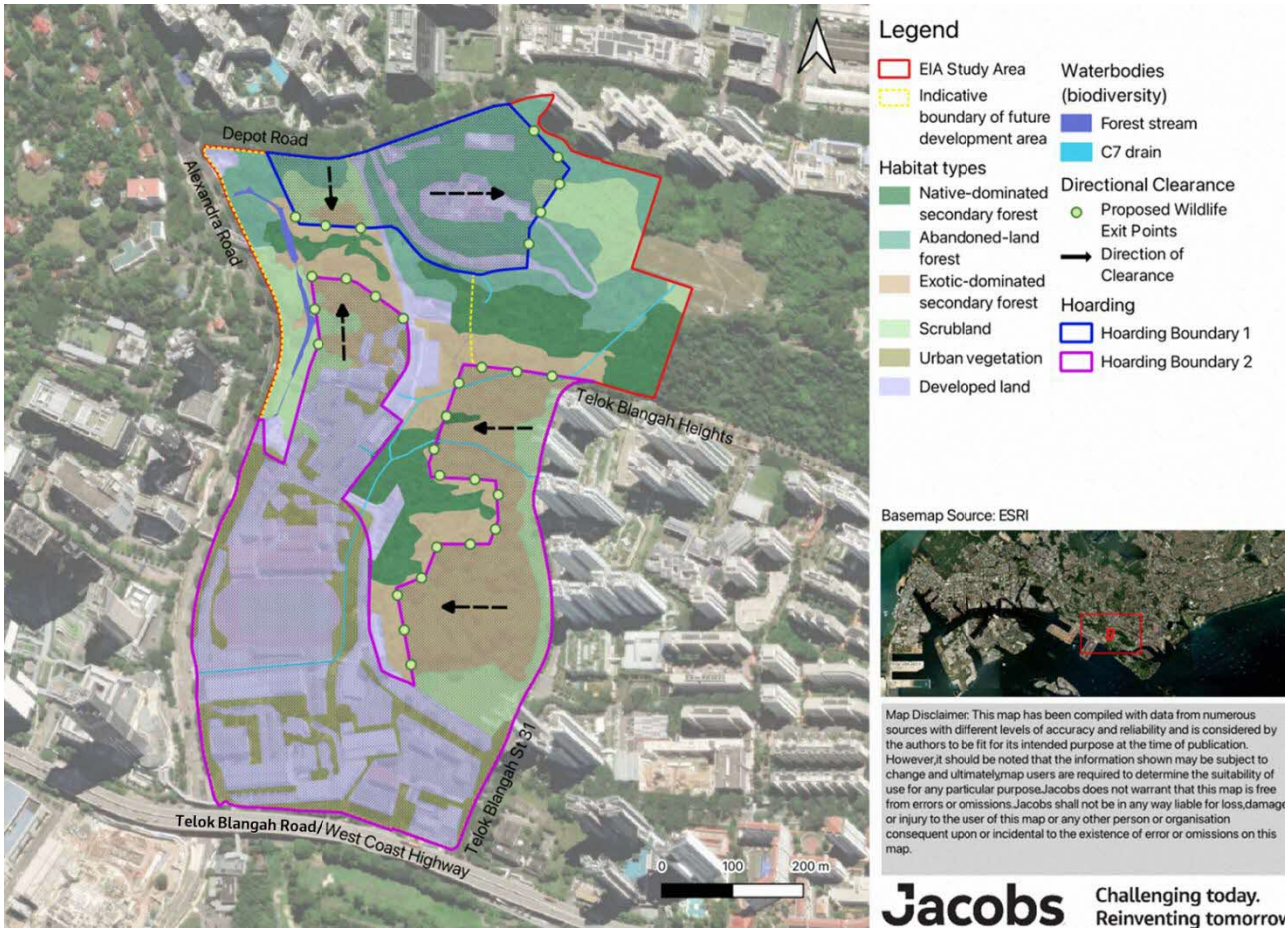


Figure 8-4: Proposed Direction of Site Clearance for Wildlife Shepherding

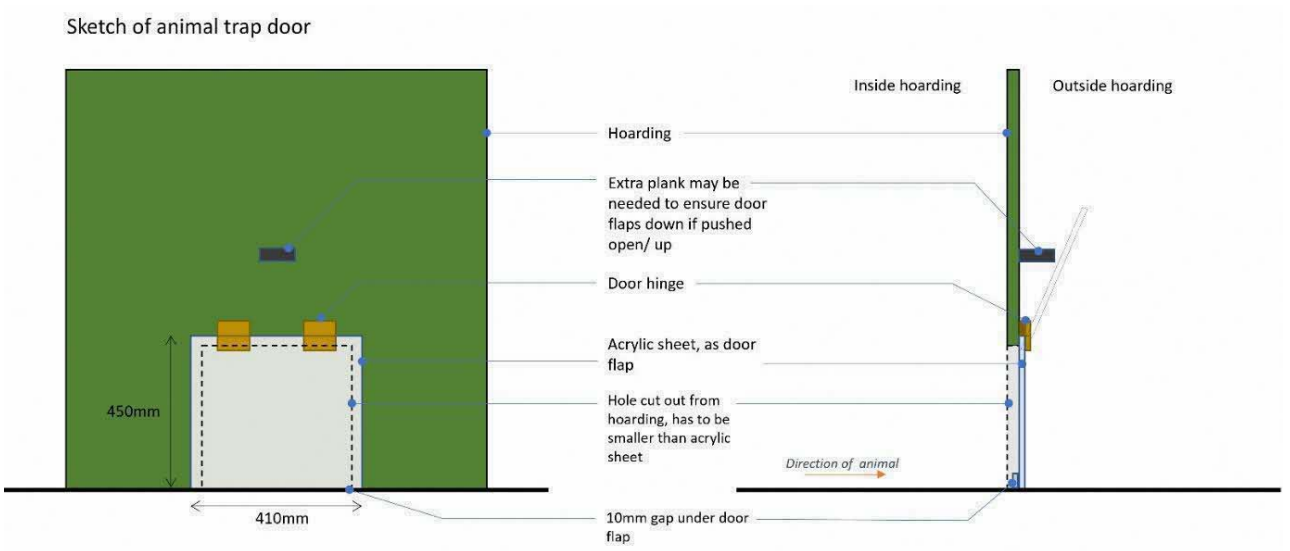


Figure 8-5: Sketch of Proposed One-way Trapdoor Wildlife Exit

8.5.1.2.2 Pre-felling Fauna Inspection

Pre-felling fauna inspections shall be carried out by Ecologist(s) appointed by the Contractor. Clearance of undergrowth will first be conducted prior to felling of trees on site. After completion of undergrowth clearance, each zone shall be left to fallow for three days to encourage arboreal fauna to leave the site, before clearance of remaining trees within the zone can take place. No vegetation clearance can take place within this fallow period of three days. Pre-felling inspections for the undergrowth and remaining trees can be conducted together on the first day of each round of inspection.

a) Conduct pre-site clearance fauna inspections for trees and non-tree vegetation to be removed (see **Figure 8-6**). The pre-site clearance fauna inspection includes the identification and reporting of the following:

    - Active bird nests, including hollows, and other forms of nesting structures utilised by birds.
    - Active mammal nests/burrows/roosts.
    - Other less mobile animals that are at risk of injury/mortality during tree felling or vegetation removal (e.g., Sunda pangolin).
    - Animals that may be susceptible to human-wildlife conflict (e.g., snakes).

b) Check tree trunks, branches and canopy with binoculars from multiple angles and distances. Any cavities in tree trunks that may be utilised as nesting/ roosting structures are to be noted for closer inspection if deemed potentially active. If a nest is potentially identified and activity level is uncertain, the Ecologist will conduct or supervise the closer investigation of the nest site utilising elevating equipment where required.

c) Produce a pre-felling fauna inspection report, indicating any relevant information collected during the inspection, including Tree Tag ID (and/or flora location coordinates if not tagged), animal observations, recommended actions, and photographic evidence.

d) Pre-felling fauna inspection is valid for seven days, i.e., if the inspected trees or vegetation are not removed within seven days of the Ecologist's inspection, the inspection shall be repeated.

e) If animals or active nests are found, the Contractor shall:

    - Not disturb the animal and allowed them to move away on their own before tree felling or vegetation removal, unless the Ecologist deems it necessary to relocate them.
    - Allow nesting birds to fledge and leave the nests on their own before tree felling or vegetation removal.

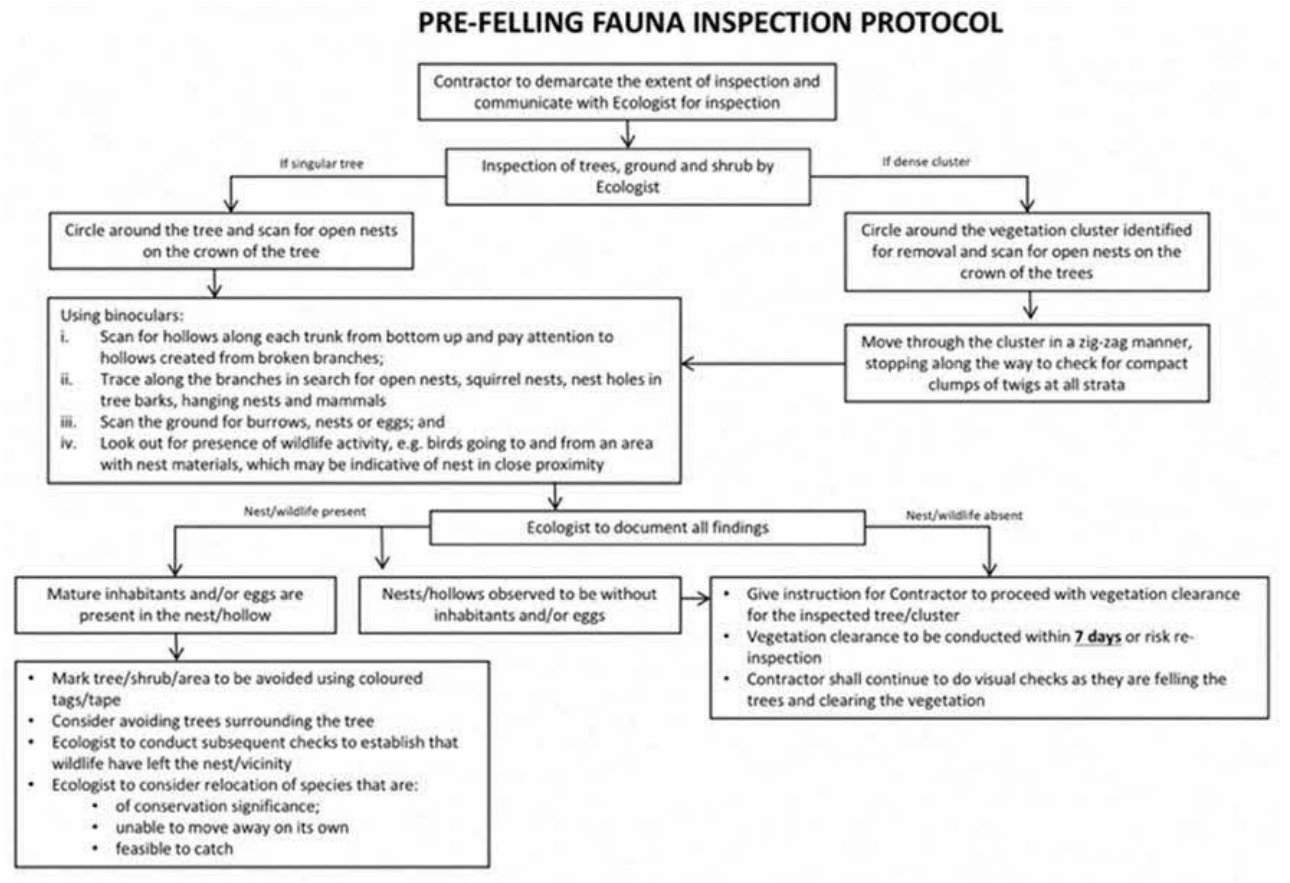


Figure 8-6: Pre-felling Fauna Inspection Protocol

8.5.1.2.3 Daily Fauna Inspection

The Contractor's appointed environmental personnel (i.e., Environmental Manager/ ECO) shall ensure that daily inspections including the following are carried out:

- Visual inspections for integrity of the site hoarding to check for gaps which would allow wildlife to enter the construction works areas involving heavy machinery.
- Visual inspections for signs of any disturbances or other violations leading to impacts on wildlife. This includes, but is not limited to, signs of trapping of animals, road kills, etc.
- Check for fauna prior to daily start of works and record inspection on the designated Fauna Inspection Form; implement Wildlife Response Plan, where necessary; and record wildlife incidents on Fauna Incident Form.

8.5.1.2.4 Monthly Fauna Inspection

It is recommended that Contractor to appoint Fauna Specialist(s)/ Ecologist(s) to carry out monthly fauna inspection within the worksite boundaries. The following are required be noted during the inspections:

- Checks for the presence of trapped, injured, or dead fauna shall be carried out daily by the Contractor to enable timely rescue, and monthly by the Ecologist during site inspections. A collation of all wildlife incidents shall be recorded in the monthly inspection checklist and report.
- The Contractor shall ensure that 100% bio-degradable erosion control blankets (ECBs) are used to prevent snake entrapment.
- Potential fauna entrapments (e.g., ECBs, TPZs, pits, drains, ponds, trenches, tanks, etc.).

- Gaps in hoarding around worksites involving heavy machinery that may allow entry of ground-dwelling fauna.
- Non-compliance of ECM measures.
- Improperly disposed/stored food and food packaging.

8.5.1.2.5 Biodiversity Awareness Training

The Contractor shall appoint Ecologist(s) to conduct toolbox briefings on biodiversity awareness to inform site personnel of but not limited to the following:

- Ecological value of the site and its surrounding habitats.
- Types of fauna present.
- Biodiversity protection strategies.
- Site personnel's responsibilities towards biodiversity.
- How to respond to fauna encounters.
- No feeding of wildlife.
- Prevention of roadkill.
- Inspection of trees before felling.

All site personnel shall undergo biodiversity awareness training prior to commencing work on-site, and regularly (every six months) throughout the duration of the construction. Documentation of such trainings and briefings shall be maintained.

Reminders on biodiversity awareness and actions to take when encountering wildlife will also be given to all site personnel during daily toolbox briefings.

8.5.1.2.6 Fauna Response Plan

A contract-specific site Fauna Response Plan shall be developed by the Contractor and their Ecologist in consultation with NParks. The Fauna Response Plan shall be followed whenever a trapped/ injured/ dead/ dangerous animal is encountered around or within the worksite. The objective of the Fauna Response Plan is to minimise animal injury and mortality by responding appropriately to the different fauna encounter scenarios. This will be emphasised during the Biodiversity and Environmental Awareness Trainings. All wildlife incidents shall be reported and documented in a Wildlife Incident Form.

Where fauna is trapped on-site, species-specific methods shall be formulated to remove them, in consultation with the HDB and NParks.

The Contractor shall engage a Wildlife Management Company to carry out trapping, rescue, and/or relocation of trapped or injured fauna in accordance with NParks' directions. The Wildlife Management Company shall be listed under NParks' public register of certified Wildlife Management Contractors.

8.5.1.2.7 Fauna Monitoring

During the construction phase, monthly fauna monitoring shall be conducted by the appointed Ecologist and comprise terrestrial transect surveys, camera trapping, and aquatic point counts. The monitoring methods and locations shall closely correspond to those undertaken during the EIA Baseline Study while taking into consideration the Proposed Retained Areas. A comparison of species presence can be made with the EIA Baseline Study, where appropriate, to indicate any changes in fauna diversity.

Details of the monitoring shall consider the construction phases, final construction footprint, and final hoarding alignment, and be further developed by the appointed EMMP Consultant/ Ecologist(s). **Table 8-3** shows a summary of the monitoring methods for each fauna group. **Figure 8-7** illustrates the recommended monitoring locations.

Table 8-3: Summary of Monitoring Methods for Each Faunal Group

Survey Type	Taxon	Timing (h)	Duration	Sampling Unit*	Technique	Data Collected
Diurnal and nocturnal transect surveys	Herpetofauna (amphibians and reptiles) Birds Mammals (non-volant)	0700–1000; 2000–2300	20–30 minutes per transect	200-m continuous transects along a sampling route	Visual and auditory; up to 50 m left, right, and front of surveyor	Location, species, quantity, date, time
Diurnal transect surveys	Butterflies and Odonates (damselflies and dragonflies)	0900-1600	20-30 minutes per transect	200-m continuous transects along a sampling route	Visual only; up to 25-m left, right, and front of surveyor	Location, species, quantity, date, time
Diurnal and nocturnal point counts	Aquatic fauna (fish and decapod crustaceans)	0700–1000; 2000–2300	20 minutes visual point count	Aquatic sampling point	Visual only; up to 10-m from sampling point	Location, species, quantity, date, time
Camera trapping	Mammals (non-volant)	24 h a day	Throughout the construction phase	24-h continuous period of recording on a camera trap	Infrared motion sensing	Location, species, quantity, date, time

***A sampling unit is the building block of the dataset that will be used for statistical analyses. For transect surveys, one sampling unit is defined as a 200-m long transect. Hence, a sampling route may consist of several 200 m transects.**

8.5.1.2.7.1 Terrestrial Transect Surveys

Faunistic surveys shall be conducted along terrestrial survey route shown in **Figure 8-7**. This shall include one diurnal and one nocturnal survey per month. The survey shall be conducted in the reverse transect direction on alternate months. All fauna encountered shall be identified as species, or the lowest taxonomic level possible. The locations of all fauna sightings shall be recorded using a handheld GPS receiver. Notable behavioural observations (e.g., displaying guarding, mating, ovipositing) and plant species that the animal is observed to be feeding, laying eggs, or nesting on, shall be recorded.

8.5.1.2.7.2 Terrestrial Camera Trapping

Six camera traps as shown in **Figure 8-7** shall be deployed and maintained for the purpose of monitoring non-volant mammals during the construction phase. The camera traps shall be deployed at approximately 20–30 cm above ground. They shall be operational 24 hour a day and programmed to record a 10-s footage per trigger with a 10-s quiet period following each trigger. Camera trap maintenance and data retrieval shall be carried out once a month.

8.5.1.2.7.3 Aquatic Monitoring

Aquatic fauna shall be monitored at five points in the vicinity of the proposed worksite as shown in **Figure 8-7**. At each aquatic sampling point, diurnal and nocturnal visual point count surveys of up to 20-minutes shall be conducted. A visual inspection of the clarity of the water as well as any impacts arising from the developments should be noted.

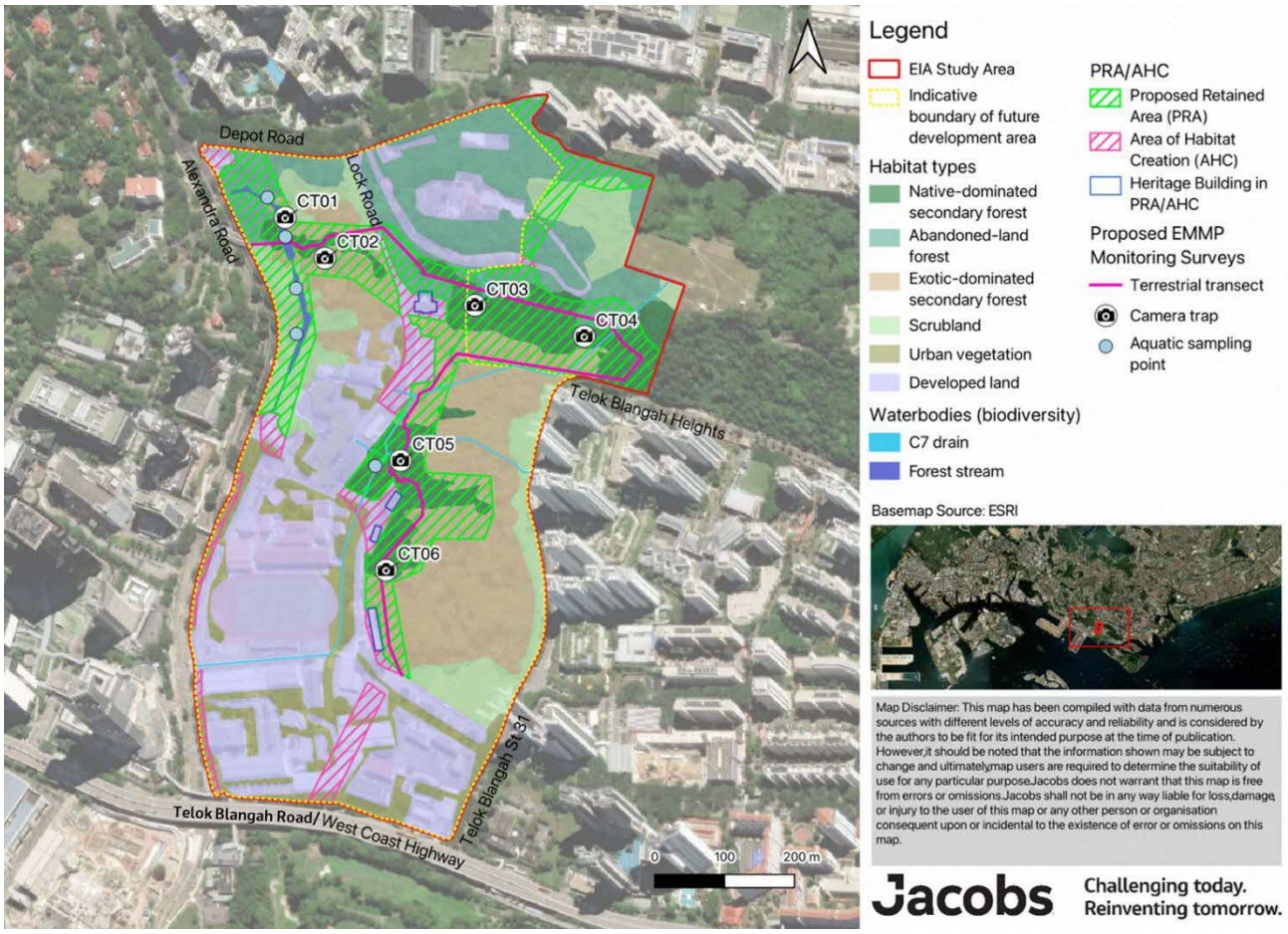


Figure 8-7: Proposed Survey Methods and Locations for Fauna Monitoring During Construction Phase

8.5.2 Post-construction/ Operation Phase

8.5.2.1 Flora, Vegetation, and Trees

The flora and arboriculture programme aims to assess post-construction/operational impacts to the retained vegetation and rectify problems identified. It is recommended to monitor flora, vegetation and trees for at least the first three months after reinstatement.

8.5.2.1.1 Fauna Monitoring

Post-construction fauna monitoring is recommended for assessing the impacts of post-construction/ operational works on the adjacent forests. The methodology for the fauna monitoring surveys should closely follow the methodology of this EIA, such that a comparison of results can be made to understand the changes in fauna diversity and distribution.

8.6 Physical Environmental Monitoring Programme Requirement

8.6.1 Water Quality Monitoring Programme

8.6.1.1 Monitoring Programme for ECM Discharge

In accordance with PUB requirements, continuous real-time turbidity and total suspended solids (TSS) monitoring shall be implemented during the construction phase at all designated discharge outlets of each Earth Control Measures (ECM) treatment plant. Monitoring shall be conducted via an online turbidity and TSS sensor system, complemented by CCTV equipped with a Silty Imagery Detection System (SIDS), installed by the appointed ECM contractor. Monitoring results shall be assessed against the turbidity and TSS allowable limits specified in Sewerage and Drainage (Surface Water Drainage) and Sewerage and Drainage (Trade Effluent) Regulations.

Additionally, daily inspections of perimeter drains shall be carried out to ensure no untreated surface runoff exits the site. The Environmental Control Officer (ECO) shall perform daily visual inspections of ECM ponds for colour, odour, clarity, and any signs of contamination, such as oil sheen or foam.

8.6.1.2 Monitoring Programme for Surface Water Quality of Retained Watercourse

Where discharges treated from the contract work zone are intended to flow into retained watercourses (i.e., forest stream WQ2), pre-construction baseline water quality of these watercourses shall be established prior to commencement of works. The baseline re-establishment locations are both the downstream point of discharge from the site's treatment systems (i.e., ECM plant), prior to connection to the public drain, and at an upstream reference location to benchmark ambient conditions. Pre-construction baseline monitoring shall commence immediately upon identification of the intended discharge point(s). The objective of the pre-construction baseline is to establish site-specific trigger level and to inform comparison of incremental changes during construction. The water quality parameters to be analysed shall be consistent with those identified during the EIA Stage as presented in **Table 6-3**.

During the construction phase, the Contractor shall prepare and implement a Water Quality Pollution Control and Management Plan that includes a comprehensive monitoring programme to evaluate the effectiveness of mitigation measures specified in the EIA and the approved Contract-Specific EMMP.

Monthly water quality monitoring shall be conducted throughout the construction phase should there are intended treated discharges from the Contract works towards the retained watercourses (i.e., forest stream WQ2). Locations of the monitoring shall be consistent with those established during the pre-construction baseline measurement (i.e., upstream reference point and downstream discharge point prior to connection to the public drain). Monitoring results shall be assessed against the re-established baseline results and allowable limits indicated in Water Quality Guidelines and Criteria given in **Table 6-3**.

The frequency of laboratory analysis shall be increased to weekly or fortnightly if *in-situ* measurement and/or monthly laboratory results indicate deterioration in the water quality compared to baseline or previous monitored conditions. Intensified monitoring shall continue until *in-situ* measurement and/or laboratory results indicate normality and consistency with earlier monitored conditions. Contractor(s) shall undertake investigation and corrective actions when ECM plan/ monitoring log/ training log/ audit reports are found inadequate or missing and/or monitored parameters exceed applicable limit as per **Table 6-3**.

Table 8-4: Summary of Recommended Water Quality Monitoring Programme during Construction Phase

Objective	▪ Check and validate compliance with regulatory and project-specific limits. ▪ Prevent pollution of retained watercourses and public drains during construction.
Method	▪ Grab sampling by Singapore Laboratory Accreditation Scheme (SAC-SINGLAS) accredited laboratory service. ▪ Laboratory analysis using SAC-SINGALS accredited laboratory and standard method.
Parameters	▪ Refer to **Table 6-3** of the EIA Report.
Limits	▪ Refer to **Table 6-3** of the EIA Report.
Number of Monitoring Point/ Location	▪ To be determined by Contractor' appointed EMMP Consultant should there are intended discharges to retained watercourses within the EIA Study Area.
Frequency/ Duration	▪ To be determined by Contractor's appointed EMMP Consultant.

8.6.2 Noise Monitoring and Management Programme

Pre-construction baseline noise measurements at the identified noise sensitive receivers (NSRs) (NSR1 – NSR10) shall be re-established prior to commencement of construction works. Updating the baseline noise data before construction begins will provide an accurate benchmark for the monitoring programme.

During the construction phase, the Contractor shall develop and implement a Noise Control and Management Plan, incorporating a monitoring programme to assess the effectiveness of mitigation measures recommended in the EIA and the approved Contract-Specific EMMP.

Noise monitoring shall be carried out by the Contractor continuously using Class 1/Type 1 Data Logging Sound Level Meter under the oversight of future developer/developing agency for their respective land parcels. Parameters to be monitored include L_{Aeq} 5 mins, L_{Aeq} 1 hour, and L_{Aeq} 12 hours noise levels. The monitoring results shall be evaluated against the re-established baseline noise data. The incremental noise levels measured during the monitoring period shall not exceed 5 dBA above the re-established baseline. Corrective actions should be implemented whenever monitoring results indicate exceedance. Noise monitoring data provided by the laboratory and environmental service providers shall be documented and included in the Monthly Environmental Performance Report. All monitoring activities and results shall be properly documented and made available for review by the relevant regulatory authorities.

Table 8-5: Summary of Recommended Noise Monitoring Programme during Construction Phase

Objective	▪ Check and validate compliance with regulatory and project-specific noise limits.
Method	▪ Class 1/Type 1 Data Logging Sound Level Meter.
Parameters	▪ L_{Aeq} 5 mins, L_{Aeq} 1 hour, and L_{Aeq} 12 hours.
Limits	▪ **At Human Sensitive Receivers (NSRs) (NSR1 – NSR6 and NSR11):** Maximum permissible noise level stipulated by NEA under the *Environmental Protection and Management (Control of Noise at Construction Sites) Regulations*. ▪ At **Fauna Sensitive Receivers (NSRs) (NSR7 – NSR10)**: Permissible noise level as per re-established baseline noise level.
Number of Monitoring Point/ Location	▪ 11 (NSR1 – NSR11). ▪ Location refer to **Figure 7-1**.
Frequency/ Duration	▪ To be determined by Contractor's appointed EMMP Consultant.

9. Environmental Impact Register

Section 4 to **Section 7** present the potential environmental impacts of the proposed development and detail the corresponding mitigation measures for each anticipated impact.

9.1 Environmental Impact Register for Ecology and Biodiversity

The Environmental Impact Register for ecology and biodiversity is provided in **Appendix 9A**. It outlines the minimum recommended procedures for managing ecology and biodiversity aspects during the pre-construction, construction and post-construction/ operation phases. This register serves as the foundation for the Environmental Management and Monitoring Plan (EMMP), which is recommended for adoption by the Developing Agencies, Project Owner, and Contractor.

9.2 Environmental Impact Register for Physical Environment

Appendix 9B presents the Environmental Impact Register for physical environment (including geomorphology, hydrology, water quality and ambient noise). It outlines the minimum recommended procedures for managing these environmental aspects during the pre-construction, construction, and post-construction phases. The table also specifies the responsibilities for implementing actions and monitoring the effectiveness of mitigation measures. This register forms the foundation for the EMMP, which is recommended for adoption by the Developing Agencies, Project Owner, and Contractor.

10. Conclusion

The conclusions drawn from the EIA, with reference to its aims and objectives as outlined in **Section 1.1**, are summarised below for each environmental aspect identified as having potential impacts on existing sensitive receptors, including biodiversity, water quality, and changes to topography and hydrology.

10.1 Ecology and Biodiversity

From the assessment, it was found that the EIA Study Area supports six terrestrial and two aquatic habitat types that host 293 plant species and 178 fauna species, including 22 flora and 11 fauna species of conservation significance. The site's strategic position within the Labrador Nature Park Network and documented faunal connectivity to adjacent areas such as Southern Ridges and former Keppel Club site also underscore its importance as an ecological corridor.

Although the proposed development may result in adverse impacts on the ecological receptors within the EIA Study Area, the implementation of comprehensive mitigation measures, such as the Proposed Retained Area (PRA), flora salvaging, and Environmental Management and Monitoring Plan (EMMP), will effectively reduce and mitigate these impacts. Notably, implementation of the PRA is expected to significantly reduce the impact significance. For the loss of habitat within the native-dominated secondary forest, the impact will be reduced from **Major Negative** to **Moderate Negative.** Similarly, for the forest stream, the impact significance will be reduced from **Major Negative** to **No Change**.

10.2 Geomorphology

Construction activities associated with the proposed development are expected to impact geomorphology, particularly through soil compaction. Based on the literature review, the predominant soil type within the EIA Study Area comprises loose sandy and clayey silt sand. During ground preparation and construction works, a reduction in soil permeability is anticipated, which may result in either temporary or permanent decreases in infiltration capacity. The unmitigated impact significance for soil infiltration capacity is assessed as **Minor Negative**. Additionally, soil loss and sediment yield are expected due to site clearance and subsequent earthworks, as erodible material is assumed to be completely removed. Although the magnitude of change is considered medium, the unmitigated impact significance for soil loss is assessed as **Minor Negative**.

A range of mitigation measures can be adopted to minimise, and where possible, eliminate geomorphology changes that may affect soil infiltration capacity and soil loss. These measures, in addition to the minimum control measures commonly adopted in Singapore, include staged site clearance and earthworks, engaging a Qualified Person (QP) and Qualified Erosion Control Professional (QECP) to design an effective Erosion Control Management (ECM) plan and implement best practices, and rehabilitating temporary construction areas to conditions as close as practicable to their pre-construction state. With the implementation of these recommended mitigation measures, the residual impact significance for soil infiltration capacity is reduced to **Slight Negative**, while the impact significance for soil loss is similarly reduced to **Slight Negative**.

10.3 Hydrology and Water Quality

The baseline survey for hydrological survey involved mapping streams and drains at 20-metre intervals, recording stream cross-sections, pool length and depth, substrate type, riparian vegetation composition, wetted width, and estimated flow velocity. For water quality assessment, water samples were collected during two dry weather events and one wet weather event across six streams.

The analytical results for water surface water quality reported that pH value, dissolved oxygen (DO), biochemical oxygen demand (BOD5), chemical oxygen demand (COD), total organic carbon (TOC), total alkalinity, nitrate (NO_3-N), ammonia (NH_4-N), phosphate (PO_4-P), total suspended solids (TSS), iron, grease

and oil (total), and enterococcus had exceeded the reference limits set out in **Table 6-3** in at least one of the water samples.

Potential impacts to hydrology and water quality include changes in runoff peak flow, degradation of water quality due to surface runoff, accidental spillage of pollutive substances, trade effluent discharge, and leakage of sewage. The change in runoff peak flow is assessed as having a **Major Negative** impact, while the unmitigated impact significance of the four-water quality related impacts is rated as **Moderate Negative**.

With the implementation of standard control measures commonly adopted in Singapore, along with appropriate mitigation strategies such as optimisation the drainage system, incorporating green infrastructure, phased construction control, spill containment measures, and a detailed ECM proposal endorsed by a QECP, the potential impact on hydrology and water quality can be significantly reduced. Following these measures, the residual impact on hydrology is expected to be **Minor Negative**, while the residual impacts on water quality are anticipated to range from **Slight Negative** to **Minor Negative**.

10.4 Ambient Noise

Baseline ambient noise measurement was conducted within the EIA Study Area and a 150 m buffer to establish existing noise levels for both human and fauna noise sensitive receivers (NSRs) prior to construction. For human NSRs, daytime noise levels were generally below NEA's permissible construction noise limits, particularly at residential and commercial NSRs such as NSR1, NSR3, NSR4, and NSR5. The highest readings occurred during the day, consistent with typical human activities such as traffic, school operations, and commercial activity. However, exceedances were observed during evening and night periods at NSR1, NSR2, NSR5, and NSR6, mainly reflected in L_{Aeq} 5-minute measurement, indicating short-term spikes. For fauna NSR (NSR7–NSR10), consistently high noise levels were recorded, ranging from 48.7 dBA to 85.2 dBA, exceeding published biological response thresholds for multiple taxa. Daytime noise was highest, with L_{Aeq} 5 minutes exceeding 68 dBA at all sites and peaks above 80 dBA at NSR7, NSR8, and NSR10, likely due to nearby traffic and existing fauna noise. These levels suggest potential impacts such as stress responses, altered vocalisation, reduced foraging efficiency, and changes in species interactions among non-volant mammals, birds, bats, amphibians, reptiles, and invertebrates. While these species may have adapted to prevailing noise conditions, any additional increase during construction could exacerbate behavioral, physiological, and reproductive impacts.

Unmitigated noise modelling predicted exceedances above NEA permissible limits for human NSRs and above baseline for fauna NSRs, resulting in High impact magnitude across most receptors for L_{Aeq} 12 hours and ranges from Low to High for L_{Aeq} 5 minutes. These impacts were assessed as **Slight Negative** to **Moderate Negative**, considering their short- to medium-term construction duration (up to five years), reversibility post-construction, and spatial extent beyond the proposed development footprint.

To address these effects, mitigation measures including noise source controls (e.g., quieter construction methods, equipment enclosures, portable noise barrier) and noise barriers were modelled. Post-mitigation, noise levels complied with NEA permissible limits for human NSRs and were significantly reduced for fauna NSRs, lowering impact magnitude to Medium or Low. Residual impacts were assessed as **Slight Negative** to **Minor Negative**, demonstrating that the recommended measures effectively reduce noise exposure to ALARP levels.

10.5 Environmental Impact Register and Environmental Management and Monitoring Plan (EMMP)

A conceptual EMMP has been developed as part of the EIA to guide the implementation of minimum environmental control measures and mitigation actions identified in the Environmental Impact Register during the pre-construction, construction, and post-construction/operational phases. Upon commencement of site works, the Contractor shall ensure that all environmental control measures are adequate to effectively minimise environmental impacts and shall validate any modifications to the recommended mitigation measures as necessary.

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