Environmental Impact Assessment for Woodlands North Coast (South of Admiralty Road West)

JTC Corporation

EIA Report

June 2025

The expert in WATER ENVIRONMENTS

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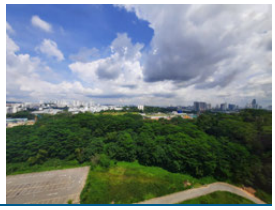
Prepared for JTC Corporation

Represented by Mr Lye Boon Kiat



Aerial view of WNC area

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Abbreviations

Abbreviation	Term
ABC	Active Beautiful Clean
ALAN	Artificial Lighting at Night
ASEAN	Association of Southeast Asian Nations
ASM	Approved Soil Mixture
ASRs	Air Quality Sensitive Receptors
BCA	Building and Construction Authority
BIA	Biodiversity Impact Assessment
BTNR	Bukit Timah Nature Reserve
CCNR	Central Catchment Nature Reserve
CEMMP	Contract-specific Environmental Monitoring and Management Plan
CO	Carbon Monoxide
CR	Critically Endangered
dB(A)	A-weighted Decibel
DD	Data Deficient
DGPS	Differential Global Positioning System
DHI	DHI Water & Environment (S) Pte Ltd
ECB	Erosion Control Blanket
ECM	Earth Control Measures
ECO	Environmental Control Officer
ECMO	Earth Control Measures Officer
EIA	Environmental Impact Assessment
EMMP	Environmental Management and Monitoring Plan
EN	Endangered
EPBC	Environment Protection and Biodiversity Conservation
EPE	Ecological Profiling Exercise
EPH	Environmental Public Health
EPHA	Environmental Public Health Act
EQO	Environmental Quality Objectives

Abbreviation	Term
ES	Environmental Scores
EX	Globally Extinct
GIIP	Good International Industry Practices
GLS	Government Land Sales
GPS	Global Positioning System
HCl	Hydrogen Chloride
HDB	Housing and Development Board
HDV	Heavy Duty Vehicle
HF	Hydrogen Fluoride
HNO_2	Nitrous Acid
HVAC	Heating, Ventilation, and Air Conditioning
IAQM	UK Institute of Air Quality Management
IEMA	Institute of Environmental Management and Assessment
ILP	Institute of Lighting Professionals
ISA	International Society of Arboriculture
IUCN	International Union for Conservation of Nature
JTC	Jurong Town Coporation
LEAF	Landscape Excellence Assessment Framework
L_{eq}	Equivalent Continuous Sound Pressure Level
LKCNHM	Lee Kong Chian Natural History Museum
LTA	Land Transport Authority
LVIA	Landscape and Visual Aesthetics Impact Assessments
MFTNH	Man Fut Tong Nursing Home
MND	Ministry of National Development
MOM	Ministry of Manpower
MSDS	Material Safety Data Sheets
NBSAP	Singapore National Biodiversity Strategy and Action Plan
NCMP	Nature Conservation Master Plan
NEA	National Environment Agency
NEx	Presumed Nationally Extinct

Abbreviation	Term
NH_3	Ammonia
NO_2	Nitrogen Dioxide
NParks	National Parks Board
NRC	Noise Reduction Coefficient
NSRs	Noise Sensitive Receptors
NW	Extinct in the Wild
OTC	Outdoor Thermal Comfort
PCO	Pest Control Officer
PCS	Pollution Control Study
PET	Physiologically Equivalent Temperature
PM_{10}, $PM_{2.5}$	Particulate Matter (with diameters of 10 or 2.5 micrometers or less, respectively)
PPE	Personal Protective Equipment
PPV	Peak Particle Velocity
PRO	Public Relations Officer
PT_j	Perceived Temperature
PUB	Public Utilities Board
QECP	Qualified Erosion Control Professional
QHPS	Qihua Primary School
RIAM	Rapid Impact Assessment Matrix
RMS	Root Mean Square
RP	Republic Polytechnic
RTS	Johor Bahru–Singapore Rapid Transit System
SAAQT	NEA Singapore Ambient Air Quality Targets
SECR	Site Environmental Control Report
SET	Standard Effective Temperature
SING	Singapore Botanic Gardens' Herbarium
SLA	Singapore Land Authority
SRDB3	Species List (Red Data Book List), Third Edition
TEL	Thomson-East Coast Line
TPZ	Tree Protection Zone

Abbreviation	Term
TRL	UK Transport Research Laboratory
TL	Transmission Loss
UHI	Urban Heat Island
URA	Urban Redevelopment Authority
USEPA	United States Environmental Protection Agency
UTCI	Universal Thermal Climate Index
VC	Vibration Criteria
VDV	Vibration Dose Value
VOC	Volatile Organic Compounds
VSRs	Vibration Sensitive Receptors
VU	Vulnerable
WHO	World Health Organisation

Executive Summary

DHI Water & Environment (S) Pte Ltd (DHI) has been appointed by Jurong Town Corporation (JTC) to conduct Environmental Impact Assessment (EIA) at the Woodlands North Coast (WNC) - South of Admiralty Road West. WNC is planned to be a vibrant new generation mixed-use estate, with good public transport connectivity via the Thomson-East Coast Line (TEL), and there will also be an upcoming Johor Bahru–Singapore Rapid Transit System (RTS) Link to Malaysia. To facilitate upcoming development of the WNC estate, there will be land preparation and infrastructural works planned for these future industrial sites. The proposed development for this EIA includes land clearance, land preparation and infrastructure work, hereafter referred as “Project”. This is to ensure infrastructure-ready land is available for future general industries and mixed-use developments. To facilitate upcoming development of the WNC estate, there will be land preparation and infrastructural works planned for these future industrial sites. The site will then be retained for future construction of buildings designated for general and light industries.

The Project site is approximately 27.7 hectares area within WNC. The Study Area is bounded by Admiralty Road West in the north, with a patch of vegetation across the road that is herein referred to as Admiralty Forest. It primarily consists of secondary forests, with a State building at 10 View Road. The site topography is elevated approximately 30-40m from the surrounding roads.

Given the ecological sensitivity present within and around the Project area, an EIA was carried out to review and analyse potential changes to the existing environmental conditions in and around the study area during construction and post-construction phase of the infrastructure work. The study evaluated the potential environmental impacts and recommend management and mitigation measures. A suitable Environmental Monitoring and Management Plan (EMMP) framework has been proposed to manage the potential environmental impacts to nearby sensitive receptors.

The Project development is expected to commence in stages from 2026 to 2035, subject to approvals by the relevant Technical Agencies, Urban Redevelopment Authority (URA) and Ministry of National Development (MND). Construction activities for this Project will include land clearance, land preparation and infrastructure works to ensure infrastructure-ready land would be available. Future works will involve the construction of substructure and superstructure works. It should be noted that the actual development plans may vary as they are subjected to further review and changes. All proposed works will be within studied Project area and is not expected to cause more extensive impact than what was assessed in this EIA. A Contract-specific EMMP will be developed prior to commencement of construction works. It will consider the specific construction plan at that time, to ensure the EMMP measures to be implemented in future are tailored to the actual construction and development works.

This EIA identifies and assesses the potential ecological and environmental impacts that arise from the proposed development works to the surrounding sensitive receptors. The potential environmental impacts are predicted and the impact significance at each receptor is evaluated based on the Rapid Impact Assessment Matrix (RIAM), taking into account the nature and magnitude of impacts and the sensitivity of receptors. A summary of the assessment of construction and post-construction impacts are as follows.

Construction Phase Impact

Construction phase impacts refer to potential impacts occur during the construction period, which are usually of short-term and the environmental pressure would be alleviated after the construction completes.

Terrestrial Ecology and Biodiversity

The potential ecological impacts predicted to arise from the construction activities include loss of flora, loss of fauna, and human-wildlife conflict.

During construction, the extensive site clearance will result in a **Major Negative** impact on flora, including conservation significant flora species, as vegetation within the project site will be removed and replaced by urban development. With mitigation measures, such as salvaging and transplantation of conservation significant flora, the potential impact is assessed to be reduced to **Minor Negative.**

Loss of fauna and human-wildlife conflict were assessed to be range from **Moderate Negative** to **Slight Negative**. A Wildlife Management Pan shall be formulated prior to commencement of construction works, with details such as proper installation of hoarding, pre-felling wildlife inspections, staged and directional site clearance. During construction, appropriate lighting management, using only fully biodegradable Erosion Control Blankets (ECBs), and checking these ECBs and any pits daily could aid in protecting avian young and reduce the risk of fauna entrapments. With proper implementation of mitigation measures, reductions in the categorisation of impacts were assessed to be **Minor Negative** to **Slight Negative**.

Air Quality

The major air quality impact during construction is anticipated to be dust emissions generated by site activities. Impacts to air quality were assessed based on the types of construction activities – earthworks, demolition (if any), general construction activities, and trackout. Without mitigation, most activities were evaluated to have **Minor Negative** to **No Impact** on the surrounding receptors, except healthcare facilities (Man Fut Tong Nursing Home) which was anticipated to experience **Moderate Negative Impact** during earthworks. Large scale of earthworks from the land clearance and levelling works would generate considerable dust emission. Man Fut Tong Nursing Home is located across the site and residents in the nursing home are usually individuals who are more vulnerable and susceptible to health issues, making them more sensitive to the dust impact from the earthworks. Elevated concentration of construction dust may potentially trigger respiratory discomfort or diseases in this population. With proper mitigation measures, the residual impact from dust emission due to earthworks was assessed to be **Minor Negative** for the nursing home.

To mitigate dust emission from WNC construction, especially from earthworks, staggered land clearance and levelling works shall be implemented to reduce the area of disturbance at any given time. Thoughtful planning of construction program to minimize exposed surfaces and plan for reinstatement of completed work areas as early as practical is required. Other mitigation measures including dust suppression measures, proactive erosion control, and actively managing on-site stockpiling and handling of materials shall be implemented to manage emission from daily construction site activities. For demolition activities (if any), it is recommended to minimize the duration of the demolition process and to implement dust barriers around demolition sites. Residual impacts for other receptors are generally **Slight Negative** to **No Impact**.

Airborne Noise

During the construction phase, in general, **Slight** to **No Negative Impact** was anticipated from the construction activities to the surrounding residential and educational receptors. However, due to their higher sensitivity to environmental changes and close proximity to

the Project site, healthcare facilities i.e. Man Fut Tong Nursing Home may experience a **Moderate Negative** Impact; and terrestrial fauna within Admiralty Forest may be subject to a **Minor Negative** Impact. Mitigation measures including using quieter construction equipment and noise barriers at work boundaries were assessed with simulations. After implementing these mitigation measures, **No Negative Impacts** were assessed for healthcare facilities and the impact on terrestrial fauna (Admiralty Forest) was reduced to **Slight Impact.**

Given the higher topographic elevation of the Project site compared to the surroundings, priority should be given to source-based mitigation measures, i.e. use of quieter construction equipment and installing localized portable noise barriers near heavy machinery. Additionally, a 6m height perimeter noise barrier must be installed along the work boundary in compliance with the latest NEA guideline. Other good site management practices such as turning off unused equipment, and regularly inspecting heavy machinery for noise issues should be implemented.

Ground Vibration

Potential vibration impact during construction is anticipated from the demolition of 10 View Road (if required) and from activities such as bored piling and diaphragm-wall construction. Impacts on receptors before and after implementation of mitigation measures were evaluated to be **Slight Negative**. Key mitigation measures include low vibration construction techniques and having a buffer distance from existing developments on site (i.e. 1 & 7 North Coast buildings) for bored piling works (25 meters) and diaphragm wall construction (30 meters).

Light

Light nuisance from night construction works was assessed to have **Slight Negative** Impact on the nearby residents and biodiversity in Admiralty Forest due to their sensitivity. Implementation of mitigation measures reduces the impact to **No Impact** for residents, while impact on fauna remains **Slight Negative**.

Key mitigation measures include avoiding night work where possible; If night works is necessary, prepare a Nightwork Light Management Plan (Agencies approval needed). Mitigation and management measures include the use of low-UV lighting, and directing all artificial night lighting downward and inward towards the site, and regularly review lighting implementation on site to minimise potential impact on the fauna in Admiralty Forest.

Soil and Groundwater

The potential impact related to soil and groundwater contamination, if any, is expected to be localised (i.e. confine within the Project site). Overall, release of contaminants from contaminated soil are assessed to have **Slight Negative** to **No Impact** and reduced to **No Impact** with mitigation measures. Impact of potential contamination of soil and groundwater due to mishandling of chemicals and surface runoff during wet weather event was assessed to be **Slight Negative**, and **No Impact** when mitigated.

Key mitigation measures include implementing a defined soil management and disposal plan, enforcing proactive and proper earth control measures, and ensuring careful management of chemicals and hazardous wastes.

Landscape and Visual Aesthetic

Throughout the construction phase, the existing forested area within the Project site would be cleared progressively, resulting in a transition of landscape character from a forested area to a construction site. The alterations of current landscape from forest to construction site is evaluated to cause a **Minor** to **Slight Negative** impact without mitigation measures. With mitigation measures in place, the impact is reduced to **Slight Negative**. These key mitigation measures include hoarding around the site perimeter, dust control, temporary landscaping to reduce visual impact, and regular debris removal to maintain site tidiness.

Construction Waste and Vector Proliferation

Impacts from pollution of construction waste during construction phase is expected to be **Slight Negative** without mitigation measures, and generally **No Impact** with mitigation measures. Key mitigation measures include maximising waste reduction and encouraging reuse, ensuring proper disposal, and providing covered bins to prevent litter.

The potential impact from proliferation of vectors which may contribute to spread of diseases among the residents and surrounding communities remains **Slight Negative**. For vector management, proactive prevention strategies will be implemented alongside active monitoring and effective mitigation measures to manage vector populations.

Post-construction Phase Impacts

Post-construction phase impacts may result in long-term changes due to project footprint in ecological connectivity, vegetation and habitat loss, illumination, microclimate and landscape and visual aesthetics. These could affect receptors such as terrestrial flora and fauna, habitats, and residential areas.

Terrestrial Ecology and Biodiversity

The potential ecological impacts include the loss of vegetation and habitat, injury or mortality of fauna, and loss of ecological connectivity, all of which were evaluated to be **Slight** to **Moderate Negative**. Mitigation measures such as habitat creation, retention of mature trees, and bird-safe implementations will help reduce the residual impact. As a result, the impact classification for the loss of ecological connectivity for bats and avifauna will be lowered to a **Slight Negative**. Whilst the residual impacts for other receptors were also ameliorated after mitigation, these residual impacts remained within the **Slight** to **Moderate Negative** range.

Air Quality, Airborne Noise, and Ground Vibration

No Significant Impact in air quality, airborne noise and ground vibration are anticipated during the operational phase of future developments in WNC. The planned land use will primarily comprise general and light industries along with commercial buildings. These operations typically do not involve heavy manufacturing processes or operations that emit substantial quantities of air pollutants. Additionally, the activities and operations of any machineries are expected to be contained indoors. The nature of light industrial and commercial activities is not expected to generate significant noise or vibration which propagate significantly beyond the boundaries of the premises.

Light

Impact from light nuisance from building operation is assessed to be **Slight** to **Minor Negative**. This is reduced to **No Impact** for residents and Slight Negative for fauna upon mitigation such as designing the development in an environmentally sensitive manner. This can make references to the principles outlined under the resilience and energy efficiency sections of the BCA Green Mark Certification Scheme, which encourages developments to minimise environmental disturbance through site-sensitive design, biodiversity conservation, and ecological resilience planning. In addition, reference can be made to the NParks Landscape Excellence Assessment Framework, which supports the integration of landscape designs including colour and lights that are ecologically friendly.

Microclimate (Ambient Air Temperature)

The impact of the long-term ambient temperature change from future building operation on the surrounding receptors including HDBs and Admiralty Forest was evaluated to be **Slight Negative** without mitigation and reduced to **No Impact** with mitigation.

Key mitigation measures include incorporating sustainable building design with reference to the BCA Green Mark Certification Scheme as well as NParks Landscape Excellence

Assessment Framework, incorporate greening effort such as vertical greenery, rooftop gardens, courtyards, and indoor planting, as well as implementing eco-friendly building technologies such as efficient HVAC and lighting systems. Higher green coverage within the development would help reduce and / or slow down the increase in ambient temperatures at the immediate surroundings, as well as reducing the reflection of heat to the surrounding sensitive receptors.

Soil and Groundwater

No Impact is expected during the post-construction phase, as it will primarily consist of general and light industries along with commercial buildings, which is not expected to be highly pollutive and proper waste and chemical management is expected to be implemented by the future businesses.

Landscape and Visual Aesthetic

The visual setting will evolve from a natural environment to a dynamic industrial and commercial hub. The predicted impact on the landscape alteration from forest to integrated industrial and commercial hub is predicted to be **Moderate** to **Slight Negative Impact**, and reduced to **Minor** to **Slight Negative Impact** with mitigation measures.

Key mitigation measures include incorporating greenery in the landscaping design, within future development.

Construction Waste and Vector Proliferation

The completion of construction activities in the post-construction phase, alongside the integration of proper waste management and drainage systems should result in a daily but managed environmental pollution. Thus, **No Significant Impact** from environmental pollution from waste or vector related impacts is expected and will be assessed in relation to the post-construction phase.

Summary

In summary, the Environmental Impact Assessment for the Woodlands North Coast (South of Admiralty Road West) identifies potential ecological and environmental impacts associated with construction and operational activities. It is anticipated that, with proper design and implementation of mitigation measures, **Slight** to **Moderate Negative** impacts would be potentially resulted for ecology and biodiversity. Other environmental impacts during construction and post-construction on the surrounding sensitive receptors, including residential area, institutions and industrial areas, are aniticipated to be **Slight** to **No Impact**. However, **Minor Impact** for dust emission from earthworks on the health care facility, and **Minor Impact** of long-term landscape and visual change to the HDB residential facing the Project site are concluded. Recommendation of mitigation measures are made and a high level Environmental Monitoring and Management Plan (EMMP) framework is outlined in this EIA, to ensure the development is properly planned and environmental protection is implemented throughout the course. Overall, with effective management strategies in place, the Project aims to balance development needs with ecological sustainability and community well-being.

1 Introduction

1.1 Study Background

Woodlands Regional Centre, comprising of Woodlands Central and Woodlands North Coast (WNC), is envisioned as the gateway to the North region with vibrant housing, office, retail, business and recreational spaces to provide live-work-play work-live-play-learn opportunities. WNC covers an area of 190 hectares north of the existing Woodlands Central, and is presently predominantly greenfield land, including ecologically sensitive habitats.

Jurong Town Corporation (JTC) is jointly developing WNC together with other government agencies, including the Land Transport Authority (LTA), and Urban Redevelopment Authority (URA).

DHI Water & Environment (S) Pte Ltd (DHI) has been commissioned by JTC to conduct Environmental Impact Assessment (EIA) study at WNC, given the biodiversity and ecologically sensitive habitats present within the Project boundary. The proposed development involves site and land preparation, along with infrastructure works (roads, drains, sewer) to facilitate future industrial developments at North Coast Avenue (Figure 1.1), hereafter referred as “Project”. The Project covers approximately 27.7 ha of land at the south-eastern region of WNC.

This EIA Report has been prepared to document the current baseline condition and ensure that environmental impacts and their significance of the proposed development based on land use as seen in URA Master Plan 2019 (“MP2019”) have been fully evaluated and assessed. The environmental impact assessment is based on the MP2019 parameters where the entire Project area would be cleared for infrastructure-ready land in preparation for development works.

All maps presented in this report are purely illustrative and are to be used solely for the purpose of assessing the environmental impact of the proposed works, and not for any other purpose.

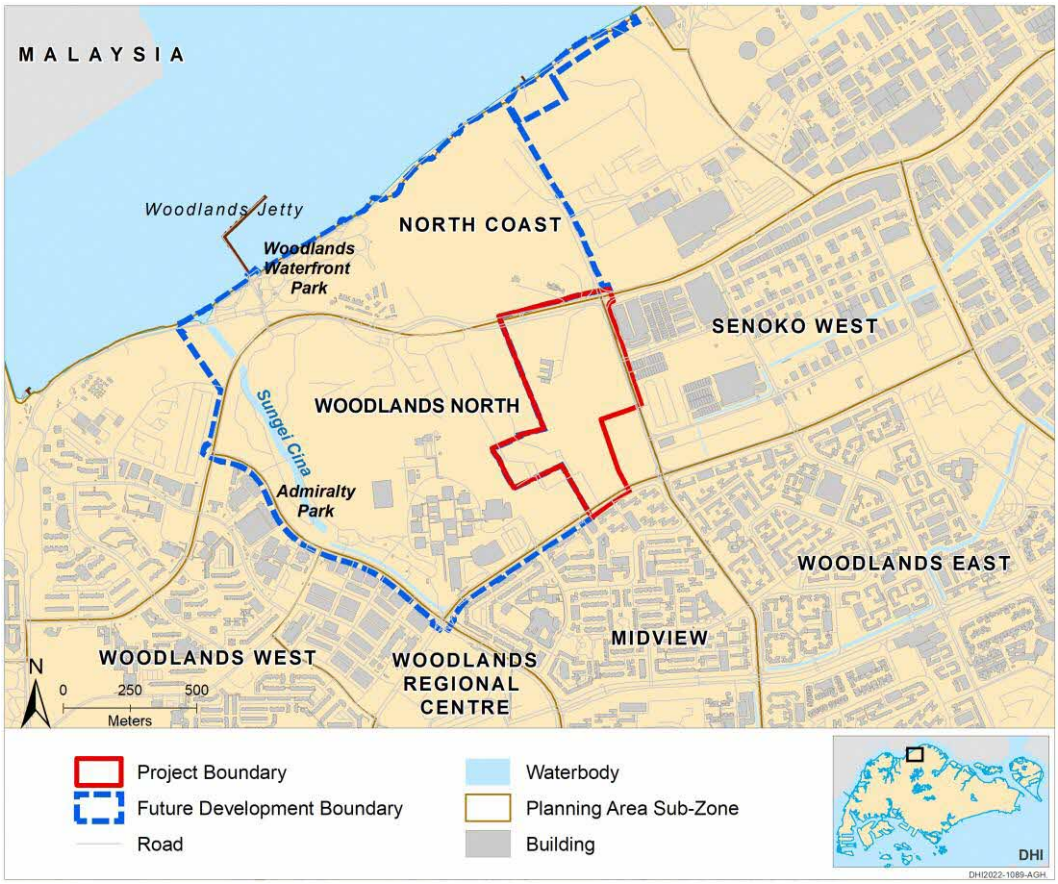


Figure 1.1 Overview of Woodland North Coast and Future Study Developments

1.2 Objectives

The objectives of the EIA are:

- Review the existing environmental conditions in and around the Project area, analyses potential changes to the physical, chemical, ecological and biological environment.
- Identify and evaluate the potential environmental impacts generated during construction and operation phases of the proposed development.
- Assess the significance of the potential impacts on environmental and socio-economic receptors within the Study Area
- Recommend management and mitigation measures to reduce environmental impact significance to reasonably acceptable levels.
- Propose Environmental Monitoring and Management Plan (EMMP) to be put in place prior to, during, and for a limited period after development works are completed to ensure that the Project meets the Environmental Quality Objectives (EQOs) defined for the Project.
- The EIA is carried out based upon Singapore's and Good International Industry Practices (GIIP) methodologies. The EIA also serves as a crucial step in obtaining development approvals, ensuring compliance with environment regulations, and incorporating recommendations from relevant authorities.

1.3 Project Description

The proposed development works includes land clearance, land preparation and infrastructure work to ensure infrastructure-ready land would be available. After that the Project area will be retained for future development works, such as construction of buildings for general and light industries.

The following subsections present the details of the existing condition and future development within the Project area, as well as the anticipated construction activities required for the development.

1.3.1 Project Area

WNC is located in the northern region of Singapore within the northern portion of Woodlands Planning Area, covering a total area of approximately 190 ha. Currently, the area consists of secondary forest fragments and urban parks that support biodiversity and may contribute to ecological connectivity on a broader scale. However, this connectivity is partially constrained by the surrounding urban landscape.

The Project area comprising largely of secondary forests is bounded by Woodlands Avenue 9, North Coast Avenue and Admiralty Road West (Figure 1.2 and Figure 1.3). The site area is approximately 27.7 ha, which mostly comprising secondary forest, with a state building at 10 View Road. Topography is elevated approximately 30 - 40m from the surrounding roads. Based on URA Master Plan 2019, the land uses for the Project area are slated for industrial developments. Building study and analysis of 10 View Road and surrounding area are being carried out separately by JTC. For this EIA, the assessment will be based on URA Master Plan 2019 where the entire Project site will be cleared and developed for industrial use.

Northeast of the Project site across the road junction of Admiralty Road West and North Coast Avenue is the wafer fabrication industry. South of the Project site are two completed JTC industrial buildings – 1 North Coast and 7 North Coast. Further across Woodlands Avenue 9 is a residential community. Construction of RTS station is on-going to the west of the Project site.

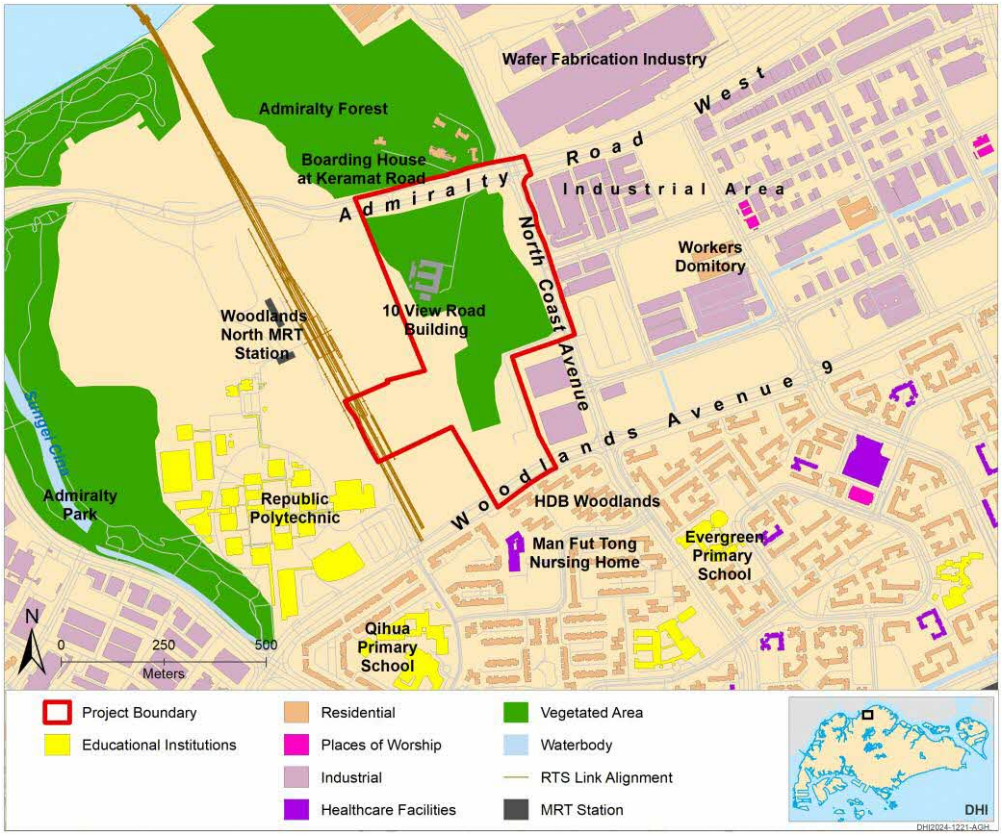


Figure 1.2 Project location and land uses in the vicinity

Figure 1.3 Project site condition (Satellite image as of 10 Mar 2022)

1.3.1.1 Land-use History

Since the arrival of the British in 1819, large swathes of the original primary lowland dipterocarp rainforests that filled the interior of Singapore were cleared for the cultivation of commercial crops, creating vast plantation estates of Gambier, Pepper, Rubber, and Pineapple throughout the island (Corlett, 1991; National Library Board, 2021). As Singapore experienced a continual boost in wealth from trade as a trans-shipment centre, economic reliance on commercial agriculture waned and these plantations gave way to modernized developments by the late 19th century (Tan, 2019). This was the case for the land within the Study Area, as reflected in early topographical maps first dating back to 1924, showing that the area was completely occupied by Rubber and Pineapple plantations at that time (Figure 1.4A; Figure 1.5A). Then in 1966, the plantations were abandoned, and spontaneous bush and grassland vegetation took over most of the Study Area (Figure 1.4B).

Only the valley along the northern edge was developed into a major road, accompanied by smaller roads branching off to support a small establishment of buildings towards the northeast and a larger building near the centre of the Study Area (Figure 1.4B). This larger building, known as Rimau Offices and Accommodation, was built in 1941 and was used as a command centre for the British Army (Krishnan, 2021). A reinforced concrete reservoir, known as Batu Rimau (Figure 1.5B), was also built for the British Army in 1936. The same infrastructure persisted in 1983 while the vegetation experienced some changes, as most of the vegetated area had succeeded into forests that were lightly used for Sundry cultivation and a small Rubber plantation towards the south (Figure 1.4C). Furthermore, following the withdrawal of British troops in the 1970s, Rimau Offices and Accommodation was converted into View Road Hospital, a government-owned institution which operated from 1975 to 2001. This building was later used as a dormitory from 2001 to 2011 and has since been left vacant (Krishnan, 2021).

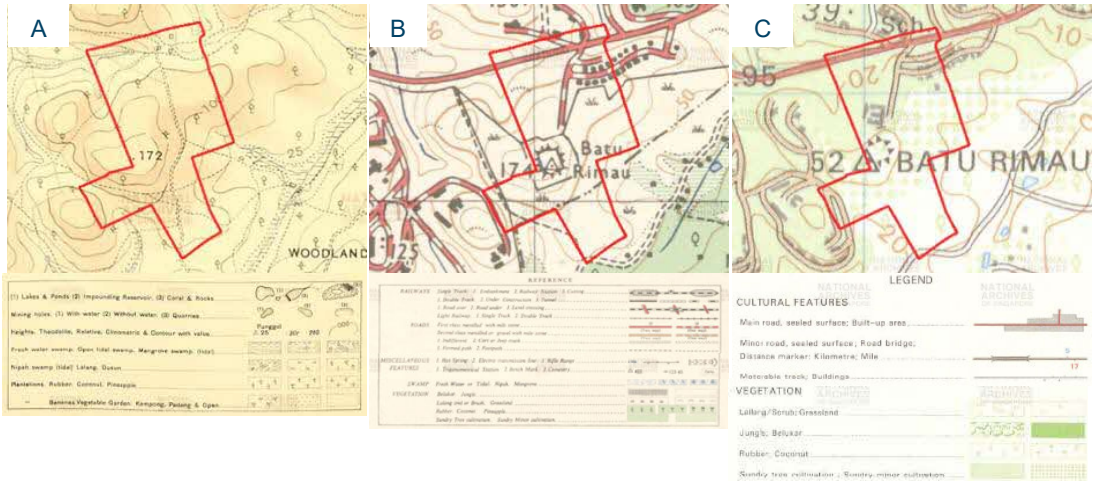


Figure 1.4 Historical maps of the Study Area (in red outline). (A) In 1924, the Study Area included Rubber tree and Pineapple plantations; (B) in 1966, the Study Area included Bush and Lalang vegetation with roads and buildings in the northeast; (C) in 1983, the Study Area included Sundry cultivation in the north and centre, a Rubber plantation in the south, and roads and buildings in the northeast (National Archives of Singapore, 2023).

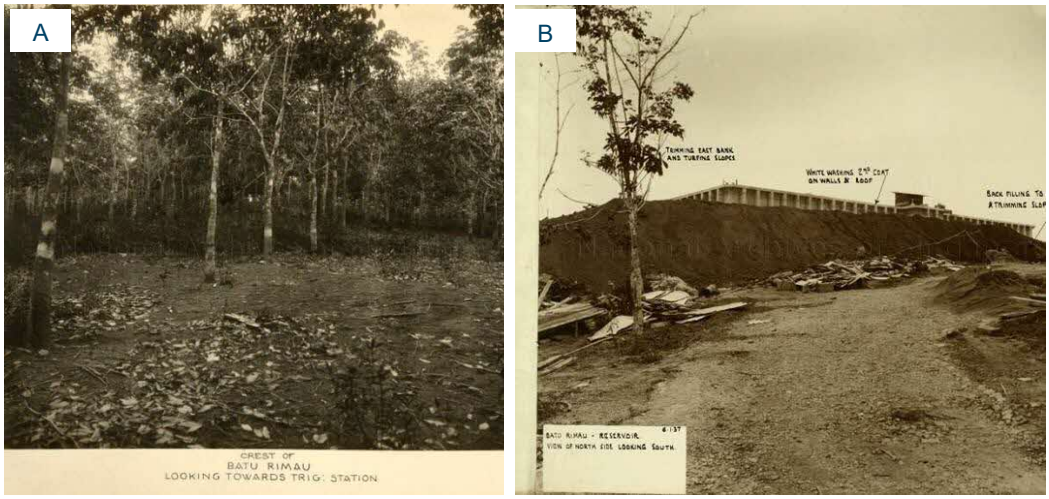


Figure 1.5 (A) Rubber plantations in the Batu Rimau area in 1923. (B) Reinforced concrete reservoir located in the British Army Base of Batu Rimau. (National Archives of Singapore, 2023).

More recent developments in the 2000s have significantly altered the vegetation in the Study Area. By studying Google Earth satellite imagery from past years, the first major change occurred briefly before 2009 when most of the vegetation in the south was cleared for the construction of industrial buildings (Figure 1.6A). After which, in 2016, clearance for the construction of Woodlands North MRT station, as part of the Thomson East Coast line which began construction in 2013, resulted in a complete loss of vegetation cover in the southwest of the Study Area (Figure 1.6B; Tan, 2019).

Contrarily, in the southeast of the Study Area, the industrial buildings were demolished, and bare land was exposed which led to spontaneous vegetation to return, as seen in the 2018 image which showed that the area was covered with grassy vegetation (Figure 1.6B&C). In 2018, the continued construction of Woodlands North MRT station and future RTS Link Woodlands North station and CIQ building developments reached the western edge and the south of View Road Hospital in the Study Area, where vegetation was completely cleared–much like it is today (Figure 1.6C&D; Land Transport Authority, 2021). The eastern edge of the Study Area also experienced some clearance in 2018 for the construction of a wide pedestrian and cyclist path along North Coast Avenue (Figure 1.6C). From 2018 to the present, no new major developments have occurred within the Study Area. A small reduction in grassy vegetation cover has been observed in the southeast due to the construction of a carpark and the removal of a small building in the south. This allowed for the quick regrowth of canopy cover (Figure 1.6D).

Figure 1.6 Satellite images of the Study Area (in red outline) from (A) 2009, (B) 2016, (C) 2018, and (D) 2022 displaying recent developments and the changes in vegetation cover (Google Earth, 2023).

1.3.2 Project Works and Activities

A brief description of the type of works which will be carried would be presented in subsequent sections. As the development is still in the planning phase, the details regarding land clearance, land preparation, infrastructure works are currently under review and cannot be confirmed at this stage. It should also be noted that the actual construction methods may vary based on actual site conditions.

Construction works will commence with land clearance and consist of a range of concurrent activities. Specific works conducted during the land clearance process may differ depending on the physical characteristics of the area in question – primarily vegetated habitats such as the Exotic-dominated secondary forest will experience tree felling and vegetation removal, whilst pre-existing built-up sites may require the demolition of pre-existing structures, such as existing View Road. The study area has uneven terrain with different ground levels. To prepare the land for development, excavation works or rock blasting may need to be carried out, depending on the type of soil and rock found beneath the ground surface. Once the site levels have been suitably prepared, land preparation and infrastructure work, such as earthworks, utility installation, laying of drainage and electrical systems will be conducted. Lastly, building works involving the construction of future developments will be carried out. The impact assessment is carried out based on these assumed construction activities. A general categorisation of different construction activities and phases are described in following subsection.

1.3.2.1 Construction Phase

A brief description of the type of works which will be carried out is given below, based on the best available information at this stage. For this EIA, assumptions are made according to the typical activities anticipated for the following construction works.

Soil Investigation
- Drilling of boreholes to verify existing ground conditions

Land Clearance
- Mobilisation of equipment such as trucks, lorry crane, mobile cranes, and excavators into Project site
- Construction of temporary site office and storage areas
- Tree felling
- Vegetation clearance
- Excavation

Land Preparation
- Earthworks
- Levelling via excavation/rock blasting

Demolition of existing building at 10 View Road (under study)
- Demolition of building structure

Infrastructure works
- Construction of roads, drains, sewer, utility service
- Landscaping works

Future Development Building works
- Construction of buildings

Site office location, site access and storage areas are not planned at this stage. It is assumed that all works and storage areas should be limited to the Project boundary indicated in Figure 1.2.

Project Timeline

The works for Project development was expected to commence in 2025, subject to planning approval by URA and Ministry of National Development (MND). The tentative development timeline is as follows.

Table 1.1 Indicative timeline for the Project

Construction Areas	Estimated years of construction	Remarks
Area 1	2026 - 2032	• Land clearance • Land preparation (include earthworks) • Infrastructure works (roads, drains, sewer) • Construction of foundation and superstructure (future development)
Area 2	2026 - 2030	• Land clearance • Land preparation (include earthworks) • Infrastructure (roads, drains, sewer) • Construction of foundation and superstructure (future development)
Area 3	2026 - 2030	• Land clearance • Land preparation (include earthworks) • Infrastructure (roads, drains, sewer) • Construction of foundation and superstructure (future development)
Area 4	2028 - 2035	• Land clearance • Land preparation (include earthworks) • Infrastructure (roads, drains, sewer) • Construction of foundation and superstructure (future development)
10 View Road Building	Under study	

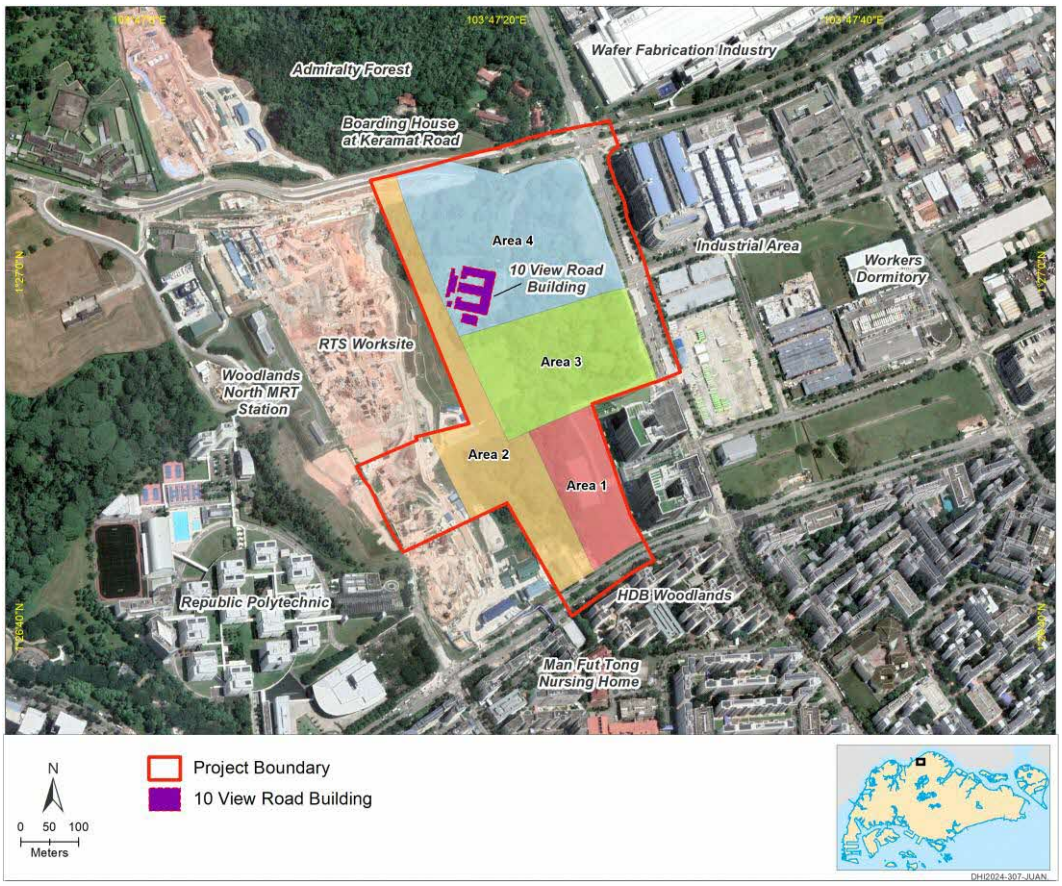


Figure 1.7 Land Clearance, Land Preparation Zoning Plan (Satellite image as of 10 Mar 2022)

The land clearance and land preparation works for WNC was planned to start in 2026, and generally follows the direction from south to north. Construction at the site is preliminary planned into four different phases of work areas (Figure 1.7). While the overall direction of development will follow a south-to-north sequence, beginning with Areas 1 and 2 and proceeding towards Areas 3 and 4, different stages of works may be carried out concurrently across these areas.

Construction will begin with Area 1, at the Southeastern region of the site, which will affect Scrubland, Grassland, Infrastructure, alongside a narrow corridor of Exotic-dominated secondary forest that is adjacent to these habitats.

Area 2 along the western length of the Study Area mostly consist of construction sites related to the adjacent RTS project along the midpoint of the Study Area's length, as well as areas of Grassland and Exotic-dominated secondary forest south of the construction site, and fringe areas of the of Exotic-dominated secondary forest and Native-dominated, young secondary forest habitats north of this middle point.

Area 3 covering the central areas of the Study Area, is currently occupied by the largest, continuous expanse of Native-dominated, young secondary forest within the Study Area. Besides this, the construction works at Area 3 will also affect a large patch of Exotic-dominated secondary forest approximately covering a similar proportion of the affected site, as well as isolated patches of Scrubland and Grassland habitat.

Area 4 is under review due to the ongoing study for 10 View Road building and surrounding area. Therefore, the construction details and timeline of Area 4 cannot be confirmed at this stage. However, it is expected to be the last area to commence works. Should land

clearance works proceed, it would involve the clearing of remaining vegetated habitats within the Study area, which would consist mostly of Native-dominated, young secondary forest, Exotic-dominated secondary forest, Scrubland and Grassland patches. Area 4 land clearance works will likely commence after clearance of Area 1 to Area 3.

After the completion of all the land preparation and infrastructure works, the Project site will be handed over to building construction works for future development.

1.3.2.2 Post-construction Phase

According to URA Master Plan 2019, the future developments within the Project area comprises of industrial and commercial uses. The actual development plans may vary as they are subjected to further review and changes.

However, for this EIA study, the assessment of post-construction phase impacts will be based on MP2019 parameters.

2 Relevant Environmental Laws, Standards and Guidelines

2.1 Local Legislative and Administrative Requirements

National environmental management requirements that are applicable to the Project are found in several Acts, Regulations and Guidelines as listed in Table 2.1. In addition, Codes of Practices have been developed to address some specific environmental aspects and are generally endorsed by the relevant agency.

Table 2.1 List of applicable laws, standards and guidelines relevant to the Project

Environmental Aspect	Applicable Acts, Regulations & Guidelines
General	• Planning Act, 1998 • Code of Practice for Pollution Control, 2013 • Code of Practice on Environmental Health, 2017 • Code of Practice for Environmental Control Officers for Construction Sites, 2020 • Environmental Public Health (Registration of Environmental Control Officers) Regulations, 2002 • NEA's Guidelines for Pollution Control Study (PCS), 2014 • Environmental Protection and Management Act, 2002
Surface Water Protection	• Sewerage and Drainage Act (Trade Effluent) Regulations, 2001 • Sewerage and Drainage Act (Surface Water Drainage) Regulations, 2008 • Environmental Protection and Management (Trade Effluent) Regulations, 2008 • Guidebook on Erosion and Sediment Control at Construction Sites (PUB, 2014) • Code of Practice on Surface Water Drainage, 7th Edition (PUB, 2018, with amendments under Addendum 1 in 2021) • Managing Urban Runoff - Drainage Handbook 1st Edition (PUB, 2013)
Soil and Groundwater	• Environmental Protection and Management Act (2013), regulating the discharge of trade effluent, oil chemical, sewage or other pollution onto land • SS 593:2013 Code of Practice for Pollution Control (COPPC) provides guidance on managing land pollution, remediating contaminated sites, and ensuring proper storage and prevention of accidental releases of oils and chemicals • Guideline on Environmental Baseline Study (2019 Edition)
Air Quality	• Environmental Protection and Management Act, 2002 • Environmental Protection and Management (Vehicular Emissions) Regulations, 2008 • Environmental Protection and Management (Air Impurities) Regulations, 2008 • Environmental Protection and Management (Off-Road Diesel Engine Emissions) Regulations, 2012

Environmental Aspect	Applicable Acts, Regulations & Guidelines
	• Environmental Protection & Management (Prohibition on the Use of Open Fires) Order 2008 • Singapore Air Quality Targets (NEA) • Guidance on the assessment of dust from demolition and construction, Institute of Air Quality Management (IAQM), 2016
Noise	• Environmental Protection and Management Act, 2002 • Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008 • Code of Practice for Noise Control on Construction and Demolition Sites, 2014 • LTA's Noise Guidance: Developing a Noise Management Plan in LTA Projects, 2019
Ground Vibration	• BS6472-1:2008 Guide to evaluation of human exposure to vibration in buildings – Part 1: Vibration sources other than blasting • BS 5228-2 2009: Code of practice for noise and vibration control on construction and open sites – vibration • Vibration Criterion (VC) curves in the ASHRAE 2019 Handbook.
Wildlife Protection and Welfare	• Wildlife Act, 2000 • Singapore Red Data Book, 3rd Edition, 2024
Habitat Protection/ Conservation of Protected Areas	• Parks and Trees Act, 2006 • Parks and Trees Regulations, 2006 • Parks and Trees (Preservation of Trees) Order, revised 1998 • Guidelines on Greenery Provision and Tree Conservation for Developments (NParks, 2023b) • Biodiversity Impact Assessment Guidelines (NParks, 2024)
Waste and Hazardous Substances Management; General Waste Management	• Environmental Public Health Act, 2002 • Environmental Protection and Management (Hazardous Substances) Regulations, 2008 • Code of Practice for Licensed General Waste Collectors, 2019 • Code of Practice for Hazardous Waste Management, 2014 • Environmental Public Health (General Waste Collection) Regulations, 2000 • Environmental Public Health (Public Cleansing) Regulations, 2000 • Environmental Public Health (Toxic Industrial Waste) Regulations, 2000 • Sewerage and Drainage Act, 2001, Chapter 294 • Sewerage and Drainage (Trade Effluent) Regulations, 2008 • LTA's Guidebook for Best Environmental Practices – Construction Waste Management at LTA Sites, 2009
Vectors and Pesticides Management	• Control of Vectors and Pesticides Act, 2002 • NEA's Handbook of Scope of Works for Mosquito Control, 1995 • Code of Practice for Vector Control Operator, Technician and Worker, 2020 • Guidebook on Vector Control at LTA Sites, 2010

3 EIA Approach and Methodology

3.1 Overall Process

DHI carries out this EIA in accordance with the standard EIA framework stipulated by URA and MND as part of the planning approval process (Figure 3.1).

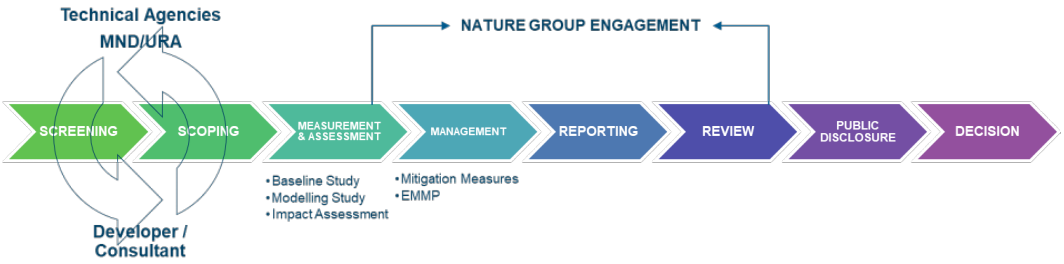


Figure 3.1 An illustration of EIA procedures in Singapore. Stakeholder engagement is project dependent, may take place at multiple stages of the study.

This EIA report documents outcomes of the subsequent stages – Scope, Measure, Assessment, Manage. DHI's approach to these tasks is illustrated in Figure 3.2 and outlined below. Subsequent to Reporting stage, DHI will together with the Developer to consult Technical Agencies, stakeholder and the public before final decision making by URA and MND.

- **Scoping** – to propose and obtain consensus on the objectives, spatial and temporal scales and parameters of the EIA as well as all the assessment criteria and methodologies.
- **Measurement (Baseline Study)** – to study and fully describe the baseline for the assessment, either through field surveys or desktop literature searches, and predict potential changes in environmental parameters as a result of the Project, either qualitatively or quantitatively.
- **Assessment** – to classify the significance of the environmental pressures and their influence on sensitive environmental receptors, through the Rapid Impact Assessment Matrix (RIAM) methodology.
- **Management** – to identify measures to manage the impacts to a reasonably practicable level and outline a monitoring program to ensure that impacts are managed accordingly. Impact significance will be re-evaluated on the basis that mitigation measures are implemented, to derive the Residual Impact significance.

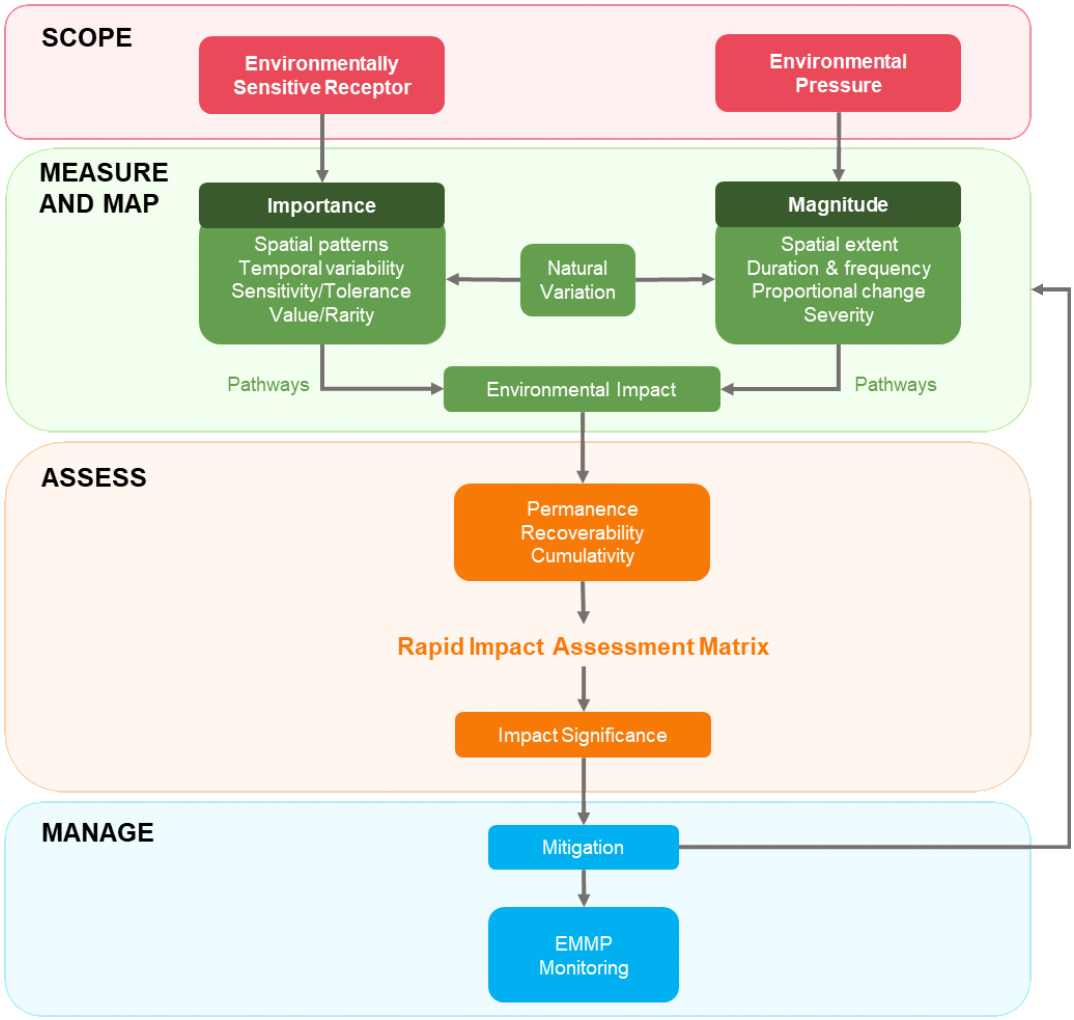


Figure 3.2 Overall workflow for the impact assessment process.

3.2 Scoping

DHI identifies potential impacts from a proposed development through developing a Scoping Matrix for the project. This process requires a clear understanding of (i) potential changes, or *pressures*, that will arise from the proposed Project, (ii) presence of environmental sensitive features, or *receptors*, in its potential impact zone and (iii) impact processes, such as ecosystem processes and linkages. An impact process is a description of how a specific receptor is affected by a specific type of impact: Pressure > Pathway > Receptor. All three elements are required for there to be an impact. For example, if there is no pathway from the source to the receptor, then no impact will eventuate; and if there is a source but no receptor, then there will also be no impact.

In this stage DHI works closely with the Development Agency and engineering consultant to understand the project design and its approach to construction and thereby identifies potential environmental pressures. DHI also conducts an extensive desktop study of the Study Area, in combination with consultation with relevant agencies (URA and NParks), to understand the existing and future land use, ecological habitats and socio-economic receptors in the area. The pressures and receptors are then tabulated in a Scoping Matrix and interactions between them are sought and to be assessed in the EIA.

3.2.1 Identification of Study Area

In general, the Study Area covers the Project site and where the environmental impacts may potentially extend. The spatial scope for analysis varies for each pressure and is respectively set at 150 m and 350 m around the development for noise and air quality impact assessment. The distances are set based on the relevant local regulation and international guidance. NEA's Environmental Protection and Management (Control of Noise at Construction Sites) Regulations set the maximum permissible construction noise levels at buildings within 150 m of construction sites. Further, Institute of Air Quality Management (IAQM)'s Guidance on the Assessment of Dust from Demolition and Construction indicates an air quality assessment is normally required where there is a human receptor within 350 m of the boundary of the site.

3.2.2 Identification of Sensitive Receptors

Based on literature review and DHI's in-house knowledge and a desktop review of public information, the key known environmental receptors within the identified Study Areas, and the Project footprint are shown in Figure 3.3. Descriptions for the various types of sensitive receptors are provided in Table 3.1. The potential impacts to these sensitive receptors are shown in the scoping matrix in Table 3.4.

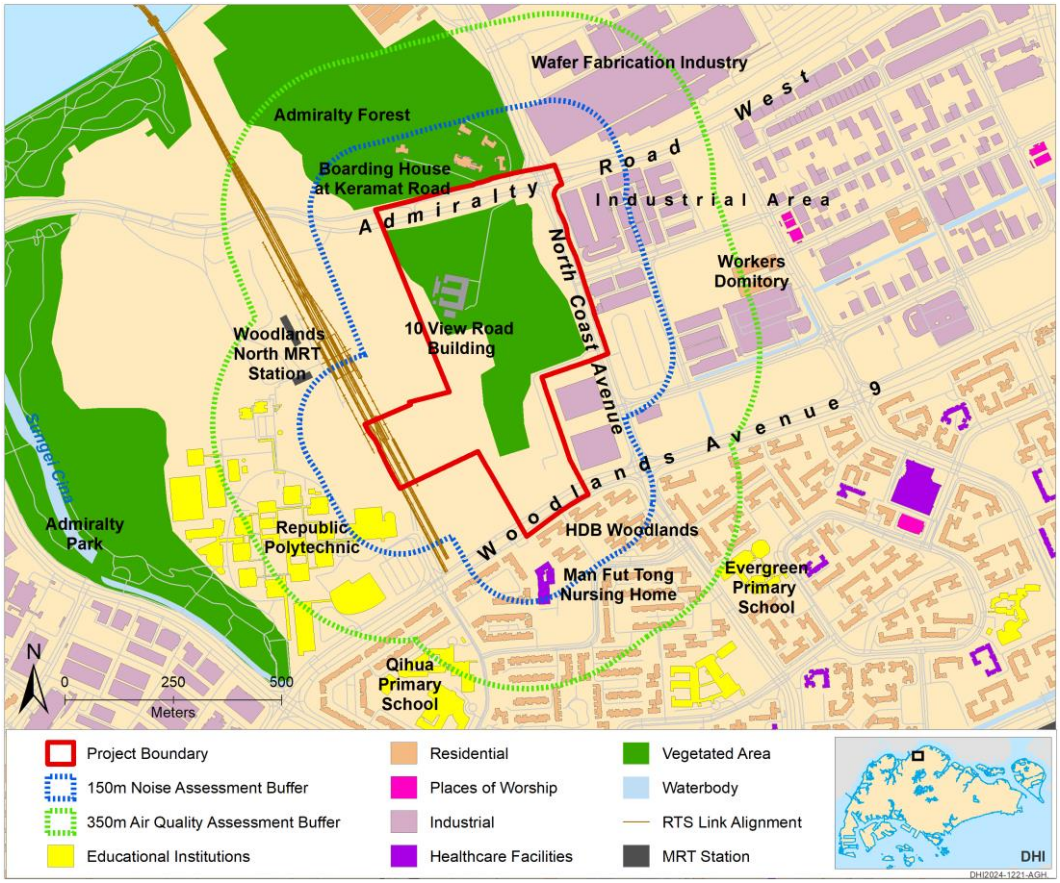
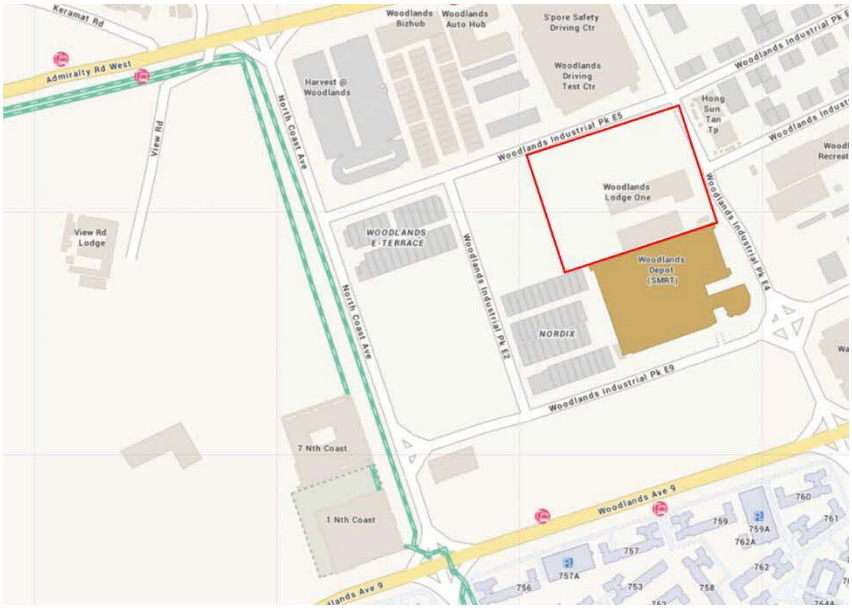


Figure 3.3 Overview of the sensitive receptors in relation to the Project footprint, Project Buffer Area of 150 m and 350 m.

Table 3.1 Overview of key environmental sensitive receptors identified within the Study Area.

Sensitive Receptor	Description
Biodiversity and Ecological	
Project site	Project site is surrounded by terrestrial forest with canopy dominated by Albizia (*Falcataria moluccana*) and understorey dominated with by native plants such as Fishtail palm, *Dillenia suffruticosa, Ficus sp., Macaranga sp., Smilax setosa* that were identified during site recce on 21 Jul 2022. Several stands of Tembusu trees were also recorded. These flora species are not nationally threatened species. The flora and fauna associated with these habitats would be susceptible to potential impacts from the planned works.
Admiralty Forest	Located at the north of Project site, Admiralty Forest has a dense patch of terrestrial forest. The flora and fauna associated with these habitats would be susceptible to potential impacts from the planned works.
Socio-Economic	
Residential Areas	Residents of these areas below would be susceptible to potential impacts from the planned works. The south of Project site is surrounded by residential HDB along Woodlands Ave 9 shown below. The HDBs within the 350 m buffer zone are Blk 749 to 757, Blk 807 to 810, Blk 816 to 818, Blk 822, Blk 838 to 848 and Blk 870 to 882. 

Sensitive Receptor	Description
	The north of Project site has small dwelling consisting of boarding house and colonial houses would be susceptible to potential impacts from the planned works.  The east of project site has a worker dormitory Woodland Lodge One. 
Educational Institutions	The west of Project site is Republic Polytechnic (RP). Located at the south of Project site, Qi Hua Primary School and Evergreen Primary School are within the 350m buffer zone.

Sensitive Receptor	Description
Healthcare Facilities	Located at the south of Project site is the Man Fut Tong Nursing Home which is within the 150 m buffer zone. 
Industrial areas	Located at the north of Project site is a wafer fabrication industry which can be sensitive to the additional dust and vibrations generated from the planned works. Located at the east of Project site, there are industrial facilities along North Coast Ave. Workers of these areas would be susceptible to potential impacts from the planned works.

3.2.3 Identification of Potential Environmental Pressures

Based on Project information described in Section 1.3.2, the following environmental pressures on the physical and biological environments are often expected as results of such activities:

Construction Phase:

- Loss of flora and fauna
- Human-wildlife conflict
- Air (dust), noise and vibration from construction activities
- Light emission from potential night works
- Landscape and visual aesthetics
- Pollution from improper site management (Waste, water quality, soil & groundwater quality, vector control)

Post-construction Phase:

- Loss of vegetation and habitat

- Injury and mortality to fauna
- Loss of ecological connectivity
- Potential air (dust), noise and vibration emission from future operations
- Light emission from buildings
- Change in microclimate
- Change in landscape

3.2.4 Planned Development in the Vicinity

This Project's construction phase may have interactions with other projects that are developed around the same timeframe. A brief description of future projects located within vicinity and around the timeframe of the proposed development is provided below (Figure 3.4). It should be noted that information provided herein are gathered from public domain, actual plans and timeline for these developments may vary.

- **Johor Bahru – Singapore Rapid Transit System (RTS) Link:** The RTS Link is a 4km rail shuttle service between the Singapore terminus at Woodlands North station and the Malaysia terminus at Bukit Chagar station in Johor Bahru. To facilitate a seamless travelling experience, there will be co-located Customs, Immigration and Quarantine (CIQ) facilities. Passengers travelling in either direction will clear both authorities at the point of departure. Construction works for the Woodlands North station, CIQ building, tunnels and viaducts started in 2021. RTS Link is expected to commence passenger service at the end of 2026 (LTA, 2024).
- **HDB – Housing by the Woods:** HDB will be developing new public housing in Woodlands North Coast in the coming years (HDB, 2024).

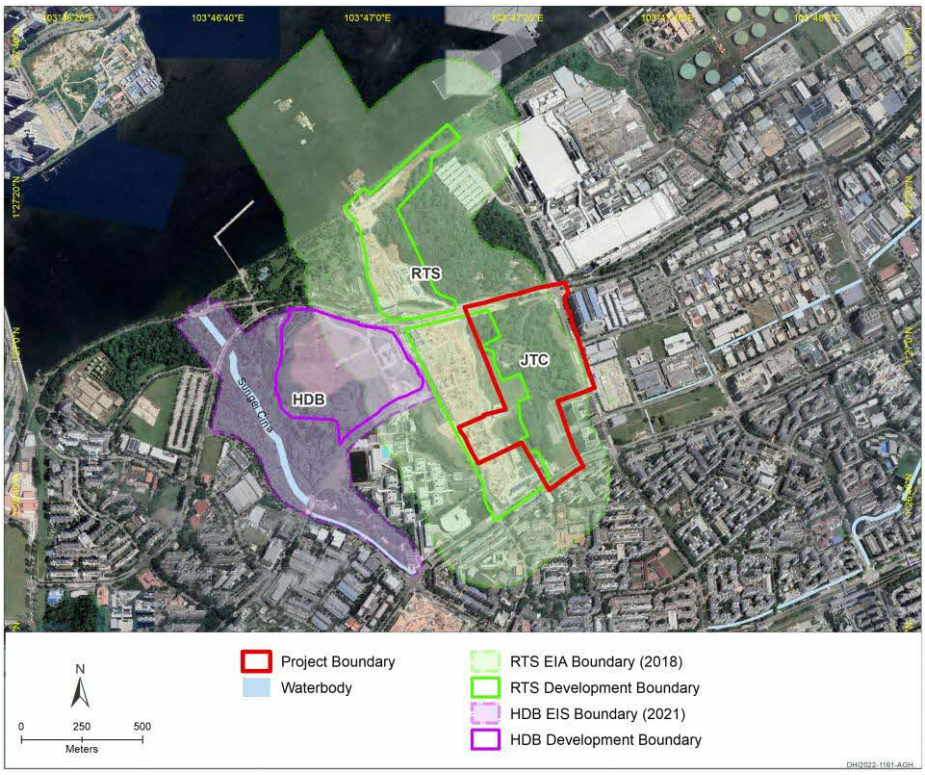


Figure 3.4 Known future developments in WNC (Satellite image as of 10 Mar 2022)

3.2.5 Identification of Potential Environmental Impacts – Scoping Matrix

Potential impacts anticipated at the relevant environmental sensitive receptors in short-term (construction phase) and long-term (operation phase) are presented in Table 3.2 and Table 3.3 respectively. The identified environmental pressures/changes, and potential environmental impacts to the environmental sensitive receptors are tabulated in the Scoping Matrix in Table 3.4 . This matrix forms the basis for the baseline study scope and impact assessment scope.

Table 3.2 Potential construction phase impacts of the proposed development

Type of Receptor	Receptor	Potential Construction Phase Environmental Impact(s)
Biodiversity and Ecology		
Fauna and Flora within secondary forest	Project site	• Loss of flora due to land clearance and construction activities • Loss and mortality of fauna due to land clearance and construction activities • Human-wildlife conflict between fauna and construction workers in the Study Area • Human-wildlife conflict between fauna and members of the public around the Study Area
Fauna within secondary forest	Admiralty Forest	• Disturbance by airborne noise, vibration, atmospheric emissions and light pollution from construction activities
Socio-Economic		
Residential Areas	HDB, Boarding House	• Potential deterioration in air quality (e.g. dust) due to construction activities • Airborne noise, ground vibration and light pollution causing adverse effects/ nuisance on humans • Improper management of construction site may lead to pollution (e.g. chemical and waste management, surface runoff, vector control) • Landscape and visual impact due to the presence of the construction site
Educational Institutions	Republic Polytechnic	
Healthcare Facilities	Man Fut Tong Nursing Home	
Industrial areas	Industrial facilities along North Coast Ave (workers)	
Industrial areas	Wafer fabrication industries	• Construction dust affecting air intake of wafer fab facilities • Ground vibration from construction activities causing impact to sensitive machineries or manufacturing process

Table 3.3 Potential operational phase impacts of the proposed development

Type of Receptor	Receptor	Potential Operational Phase Environmental Impact(s)
Biodiversity and Ecology		
Fauna and Flora within secondary forest	Project site	• Permanent habitat, flora and fauna loss due to clearing of forest within Project site
Fauna within secondary forest	Admiralty Forest	• Disturbance by airborne noise, atmospheric emissions and light pollution during operational phase. • Potential mortality from bird strikes and wildlife collisions • Potential loss of ecological connectivity between Admiralty Forest and distant habitat patches • Potential change in microclimate
Socio-Economic		
Residential Areas	HDB, Boarding House	• Atmospheric emissions and airborne noise from heavy industrial process (if any) causing adverse effects/ nuisance on humans • Light emission from the future building causing nuisance on the neighbourhood • Potential change in landscape • Potential change in microclimate
Educational Institutions	Republic Polytechnic	
Healthcare Facilities	Man Fut Tong Nursing Home	

Table 3.4 Preliminary scoping matrix.
Pressures = changes in environmental parameters as a result of the Project. Receptors = social, economic or ecological features that may be affected by the pressure. S = Short-term impacts/ construction phase impacts. L = Long-term impacts/ operational phase impacts.

Ecological and Environmental Receptors	Environmental changes												
	Ecological Pressures						Physical Pressures						
	Loss of flora	Loss or fauna	Human-wildlife conflict	Loss of vegetation and habitat	Injury and mortality to fauna	Loss of ecological connectivity	Air Quality	Noise	Vibration	Light	Microclimate (Temperature)	Landscape and Visual Aesthetics	Environmental Pollution (Waste and Water)
Flora (Project area)	SL			L									S
Fauna (Project area)		SL	S										
Fauna (Admiralty Forest)					L	L	SL	SL	SL	SL	L		S
Residential areas			S				SL	SL	SL	SL	L	SL	S
Educational Institutions			S				SL	SL	SL		L	SL	S
Health Care facilities			S				SL	SL	SL	SL	L	SL	S
Industrial facilities			S				SL		SL				S

3.3 Baseline Study

The primary objectives of an Environmental Baseline Study are to understand the receptors, establish baseline conditions and collect data for subsequent impact assessments. The scope of this baseline study is designed based on the receptors identified (Table 3.1) and the relevant impacts (Table 3.4) that will need to be assessed in this EIA.

The baseline conditions will be established through a combination of a desktop study of readily available information (secondary data) and field surveys (primary data). Specifically, baseline ecological and environmental data collected from previous Environmental Impact Assessments (EIAs) and Biodiversity Impact Assessments (BIAs) conducted within and around the Project area will be used to supplement the field baseline data collected here, wherever applicable. A list of these past environmental studies, along with their relevant survey dates and features are included in Table 3.5.

Table 3.5 Baseline surveys previously conducted within and around the Project area.

Study	Baseline Survey(s)	Survey Date(s)
Fauna Biodiversity Surveys for Environment Impact Assessment of Development at Admiralty Forest	Terrestrial flora, vegetation, and habitat assessment	28 Sep 2016 to 06 Oct 2016
	Terrestrial fauna	23 Oct 2016 to 15 Nov 2016
	Camera trapping	14 Oct 2016 to 15 Nov 2016
Soil Investigation Report	Soil investigation	20 Sep 2019 to 22 Jan 2020
RTS EIA	Air, noise, vibration and ground-borne noise, surface water quality, marine water and ecology, terrestrial ecology, and habitat assessment	8 Jul 2016 to 28 Mar 2017
Air Dispersion Study	Ambient air quality, including $PM_{2.5}$, PM_{10}, NO_2 and CO	29 Jun 2018 to 6 Jul 2018

Given that previous surveys were carried out more than 2 years ago and that several developments have been carried out within the vicinity of the Project area, the data would no longer be valid and it would be prudent to carry out new ecological surveys to verify the present-day relevance of previous findings. Therefore, the scope of this baseline study would also include 1) verify the historical baseline study results, and 2) supplement the existing data with additional surveys to fill the information gap.

In addition, baseline studies performed in these previous studies may not sufficiently cover all the sensitive receptors and environmental pressures for the planned development that are deemed relevant for this Project. Thus, measurements of parameters such as air quality, noise, vibration, illuminance, and microclimate were assessed for an adequately comprehensive study.

It has been noted that no waterbodies or streams were identified within the Study Area. Hence, no water quality or aquatic surveys were proposed.

In summary, the survey plan for this Project is presented in Table 3.6 and further elaborated in the sections to follow.

Table 3.6 Summary of baseline surveys approach

Environmental Aspect	Location/Extent	Methods	Parameters	Frequency and Duration
Terrestrial Flora	Within the Project site	• Satellite data and ground truthing • Visual surveys • Mapping of habitat types • Vegetation sampling plots • Mapping and tagging of trees (including strangling Ficus sp.) with girth/spread ≥ 1.0 m • Mapping and tagging of conservation-significant plants with girth ≥ 0.3 m • Mapping of other plant specimens of value	• Map of habitats/vegetation types; • Floral inventory checklists: identification to the lowest possible taxon, conservation status, species origin (i.e., native, exotic, etc.); • Map and shapefiles of trees with girth/spread ≥ 1.0 m and conservation-significant plants with girth ≥ 0.3 m; • Identification and girth measurement of woody and non-woody plant specimens ≥ 0.05 m girth within sampling plot	• One-time survey
Terrestrial Fauna	Within the Project site	• Visual and auditory transect surveys (diurnal and nocturnal) • Camera trapping • Bioacoustic surveys (bats) • Roost emergence surveys (bamboo bats) • Leaf Sifting/Umbrella beating (Spiders)	• Fauna checklist: Identification to the lowest possible taxon, abundance, conservation status, noteworthy behaviour; and • Distribution maps of conservation-significant fauna species encountered • Taxon Sampling Curves evaluating sampling effort and coverage	• Transect surveys; 2 replicates per taxon, minimally separated by a week between each replicate; survey duration and timing will be specific to target fauna taxa (see Table 4.4). • For avifauna, 2 replicates during migratory season • Three replicates of bioacoustics surveys for bats • One bamboo bat roost emergency survey per bamboo cluster (if present) • Camera traps: Continuous deployment for 60 days

Environmental Aspect	Location/Extent	Methods	Parameters	Frequency and Duration
Air Quality	5 representative locations (Figure 5.1)	• Deployment of dust sensors for measurement of PM2.5 and PM10 • Gas sampling and testing at accredited SINGLAS laboratory	• PM2.5 and PM10 • Nitrogen dioxide (NO2), Hydrogen Chloride (HCl), Hydrogen Fluoride (HF), Nitrous acid (HNO2), and Ammonia (NH3)	• 7-day continuous measurement for dust • 1 time sampling for other pollutants
Airborne Noise	3 representative locations (Figure 6.1)	• Measurement with calibrated NEA approved Type 1 sound level meter	• Sound level (Leq A-weighted) measurements	• 7-day continuous monitoring of Leq 5mins, Leq 1hr and Leq 12-hour • Spot measurements of Leq 5mins at three (3) locations
Vibration	4 representative locations (Figure 7.2)	• Measurement with vibration sensor	• Tri-axial movement measurement in peak particle velocity (ppv)	• 48-hour measurement
Ambient Light Levels	3 representative locations (Figure 8.2)	• Measurement of lux levels using micro-data loggers	• Mean daily mean, maximum, and minimum lux levels during night hours; • Time-series lux level graphs for selected land use classes	• Continuous logging on a 5-minute interval for 2 weeks
Microclimate (Ambient Air Temperature)	10 representative locations across the forest-urban gradient (Figure 9.2)	• Measurement of ambient air temperature using micro-data loggers	• Mean daily mean temperature, maximum, and minimum temperatures for all locations	• Continuous logging on a 5-minute interval for 2 weeks

3.4 Impact Assessment

3.4.1 Methodology: Rapid Impact Assessment Matrix

All the identified impacts will be assessed using the Rapid Impact Assessment Matrix (RIAM), originally developed by Pastakia & Jensen (1998). RIAM allows for a holistic, rapid and easily comparable presentation and summary of the overall project impacts, which ultimately aids in pinpointing the most significant impacts predicted, in accordance with the broad definitions presented in Table 3.7. Besides the reduction in assessment subjectivity as compared to other methodologies, RIAM also accounts for the presence of impacts that may be cumulative and may have cascade effect in nature. The Biodiversity Impact Assessment (BIA) Guidelines of Singapore (NParks, 2024) recommends the use of RIAM as one of three approved methods for assessing and summarizing the overall significance of impacts.

Table 3.7 Broad definitions for each level of predicted impact significance. Impacts can be either negative or positive.

Impact Significance	Broad Definition
No Impact	Changes are significantly below physical detection level and below the reliability of numerical models, so that no change to the quality or functionality of the receptor will occur.
Slight Impact	Changes can be resolved by numerical models and are detectable in the field, which may cause slight and localised nuisance or disruption of daily activities.
Minor Impact	Changes can be resolved by numerical models and are likely to be detected in the field, which may cause stress to a portion of the population at endurable levels, but to a spatial scale that is unlikely to have any secondary consequences.
Moderate Impact	Changes can be resolved by numerical models and are obviously detectable in the field, which may cause significant stress to a large portion of population and would likely disrupt the quality and functionality of the receptor.
Major Impact	Changes are highly detectable in the field and are likely to be related to significant habitat loss. Major impacts are likely to have secondary influences beyond the area of assessment.

RIAM translates qualitative standard definitions of evaluation criteria into semi-quantitative ordinal scores which are then used to calculate Environmental Scores (ES), via the formula:

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

The five evaluation criteria (variables) used in the formula are defined as:

(I) Importance – This defines the importance of the sensitive receptor identified, which is assessed against spatial or political boundaries, socio-economic value, intrinsic quality, or the degree of rarity.

(M) Magnitude – Impact Magnitude is based on the relationship between the analysed physio-chemical, biological, or socio-economic deviation from baseline conditions and the relevant environmental standards, benchmarks, guidelines, or tolerance limits. Importantly, the Magnitude value should reflect the magnitude of change experienced at a particular sensitive receptor. In this way, the impact pathway is considered, i.e., whether there is a spatial and/or temporal overlap between the environmental change and receptor. Positive or negative impacts are represented though positive or negative ordinal scores for Magnitude respectively.

(P) Permanence – This defines whether an impact is temporary or permanent, i.e. a measure of the temporal status of the loss/change. For example, slope stabilization with gabion walls will be a permanent impact, while slope stabilization with sheet piles will be a temporary impact, given their eventual removal.

(R) Recoverability – The score expresses whether the receptor can recover from the impact, either unassisted or via mitigation measures. Recoverability is also a measure of the control over the effect of the condition. It is not equated with permanence. For example, the loss of streetscape trees is recoverable with replacement plantings, while the loss of an endemic species is irrecoverable.

(C) Cumulative Impact – This is a measure of whether the effect will have a single direct impact or whether there will be a cumulative effect over time, or a synergistic effect with other conditions. For example, the loss of flora and fauna species is cumulative, given that it is also associated with other impacts such as the loss of ecosystem functioning and ecological connectivity.

The approach of RIAM is therefore to couple the potential impact Magnitude experienced at the sensitive receptor(s) of interest, with a concurrent assessment of receptor Importance, impact Permanence, Recoverability, and Cumulative potential.

The multiplication of Magnitude and Importance in the formula ensures that the weight of each evaluation criteria is expressed and is individually able to significantly influence the resultant ES. The summation of Permanence, Importance, and Cumulative ensures that these criteria are represented collectively, but do not have a large influence on the resultant ES individually.

The standard (generic) definitions of each evaluation criteria, and the associated ordinal scores used to calculate ES, are shown in Table 3.8. To account for the wide variability and context-specificity of sensitive receptors and predicted environmental impacts (pressures), the generic definitions of Importance and Magnitude in Table 3.8 will be customized and made specific for sensitive receptors and predicted environmental impacts respectively, with justifications elaborated in each assessment section.

Table 3.8 Evaluation criteria and the associated standard definitions and ordinal scores used in the calculation of Environmental Scores.

Evaluation Criteria	Standard Definitions	Ordinal Score
Importance*	Important to national/international interests	5
	Important to regional/national interests	4
	Important to areas immediately outside the local condition	3
	Important to the local conditions (within a large direct impact area)	2
	Important only to the local condition (within a small direct impact area)	1
Magnitude*	Major positive benefit or change	+4
	Moderate positive benefit or change	+3
	Minor positive benefit or change	+2
	Slight positive benefit or change	+1
	No change/status quo	0
	Slight negative disadvantage or change	-1
	Minor negative disadvantage or change	-2
	Moderate negative disadvantage or change	-3
	Major negative disadvantage or change	-4
Permanence	Temporary or short-term change.	2
	Permanent change or long-term; value and/or function unlikely to return.	3
Recoverability	Recoverable or controllable through EMMP	2
	Irrecoverable	3
Cumulativity	Impact can be defined as non-cumulative/single (not interaction with other impacts).	2
	Presence of obvious cumulative/cascading effect that will affect other projects or activities or trigger secondary impacts.	3

**Definitions and scorings of Importance and Magnitude will be customised for all identified sensitive receptors and environmental impacts respectively in subsequent assessment sections.*

For each identified environmental impact affecting a sensitive receptor, an ES will be calculated. The ES are then banded together and ranked in range bands as presented in Table 3.9, which are then translated to Impact Significance – the reported output of the impact assessment process.

Table 3.9 Range bands of ES and the associated Impact Significance used in RIAM

Environmental Scores (Range Bands)	Impact Significance Translated from Environmental Scores
116 to 180	Major positive change/impact
81 to 115	Moderate positive change/impact
37 to 80	Minor positive change/impact
7 to 36	Slight positive impact
-6 to +6	No impact/Status quo
-7 to -36	Slight negative change/impact
-37 to -80	Minor negative change/impact
-81 to -115	Moderate negative change/impact
-116 to -180	Major negative change/impact

3.5 Management of Environmental Impacts

Mitigation is typically required at least for identified environmental impacts predicted to be Moderate or Major. Mitigation measures are recommended and designed to reduce the impact down to an as-low-as-practicable level. Slight or Minor impacts may also require some type of mitigation, but it may also be enough to manage by having appropriate environmental management procedures in place.

The term “mitigation measures” includes operational controls as well as management actions. These measures are often established through industry standards and may include:

- Changes to the design of the Project during the design process
- Engineering controls and other physical measures applied (e.g., noise barrier)
- Operational plans and procedures (e.g., noise pollution control management plan)
- Provision of like-for-like replacement, restoration, or compensation

The mitigation hierarchy concept is presented in Figure 3.5. In developing mitigation measures, the first focus is on measures that will avoid or minimise impacts through the design and management of the Project followed by those that restore or offset. Where impacts cannot be avoided, environmental mitigation measures will also be incorporated into the final detailed construction design and specified for appropriate construction methodology.

It is important to note that not all impacts are necessarily negative. There are actions that can be recommended to create net positive gains. Avoidance, minimisation and/or restoration alone are generally not enough to achieve a net gain and some form of offset is also necessary.

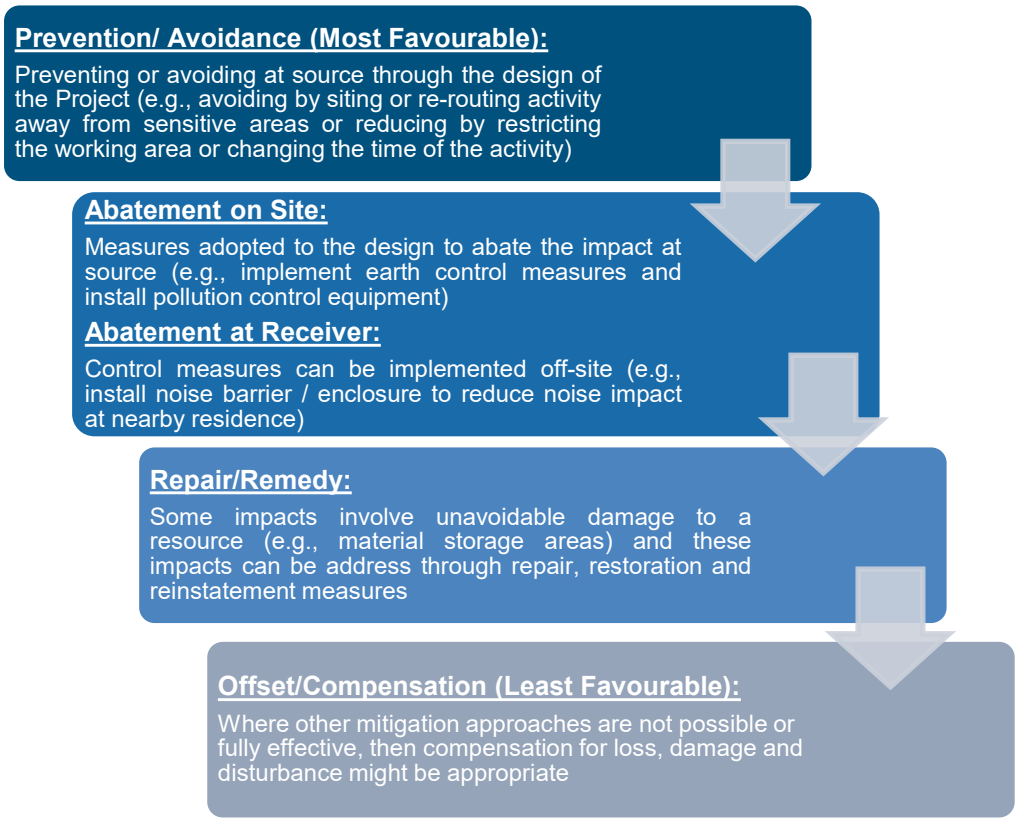


Figure 3.5 Hierarchy of mitigation strategy adopted in this EIA.

4 Ecology and Biodiversity

4.1 Applicable Legislation, Guidelines and Standards

National environmental management requirements that are applicable to the management and conservation of local biodiversity and ecology are found in several Acts, Regulations and Guidelines, as listed in Table 4.1.

Table 4.1 Applicable acts, regulation and guidelines for ecology and biodiversity receptors

Environmental Aspect	Applicable Acts, Regulations & Guidelines
Wildlife Protection and Welfare	• Wildlife Act, Chapter 351, 2020 • Singapore Red Data Book, 3rd Edition, 2024
Habitat Protection/ Conservation of Protected Areas	• Parks and Trees Act, 2006 • Parks and Trees Regulations, 2006 • Parks and Trees (Preservation of Trees) Order, revised 1998 • Guidelines on Greenery Provision and Tree Conservation for Developments (NParks, 2023b) • Biodiversity Impact Assessment Guidelines (NParks, 2024)

National Biodiversity Strategy and Action Plan

The Singapore National Biodiversity Strategy and Action Plan (NBSAP) was developed and launched in 2009 by NParks as Singapore's blueprint for biodiversity conservation and to fulfil Singapore's commitment as a signatory to the Convention Biological Diversity. The NBSAP provides a framework for conservation of biodiversity in Singapore and allows greater consideration of biodiversity issues in policy decisions. The NBSAP advocates the conduct of an EIA in the early stages of development projects to assess potential environmental impacts and to recommend mitigation measures to remediate these impacts.

Singapore's NBSAP was updated in 2019 with national targets developed with reference to the Strategic Plan for Biodiversity 2011-2020 and the Aichi Targets established during the Tenth Meeting of the Conference of Parties to the Convention on Biological Diversity (COP-10) in 2010. The national targets were finetuned in the context of Singapore's unique circumstances as a highly urbanised city-state and one of the most densely populated countries in the world. Singapore's NBSAP is also updated regularly, e.g. NParks plans to further develop national targets to contribute to the Kunming-Montreal Global Biodiversity Framework prior to the 16th meeting of the Conference of the Parties to the Convention on Biological Diversity in 2024.

Nature Conservation Master Plan

In 2015, NParks launched a holistic Nature Conservation Master Plan (NCMP) that outlines the course of Singapore's biodiversity conservation plans for the next five years. The NCMP comprises four aspects, namely: 1) the conservation of key habitats, including the safeguarding and strengthening of Singapore's core biodiversity areas by creating greenery nodes or buffer areas integrating with the urban landscape; 2) habitat enhancement, restoration, and species recovery; 3) applied research in conservation biology and planning, including comprehensive surveys and long-term monitoring of ecosystems and species; and 4) community stewardship and outreach in nature, which aims to encourage and build public interest and involvement in biodiversity conservation.

Under the NCMP, NParks launched the Ecological Profiling Exercise (EPE) in February 2021 to study the ecological profile of green spaces in Singapore and to better understand their role in strengthening ecological connectivity. This exercise was carried out in consultation with the nature community and academics. The Bukit Batok and Clementi Nature Corridors were conceptualised as part of the EPE to maintain and bolster island-wide ecological connectivity.

Singapore Green Plan 2030 and City in Nature

The Singapore Green Plan 2030 was launched in February 2021 as a whole-of-nation movement to advance Singapore's national agenda on sustainable development. It charts ambitious and concrete targets for the rest of this decade under five thematic pillars. One of the pillars is the City in Nature initiative, which is guided by four key strategies – extending the nature park network, intensifying nature in gardens and parks, restoring nature into the built environment, and strengthening connectivity between Singapore's green spaces. Examples of the targets include the planting of 1 million trees across Singapore under the One Million Trees movement, and the increasing of total Nature Park land area by over 50% from 2020 baseline by 2030.

Greenery Provisions for Development Projects and Handbook on Developing Sustainable Skyrise Gardens

NParks has guidelines that describe the statutory requirements on greenery provision, tree planting and conservation for development projects in Singapore, both within the premises at ground level (NParks, 2023b) or as skyrise greenery (NParks, 2017). Planting specifications, flora species palette, applicable buffer and setback distances, and safety and maintenance regimes are provided in the guidelines for developers' consideration.

4.2 Baseline Study

4.2.1 Methodology

Ecological baseline information was collected using both primary data obtained through ecological field surveys (Section 4.2.1.1) and secondary data obtained through a desktop study of established literature sources, including existing records, reports, and publications relevant to the ecology of the Study Area (Section 4.2.1.4).

4.2.1.1 Biodiversity, Nomenclature and Taxonomy

The nomenclature of flora and fauna species recorded from primary field surveys and desktop study were cross-referenced with relevant key references that include books, scientific publications, unpublished literature, and online databases. Sources of databases include The Biodiversity of Singapore by the Lee Kong Chian Natural History Museum (LKCNHM, 2023), Flora and Fauna Web by the National Parks Board (NParks, 2023a) and iNaturalist (California Academy of Sciences, 2023). Other key references include Singapore Biodiversity Records, encyclopedia on Singapore's biodiversity (Ng et al., 2011), the database of flora and fauna records compiled by Camphora Pte Ltd (unpublished data), and the 2017 Fauna Baseline Survey (Fung et al., 2017).

The local conservation statuses of species observed were derived from the third edition of the Singapore Red Data Book (NParks, 2024). Global conservation statuses were referenced from the IUCN Red List of Threatened Species (IUCN, 2023).

Key local and/or regional references for various taxonomic groups are listed in Table 4.2.

Table 4.2 Key references for the nomenclature and taxonomy for each taxonomic group

Taxon	Key References
Plants	NParks (2024); Lindsay et al. (2022); Chong et al. (2009); World Checklist of Selected Plant Families (Royal Botanic Gardens Kew, 2023b); Plants of the World Online (GBIF, 2023)
Butterflies	NParks (2024); Khew (2015)
Odonates	Ngiam & Cheong (2016); Soh & Ngiam (2019); NParks (2024)
Aculeata hymenopterans	Ascher & Pickering (2018); Ascher et al. (2022)
Spiders	Koh et al. (2022)
Herpetofauna (amphibians and reptiles)	NParks (2024)
Birds	Gill et al. (2022); NParks (2024)
Mammals (including bats)	NParks (2024)

4.2.1.2 Assessment of Conservation Significance

The assessment of whether certain species are of conservation significance is important for highlighting the need and priorities for conservation.

Threatened species of flora—i.e., listed in NParks (2024) and where applicable, Lindsay et al. (2022) and Chong et al. (2009), as nationally Vulnerable, Endangered, Critically Endangered, or Presumed Extinct (which indicates a rediscovery)—were assessed to determine whether they are of conservation significance. While the national conservation status of threatened species is true of wild populations that originate in an area without direct or indirect human intervention, some populations may be relics that persist from past cultivation or escapees from present-day cultivation that do not belong to native genetic stock. The assessment of whether a threatened species is of conservation significance was based on, but not limited to, information on the following: (1) land use history, (2) presence of large parent tree(s), (3) commercial availability, (4) data from previous environmental impact assessments, (5) reforestation efforts, (6) natural range, and (7) importance for associated fauna. Where the origin of a threatened species population is disputable or difficult to determine, the more conservative approach was adopted, i.e., they were considered of conservation significance, with or without corroborating findings from field surveys of fauna. In carrying out such assessments, conservation needs can then be prioritised, and resources gathered in conserving them.

Faunal species of conservation significance are threatened species which are listed as nationally or globally Vulnerable, Endangered, Critically Endangered, or Extinct. The national conservation statuses mainly reference the Singapore Red Data Book Third Edition (NParks, 2024) for butterflies, odonates, amphibians, reptiles, birds, and mammals (including bats). The global conservation status references the Red List of Threatened Species by the International Union for Conservation of Nature (IUCN, 2023). Where main sources of literature were inconclusive, other updated references (Table 4.2) were utilised for the assessment accordingly.

Table 4.3 Criterion for conservation significance for flora and fauna under different classification systems

Conservation Status	Definition
Local (Flora) – Lindsay et al., 2022	
Vulnerable (VU)	Between 250 to 1000 mature individuals estimated in Singapore
Endangered (EN)	Between 50 and 250 mature individuals estimated to be in Singapore, with no evidence of decline or fragmentation of populations
Critically Endangered (CR)	Fewer than 50 mature individuals estimated to be in Singapore; or if more than 50 but fewer than 250 mature individuals, with evidence of rapid decline or decline and fragmentation of populations
Presumed Nationally Extinct (NEx)	Not recorded in Singapore within the last 30 years. Endemic species that are presumed nationally extinct will consequently also be presumed to be globally extinct
Globally Extinct (EX)	Globally extinct
Data Deficient (DD)	Not enough information available to assess the risk of extinction
Local (Fauna) - NParks, 2024	
Vulnerable (VU)	Species with <1,000 mature individuals and >250 total individuals
Endangered (EN)	Species with <250 mature individuals
Critically Endangered (CR)	Species with <50 mature individuals or <250 total individuals
Presumed Nationally Extinct (NE)	Flora and fauna not recorded within the last 30 and 50 years, respectively
Globally Extinct (EX)	Globally extinct, including in captivity or through cultivation
International/Global (Fauna) - IUCN Red List	
Vulnerable (VU)	Species facing a high risk of extinction in the wild
Endangered (EN)	Species facing a very high risk of extinction in the wild
Critically Endangered (CR)	Species facing an extremely high risk of extinction in the wild
Extinct in the Wild (NW)	Species that only survives through cultivation, captivity or as a naturalized population(s) outside its natural range
Extinct (EX)	Globally extinct, including in captivity or through cultivation

4.2.1.3 Primary Data Collection (Ecological Field Surveys)

Flora

The field surveys conducted to obtain flora baseline data consist of habitat and vegetation mapping, general walking floristic surveys, and tree tagging and assessments, which are elaborated in subsequent sections.

Habitat and Vegetation Mapping

A preliminary vegetation map was first prepared based on visual interpretations of satellite images from Google Earth 9.182.0.1 (Google Inc. 2023). Preliminary classification of the vegetation types—for example, forests, grasslands, or managed vegetation— was determined using visual features, such as textures and colours, observed in the satellite images. Adjustments were then be 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 GPS receiver (Garmin GPSMap® 64s). Photographs of the vegetated areas were also taken. The boundaries of each vegetation type were tracked on the GPS receiver and mapped out on Google Earth 9.182.0.1. The classification of vegetation types referenced NParks (2024) and relevant publications such as Yee et al. (2016).

General Walking Floristic Surveys

All plants observed in the Study Area during floristic surveys were identified to species whenever possible. A checklist of all the plant species recorded from the present floristic surveys was compiled. The nomenclature of plants observed followed that of the Singapore Red Data Book Third Edition (NParks, 2024). Secondary sources used include Lindsay et al. (2022) and Chong et al. (2009), and/or other published papers with updated information. The latter references were usually only used for one or a few individual species. Other information on the plant species was also cross referenced with online databases, namely, the National Parks Board Flora and Fauna Web (NParks, 2023a) and The Biodiversity of Singapore (LKCNHM, 2023).

For plants that could not be immediately identified with certainty in the field, photographs and/or voucher specimens were taken. They were then be 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 unidentifiable trees 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 the species identification.

Flora Species of Conservation Significance

The assessment of whether flora species recorded were considered to be of conservation significance is elaborated on in Section 4.2.2.2. For flora specimens of conservation significance, their geographic locations were marked using a Global Positioning System (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, palm clusters, and strangling *Ficus* species of ≥ 3 m spread. Individuals were identified to species whenever possible. The girth (for trees) and spread (for 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 include exotic trees of < 3 m girth with active raptor nests, amongst others.

Tree Tagging and Assessment

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 assessed during arboricultural surveys and tagged with a unique serial number. Other specimens that were 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.

Differential Global Positioning System (DGPS) that can achieve up to sub-meter accuracy was used to record 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) (SLA, 2015).

Where specimens were inaccessible due to obstructions, (e.g., stream, nearby tree fall), these were not given a physical tag on site. However, the location of these specimens were still marked using the DGPS and they were still assessed by certified arborists.

Arboriculture assessment of the trees was conducted by certified arborists. Plant health and structural stability were assessed by observing for damages, decays, and/or canopy asymmetry, of which, if present, may compromise plant longevity and stability. Other characteristics that were recorded include presence of habitats and canopy linkages across roads for fauna.

There were more specimens assessed than tagged as some specimens occur in clusters, i.e., within 1–2 m of each other or are inaccessible during the tree mapping survey due to the terrain.

Fauna

Fauna field surveys were carried out for the following taxa: (1) butterflies, (2) odonates (damselflies and dragonflies), (3) aculeate hymenopterans, (4) spiders, (5) herpetofauna (amphibians and reptiles), (6) birds and (7) non-volant mammals, and (8) bats. Each survey was conducted twice, unless otherwise stated. All observations of notable species from the aforementioned taxa were also recorded as incidental observations if seen outside the stated survey times. A checklist of all species of fauna observed from the surveys was compiled.

Figure 4.1 shows the alignment of terrestrial transects, as well as locations of camera traps, and harp traps. The total transect length is at 1.7 km. Figure 4.2 shows the location of sampling points for spider surveys.

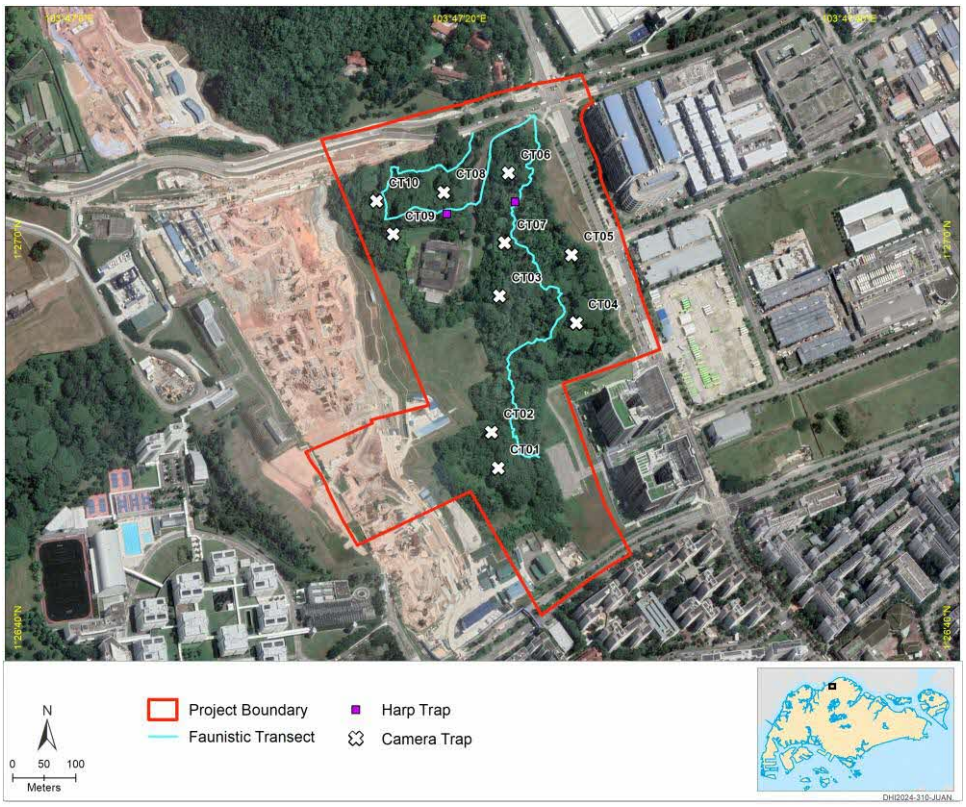


Figure 4.1 Location of terrestrial transects, camera traps and harp traps (Satellite image as of 10 Mar 2022)

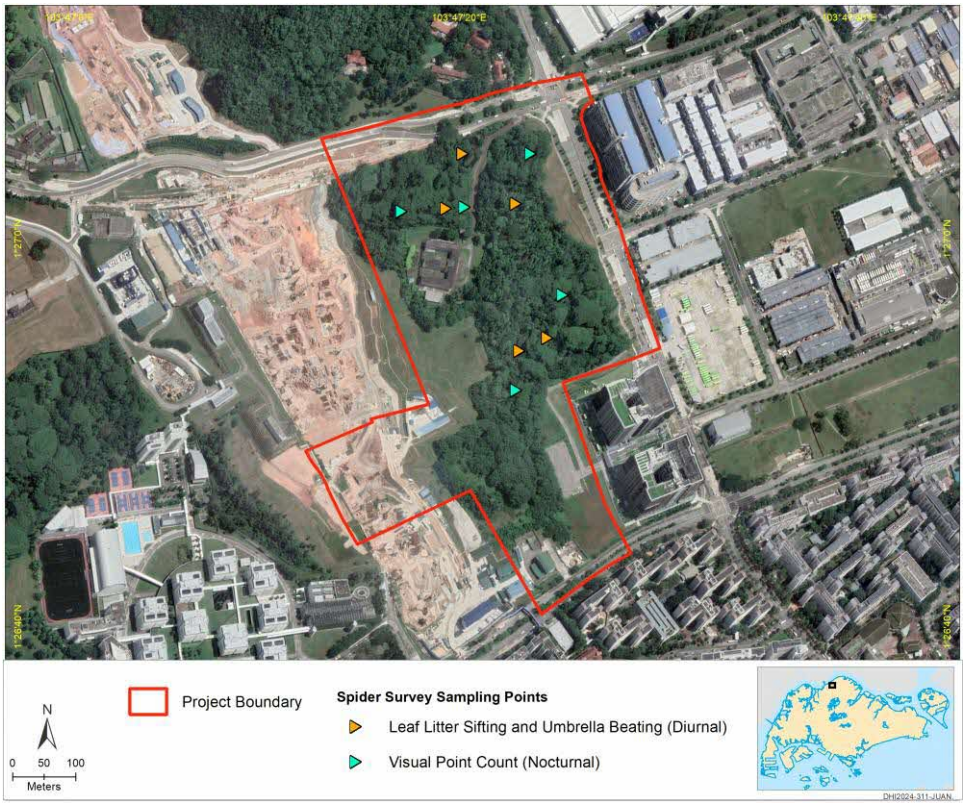


Figure 4.2 Location of diurnal (leaf litter sifting and umbrella beating) and nocturnal (visual) sampling points for spider surveys (Satellite image as of 10 Mar 2022)

Table 4.4 summarises all fauna surveys that were carried out, and the survey methodology associated with each fauna taxon. Each survey was performed by at least two surveyors. All fauna encountered was identified to species, or to the next lowest taxonomic level possible, and the location of each sighting was recorded using a handheld GPS (Garmin GPSMAP 64s). The number of individuals observed was also documented.

Table 4.4 A summary of faunal survey methods across taxonomic groups.

Survey Type	Taxon	Timing (h)	Duration	Sampling Unit	Technique
Diurnal transect surveys	Butterflies	0900-1600	20–30 minutes per transect; two cycles	200-m continuous transects along a sampling route	Visual only; up to 25 m left, right, and front of surveyor
	Odonates (damselflies and dragonflies)				
	Aculeate hymenopterans (bees and stinging wasps)				
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
	Birds				
	Mammals (non-volant)				
Camera trapping	Mammals (non-volant)	24 h a day	60 days per camera trap (10 deployed)	24-h continuous period of recording on a camera trap	Infrared motion sensing
Bioacoustic surveys	Mammals (bats)	2000–2300	20–30 minutes per transect; three cycles	200-m continuous transects along a sampling route	Auditory only
Harp trapping	Mammals (bats)	Overnight	Once at 2 locations	Sampling points at suitable forested location	-
Visual point count	Spider	2000–2300	10 minutes per point; once per location	Terrestrial sampling points at suitable forested locations	Visual only; up to 250m from the sampling point

Survey Type	Taxon	Timing (h)	Duration	Sampling Unit	Technique
Leaf litter sifting		0900–1200	20–30 minutes per quadrat; once per quadrat	50 x 50 cm quadrat at suitable forested locations	–
Umbrella beating				20 “shakes” at each location	–

Butterflies

Diurnal transect surveys were carried out for adult butterflies along 200 m continuous transects on a sampling route between 0900h and 1600h (Figure 4.1). 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, if required. Captured individuals were released immediately after identification.

Odonates (Dragonflies and Damselflies)

Diurnal transect surveys were carried out for adult damselflies and dragonflies along 200 m continuous transects on a sampling route (Figure 4.1) between 0900h and 1600h. Owing to difficulties in sampling and identification, aquatic larvae and exuviae was not surveyed. Adult odonates were identified visually (with binoculars where necessary), photographed or caught using insect nets, if required. Captured individuals were released immediately after identification.

Aculeate Hymenopterans (Bees and Stinging Wasps)

Diurnal transect surveys were carried out for aculeate hymenopterans along 200 m continuous transects on a sampling route (Figure 4.1) between 0900h and 1600h. Aculeate hymenopterans were identified visually (with binoculars where necessary), photographed, or caught using insect nets, if 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.

Spiders

The following survey methods were carried out – (1) visual point counts, (2) leaf litter sifting, and (3) umbrella beating.

Nocturnal (2000–2300h) 10-min visual point count surveys were carried out at suitable forested locations. Torches and/or headlamps were used to elicit eyeshine during nocturnal surveys.

Diurnal (0900–1200h) leaf litter sifting and umbrella beating were carried out at total of 10 forested locations (Figure 4.2) deemed suitable for sampling. For leaf litter sifting, one heap of leaf litter within a 50 x 50-cm quadrat was sifted at each location (Figure 4.3A). The leaf litter was returned to the quadrat after sifting. For umbrella beating, an inverted umbrella was held beneath vegetation within reach at each location and 20 “shakes” of the vegetation were executed (Figure 4.3B). Spiders that fall onto the umbrella were identified or collected for identification.

Figure 4.3 Photographs of spider surveys. (A) Leaf litter sifting and (B) Umbrella beating.

Spiders were identified visually or photographed. When identification in the field is not possible, live specimens were collected and examined *post-hoc* under a microscope before being deposited at the Lee Kong Chian Natural History Museum. The specimens were identified to the lowest taxonomic level using relevant references, identification keys, or in consultation with taxonomic experts.

For morphologically distinct specimens that could not be identified to a species level, a two-lettered code was assigned following the genus or family (e.g., *Belisana* CS) =*Belisana* "Carapace Stripe".

Herpetofauna (Amphibians and Reptiles)

Diurnal (0700h–1000h) and nocturnal (2000h–2300h) surveys were carried out for amphibians and reptiles along 200 m continuous transects on a sampling route (Figure 4.1). 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. Torches and/or headlamps were used to elicit eyeshine during nocturnal surveys. Vocalising fauna was also be 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 using hooks, tongs, or dip nets for identification. Captured individuals were released immediately after identification.

Birds

Diurnal (0700h–1000h) and nocturnal (2000h–2300h) surveys were carried out for birds along 200 m continuous transects on a sampling route (Figure 4.1). 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 located or identified by call recognition, whenever possible. Surveys were carried out during the peak bird migratory season which is between September and February (Lim, 2009).

Mammals (Non-Volant)

Diurnal (0700h–1000h) and nocturnal (2000h–2300h) surveys were carried out for non-volant mammals along 200 m continuous transects on a sampling route (Figure 4.1). Both the diurnal and nocturnal surveys also involve 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.

Ten camera traps (Browning Trail Cameras – Dark Ops Series) were also deployed across the Study Area. Locations of the camera traps are as shown in (Figure 4.1). Each terrestrial camera trap was set up approximately 20–30 cm above ground (Figure 4.4). They operated 24 hours a day and was 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.

Figure 4.4 A camera trap setup

Mammals (Bats Only)

Acoustics surveys were carried out for bats along 200 m continuous transects on a sampling route between 2000h and 2300h. The Echo Meter Touch 2 Pro (Wildlife Acoustics, Inc.) was used to record, stream, 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.

Two harp traps (Figure 4.1) were deployed to target insectivorous bats (Microchiroptera) (Figure 4.5). The location of the harp traps is shown in Figure 4.1. Traps were set up between 1830h–1930, checked once before 2300h, and subsequently left overnight and checked the following morning between 0700h and 0800h and removed.

Figure 4.5 A harp trap setup

Analysis of Fauna Survey Data

Species Distribution Maps

The distribution of species of conservation significance were mapped using QGIS v.3.4 (Quantum GIS Development Team, 2019).

Taxon Sampling Curves

To determine the adequacy of sampling effort, coverage-based rarefaction and extrapolation sampling curves will be generated for all taxa using the iNEXT Online software (Hsieh et al., 2019) when baseline surveys are completed. For this analysis, sampling-units-based incidence data will be used with 50 bootstrap replications, 0.95 confidence interval, endpoint of double the minimum reference sample size and 40 knots (Hsieh et al., 2019). The total number of species will be approximated using the chao estimator in "iNEXT" package 2.0.19 (Hsieh et al., 2019) — by estimating the number of undetected species and adding them to the observed species richness (Palmer, 1990; Colwell & Coddington, 1994).

Camera Trapping

Camera trap location, species identity, and the number of individuals were recorded for each video with a positive capture of faunal species (i.e., with a faunal species recorded on the video). An independent detection constitutes video(s) of one (1) or a group of individuals of the same faunal species occurring within 60 minutes at each camera trap.

To determine the adequacy of sampling effort, coverage-based rarefaction and extrapolation sampling curves were generated for non-volant mammals using the iNEXT Online software (Hsieh et al., 2019). The same method was adopted as per for all taxa stated above.

Acoustic Bat Sampling

All recorded bat calls will be analysed using Kaleidoscope v.4.5.4 (Wildlife Acoustics, Inc.). Identification of calls to species was based on the call shape, maximum frequency, minimum peak, call duration and pulse repetition rate (Pottie et al., 2005). Once these parameters were analysed, the results will be compared to Pottie et al. (2005), which provides bat echolocation signatures for Singapore. It should be noted that species identification may be hampered by the lack of publicly available echolocation recordings that can be used for comparison.

4.2.1.4 Secondary Data Collection (Desktop Study)

Primary data collected through ecological field surveys was supplemented with a desktop study of historical or secondary data (reports, past and present biodiversity records, and published literature) and historical land-use.

2017 Fauna Baseline Survey

A preliminary assessment of fauna within the same approximate area was conducted previously and served as a primary historical reference for the primary baseline surveys conducted for this EIA. This study – Fauna Biodiversity Surveys for Environment Impact Assessment of Development at Admiralty Forest (Fung et al., 2017), hereinafter referred to as the "2017 Fauna Baseline Survey", was similarly commissioned by Jurong Town Corporation (JTC) and conducted by Camphora Pte. Ltd in view of the long-term plan to develop the Study Area into Woodland's North Coast District, a mixed-use precinct of corporate and commercial spaces (Table 3.5). Given the potential ecological impacts of the proposed development, the 2017 Fauna Baseline Survey aimed to determine faunal species composition, identify species of conservation status, assess potential impacts of the proposed development on fauna and to provide recommendations of mitigation measures to reduce the impacts of the proposed development.

Nonetheless, the primary ecological surveys conducted in this EIA differed slightly from the 2017 Fauna Baseline Survey, primarily in the ecological receptors that were surveyed, techniques employed (Table 4.5) and the spatial extent of the Study Areas – the Study Area surveyed in the 2017 Fauna Baseline Survey consisted of two separate areas amounting to a total area of 25 ha, while the primary ecological surveys conducted covered a single continuous survey area of 27.5 ha (Figure 4.6). Moreover, the survey of terrestrial fauna also differed in the taxonomic groups studied, e.g., odonates, aculeata and spider were surveyed in the primary ecological surveys conducted here but were not included in the 2017 Fauna Baseline Survey. These differences will be highlighted in applicable taxa-specific subsections in Section 4.2.2.

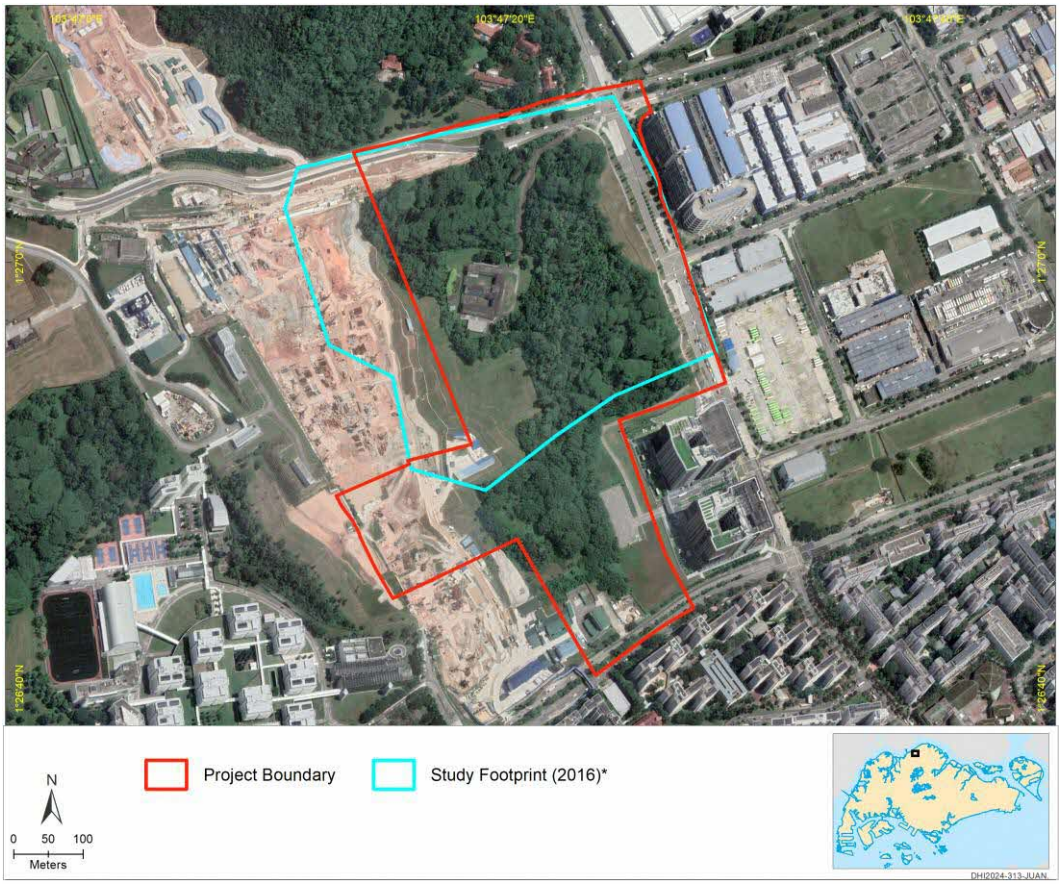


Figure 4.6 Differences in survey areas between the primary ecological surveys conducted in this EIA and the 2017 Fauna Baseline Survey (Satellite image as of 10 Mar 2022)

Table 4.5 Ecological receptors, survey techniques employed during the 2023 study and 2017 study

Ecological Receptor	Survey Technique	Primary Ecological Baseline Surveys (2022)	2017 Fauna Baseline Survey
Terrestrial Flora / Habitat	Vegetation and habitat mapping	✓	
	Visual surveys	✓	
	Vegetation plots	✓	
	Arboricultural assessments	✓	

Ecological Receptor	Survey Technique	Primary Ecological Baseline Surveys (2022)	2017 Fauna Baseline Survey
Terrestrial Fauna	Line transects	✓	✓
	Camera trapping	✓	✓
	Desktop study	✓	✓
	Acoustic surveys (bats only)	✓	
	Harp trapping (bats only)	✓	

4.2.2 Results

This section presents the baseline findings compiled from primary data (field surveys) and secondary data (desktop study of historical data). The ecological field surveys were carried out from 26th November 2022 and completed on 23 March 2023.

4.2.2.1 Habitat Mapping

Seven habitat types (five vegetated and two non-vegetated) were recorded within the Study Area (Figure 4.7; Table 4.6). Exotic-dominated secondary forest (6.25 ha; 22.6%) was the largest vegetated habitat type and was found across the edges and the south of the Study Area (Figure 4.7). This was followed by Native-dominated, young secondary forest (4.19 ha; 15.2%), which was concentrated within the centre and north of the Study Area (Figure 4.7). The third-largest vegetated habitat type was Urban vegetation (2.81 ha; 10.1%), abutting roads and buildings in the Study Area (Figure 4.7). Patches of Grassland (1.93 ha; 7.0%) were interspersed across the forest edges of the Study Area, while Scrubland patches (0.98 ha; 3.5%) were similarly present along the forest edges but also within the forested areas (Figure 4.7). The other two non-vegetated or sparsely vegetated habitat types were Construction (RTS Worksite) (6.05 ha; 21.9%) and Infrastructure (5.47 ha; 19.8%), which together comprise nearly half of the Study Area (Figure 4.7).

Table 4.6 Absolute and relative sizes of each habitat type in the Study Area

Category	Habitat type	Absolute size (ha)	Relative size (%)
Vegetated	Native-dominated, young secondary forest	4.19	15.1
	Exotic-dominated secondary forest	6.25	22.6
	Scrubland	0.98	3.5
	Grassland	1.93	7.0
	Urban vegetation	2.81	10.1
Non-vegetated	Construction	6.05	21.9
	Infrastructure	5.47	19.8
	Total	**27.68**	**100**

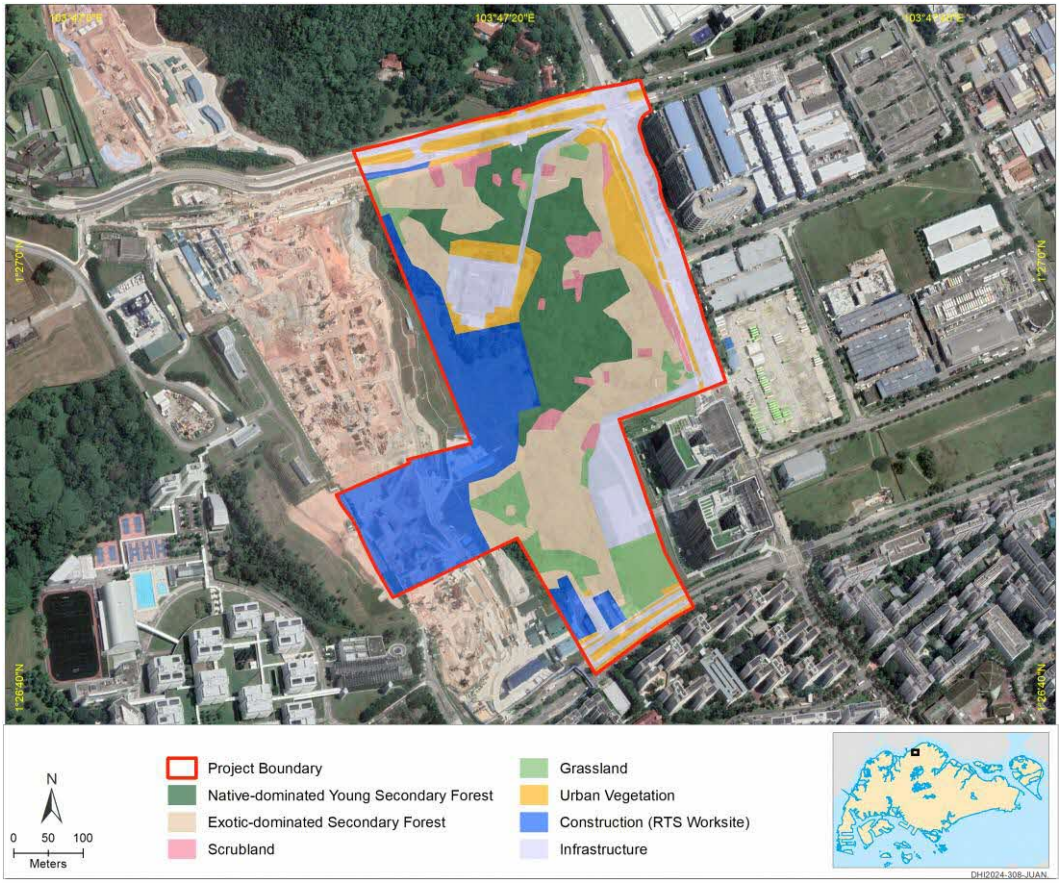


Figure 4.7 Habitat and vegetation map of the Study Area (Satellite image as of 10 Mar 2022)

Exotic-dominated secondary forest

Exotic-dominated secondary forest was the largest vegetated habitat type found in the Study Area, occupying 6.25 ha (22.6%) of the total area (Table 4.6). It was represented by two patches in the north-western corner and one large continuous patch that occupied most of the southern half of the Study Area as well as the eastern forest edge (Figure 4.7). The presence of Exotic-dominated secondary forest is aligned with the areas that have experienced vegetation clearance or were adjacent to cleared areas in the land use history of the Study Area (Section 1.3.1.1), as this vegetation type is characterized by a canopy dominated by exotic, and even invasive, fast-growing species that can quickly establish themselves on poor soils of recently cleared areas (Yee et al., 2016). Within this Study Area, these species include Moluccan albizia (*Falcataria falcata*), Pumpwood (*Cecropia pachystachya*), *Leucaena leucocephala*, African tulip (*Spathodea campanulata*), and Earleaf acacia (*Acacia auriculiformis*), which were widely planted in the 1960s and most of them have the ability to fix their own nitrogen (Wee & Corlett, 1986).

In the Exotic-dominated secondary forest patches in the north-western corner (Figure 4.7), some common native forest species such as the Yellow-stem fig (*Ficus variegata*), *Syzygium grande*, *Litsea elliptica*, Giant mahang (*Macaranga gigantea)*, and Simpoh air (*Dillenia suffruticosa*) could still be found in the canopy and understorey (Figure 4.8 A). Additionally, multiple specimens of species of conservation significance, including the nationally Endangered *Tectaria semipinnata*, and nationally Vulnerable *Macaranga griffithiana*, *Palaquium obovatum* var*. obovatum*, *Lindera lucida*, and *Endospermum* cf. *diadenum*, were encountered in the understorey. The Exotic-dominated secondary forest along the eastern forest edge (Figure 4.7) was also observed to support some species of conservation significance as well, including the nationally Vulnerable *Angelesia splendens* and *Hoya diversifolia*. The greater presence of native species in these Exotic-dominated

secondary forest patches can be explained as these areas were only partially cleared or adjacent to cleared areas, allowing edge effects to result in the establishment of an Exotic-dominated canopy while native forest species persisted.

On the contrary, the Exotic-dominated secondary forest covering the southern half of the Study Area (Figure 4.7; Figure 4.8A) was once completely cleared for past developments and found to be heavily dominated by Moluccan albizia (*F. falcata*) in the canopy (Figure 4.8B). Sparse remnants of cultivation such as trees and saplings of Rubber (*Hevea brasiliensis*), Oil palm (*Elaeis guineensis*), and Giant taro (*Alocasia macrorrhizos*) were found in the understorey. No specimens of conservation significance were encountered here.

Figure 4.8 Exotic-dominated secondary forests in the Study Area. (A) Exotic-dominated Forest canopy with persisting native diversity in the understorey; and (B) Moluccan albizia (*F. falcata*)-dominated forest with an exotic-dominated understorey.

Native-dominated, young secondary forest

Native-dominated, young secondary forest was the second largest vegetation type, taking up 4.19 ha (15.2%) of the total Study Area (Table 4.6). This native forest is concentrated in the middle and northern portion of the Study Area (Figure 4.7). The canopy of this native forest was mostly dominated by two different species: Giant mahang (*M. gigantea)* and Tembusu (*Cyrtophyllum fragrans*). This canopy of *M. gigantea* trees (Figure 4.9A) covered most of the northern and southern end of the native forest. In the north, the understorey was found to be largely occupied by Wild Cinnamon (*Cinnamomum iners*), *Syzygium* species, and MacArthur's palm (*Ptychosperma macarthurii*). Nationally Vulnerable species, such as *Elaeocarpus ferrugineus* and *P. obovatum* var. *obovatum*, were more frequently encountered here, accompanied by a cluster of a nationally Endangered fern, *T. semipinnata*. In the south, the understorey was apportioned between MacArthur's palm (Figure 4.9B) and the nationally Vulnerable *L. lucida*. Threatened native species, such as the nationally Vulnerable *Curculigo latifolia* were recorded in this area.

Higher native species richness was found nearer to the central area of the native forest. Slow-growing *C. fragrans* trees were observed to dominate the canopy layer in these areas (Figure 4.9C), interspersed with small trees of *Adinandra dumosa*, *L. elliptica*, and nationally Vulnerable *M. griffithiana*. Meanwhile, the understorey layer comprised of Wild Cinnamon, MacArthur's Palms, *Elaeocarpus petiolatus*, *Ficus aurata* var. *aurata* (Figure 4.9D), and *L. lucida*. Numerous clusters of nationally Vulnerable *A. splendens* were recorded throughout this area. Individuals of rarer native species, such as the nationally Critically Endangered *Psychotria polycarpa* were logged here as well. It is interesting to note that these clusters of *P. polycarpa* were discovered to be widespread across the central native forest patch. This rich native assemblage observed is characteristic of a secondary forest that has been allowed to succeed for multiple decades, which is agreeable with the land use history of this area described in Section 1.3.1.1 (Yee et al., 2016).

Figure 4.9 Native-dominated young secondary forest in the Study Area. (A) Canopy dominated by *M. gigantea*; (B) Understorey dominated by *P. macarthurii*; (C) Canopy dominated by *C. fragans*; and (D) Understorey with *E. petiolatus* and *F. aurata var. aurata*.

Scrubland

Scrubland habitats are generally characterized by an open-canopy and low vegetation, dominated by short ferns, grasses, and shrubs. Scrubland (0.98 ha; 3.5%) occupied the least of the Study Area and was interspersed in patches within the forest and as strips along the eastern forest edges (Table 4.6; Figure 4.7). Scrubland types encountered in this Study Area include scrubland dominated by remnant cultivated species such as Parrot heliconia (*Heliconia psittacorum*), Tapioca (*Manihot esculenta*), Dumbcane (*Dieffenbachia seguine*), and Giant taro (*A. macrorrhizos*) (Figure 4.10A), scrubland dominated by Sword fern (*Nephrolepis biserrata*) (Figure 4.10B), Simpoh air (*D. suffruticosa*) dominated scrubland (Figure 4.10C), and scrubland that had resulted from a recent large tree fall (Figure 4.10D).

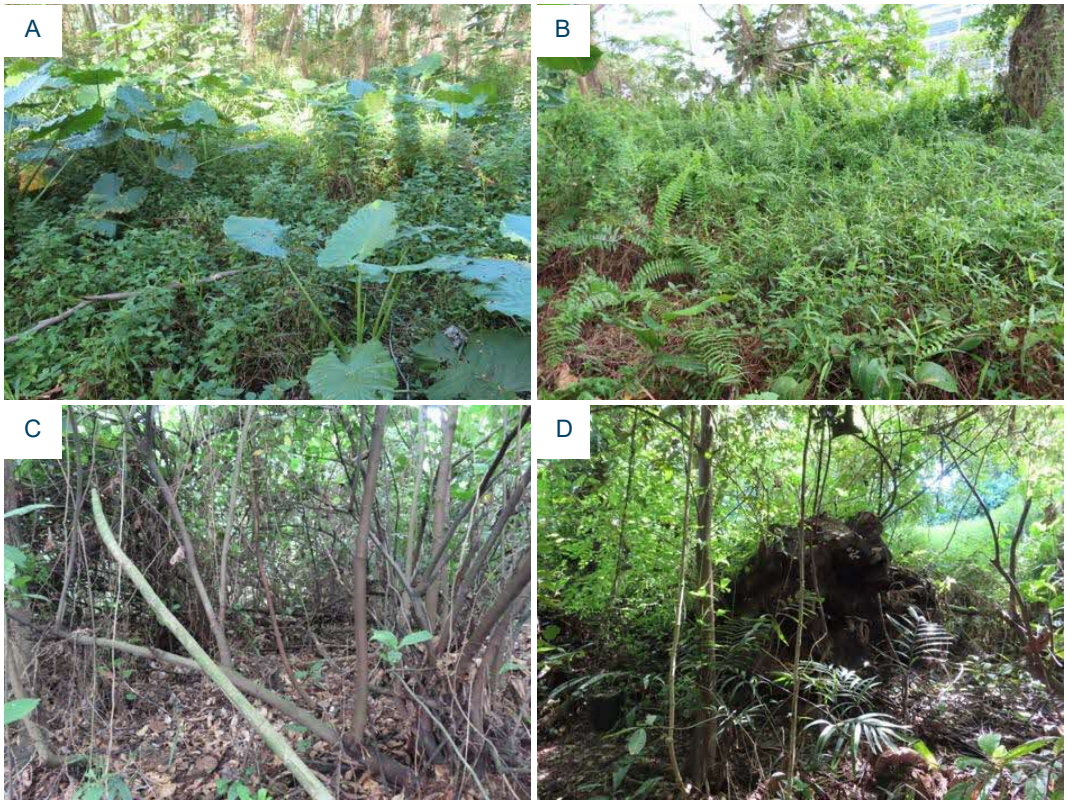


Figure 4.10 Scrubland in the Study Area. Various scrubland types dominated by (A) Giant Taro (*A. macrorrhizos*); (B) Sword Fern (*N. biserrata*); (C) Simpoh Air (*D. suffruticosa*); and (D) a large tree fall resulting in an open canopy.

Grassland

Grassland habitats (1.93 ha; 7.0%) were present as small patches along the northern and eastern edges of the forested areas and as large swathes towards the south in this Study Area (Table 4.6; Figure 4.7). This habitat type was characterized by open-canopy vegetation dominated by fast-growing and sun-loving grasses such as Elephant grass (*Cenchrus purpureus*) (Figure 4.11A) and Smutgrass (*Ischaemum ciliare*) (Figure 4.11B) in this Study Area. Exotic trees, such as Moluccan albizia (*F. falcata*) and Pumpwood (*C. pachystachya*) were also found to be scattered sparsely throughout the grassland patches (Figure 4.11B).

Figure 4.11 Grassland in the Study Area dominated by (A) Elephant Grass (*C. purpureus*); and (B) Smutgrass (*I. ciliare*) with construction hoarding and the RTS Link construction site in the distance.

Urban Vegetation

Urban vegetation was present in multiple locations around the Study Area, adding up to a total of 2.81 ha (10.2%) (Table 4.6; Figure 4.7). The first type of urban vegetation was located within the fenced-up compound of the former View Road Hospital, surrounding the unused infrastructure. This managed turf area was mainly comprised of Cow grass (*Axonopus compressus*) with a few scattered trees within the compound (e.g., *Mangifera indica*, *C. fragrans,* and *Nephelium lappaceum*) which were likely remnants of past cultivation.

The second type of urban vegetation included rows of managed turf or streetscape trees planted along Admiralty Road West, North Coast Avenue, and Woodlands Avenue 9 (Figure 4.12A). The largest portion of managed area was on the eastern edge of the Study Area, right next to North Coast Avenue. Large swathes of Cow grass and other spontaneous grasses were found along this sloped edge (Figure 4.12B).

Figure 4.12 Urban vegetation in the Study Area. (A) Urban vegetation with managed turf and planted streetscape trees along Admiralty Road West; and (B) large managed turf area on a slope between the eastern forest edge and North Coast Avenue.

Construction (RTS Worksite)

Construction area (6.05 ha; 21.9%) made up more than one-fifth of the Study Area (Table 4.6; Figure 4.7). The construction of the Woodlands North MRT station, RTS link and CIQ building covered the large hoarded area in the west (Figure 4.13A), while there were two other smaller hoarded areas in the south presumably for temporary offices and dormitories, and one short strip for the construction of a footpath along the north-eastern edge (Figure 4.13B). Little to no vegetation was observed within the construction areas.

Figure 4.13 Construction within the Study Area. (A) Hoarding for the RTS Link construction area; and (B) footpath construction.

Infrastructure

Another one-fifth of the Study Area was comprised of infrastructure (5.47 ha; 19.8%) (Table 4.6; Figure 4.7), including a bus stop, concrete drains, pedestrian walkways (Figure 4.14A), cycling paths, roads (Figure 4.14B), the former View Road Hospital (Figure 4.14C), the RTS Link Project Information Centre situated in the south, and an open-air carpark in the JTC Woodlands North Coast building compound (Figure 4.14D) in the southeast of the Study Area. Little to no vegetation was present within the infrastructure.

Figure 4.14 Infrastructure within the Study Area. (A) Concrete drain, footpath, and bus stop along Admiralty Road West; (B) View Road leading up to the former View Road Hospital; (C) former View Road Hospital building with concrete drain and paths; and (D) corner of open-air carpark bordering vegetation.

4.2.2.2 Terrestrial Flora

A total of 195 species and four species groups (i.e., plants that could not be identified to species with certainty), belonging to 72 families were recorded from the Study Area (Table 4.7; Appendix A). Out of the 199 species and species groups recorded, 110 (55.3%) were classified as native, 76 (38.2%) were exotic, and 13 (6.5%) were cryptogenic (i.e., species that have unknown or uncertain origins). The four species groups consisted of (1) *Acacia* cf. *mangium*, (2) *E.* cf. *diadenum*, (3) *Lygodium* sp. and (4) *Musa* cultivar (Appendix A).

Native threatened species comprise species that have been accorded to the following statuses: Vulnerable, Endangered, Critically Endangered, or Presumed Extinct. Up to 20 (10.1%) of such species were recorded. For overall findings, however, a distinction was not made as to whether threatened species are from native wild populations or are cultivated locally and/or are relics from past cultivation. Species belonging to the latter category may not be of conservation significance even though they have been accorded with a threatened status. This is discussed in greater detail in 'Species of Conservation Significance'. The status of two (1.0%) species, *Anodendron candolleanum* and *Dimocarpus lichi*, were not assessed due to data deficiency.

Table 4.7 Number and percentage of plant species belonging to each status category

Origin	Status	Number of species	Percentage (%)
Native		110	55.3
	Common	88	44.2
	Vulnerable	13	6.5
	Endangered	1	0.5
	Critically Endangered	6	3.0
	Data Deficient	2	1.0
Exotic		76	38.2
	Cultivated Only	8	4.0
	Casual	22	11.1
	Naturalised	44	22.1
	Not Assessed	2	1.0
Cryptogenic		13	6.5
Total		199	100

Species of Conservation Significance

A total of 13 plant species were considered to be of conservation significance (Table 4.8; Appendix B). Altogether, 102 specimens and/or clusters of specimens belonging to these species of conservation significance were recorded in the Study Area (Appendix B). Majority of the specimens are concentrated within the Native-dominated secondary forest patches (Figure 4.15). Species such as Red lip (*Syzygium myrtifolium*), Rambai (*Baccaurea motleyana*), Long-leaved beauty berry (*Callicarpa longifolia*), *Sterculia parviflora*, *Sterculia cordata*, and Horse mango (*Mangifera foetida*), though listed as nationally threatened, were not considered to be of conservation significance in this study because they were most likely escapees from present-day cultivation or relics that had persisted from past cultivation. The assessment of whether a threatened plant species is of conservation significance was carried out based on the criteria detailed in Section 4.2.1.1.

Table 4.8 Number of plant species of conservation significance.

Status	Vulnerable	Endangered	Critically Endangered	Total
Non-cultivated threatened Species	11	1	1	13
Cultivated threatened species	2	0	5	7

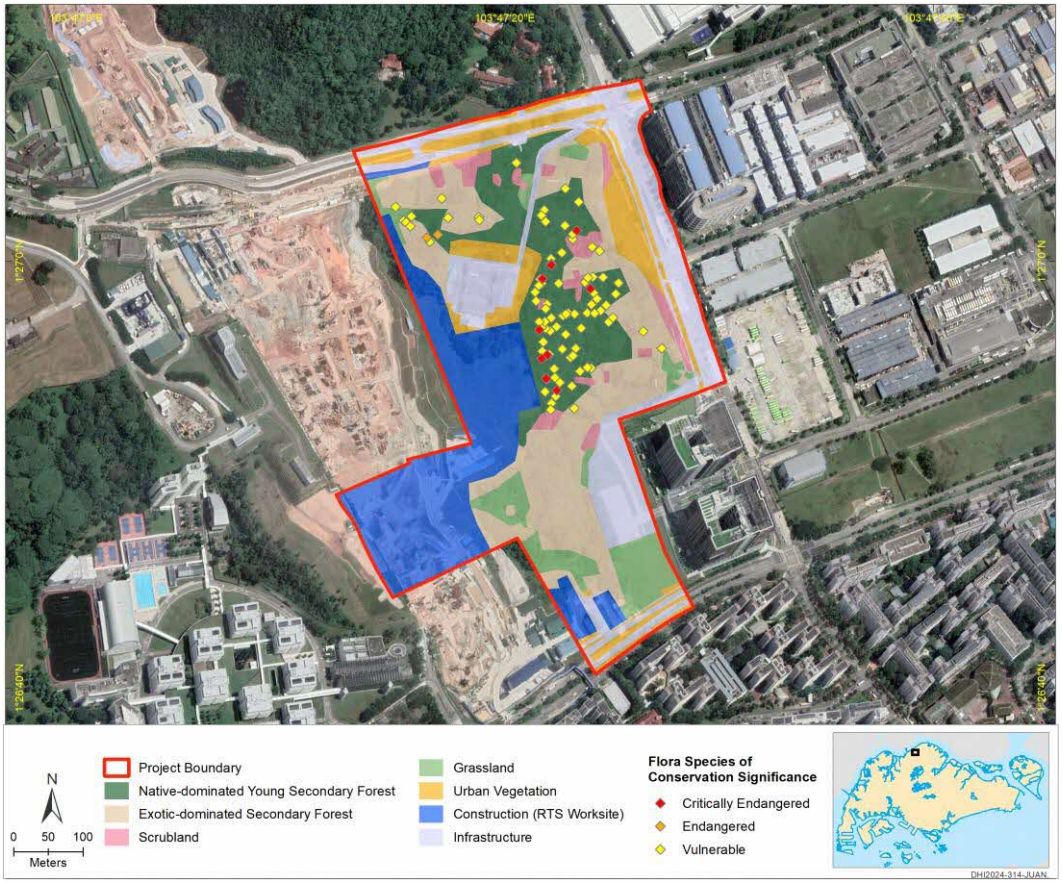


Figure 4.15 Locations of plant species of conservation significance recorded within the Study Area, excluding threatened species that are of cultivated origin (Satellite image as of 10 Mar 2022)

Critically Endangered species

One nationally Critically Endangered species of conservation significance, *P. polycarpa*, was recorded in this Study Area (Figure 4.16A; Appendix B). Numerous (9) clusters of *P. polycarpa* climbers were concentrated within the central Native-dominated secondary forest patch and observed to be growing robustly across the soil or creeping on tree trunks to a height of up to 4 m (Figure 4.15; Figure 4.16A; Appendix B). This species is not known to be cultivated and has only been recorded in vegetation with good forest structure and high humidity, including Native-dominated forests and abandoned-land forests found in Admiralty, Mandai, Eng Neo, and Bukit Batok (Camphora internal data).

Endangered species

One nationally Endangered species, *T. semipinnata*, was considered to be of conservation significance in this study (Figure 4.16 B). *T. semipinnata* is a large ground-dwelling fern that has been recorded in the forests in Bukit Timah but very rarely in other secondary forests of Singapore (Royal Botanic Gardens Kew, 2023b; Camphora internal data). As this species is not cultivated locally, the two specimens found in the north-eastern Native-dominated and Exotic-dominated forest patches of the Study Area were believed to be of native genetic stock with true conservation value (Figure 4.15; Figure 4.16B).

Figure 4.16 Critically Endangered and Endangered plant species of conservation significance recorded in the Study Area. (A) *P. polycarpa* cluster; (B) *T. semipinnata*, recorded in the Study Area.

Vulnerable species

With the exception of the urban vegetation habitat, specimens of nationally Vulnerable species were found to occur throughout all other vegetation types in the Study Area, especially in the central Native-dominated secondary forest (Figure 4.15). The majority of these species, 11 out of 13 species, were deemed to be of conservation significance (Appendix B).

Some of these nationally Vulnerable species found to be widespread in the Study Area, including *A. splendens* (Figure 4.17A), *L. lucida*, and *M. griffithiana*, are also more commonly encountered in the secondary forests in Singapore. Furthermore, mature fruiting trees of *L. lucida* (up to 0.9 m girth) (Figure 4.17B; Appendix B).

Nationally Vulnerable species that were less abundant in this Study Area and more rarely encountered in other forests in Singapore include *C. latifolia* (Figure 4.17C), *E. ferrugineus* (Figure 4.17D), *E.* cf. *diadenum* (Figure 4.17E), *H. diversifolia* (Figure 4.17F), and *Microlepia speluncae*. *C. latifolia*, *E. ferrugineus*, and *E. diadenum* are indicator species for more mature secondary forests as they are known to mainly occur in the primary and old mature secondary forests of BTNR (Ho et al, 2019). Although *C. latifolia* is cultivated as ornamental foliage, it is rarely planted in Singapore. Thus, the two specimens encountered deep within the central Native-dominated secondary forest patch in the Study Area were unlikely to be of cultivated origin (Figure 4.15; NParks, 2022a). *E. ferrugineus* and *E. diadenum* are not known to be cultivated and the relatively large sizes of these tree specimens (up to 8 m height) in the central Native-dominated secondary forest patch suggest that they have been present for a long time (Appendix A). Hence, these specimens hold conservation significance and are testament to the decades of regrowth of the Native-dominated secondary forest in the Study Area.

One cluster of *H. diversifolia*, an epiphytic climber, was recorded in the eastern edge of the Exotic-dominated secondary forest (Figure 4.15; Figure 4.17F). Although *H. diversifolia* is widely cultivated as a garden ornamental plant, this cluster was conservatively determined to be of conservation significance as there were no planted *H. diversifolia* specimens known nor observed in the vicinity of the Study Area (NParks, 2022a).

M. speluncae was recently revised in the Singapore Red List 3rd edition (NParks, 2024) from nationally Common to nationally Vulnerable. As this revision was only made known recently, the specific location of each specimen was not recorded during the survey period. Commonly known as Limpleaf fern, *M. speluncae* is a ground-dwelling fern that can be found in wet tropical rainforest biomes and is not known to be cultivated. Hence, the *M. speluncae* specimen(s) can be assumed to have been encountered in the forested habitats of the Study Area and are of native conservation significance.

The remaining nationally Vulnerable species of conservation significance found in the Study Area are *Ficus vasculosa*, *Litsea umbellata*, and *P. obovatum* var. *obovatum*, which are also often encountered in other similar secondary forest fragments in Singapore.

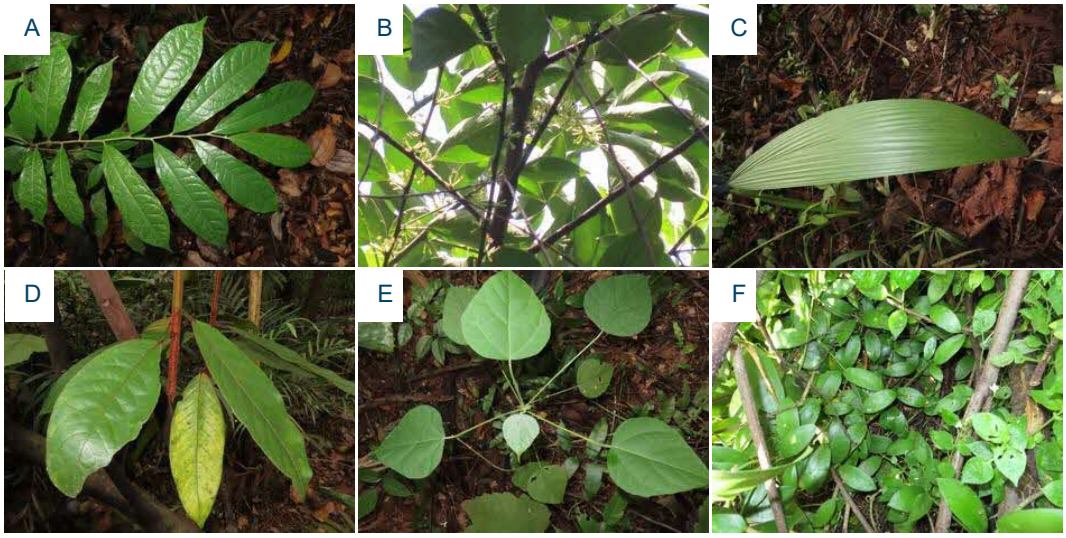


Figure 4.17 Nationally Vulnerable plant species of conservation significance recorded in the Study Area. (A) *A. splendens;* (B) flowering and fruiting *L. lucida* tree; (C) *C. latifolia*; (D) *E. ferrugineus*; (E) *E.* cf. *diadenum*; and (F) *H. diversifolia*.

Large Plant Specimens

There were 44 large specimens recorded within the Study Area (Table 4.9; Figure 4.18, Appendix B). The majority of these were Moluccan albizia trees (*F. falcata*) situated in the Exotic-dominated secondary forest, especially towards the north-western region. The remaining large trees were mainly dispersed either within the Native-dominated secondary forest or Exotic-dominated secondary forest patches across the Study Area. All the large specimens had a girth or spread ranging from 3.0 m to 20.0 m, and height measurements ranging from 14 m to 35 m. The specimen with the largest girth recorded in the Study Area was a *C. pachystachya* (Figure 4.19) tree with an estimated spread of 20 m and height of 16 m. This large spread is attributed to multiple huge stems sprouting horizontally from the large main trunk of the *C. pachystachya* tree.

Table 4.9 Type and species of large plant specimens recorded, accompanied by their origin, status, and count of individuals of each species.

Habit	Species	Origin	Status	No. of specimens
Tree	*Cecropia pachystachya*	Exotic	Naturalised	1
	Cyrtophyllum fragrans	Native	Common	1
	Falcataria falcata	Exotic	Naturalised	32
	Ficus religiosa	Exotic	Naturalised	1
	Macaranga gigantea	Native	Common	1
	Pterocarpus indicus	Exotic	Casual	5
	Spathodea campanulata	Exotic	Naturalised	2
	Terminalia catappa	Native	Common	1
Total				44

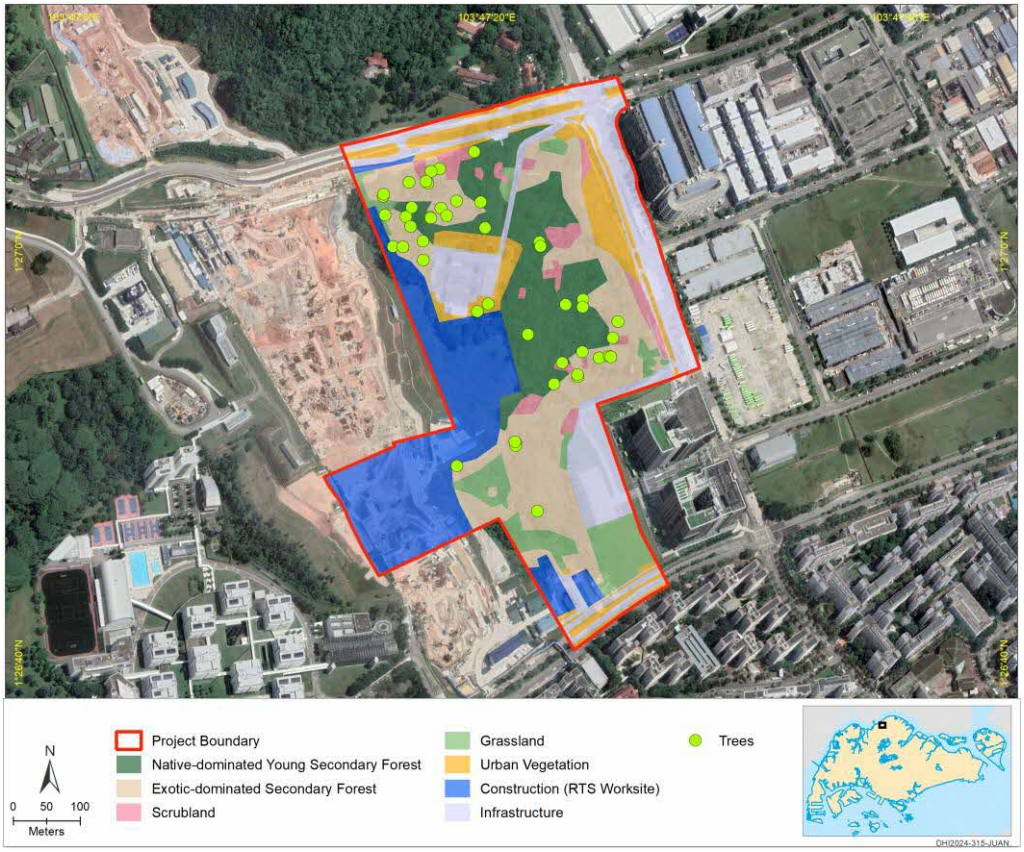


Figure 4.18 Distribution of large plant specimens in the Study Area (Satellite image as of 10 Mar 2022)

Figure 4.19 Example of a large plant specimen in the Study Area – *C. pachystachya* with spread of 20.0 m and height of 16.0 m.

Other Plant Specimens of Value

A raptor nest was found on a Moluccan albizia (*F. falcata*) tree measuring 2 m in girth and 25 m in height (Figure 4.20A; Appendix C). The tree is located at the north-western corner of the Native-dominated secondary forest in the Study Area (Figure 4.18). One adult Brahminy kite (*Haliastur indus*) was observed to be flying out of the nest (Figure 4.20A) and perching nearby (Figure 4.20B). This is further discussed under fauna baseline results (Birds) in Section 4.2.2.10.

A follow-up visit was conducted on 05 Sep 2024 to assess the status of the previously identified raptor nest. During this inspection, the nest was not observed. However, a Brahminy Kite was sighted in the vicinity, circling near the same tree where the nest had been initially found, indicating raptor presence in the area.

Figure 4.20 Other specimens of value in the Study Area. (A) Moluccan albizia tree (*Falcataria falcata*) with raptor nest; and (B) an adult Brahminy kite (*Haliastur indus*) perching nearby.

Tree Mapping

A total of 656 specimens belonging to 27 species were assessed during the arboriculture surveys (Appendix D). These specimens belonged to 13 families in total.

Most of the specimens assessed were Moluccan albizia (*F. falcata*), making up more than half (338 specimens; 51.5%) of all the specimens assessed. This was followed by Tembusu (*C. fragrans*) (52 specimens; 7.9%), Pumpwood (*C. pachystachya*) (52 specimens; 7.9%), and *M. gigantea* (51 specimens; 7.8%). Altogether, 38 specimens belonging to three species of conservation significance were tagged and assessed. These species were the nationally Vulnerable *M. griffithiana* (1 specimen), and *L. lucida* (37 specimens).

4.2.2.3 Fauna

The primary fauna field surveys documented 204 species, including 10 species of conservation significance. Species recorded were predominantly birds (54 species) and butterflies (25 species). The list of recorded faunal species is available in Appendix E and summarised in Table 4.10.

Broad trends in fauna diversity will be briefly summarised before taxa specific breakdowns are individually discussed in each subsection. A comparison of the primary data collected here with the 2017 Fauna Baseline Survey will also be examined accordingly.

Comparison with 2017 Fauna Baseline Survey

The 2017 Fauna Baseline Survey (Fung et al., 2017) consisted only of assessments for butterflies, herpetofauna, birds and mammals. Odonate, aculeate and spider assessments, which were conducted during the primary surveys here were not carried out during the 2017 Fauna Baseline Survey.

Restricting to the taxonomic groups that were surveyed across both surveys (butterflies, herpetofauna, birds and mammals), the total species richness appeared to decline, from 110 species recorded during 2017 Fauna Baseline Survey to 105 species in the present primary surveys (Table 4.10). This decrease in species richness was largely contributed to by the reduction in the number of butterfly species (11 fewer) and bird species (4 fewer). The loss of species richness of these taxa may be ascribed to the reduction in the total vegetated area, from 27ha to 16ha between 2017 and 2023 due to land clearance works (Figure 1.4; Section 1.3.1.1) alongside an increase in associated disturbances from works and edge effects.

Conversely, a greater number of reptiles (2 more), non-volant mammals (4 more) and bats (4 more) were observed. Specific reasons for the appearance and disappearance of species in these taxa between the survey periods will be explored in subsequent taxa-specific sections.

Table 4.10 Summary of recorded faunal species richness identified in 2023 Fauna Baseline Survey and 2017 Fauna Baseline Survey. Recorded fauna counts are arranged according to taxonomic classification and conservation significance.

Taxon	2023 Fauna Baseline Survey		2017 Fauna Baseline Survey	
	All species	Conservation significant species	All species	Conservation significant species
Odonates	**7**	**0**	Excluded	
Dragonflies	6	0		
Damselflies	1	0		
Spiders	**82**	**0**		
Aculeata	**10**	**0**		
Bees	7	0		
Wasps	3	0		
Butterflies	**25**	**0**	**36**	**0**
Herpetofauna	**13**	**0**	**11**	**0**

Taxon	2023 Fauna Baseline Survey		2017 Fauna Baseline Survey	
	All species	Conservation significant species	All species	Conservation significant species
Amphibians	6	0	6	0
Reptiles	7	0	5	0
Birds	**54**	**8**	**58**	**6**
Mammals	**13**	**2**	**5**	**0**
Non-volant	8	2	4	0
Bats	5	0	1	0
Total	**204**	**10**	**110**	**6**

Species of Conservation Significance

Ten species of conservation significance were recorded during the 2023 Fauna Baseline Survey (Table 4.11). Of the 10 species, eight were birds and two were non-volant mammal species. Seven of the listed bird species were exclusively of national conservation significance – five of these were Vulnerable, one was Endangered, and one was Critically Endangered. The last bird species was not nationally threatened but was globally Vulnerable. Amongst the mammal species, the Long-tailed macaque (*Macaca fascicularis*) was globally Endangered, whilst the Smooth-coated otter (*Lutrogale perspiciliata*), was of both national and global conservation significance, being accorded a status of Endangered at a national level and Vulnerable at the global level.

All 10 conservation significant species were found to have been distributed across the Study Area, with no distinct hotspot observed, suggesting that the conservation significant species recorded were not restricted to particular habitats (Figure 4.21).

Comparison with 2017 Fauna Baseline Survey

Seven conservation significant species were identified during the 2017 Fauna Baseline Survey, in comparison to the 10 conservation significant species observed during the 2023 Fauna Baseline Survey. Six of the seven conservation significant species found in 2017 were also present in 2023, with only the locally Vulnerable Oriental magpie-robin absent during the 2023 survey (Table 4.11).

Four conservation significant species identified during the 2023 Fauna Baseline Survey were not present in the 2017 Fauna Baseline Survey. These included three bird species, namely *Alcedo atthis*, *Nycticorax nycticorax* and *Spilornis cheela* as well as one mammal species, *L. perspicilata.* The Long-tailed macaque (*M. fascicularis*) was present on site during the 2017 Fauna Baseline Survey, it was not deemed to be a conservation significant species at the time (IUCN, 2017) and was accordingly excluded.

Table 4.11 List of faunal species of national and global conservation significance

Taxon	Species	Common Name	National Status	Global Status	Year of Survey	
					2023	2017
Bird	*Spilornis cheela*	Crested serpent eagle	Critically Endangered	Least Concern	✓	
	Nycticorax nycticorax	Black-crowned night heron	Endangered	Least Concern	✓	
	Alcedo atthis	Common kingfisher	Vulnerable	Least Concern	✓	
	Copsychus saularis	Oriental magpie-robin	Vulnerable	Least Concern		✓
	Corvus macrorhynchos	Large-billed crow	Vulnerable	Least Concern	✓	✓
	Lanius cristatus	Brown shrike	Vulnerable	Least Concern	✓	✓
	Nisaetus cirrhatus	Changeable hawk-eagle	Vulnerable	Least Concern	✓	✓
	Zosterops simplex	Swinhoe's white-eye	Vulnerable	Least Concern	✓	✓
	Psittacula longicauda	Long-tailed parakeet	Near Threatened	Vulnerable	✓	✓
Mammal	*Lutrogale perspicilata*	Smooth-coated otter	Endangered	Vulnerable	✓	
	*Macaca fascicularis**	Long-tailed macaque	Least Concern	Endangered	✓	✓

* *M. fascicularis was not a conservation significant species at the time of the 2017 Fauna Baseline Survey (IUCN, 2017)*

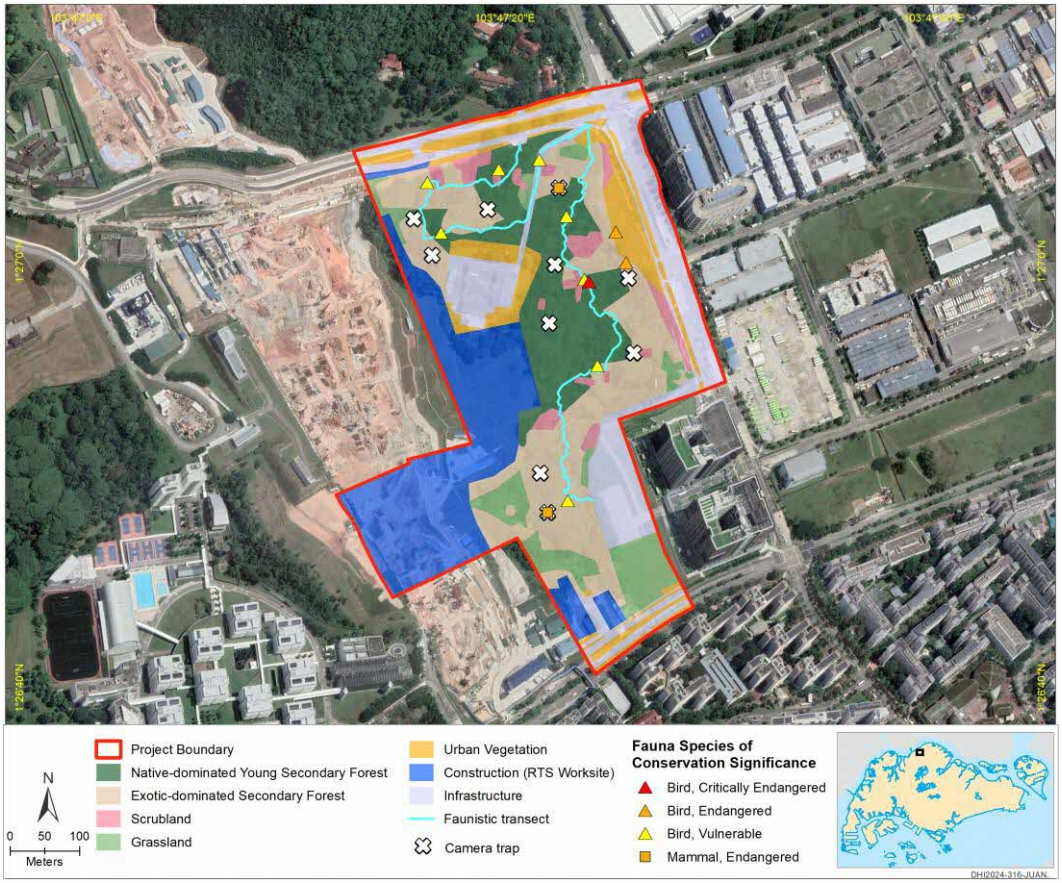


Figure 4.21 Location of faunal species of conservation significance (Satellite image as of 10 Mar 2022)

4.2.2.4 Sample Completeness

Assessments of sample completeness provide an estimation of the comprehensiveness of survey methodologies in obtaining a representative sample of the extant faunal biodiversity within the Study Area. Sample completeness was assessed for the 2023 Fauna Baseline survey, for the following target taxa: 1) aculeata 2) butterfly, 3) amphibian, 4) reptile, 5) bird and 6) mammal (including bats). Odonata was excluded due to low species richness count. For camera trapping, sample coverage was generated for mammals only. Since the taxon sampling curve analysis only considers targeted transect or point count data (i.e., incidental records were removed from analysis), the observed richness stated in Table 4.12 may differ from that stated in Table 4.10.

For transect surveys, birds and amphibians recorded high sampling completeness of above 90%. The remaining faunal groups recorded sampling completeness of at least 67% (Table 4.12; Figure 4.22). For camera trapping, non-volant mammals recorded a high sampling completeness of 97.1% (Table 4.12; Figure 4.23). With the observed richness obtained via sampling, the estimated richness for each taxon was derived for the Study Area per sampling method.

Table 4.12 Sample completeness and the estimated species richness per taxon and sampling method.

Faunal group	Sample completeness (%)	Observed richness	Estimated richness (± S.E.)	95% confidence interval
Transect surveys				
Butterfly	74.8	21	29.64 ± 6.95	23.17 – 55.48
Aculeata	68.8	7	10.43 ± 4.59	7.47 – 31.98
Amphibian	90.0	6	6.86 ± 1.64	6.08 – 15.76
Reptile	67.0	6	11.14 ± 6.08	6.82 – 38.13
Bird	92.0	44	52.05 ± 5.93	46.21 – 73.26
Mammal	77.0	5	7.57 ± 6.08	6.82 – 38.13
Camera trapping				
Non-volant mammal	97.1	6	6.23 ± 0.67	6.01 – 10.39

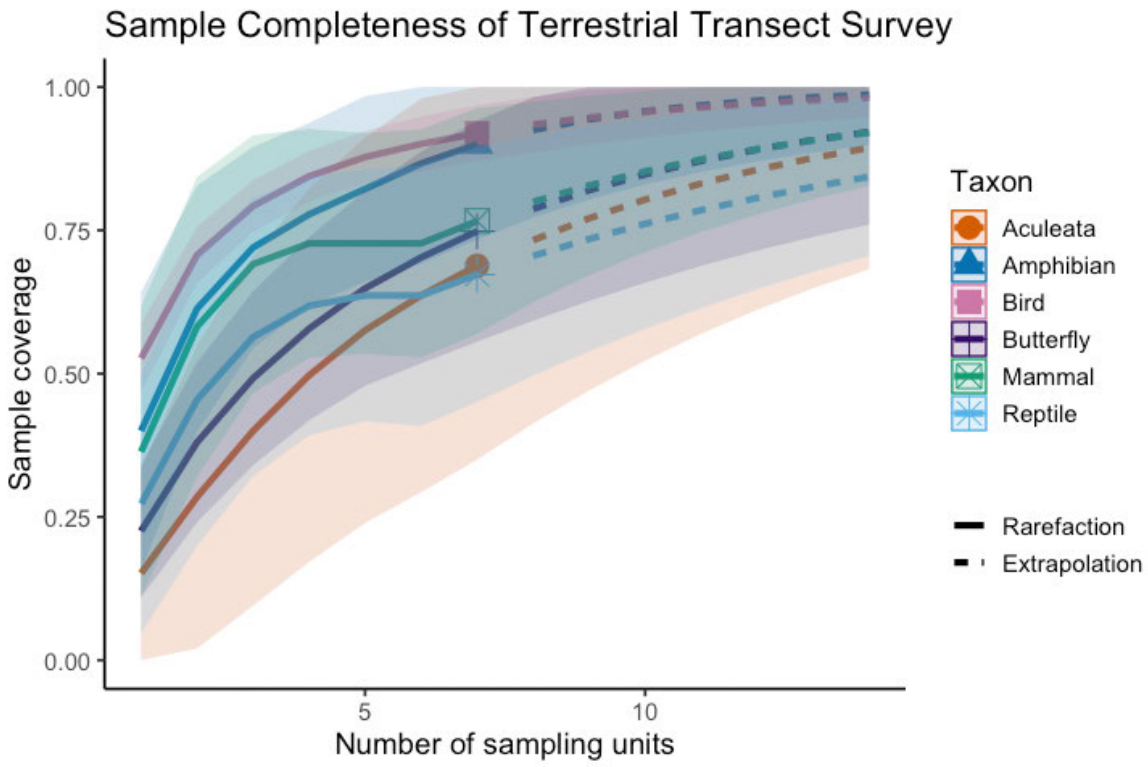


Figure 4.22 Sampling completeness of each taxon from transect surveys

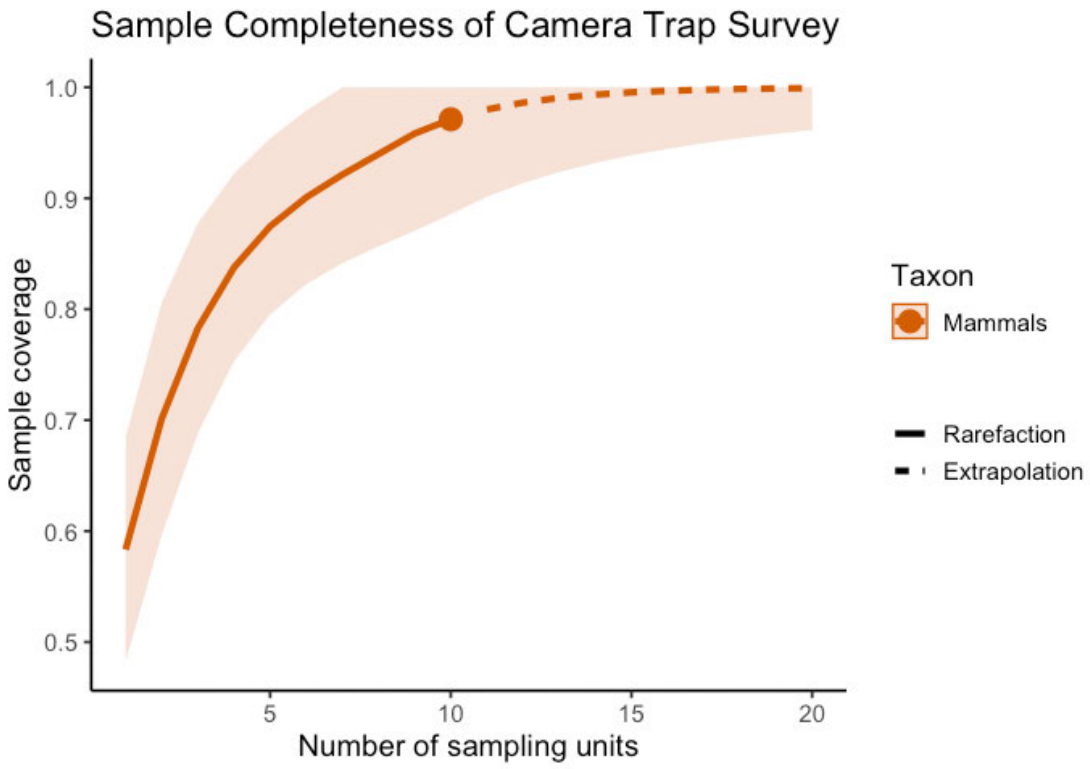


Figure 4.23 Sampling completeness of non-volant mammals from camera trapping

4.2.2.5 Butterflies

Twenty-five butterfly species were recorded during the 2023 Fauna Baseline Survey, and none were of conservation significance. Species commonly recorded include the Common grass yellow (*Eurema hecabe contubernalis*), Common palmfly (*Elymnias hypermnestra agina*) and Malayan eggfly (*Hypolimnas anomala anomala*).

While not of conservation significance, the Study Area was observed to be a breeding site for the Malayan eggfly. Large numbers of caterpillars were observed on its host plant, *Pipturus argentus*, at several locations in the Study Area (Figure 4.24).

A complete list of the butterfly species identified is shown in Appendix E.

Figure 4.24 Caterpillars of the Malayan eggfly (*H. anomala anomala*) on host plant, *P. argentus.*

Comparison with 2017 Fauna Baseline Survey

Thirty-six butterfly species identified during the 2017 Fauna Baseline Survey in comparison to 25 butterfly species were identified during the 2023 Fauna Baseline Survey (Fung et al., 2017). Thus, there were 11 fewer species of butterflies identified in the 2023 Fauna Baseline Survey compared to the 2017 Fauna Baseline Survey.

The reduction in the number of butterfly species across the two studies was possibly the result of disturbances and clearance of suitable grassland habitat for species such as Small-branded swift (*Pelopidas mathias mathias*), Banana skipper (*Erionota thrax thrax*) and the Malayan (*Megisba malaya sikkima*).

Besides the reduction in the number of butterfly species, there was also a limited overlap of butterfly species compositions between the two surveys, with only 11 species that were found in common between both surveys, suggesting a potential shift in the butterfly composition present at the site (Appendix E). Some species which were present only during the 2023 Fauna Baseline Survey, such as *Eurema blanda snelleni*, *H. anomala anomala* and *Tanaecia pelea pelea,* were likely the result of translocation from adjacent natural areas and were noted to have been spotted within 2km of the site during the 2017 Fauna Baseline Survey (Fung et al., 2017). Their current presence at the site may suggest the recruitment of these species from adjacent areas to suitable habitat in the surveyed site.

4.2.2.6 Odonates

Seven odonate species were recorded during the 2023 Fauna Baseline Survey and none of were of conservation significance. An assessment of odonate populations was not conducted in the 2017 Fauna Baseline Survey.

Commonly recorded odonates include the Common blue skimmer (*Orthetrum glaucum*), Grenadier (*Agrionoptera insignis*) and Ornate coraltail (*Ceriagrion cerinorubellum*). Only the Ornate coraltail was a damselfly of the Zygoptera (damselfly) suborder, while the other six were dragonflies of the Anisoptera (dragonfly) suborder.

All recorded odonate species were considered to be widespread and common, except for the Dingy duskhawker (*Gynacantha subinterrupta*), which was uncommon, though not of conservation significance.

The poor odonate diversity observed is likely attributed to the lack of considerable permanent waterbodies in the Study Area. Since most odonates spend their larval stage and begin their life as a nymph in aquatic environments (Ngiam, 2011), the lack of suitable waterbodies on sites would greatly reduce its odonate diversity.

A complete list of the odonate species identified is shown in Appendix E.

4.2.2.7 Aculeata

Ten species of aculeate hymenopterans (seven bees, three wasps) were recorded during the 2023 Fauna Baseline Survey, and none were of conservation significance. An assessment of aculeate hymenopteran populations was not conducted in the 2017 Fauna Baseline Survey.

Commonly recorded species include Broad-handed carpenter bee (*Xylocopa latipes*) and the Wasp, *Ropalidia stigma*. Active nests of two species, *X. latipes* and *Parischnogaster mellyi* were spotted, as well as an abandoned *Apis dorsata* nest, showing that the Study Area provides nesting sites for these species.

A complete list of the aculeate hymenopteran species identified is shown in Appendix E.

4.2.2.8 Spiders

82 species from 25 families were recorded during the 2023 Fauna Baseline Survey, and none were of conservation significance, as spiders are currently not included for national assessment. An assessment of spider populations was not conducted in the 2017 Fauna Baseline Survey.

Most of the species were recorded from diurnal umbrella beatings (50 species), followed by nocturnal visual searches (43 species) and the diurnal leaf litter sifting (16 species).

The most commonly encountered species during umbrella beatings were the Comb-foot spiders (Family Theridiidae). They are considered the most common arthropod found around the world in urban dwellings (Leong et al., 2017). During the visual searches, the most commonly encountered were the Jumping spiders (Family Salticidae) and Orb-weavers (Family Araneidae). Within the leaf litter, spiders from the Pholcidae family were most commonly observed. Being thin and delicate, these spiders have very long legs that helps them to navigate through the densely packed forest floor easily.

Although the conservational importance of spider species has not been formally assessed, five notable records were highlighted in this section based on specialists' observation.

Uloborus SW is only known from the two specimens collected during this survey during umbrella beatings. Spiders from this family are generally small and easily overlooked, and common even in urban areas. It is likely that this species is more widespread and common, which may be elucidated with future work.

aff. *Malayathele* SC was recorded during leaf litter sifting. It is considered an uncommon species. Individuals have been recorded in BTNR (Bukit Timah Nature Reserve) and CCNR (Central Catchment Nature Reserve) and used to be recorded in Singapore Botanic Gardens and Sentosa in 1993 and 1987 respectively (Schwendinger et al., 2020) but it is unclear if the populations still exist there.

Brignoliella michaeli (Figure 4.25) is a species of armoured spider that was recently recorded in Singapore. It had been recorded from CCNR and Bukit Batok area (Ng P, pers comm.). It is likely to be widespread in CCNR but absent from BTNR (Ng P, pers comm.). Most species from this family (Tetrablemmidae) are often found in leaf litter and soil. This individual was observed during leaf litter sifting.

Cocalus murinus is an uncommon jumping spider normally found sleeping on twigs. One individual was collected during the visual search surveys. This species is known to have a preference for mangrove habitats. They have been sighted in locations at or near coastal habitats, such as Admiralty Park and Pasir Ris Park (Ng P, pers. comm.). Given the known record in Admiralty Park, it is not surprising that this species was recorded in the Study Area.

Alistra BC is an uncommon species collected during umbrella beating. Previous records suggest that this species may have a preference for coastal and mangrove habitats (Ng P, pers. comm.). The presence of this species could be explained by the proximity of the Study Area to the northern coast. Species of this family are extremely small and no larger than 2mm. As it is a very small spider, it could be easily overlooked and may be more widespread than thought.

A complete list of the spider species identified is shown in Appendix E.

Figure 4.25 Photo of *B. michaeli*

4.2.2.9 Herpetofauna (Amphibians and Reptiles)

A total of 12 species of herpetofauna (six amphibians, six reptiles) were recorded during the 2023 Fauna Baseline Survey, none of which were of conservation significance.

All recorded amphibians were common, comprising of two native and four non-native species. Commonly recorded species include the native Dark-sided chorus frog (*Microhyla heymonsi*), Four-lined tree frog (*Polypedates leucomystax*), the non-native Greenhouse frog (*Eleutherodactylus planirostris*) and the East asian ornate chorus frog (*Microhyla mukhlesuri*).

Most recorded reptiles were common, all were native except for the non-native Changeable lizard (*Calotes versicolor*). The most notable sighting was the Lowland dwarf gecko (*Hemiphyllodactylus typus*), a nationally Near Threatened species with a known restricted locality in BTNR, CCNR, Mandai mangroves, Pasir Ris mangroves and Bidadari (Baker & Lim, 2012; Thomas, 2013; Tay, 2013). It was observed once within understorey of the Exotic-dominated secondary forest during nocturnal survey (Figure 4.26).

A complete list of the herpetofauna recorded is shown in Appendix E.

Figure 4.26 Nationally Near Threatened Lowland Dwarf Gecko (*H. typus*) observed in the north-western part of the Study Area (Exotic-dominated secondary forest)

Comparison with 2017 Fauna Baseline Survey

A total of 11 herpetofauna species (6 amphibians, 5 reptiles) were identified in 2017 Fauna Baseline Survey in comparison to the 12 herpetofauna species (6 amphibians, 6 reptiles) identified during the 2023 Fauna Baseline Survey.

Although herpetofauna species richness was comparable between both studies, there were changes in species composition.

Three amphibian species from the 2017 Fauna Baseline Survey were no longer found during the 2023 Fauna Baseline Survey. Two of these, namely, *Duttaphrynus bengalensis* (previously *Duttaphrynus melanosticus*) and *Fejervarya cancrivora* are known urban adaptive species with a preference with moist grassland habitats. The removal of the grassland and scrubland habitats south and west of the Study Area (Figure 4.7) were likely to be responsible for reductions in their populations. The last of these, *Microhyla butleri* could merely have been misidentified during the earlier survey as the taxonomy and classification of Microhylids remains in flux.

Two new species of amphibian not found during the 2017 Fauna Baseline Survey were identified during the present one. The first species, *M. mukhlesuri,* is not unlike the aforementioned *M. butleri.* Formally identified as a distinct species in 2014, previous populations of the former could have been wrongly identified as the latter species. The second species identified was the non-native Greenhouse frog (*E. planirostris*) was a notable finding of the 2023 Fauna Baseline Survey. First reported in Singapore in the vicinity of Sembawang Park in 2016, the Greenhouse frog has since been sighted across the country (Singapore Biodiversity Records, 2016). Known to be a highly adaptable species, its recording in the most recent survey suggests that it is has also established itself in the Study Area.

Changes in the reptile species composition between 2017 and the 2023 Fauna Baseline Surveys saw the disappearance of three urban dwelling species, Spotted house gecko (*Gekko monarchus*), Common house gecko (*Hemidactylus frenatus*) and Many-striped skink (*Eutropis multifasciata*). Whilst it is unlikely that members of the three species have disappeared in their entirety due to their ubiquity across both urban and natural habitats in Singapore's ecological landscape, their absence in the survey suggests a general

reduction in their population size and density within the study site. This may be attributable to the construction and operation of the JTC Woodland's North Coast buildings. In particular, sources of human activity often increase the availability of food items for the insectivorous gecko species, which then tend to congregate nearer to sites of human activity.

Alongside these changes, the Green crested lizard (*Bronchocela cristatella*), Striped bronzeback (*Dendrelaphis caudolineatus)*, Painted bronzeback (*Dendrelaphis pictus)* and Lowland dwarf gecko (*H. typus)* were newly found at the site during the 2023 Fauna Baseline Survey. Whilst adaptable, both Bronzeback species remain cryptic and prefer the vegetated conditions of forest edge and secondary forest habitat. Similarly, the general decline in the distribution and population size of the Green crested lizard (*B. cristatella*) across Singapore is thought to correspond with the loss of suitable forest (Diong & Lim, 1998). Finally, *H. typus* has the most restricted habitat of the aforementioned species and is exclusively found in tropical and coastal forests within Singapore. The presence of these forest-dependent species highlights the continued maturation of the secondary forest habitat within the Study Area.

4.2.2.10 Birds

A total of 54 bird species were recorded during the 2023 Fauna Baseline Survey. Forty-four of these were resident species, comprising of 37 native and seven introduced species. Nine other species were categorised as migratory species and visitors. Lastly, an unidentified swiftlet (*Aerodramus* sp.), was only recorded to genus level and was hence unable to be classified according to its provenance. A complete list of the bird species identified is shown in Appendix E.

A total of eight species of conservation significance were recorded, consisting of five nationally Vulnerable species, one nationally Endangered species, one nationally Critically Endangered species and finally, one globally Vulnerable species (Table 4.13). These species were distributed across the Study Area, with no distinct hotspot observed (Figure 4.21).

Table 4.13 List of avifauna of national and global conservation significance

Species	Common Name	National Status	Global Status	Survey year	
				2023	2017
Spilornis cheela	Crested serpent eagle	Critically Endangered	Least Concern	✓	
Nycticorax nycticorax	Black-crowned night heron	Endangered	Least Concern	✓	
Alcedo atthis	Common kingfisher	Vulnerable	Least Concern	✓	
Nisaetus cirrhatus	Changeable hawk-eagle	Vulnerable	Least Concern	✓	✓
Corvus macrorhynchos	Large-billed crow	Vulnerable	Least Concern	✓	✓
Lanius cristatus	Brown shrike	Vulnerable	Least Concern	✓	✓
Zosterops simplex	Swinhoe's white-eye	Vulnerable	Least Concern	✓	✓
Copsychus saularis	Oriental magpie-robin	Vulnerable	Least Concern		✓
Psittacula longicauda	Long-tailed parakeet	Near Threatened	Vulnerable	✓	✓

Five nationally Vulnerable species were recorded and described below.

The Changeable hawk-eagle (*Nisaetus cirrhatus*) was heard twice in the north-western part of the Study Area (Figure 4.21). Across Singapore, this species has been sighted in several

wooded areas. They are also known to adapt to some degraded habitats with tall trees (e.g., Moluccan albizia), which they utilise for nesting (Singapore Birds Project, 2023). However, nesting was not observed for this species in the Study Area. The Common kingfisher (*A. atthis*; Figure 4.27B) was heard once in the north-western part of the Study Area (Figure 4.21). It is a migratory species, and is typically found in habitats such as drains, canals, and ponds in Singapore (NParks, 2019). The record of this species in the Study Area may be explained by the presence of these features in the surrounding of the Study Area (e.g., Admiralty Park). The Large-billed crow (*Corvus macrorhynchos*; Figure 4.27C) was seen along the View Road in the north. The Brown shrike (*Lanius cristatus*; Figure 4.27D), a migratory species, as well as the Swinehoe's white-eye (*Zosterops simplex*) were encountered within the Exotic-dominated secondary forest in the south (Figure 4.21).

The nationally Endangered, Black-crowned night heron (*N. nycticorax;* Figure 4.27A) was recorded twice foraging on the slope on the eastern edge of the Study Area at night. This species inhibits a wide range of aquatic environments, including mangroves, ponds, mudflats, canals, and well-vegetated reservoir fringes (Yong et al., 2013). They usually roost in wetland habitats such as mangroves and mudflats (Singapore Birds Project, 2023). Hence, this species is likely using this area for foraging, rather than roosting.

Two individuals of the nationally Critically Endangered Crested serpent eagle (*S. cheela*) were heard in the eastern part of the Study Area. This species is considered a rare resident and migrant (NSS, 2022). It is known to inhabit forests and old plantations, and mainly predates on snakes (Yong et al., 2013).

Finally, the globally Vulnerable Long-tailed parakeet (*Psittacula longicauda)* was recorded in several locations across the north-eastern and north-western parts of the Study Area (Figure 4.21).

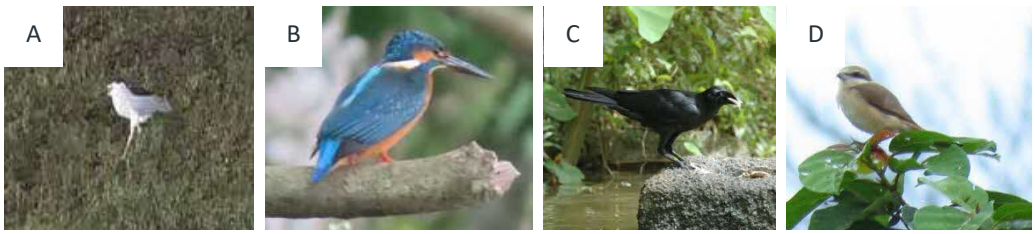


Figure 4.27 Birds of conservation significance recorded. (A) Black-crowned night heron (*N. nycticorax*); (B) Common kingfisher (*A. atthis*); (C) Large-billed crow (*C. macrorhynchos*); (D) Brown shrike (*L. cristatus*)

Notably, a raptor nest on a Moluccan albizia tree (*F. falcata*) was found in the north-western part of site, belonging to a Brahminy kite (*H. indus*) (Figure 4.28; Figure 4.29). The raptor was observed carrying nesting material in and out of the nest and often perched on the same tree near the nest. While no nesting was confirmed, a pair of White-bellied sea eagles was also frequently seen thermalling and heard vocalising in the south-eastern part of the Study Area.

A follow-up visit on 05 Sep 2024 found that the raptor nest was no longer present. However, a Brahminy Kite was sighted in the vicinity, circling near the same tree where the nest had been initially found, indicating raptor presence in the area.

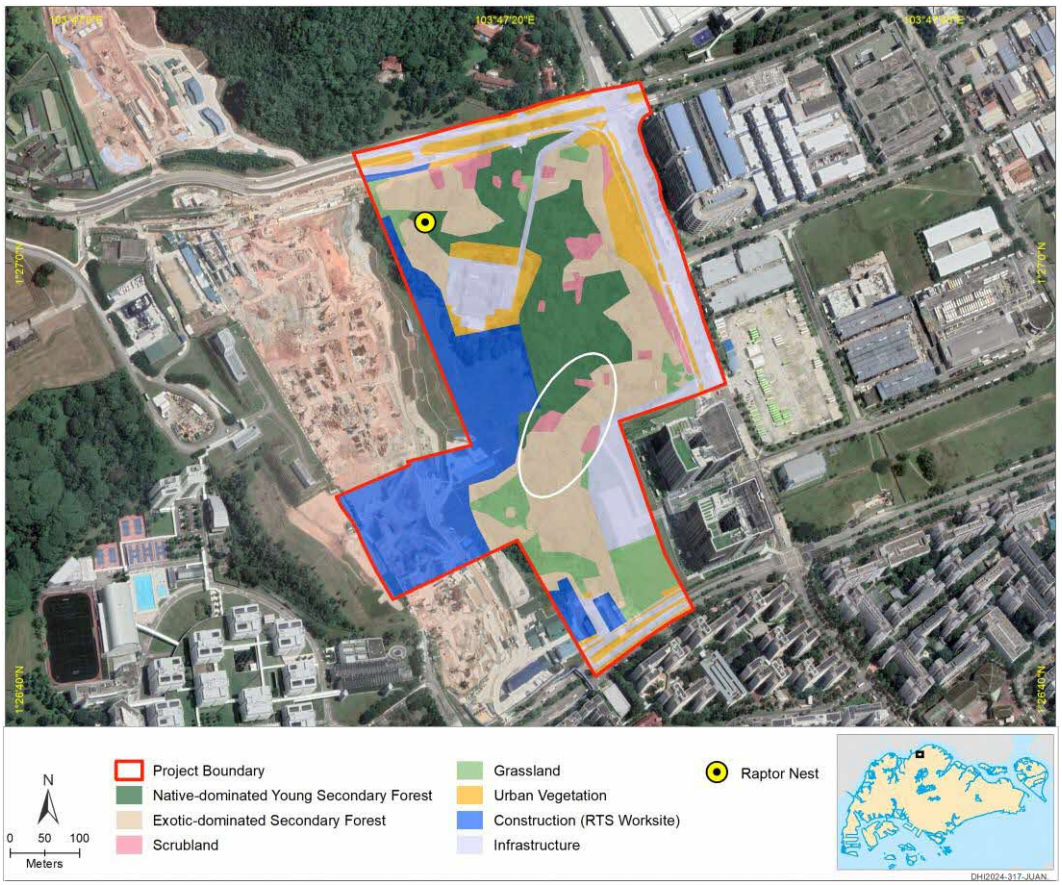


Figure 4.28 Location of Brahminy kite nest (*H. indus*) in the north-western part of the Study Area (Satellite image as of 10 Mar 2022)

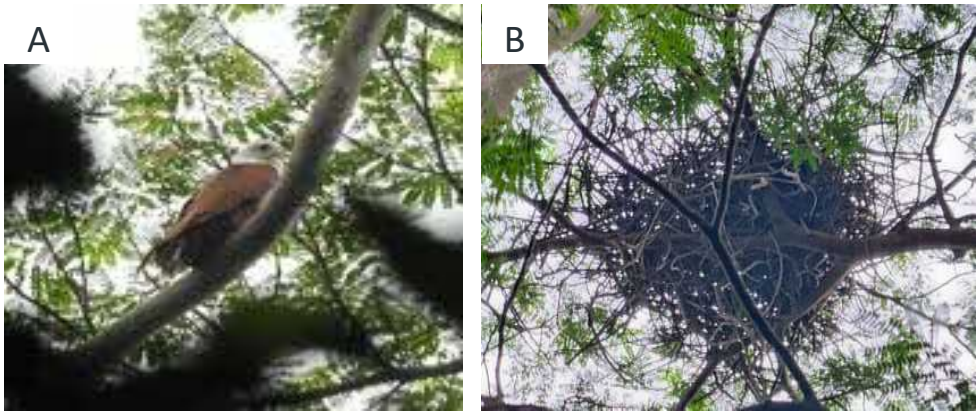


Figure 4.29 (A) Brahminy kite (*H. indus*) perching on a Moluccan albizia tree (*F. falcata*); (B) Nest of the Brahminy kite (*H. indus*)

Migratory species

Nine migratory bird species were also recorded during the 2023 Fauna Baseline Survey (Table 4.14). All migratory bird species recorded were considered common, other than the uncommon Malayan night heron (*Gorsachius melanolophus*), Yellow-rumped flycatcher (*Ficedula zanthopygia*) and Mugimaki flycatcher (*Ficedula mugimaki*). The former two species were sighted on camera traps, whilst the latter was observed by a surveyor. The Malayan night heron was observed catching and feeding on an unidentified snake on two separate occasions in the south-eastern part of the Study Area (CT04).

None of the migratory birds identified were of conservation significance, except the Common kingfisher (*A. atthis*) and the Brown shrike (*L. cristatus*) were accorded a national conservation status of Vulnerable.

Table 4.14 List of migratory bird species recorded

Species	Common Name	Primary Native Status	Survey year	
			2023	2017
Alcedo atthis	Common kingfisher	Winter visitor	✓	
Gorsachius melanolophus	Malayan night heron	Winter visitor	✓	
Pericrocotus divaricatus	Ashy minivet	Winter visitor	✓	
Ficedula zanthopygia	Yellow-rumped flycatcher	Passage migrant	✓	
Ficedula mugimaki	Mugimaki flycatcher	Passage migrant	✓	
Lanius cristatus	Brown shrike	Winter visitor	✓	✓
Merops viridis	Blue-throated bee-eater	Migrant breeder	✓	✓
Muscicapa dauurica	Asian brown flycatcher	Winter visitor	✓	✓
Phylloscopus borealis	Arctic warbler	Winter visitor	✓	✓
Accipiter gularis	Japanese sparrowhawk	Passage migrant		✓
Cuculus micropterus	Indian cuckoo	Winter visitor		✓
Cecropis daurica	Red-rumped swallow	Winter visitor		✓
Hirundo rustica	Barn swallow	Passage migrant		✓
Terpsiphone incei	Amur paradise flycatcher	Passage migrant		✓
Muscicapa sibirica	Dark-sided flycatcher	Winter visitor		✓
Agropsar sturninus	Daurian starling	Winter visitor		✓

Species	Common Name	Primary Native Status	Survey year	
			2023	2017
Pandion haliaetus	Western osprey	Non-breeding visitor		✓

Comparison with 2017 Fauna Baseline Survey

A total of 51 species of birds were found during the 2017 Fauna Baseline Survey, whilst a total of 54 bird species were found during the 2023 Fauna Baseline Survey. Despite the comparable species richness, there was an incomplete overlap of bird species found during the two surveys, 17 species identified during the 2017 Fauna Baseline Survey were not found during the 2023 Fauna Baseline Survey, whilst 13 species from the 2023 Fauna Baseline Survey were not found during the 2017 Fauna Baseline Survey. Uncommon species present during the 2017 Fauna Baseline Survey but were absent during the 2023 Fauna Baseline Survey include the Paradise flycatcher (*Terpsiphone incei*) which prefers wooded habitats (Singapore Birds Project, 2023), the Dark-sided flycatcher (*Muscicapa sibirica*) and the Red-rumped swallow (*Cecropis daurica*).

Amongst conservation significant species, the nationally Vulnerable Oriental magpie-robin (*Copsychus saularis*), was not recorded in the 2023 Fauna Baseline Survey but was observed in the 2017 Fauna Baseline Survey. Comparatively, three species of conservation significance, the Black-crowned night heron (*N. nycticorax*), Common kingfisher (*A. attis*), and Swinhoe's white-eye (*Z. simplex*) recorded during the 2023 Fauna Baseline Survey were not found in 2017 Fauna Baseline Survey (Table 4.13).

One reason for the variation in the species composition of bird species could be due to variations in migratory patterns. Of the migratory species, eight expected species found in 2017 were not present in 2023 whilst four species found during the 2023 Fauna Baseline Survey were not found in 2017, comprising 47% and 31% of the non-overlapping avian species from their respective time periods. In particular, the mobility of avifauna allows for frequent movement between suitable habitats, allowing for more prominent fluctuations in avifauna composition compared to that of other fauna groups.

Other explanations for absence of particular species include changes in habitat composition, whereby Native-dominated secondary forest is replaced by Exotic-dominated secondary forest, and reduction of habitat size due to clearings in the west and northern parts of the Study Area. It is also possible that the species was present but was undetected due to the nature of biodiversity surveys which are conducted over a finite time period in a limited area. Therefore, the absence of a previously detected species does not conclusively indicate that it is no longer present in the Study Area.

4.2.2.11 Non-volant Mammals

A combined total of eight species of non-volant mammals were recorded through camera trapping and transect surveys. The only mammal that was identified during transect surveys was the Plantain squirrel (*Callosciurus notatus*), whilst camera traps managed to record activity from all aforementioned species. The attribution of species activity to camera traps is provided in Table 4.15.

Among the recorded species, two species were of conservation significance. An unidentified otter was recorded once on camera trap (CT06) in the north-eastern part of the Study Area. It was deemed most likely to be the Smooth-coated otter (*L. perspicilata*) based on the habitat types present and the species' known presence within the adjacent Admiralty Park. The Smooth-coated otter is Vulnerable globally and Endangered nationally.

In contrast, the globally Endangered Long-tailed macaque (*M. fascicularis*) was also recorded. Whilst the species is nationally widespread and common, its global conservation status was recently uplisted as a result of human persecution across the rest of South-east Asia (IUCN, 2022). There has only been one sighting of an adult male Macaque on camera trap CT01 (Figure 4.30) in the southern part of the Study Area. This individual may be from the nearby troops known to be present around Admiralty Park and Woodlands Waterfront area (Riley et al., 2015). Notable absences from the area include the Eurasian wild boar (*Sus scrofa*), an otherwise widespread mammal species that would be well adapted to the habitats present within the Study Area.

Comparison with 2017 Fauna Baseline Survey

A total of four non-volant mammals were recorded during the 2017 Fauna Baseline Survey whilst eight non-volant mammals were recorded during the 2023 Fauna Baseline Survey. Despite the doubling of species observed in 2023, three of the additional species were associated with increased anthropogenic activity and urbanisation. These species were the Domestic cat (*Felis catus*), the Domestic dog (*Canis lupus familiaris*) and Asian house rat (*Rattus tanezumi*). Based on these observations, the increase in the apparent mammalian species richness may not be attributed to any potential changes in habitat complexity and maturity, since these species usually occur chiefly as a result of human activity.

Additional differences between the 2017 and 2023 Fauna Baseline Studies saw the absence of the House shrew (*Suncus marinus*) from the former and the presence of the Long-tailed macaque (*M. fascicularis*) and Smooth-coated otter (*L. perspicilata*) in the latter.

The Long-tailed macaque was in fact, observed in the natural areas outside the periphery of the Study Area in the 2017 Fauna Baseline Study (Fung et al., 2017). Its presence within the Study Area of the 2023 Fauna Baseline Study likely reflects the fact that the aforementioned natural areas have now been cleared of vegetation. Contrastingly, the presence of the Smooth-coated otter likely reflects an opportunistic sighting of an animal not inhabiting the Study Area.

S. marinus was likely not observed during this study due to the removal of grassland habitats and the species cryptic ecology. With a tendency to dart quickly across low undergrowth and avoidance of open areas, *S. marinus* is often only spotted when moving amongst short grasses or urban infrastructure. These observations corroborate with the 2017 Fauna Baseline Survey, during which, *S. marinus* was only observed opportunistically. A generalist species, *S. marinus* likely still persists within the Study Area but was less likely to have been observed amidst the remaining habitat consisting of thick undergrowth and leaf litter.

Table 4.15 List of non-volant mammal species and respective camera trap stations observed

Species	Stations observed
Smooth-coated otter (*Lutrogale perspicilata*)	CT06
Long-tailed macaque (*Macaca fascicularis*)	CT01
Common treeshrew (*Tupaia glis*)	CT01, 04, 05, 06, 07, 08, 09, 10
Asian house rat (*Rattus tanezumi*)	CT05, CT09
Malaysian wood rat (*Rattus tiomanicus*)	CT03, CT08
Unidentified rat (*Rattus* spp.)	CT01, 04, 05, 06, 08, 09, 10
Plantain squirrel (*Callosciurus notatus*)	CT01, 04, 05, 06, 07, 08, 09, 10

Feral cat (*Felis catus*)	CT04, CT09

Figure 4.30 Long-tailed macaque (*M. fascicularis*) recorded from camera trap station CT01

4.2.2.12 Bats

Five bat species were recorded from transect surveys, either via means of visual sighting or bioacoustic recording. This comprised one fruit bat – the Lesser short-nosed fruit bat (*Cynopterus brachyotis*), and four insectivorous bats – the Lesser asian house bat (*Scotophilus kuhlii*), Asian whiskered myotis (*Myotis muricola)*, Pouch tomb bat (*Saccolaimus saccolaimus*), Black-bearded tomb bat (*Taphozous melanopogon*). Examples of sonograms are presented in Figure 4.31. All species are considered native and widespread in Singapore. None are of conservation significance. Harp trapping did not yield any bat species.

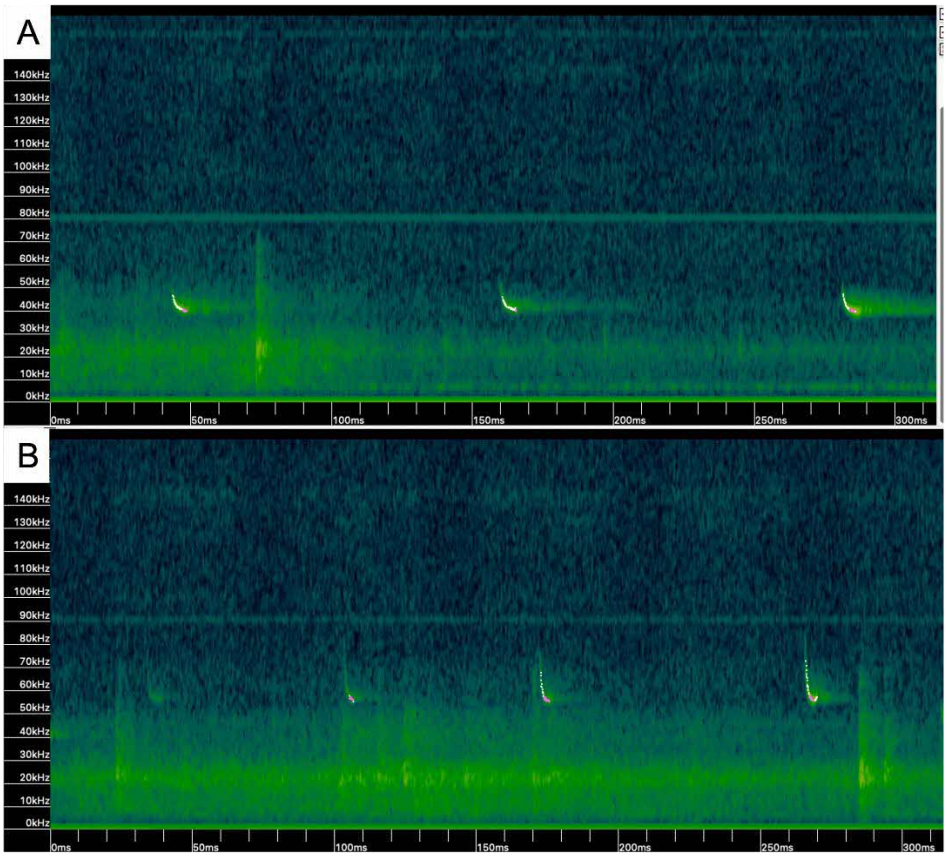


Figure 4.31 Sonograms of (A) Lesser asian house bat (*S. kuhlii*) and (B) Asian whiskered myotis (*M. muricola)*

Comparison with 2017 Fauna Baseline Survey

Only one bat species, the Lesser short-nosed fruit bat (*C. brachyotis*) was recorded in the 2017 Fauna Baseline Survey in comparison to the five bat species recorded in the 2023 Fauna Baseline Survey.

The increase in the number of bat species is likely attributable to the fact that acoustic traps were deployed only during the 2023 Fauna Baseline Survey, but not the 2017 Fauna Baseline Survey. A cryptic group with nocturnal or crepuscular activity periods, bats are difficult to spot solely using transect survey methodologies. The distinct sound signature of different species and non-invasive survey method make acoustic traps ideal for characterising the presence of a range of bat species.

4.3 Impact Assessment Framework

4.3.1 Importance Rating of Sensitive Receptors

The generic criterion used to evaluate the Importance of ecological and biodiversity receptors, as stipulated in the BIA Guidelines (NParks, 2024), is adapted here (Table 4.16) following a customisation that considers the context-specificity of Singapore's ecological landscape, and its constituent biodiversity, habitat types, and conservation values. The evaluation of the Importance of identified receptors here utilised findings from the baseline surveys, the team's expert judgement, available scientific literature, and experience from similar developments within Singapore. The evaluation of Importance scores also considers the sensitivity or susceptibility of ecological receptors to the environmental pressure being assessed (e.g. airborne noise and air pollution).

Table 4.16 Criteria applied in the scoring of Importance for terrestrial biodiversity and ecological receptors.

Score	Specific Criteria	
	Habitat/Vegetation types	**Fauna/Flora**
5	• Nationally or internationally designated habitat/sites of biological and ecological importance, e.g. designated Nature Reserves, Nature Areas, ASEAN Heritage Parks • Unrecognised habitat/sites of equivalent ecological value to designated and protected nature areas i.e. Primary forest, Freshwater swamp forests, Mangrove forests with distinct intertidal zonation • Natural freshwater streams within deep canopy cover • Highest ecological importance, near-inexistent potential for substitution, suis generis habitat nationally; many species with a highly restricted spatial distribution	• Contains species that are deemed to be Critically Endangered based on local (SRDB3) and global (IUCN) conservation assessments • Critically Endangered species found onsite demonstrate high site fidelity and/or narrow habitat specificity • Proportion of conservation-significant taxa/species between 40-50% of all species, e.g. listed in Singapore Red Data Book and IUCN conservation assessments as Vulnerable and above • Presence of species with keystone ecological functions i.e. bamboo clusters where there are bamboo bats
4	• Nationally or regionally recognised sites of biological and ecological importance • Large, forested sites (≥20 ha) with closed canopy cover, outside of designated nature reserves, nature areas and other legally protected areas including Native-dominated, old secondary forest, Coastal forests and Mangrove relic forests • Natural freshwater streams, marshes or ponds within open canopy cover • High ecological importance with limited potential for substitution; core habitat nationally; many species with restricted spatial distribution	• Contains species that are deemed to be Endangered based on local (SRDB3) and Critically Endangered based on global (IUCN) conservation assessments • Endangered species found onsite demonstrate high site fidelity and/or Critically Endangered species with lower site specificity • Proportion of conservation-significant taxa/species between 30-40%, e.g. listed in Singapore Red Data Book and IUCN conservation assessments as Vulnerable and above • Presence of species with important ecological functions – Fig wasps for specific *Ficus* species

Score	Specific Criteria	
	Habitat/Vegetation types	Fauna/Flora
3	• Medium forested sites (5-20 ha) with closed canopy cover, outside of designated nature reserves, nature areas and other legally protected areas • Native-dominated, young secondary forest, Exotic-dominated secondary forest, and restored Mangrove forests • Naturalised streams, marshes or ponds with riparian vegetation • Moderate ecological importance with some potential for substitution, important habitat nationally; uncommon species with limited spatial distribution	• Contains species that are deemed to be Vulnerable based on local (SRDB3) and Endangered based on global (IUCN) conservation assessments • Proportion of conservation-significant taxa/species between 20-30%, e.g. listed in Singapore Red Data Book and IUCN conservation assessments as Vulnerable and above • Presence of species with defined ecological functions – most pollinators, food source for many species
2	• Smaller forested sites (1-5 ha), unmanaged vegetation under open canopy cover, such as Grassland or Shrubland habitats • Modified-urbanised streams with soft landscaping features, e.g. ABC projects • Modest ecological importance with the potential for substitution; important habitat locally, harbours common, non-urban species	• Contains species that are deemed to be Least Concern based on local (SRDB3) and Vulnerable based on global (IUCN) conservation assessments • Proportion of conservation-significant taxa/species between 10-20%, e.g. listed in Singapore Red Data Book and IUCN conservation assessments as Vulnerable and above
1	• Non-forested sites with urban vegetation • Highly modified or fragmented habitats; managed turf, streetscapes • Low to non-existent ecological importance, highly substitutable	• Species of no national importance • Urban adapting or exploiting species

4.3.1.1 Identified Sensitive Receptors and Importance

Table 4.17 Evaluation Framework for Importance scoring of Ecological receptors identified to be affected by the development within the Study Area.

Category	Location	Receptor	Importance Score	Justification
Vegetation Types	Within Project area	Native-dominated, young secondary forest	3	• Native-dominated, young secondary forest represents basal level habitat resembling the original vegetation and habitat typology of Singapore, which consisted primarily of lowland, mixed dipterocarp forests (Corlett, 1991, 1992). Thus, ecological characteristics and conditions present within this habitat type provide a fundamental suitability for Singapore's native flora and fauna, which would be ill-adapted to survive outside of Forest-type habitat. • The area occupied by Native-dominated, young secondary forest within the Study Area is relatively limited (4.19 Ha). • Native-dominated, young secondary forests originate from the regrowth and colonisation of native plants over previously altered habitat. Thus, such habitat is definitionally possible to replace and regenerate. However, vegetation succession of native species may necessitate a period of up to 70 years and thus, any substitution may similarly be described as taking place only in the long-term (Yee et al., 2019). • Broadly, secondary forests are deemed to be an uncommon habitat type within Singapore's ecological landscape, only occupying 19.64% of total land cover (Yee et al., 2011). Of the two sub-classifications of secondary Forest habitat, Native-dominated, young secondary forests are deemed to be the rarer of the two, and was expected to comprise of a small proportion of Singapore's secondary forests.
		Exotic-dominated secondary forest	3	• Exotic-dominated secondary forests provide non-native forested conditions for Singapore's flora and fauna. Whilst many ecosystem characteristics true of forests would be shared with this habitat type, its conditions would be less specific and therefore less suitable for the range of native flora and fauna, and would likely therefore comprise of a greater proportion of introduced or generalist species. • Exotic-dominated secondary forests originate from the regrowth and colonisation of native plants over previously altered habitat. Thus, such habitat is definitionally possible to replace and regenerate. Unlike Native-dominated secondary forests, which necessitate the succession of start-state vegetation with native species, the composition of Exotic-dominated secondary

Category	Location	Receptor	Importance Score	Justification
				forests are dependent on pre-existing non-native vegetation already in place, and therefore requires considerably less time (Yee et al., 2019). • Broadly, secondary forests are deemed to be an uncommon habitat type within Singapore's ecological landscape, only occupying 19.64% of total land cover (Yee et al., 2011). Of the two sub-classifications of secondary forest habitat, Exotic-dominated secondary forests are deemed to be the more common of the two, and are expected to comprise of the bulk of Singapore's secondary forests.
		Scrubland/ Grassland	2	• Scrubland and/or Grassland habitats consist mostly of shorter, non-tree species including various herbs and grasses. In the absence of a distinct canopy and substantive tree cover, such habitats provide a limited range of ecological conditions and services to native flora and fauna. Instead, Scrubland and/or Grassland habitats are typically colonised by a variety of generalist flora and fauna species. • Scrubland and/or Grassland habitats form as a result of an early successional stage between cleared and vegetated land areas. In the absence of a distinct canopy, sun-loving and fast-growing species quickly populate undisturbed cleared land areas, and eventually achieve a Scrubland or Grassland habitat state. The pace of vegetation succession from cleared land and this general spontaneity demonstrate that Scrubland and/or Grassland habitats have a degree of substitutability and recoverability. • Broadly, Scrubland and/or Grassland habitats are thought to occupy about 5.92% of Singapore's land area, comprising 20.41% of spontaneously vegetated areas within Singapore (Yee et al., 2011).
		Urban vegetation	1	• Urban vegetation sites consist primarily of non-native flora, intentionally planted and maintained anthropogenically. Since Urban vegetation is primarily aesthetic, the structure and composition of such sites do not naturally lend themselves to be functionally suitable for the natural development of native biodiversity. Thus, Urban vegetation often functions as rudimentary habitat that is temporarily occupied by urban adaptive and exploitative species as they move through otherwise built-up environments. • Urban vegetation is easily sourced and replaced as part of the Singapore's government commitment to keep urban areas planted (Tan et al., 2010; Er et al., 2016).

Category	Location	Receptor	Importance Score	Justification
				• Broadly, Urban vegetation is thought to occupy about 27.45% of Singapore's land area, and is nearly equal in coverage to Singapore's spontaneously vegetated habitats. Thus, Urban vegetation is deemed to be ubiquitous and a common habitat.
Fauna*	Within Project area	Mammals	3	• 13 mammal species were found onsite, of which 2 were deemed conservation significant (15.38%). • Conservation-significant mammals found on site were the globally 'Endangered" Long tailed macaque (*M. fascicularis*), and locally 'Endangered", globally 'Vulnerable' Smooth-coated otter (*L. perspicillata*).
		Avifauna	4	• 54 bird species were found on site, of which 8 were deemed to be conservation significant (12.96%). • Of the conservation significant avifauna, five were vulnerable, two were endangered and one species, the Crested serpent eagle (*S. cheela*) was nationally 'Critically Endangered'. • In addition to these, raptors nests and breeding pair of White-bellied sea eagles were sighted, suggesting that breeding populations were present within the Study Area.
		Herpetofauna	2	• 12 reptile and amphibian species were found onsite, of which none were conservation significant.
		Butterflies	2	• 25 butterfly species were found onsite, of which none were conservation significant.
		Odonates	2	• 7 odonate species were were found onsite, of which none were conservation significant.
Flora	Within Project area	Conservation significant flora	5	• 200 species of flora were found on site, of which 23 species were deemed to be conservation significant (11.50%). • Of the 23 conservation significant species, 4 were nationally 'Critically Endangered', 2 were 'Endangered' and the remaining 17 species were 'Vulnerable'.

** No importance scoring was performed for Arachnids (Spiders) as there is no appropriate framework for accurate population and rarity assessments at the current time.*

4.3.3 Magnitude of Change

The evaluation of impact magnitude for injury or mortality to fauna and human-wildlife conflict on ecological receptors are presented in Table 4.18. Similarly, the evaluation of impact magnitude for the loss of flora, fauna, habitat types and ecological connectivity are presented in Table 4.19.

Table 4.18 Evaluation Framework for Magnitude of Change for construction phase impacts resulting in injury or increased mortality of fauna, and increased probability of human wildlife conflict with regards to fauna receptors. Where multiple criteria result in multiple possible scores, the more conservative score (higher Magnitude) is adopted in evaluating the Magnitude of Change.

Score	Generic Criteria	Specific Criteria	
		Loss of Fauna/Flora	Human-wildlife conflict
-4	Major negative disadvantage or change	• Expected depletion of the population beyond 75% of current abundance or diversity • Loss of sufficient population numbers such that expected fecundity or recoverability of the population is negligible or unlikely • Affects species without the ability to respond and relocate rapidly and further away from the source of potential injurious activities, and thus are likely to experience significant mortality and/or injuries consequential to fitness	• Increase to the rate of encounters with species that may result in severe injury or mortality in humans. • Species likely to receive extreme and widespread persecution, such as trapping and culling measures.
-3	Moderate negative disadvantage or change	• Expected depletion of the population between 50 - 75% of current abundance or diversity • Loss of sufficient population numbers such that expected fecundity or recoverability of the population is possible only in the long term, and/or up to 50% of current abundance or diversity • Affects species likely to respond quickly but lack the means to relocate rapidly and further away from the source of potential injurious activities. Species in this group are likely to be able to live amidst and evade deleterious activities/find alternative shelter (Urban adaptive mammals). Injuries/mortality likely to be occasional in nature.	• Increase to the rate of encounters with species that may result in injury in humans. • Species likely to experience moderate persecution such as trapping and relocation, including urgent requests for removal.

Score	Generic Criteria	Specific Criteria	
		Loss of Fauna/Flora	Human-wildlife conflict
-2	Minor negative disadvantage or change	• Expected depletion of the population between 25 - 50% of current abundance or diversity • Loss of sufficient population numbers such that expected fecundity or recoverability of the population is possible in the long term, and/or up to 75% of current abundance or diversity • Affects species with a delayed response to disturbances, but with the means to relocate rapidly and further away from the source of potential injurious activities.	• Increase to the rate of encounters with species that may result in fear, revulsion, or concern in humans • Species likely to experience slight to moderate persecution in abundance, such as trapping.
-1	Slight negative disadvantage or change	• Expected depletion of the population between < 25% of current abundance or diversity • Loss of sufficient population numbers such that expected fecundity or recoverability of the population is possible in the long term, and/or up to 90% of current abundance or diversity • Affects species with the ability to respond and relocate rapidly and further away from the source of potential injurious activities, and thus are likely to experience limited to no mortality and/or mild injuries	• Increase to the rate of encounters with species that may result in annoyance in humans. • Species likely face restricted to slight persecution in abundance.
0	No change	• No expected loss of flora and fauna • No increments to the expected rate of animal mortality and injury compared to the baseline level	• Increase to the rate of encounters with species likely to incite no negative responses in humans. • Species unlikely to be noticed or face persecution.

Table 4.19 Evaluation Framework for Magnitude of Change for post-construction phase impacts resulting in loss of habitat, flora, fauna and ecological connectivity with regards to fauna receptors. Where multiple criteria result in multiple possible scores, the more conservative score (higher Magnitude) is adopted in evaluating the Magnitude of Change.

Score	Generic Criteria	Specific Criteria	
		Loss of habitat	Loss of ecological connectivity
-4	Major negative disadvantage or change	• Removal of beyond 75% of habitat type • Loss of habitat beyond point of recoverability • Habitat is likely to degrade into other habitats of lesser ecological value	• Developed site is connected to at least three or more other natural sites that are at least translocatable through short-distance flight, terrestrial or aquatic locomotion • Developed site is keystone position for connectivity across global or regional ecological landscape
-3	Moderate negative disadvantage or change	• Removal of between 50 - 75% of habitat type • Loss of habitat to point of low recoverability • Habitat may only recover in the long-term	• Developed site is connected to at least or three or more natural sites through short-distance flight, or at least two adjacent sites through terrestrial or aquatic locomotion • Developed site is important place for connectivity across global or regional ecological landscape
-2	Minor negative disadvantage or change	• Removal of between 25 - 50% of habitat type • Loss of habitat to point of moderate potential recoverability • Habitat may only recover in the medium term	• Developed site is connected to two or more other natural sites that are translocatable only through short-distance flight or at least one adjacent site through terrestrial or aquatic locomotion • Developed site is important place for connectivity across global or regional ecological landscape
-1	Slight negative disadvantage or change	• Removal of < 25% of habitat type • Loss of habitat to point of moderate potential recoverability • Habitat may recover in the short term	• No nearby connected ecological sites that translocatable through terrestrial or aquatic forms of locomotion • At least one connected ecological site translocatable only through flight • Developed site is utilised for connectivity across global or regional ecological landscape
0	No change	• No loss of habitat	• No effects on ecological connectivity – developed site has no important habitats across local/regional/global ecological landscape

4.4 Prediction and Assessment of Impacts

A variety of environmental impacts are expected as result of the development during the construction and post-construction (operational) phases of the Project. This chapter describes and analyses the predicted environmental impacts on ecological receptors identified to be affected by the development in both phases. Finally, the significance of these environmental impacts will be scored in accordance with the framework delineated in Section 3.4.1.

4.4.1 Construction Phase

4.4.1.1 Loss of Flora

Conservation-significant Flora

A total of 102 specimens across 13 different conservation-significant flora species were identified within the Study Area (Table 4.8). The highest level of conservation significance attained by these species was “Critically Endangered”, and attributed to the climbing epiphyte, *P. polycarpa.* Thus, the conservation significant flora within the site is of highest importance, and was given an importance score of 5 in accordance with the justification listed in Table 4.17. The replacement of preexisting habitat with urban development is likely to result in the total clearance of conservation-significant flora within the Study Area, assuming full clearance and levelling of the Project area.

Furthermore, without intentional, anthropogenically driven efforts to carve out specific niches, it is unlikely that seed sources of conservation-significant flora will be able to recolonise the urban development from adjacent forest patches, nor would any saplings be able to be reestablish themselves, even if they were somehow successfully dispersed into the Study Area. Thus, the impacts are expected to be permanent.

However, the loss of conservation-significant flora is not expected to be irreversible. Transplantation measures, as well as the intentional carving of suitable pockets of habitat within the future development provide leeway for the continued existence of these species, both in the Study Area and beyond.

Finally, the loss of the conservation-significant flora within the site is not expected to have cumulative effects across Singapore’s ecological landscape. Conservation significant plants were not considered to have been found in especially high numbers, and the relative isolation of the patch from other forest patches suggests that the plants found within the Study Area are unlikely to contribute much as sources of flora dispersal.

With previously established Importance, Magnitude, Permanence, Reversibility and Cumulativity scores, the final significance of this impact on conservation-significant flora is expected to be a Major negative Impact.

4.4.1.2 Loss of Fauna

The main expected impact to ecological receptors during the construction phase concerns the development of injury and killing of fauna within the Study Area, culminating in an almost complete loss of fauna diversity and populations as the development concludes.

The extent by which construction works are expected to result in injury or mortality to different groups of fauna is unequal. Primarily, the extent and/or probability of injury or mortality depends on an organism's ability to rapidly sense and adequately react to sources of injurious disturbances. Secondarily, relevant ecological and biological characteristics relating to these traits include the life expectancy, reproductive regimes, habitat fidelity, general mobility and biological responses to disturbances of different fauna. These differing levels of impact are further elaborated upon in the taxon-specific subsections.

Although the conduct of injurious or fatal construction activities is temporary, the loss of fauna from the Study Area is expected to be a mostly permanent state of affairs. Similarly, the loss of fauna will not be reversible; since populations from the Study Area are expected to be injured, killed or evicted in their totality.

Mammals

Mammals were given an importance score of 3 in accordance with the justification listed in Table 4.17.

Habitat clearance and construction activities will eventually result in the mortality or eviction of some mammal species and populations within the Study Area. Since non-volant mammals are restricted to terrestrial locomotion, alongside the fact that the Study Area is surrounded along its perimeter by a slew of heavily utilised roads, non-volant mammals face the dilemma of being subject to construction activity or risk becoming roadkill in their attempts to leave the Study Area. Several volant mammals were also found within the Study Area; these species are expected to fare better and are likely to endure fewer instances of injury and mortality during the construction phase. However, the nocturnal activity periods of many non-volant mammals may result in them being caught unaware during the day, when many of the construction activities, such as tree felling and vegetation clearance, are conducted.

These dim prospects may be assuaged by the urban adaptive or exploitative characteristics of some mammal species found within the site. These species include the various rats (*R. tanezumi, R. tiomanicus*), Domestic cat (*F. catus*), Plantain squirrel (*C. notatus*), and Common treeshrew (*T. glis*). The possession of urban adaptive or exploitative characteristics raises the likelihood that individuals from these species may successfully survive amidst the rubble and chaos of the construction sites. However, conservation-significant species found within the Study Area including the Long-tailed macaque (*M. fascicularis*) and the Smooth-coated otter (*L. perspicillata*) are less adept for survival in such environments compared to their aforementioned counterparts, and would likely be evicted or killed.

These impacts are also unlikely to have cumulative consequences. In particular, the patch remains relatively isolated from other vegetated habitats, and contain no large, breeding populations of conservation-significant mammal species.

With previously established Importance, Magnitude, Permanence, Reversibility and Cumulativity scores, the final significance of this impact on mammals is expected to be a Minor Negative Impact.

Avifauna

Avifauna were given an importance score of 4 in accordance with the justification listed in Table 4.17.

Compared to most other taxa, avifauna are expected to experience a reduced degree of injury and mortality, owing to their ability to fly away and distance themselves from potential injurious construction activities. It is therefore anticipated that many of the avifauna affected by disturbances are likely to respond quickly and leave ahead of any conduct of injurious activity, evading injury or death. Nevertheless, the extant populations of some species, such as those of the Red junglefowl, may exhibit a reduced ability or tendency to fly. Nesting or fledgling birds incapable of flight are similarly prone to injury or mortality, particularly during the tree felling stage. Species in this latter category may include the Brahminy kite (*H. indus*) or White-bellied sea eagle (*Haliaeetus leucogaster*) which were found to be nesting or thought to be potentially nesting on site (Figure 4.28). That some avifauna be injured or killed may be inadvertent.

Beyond the immediate threat of injury and mortality, avifauna evading destroyed habitat may subsequently fall prey to disease, injury and mortality in the short to medium term in the absence of suitable habitat to relocate to, which must necessarily possess sufficient food, water and shelter for the continued survival of individual birds. In context, suitable habitat in such a vein is likely to be present within the nearby Admiralty Forest, Mangroves, Admiralty Park and Woodland's Waterfront park that are all within a 0.5 – 1.5km radius from the Study Area. Despite this, it is possible that some individuals will be unable to obtain the resources necessary for survival due to competition for increasingly limited habitats available in the aforementioned sites. On the whole, it may be expected that avifauna will still experience injury and mortality, albeit on a limited level, from the planned development of the site.

The completion of the construction process will result in the eventual clearance of the site and an almost complete eviction of pre-existing avifauna, although most of the evicted avifauna are expected to relocate and resettle in suitable nearby habitats. Thus, these impacts are not expected to be cumulative.

With previously established Importance, Permanence, Reversibility and Cumulativity scores, the final significance of this impact on Avifauna is expected to be a Minor Negative Impact.

Herpetofauna

Herpetofauna were given an importance score of 2 in accordance with the justification listed in Table 4.17.

Unlike most avifauna, herpetofauna populations are expected to suffer a greater degree of injury and mortality as a consequence of construction activities. Besides a significant reduction in the mobility of herpetofauna to move to suitable habitats from disturbed areas compared to avifauna, the survivability of herpetofauna is further restricted by several behavioural adaptations in this respect. For one, various amphibian species are known to respond to incoming disturbances by keeping still. Other herpetofauna exhibiting evasive behaviour often opt to find shelter under the nearest patches of leaf litter, wood or vegetation. Individuals may be injured or killed as they move out of the forest onto major roads, particularly during the tree-felling and site clearance stage. During the construction stage, herpetofauna species may also become entrapped in Earth Control Blankets or pits as they attempt to move through the construction worksite. Overall, these biological restrictions and behavioural maladaptations will likely predispose herpetofauna on site to significant injury and mortality from construction activities.

In a similar manner to mammals, herpetofauna populations within the Study Area remain isolated from adjacent habitat, and thus should be subject to minimal intermixing. Thus, these impacts are not expected to be cumulative.

With previously established Importance, Permanence, Reversibility and Cumulativity scores, the final significance of this impact on Herpetofauna is expected to be a Minor Negative Impact.

Butterflies

Butterflies were given an importance score of 2 in accordance with the justification listed in Table 4.17.

The total clearance of habitat will result in the eviction of the butterfly species found within the Study Area. However, it is likely that most of the butterfly populations would successfully relocate to adjacent habitats. The clearance of suitable plants for pollination and host plants for egg laying and caterpillar consumption mean that butterfly populations are not likely to return to the site once evicted. The survival of a substantial proportion of species and populations suggests that the magnitude of the impact is more moderate.

The impacts are expected to be cumulative since the Study Area was noted as a breeding ground for several butterfly species, and was therefore a possible source for dispersal of certain butterfly species.

With previously established Importance, Magnitude, Permanence, Reversibility and Cumulativity scores, the final significance of this impact on butterflies is expected to be a Slight Negative Impact.

Odonates

Odonates were given an importance score of 2 in accordance with the justification listed in Table 4.17.

The total clearance of habitat will result in the eviction of the vast majority of odonate species found within the Study Area. However, it is likely that most of the odonate populations would successfully relocate to adjacent habitats. Additionally, the odonate found from the baseline survey were in general common species not highly dependent on mature forest habitat.

The absence of permanent waterbodies suggests that breeding grounds for odonates were not present within the Study Area. Thus, the impacts on odonate populations as a whole were considered to be non-cumulative.

With previously established Importance, Magnitude, Permanence, Reversibility and Cumulativity scores, the final significance of this impact on odonates is expected to be a Slight Negative Impact.

4.4.1.3 Human-wildlife conflict

The eviction of fauna species from their habitat within the area raises the possibility of human-wildlife conflict, as interactions between wildlife and humans utilising the adjacent commercial, industrial and residential infrastructure are likely to increase. The probability of human-wildlife interactions is especially elevated at the interfaces between the construction site and original habitat, as disturbed fauna emerges from their refuges, typically in a state of apprehension and belligerence.

Human-wildlife conflict is expected to have a bifold effect on both ecological and human receptors. The impacts of human-wildlife conflict on ecological receptors are likely to be contingent on broad psychological biases regarding the desirability, threat posed by, expected abundance and observational frequency of evicted species. Responses in this vein range from simply ignoring the increased presence of particular species, to avoidance, and may even result in active attempts at the extermination of particularly undesirable species. In turn, coerced interactions with wildlife, often in misguided attempts to relocate or remove species that are perceived to be dangerous, may also cause injuries to people due to attacks, bites and potential envenomation.

On the whole, the occurrence of human-wildlife conflict is likely to be transient, lasting for several years throughout the construction phase. However, instances of human-wildlife conflict will lead to non-reversible effects on the individuals involved. The impacts of human-wildlife conflict are not expected to be cumulative, primarily affecting only the individuals in question.

Mammals

Mammals were given an importance score of 3 in accordance with the justification listed in Table 4.17.

Although not immediately repulsive to most individuals, the presence of large mammals within urban areas often causes consternation and avoidance. These negative interactions may be exacerbated by a reputation of aggression, as all the aforementioned species have previously been known to attack and injure people. Thus, a response to the presence of such species is likely to involve their removal or relocation by professionals.

Given their initial scarcity, it is unlikely that any of the aforementioned species will become more prevalent as construction progresses. Both the Long-tailed Macaque and Smooth-Coated otter were represented by single individuals in the baseline study, whilst the presence of wild boars was speculated upon based on the existence of suitable habitat. Their low abundances reflect two possibilities. Firstly, there may exist alternative ecological pathways by which lone individuals of either species may have accessed the Study Area, having strayed from a larger group. Secondly, these lone individuals may simply represent as remnants of a declining population within the Study Area. Both of these possibilities attain to the same conclusion, namely, that further encroachment on the Study Area during construction is unlikely to result in a substantive probability of human-wildlife conflict; where the former is pursued, these lone individuals may simply return to their original habitat through a preferred ecological pathway. In the latter instance, these lone individuals may succumb to environmental pressures.

Besides the larger mammals, various rat species (*R. tanezumi*, *R. tiomanicus*) may contribute to human-wildlife conflict. Unlike the larger mammals, from whose negative perceptions stem from the possibility of antagonistic interactions, human distaste towards rodents is likely to be rooted in less rational, and more primeval origins. Accordingly, the persecution of rodents is likely to be considerably more zealous, with a general indifference towards the eventual welfare of captured individuals. To this effect, various contraptions and poisons after often used in an effort to trap, maim or kill rats within urban areas. The possibility of various rats being found in surrounding urban developments is considerable.

Many rat species are successful urban exploiters, thriving, reproducing and occupying an available niche within the urban matrix. It is not unthinkable that a number of individual Rats are likely to successful cross the roads surrounding the Study Area, due to their substantial abundance and general mobility.

With previously established Importance, Permanence, Reversibility and Cumulativity scores, the final significance of this impact on Mammals is expected to be a Minor Negative Impact.

Herpetofauna

Herpetofauna was given an importance score of 2 in accordance with the justification listed in Table 4.17.

As a group, Herpetofauna are often the recipients of a broad range of persecutive behaviours and negative responses. For example, most frogs and lizards can often be regarded as undesirable despite their generally innocuous and inconspicuous nature. However, responses to these groups are generally unproblematic, with most people simply opting to avoid them.

Whilst various frogs and lizard species may be occasionally disliked, the persecution of snakes is especially caustic. Besides being generally reviled by an ophiophobic population, the perception of snakes on a whole as an unseen but immediate threat to safety, along with the lack of general knowledge in differentiating between species, often results in a snake being captured and killed capriciously. These responses would prove problematic to the snake species found within the Study Area, which include the urban adaptive, Equatorial spitting cobra (*Naja sumatrana*).

With previously established Importance, Permanence, Reversibility and Cumulativity scores, the final significance of this impact on Herpetofauna is expected to be a Minor Negative Impact.

Humans

Human receptors were given an importance score of 3 in accordance with the justification listed in Table 4.17.

The presence of several injurious species within the Study Area raises the possibility of human-wildlife conflict with potentially detrimental effects on human receptors. These include the Long-tailed macaque (*M. fascicularis*), Smooth-coated otter (*L. perspicillata*), and Equatorial spitting cobra (*N. sumatrana*). Although Eurasian wild boar (*S. scrofa*) was not observed in this particular study, the secondary forests found within the Study Area are highly suitable sites for satisfying the ecological requirements of wild boars. Therefore, the potential presence of wild boars within the site should not be ruled out. Attacks from the Long-tailed macaque, otter, and wild boar may result in bites, scratches, or bruises. Envenomation by the Equatorial spitting cobra is a more serious prospect, characterised by local necrosis, respiratory paralysis and cardiovascular effects. In addition to biting, Equatorial spitting cobras are capable of ‘spitting’ their venom, typically aiming for the eyes and other sensitive areas on a perceived aggressor. Should this be successful, ocular envenomation may occur, and this is associated with temporary and permanent blindness.

Despite the severe consequences of potential human-wildlife conflict, it is likely that the probability of such attacks is low. Where the Long-tailed macaque and Smooth-coated otter are concerned, aggression usually arises in groups. The presence of singular, isolated individuals within the Study Area is likely to limit the scope of human-wildlife conflict, but also suggests that these species are transient within the site. Where the Equatorial spitting cobra is concerned, envenomation events on humans by wild individuals are rare. This is helped by the general tendency of the species to remain cryptic, its general avoidance of predators and preference to escape than to react petulantly.

With previously established Importance, Permanence, Reversibility and Cumulativity scores, the final significance of this impact on human receptors is expected to be a Minor Negative Impact.

4.4.2 Post-construction Phase

This section will look mainly at the longer-term effects of the planned development on the Study Area. Overall, the planned development is likely to strip the Study Area of the vast majority of pre-existing natural habitat, flora and fauna. Operational-phase effects will also be looked at where relevant, but are likely to have significantly reduced influence as the urban-natural interface will be relatively unimportant, given the expected absence of the latter.

4.4.2.1 Loss of Vegetation & Habitat

The loss of vegetation and consequently, of natural habitats found within the Study Area are expected to be comprehensive. Current plans based on Master Plan 2019 parameters indicate that the construction and urban development of the Study Area should result in the total clearance of all pre-existing habitat types, and further impediments to natural regeneration will result through the concretisation of natural earth and other facets of urban development, including the construction of buildings, pavements and structural networks. Accordingly, the magnitude and permanence of such impacts will be scored at the highest level.

Native-dominated, young secondary forest

Native-dominated, young secondary forests were given an importance score of 3 in accordance with the justification listed in Table 4.17.

The depletion of Native-dominated, young secondary forests within the Study Area are likely to be minimally reversible. The course of natural succession in Native-dominated, young secondary forests typically requires decades, and progresses through other faster growing habitat types, such as Grasslands, Scrublands, before slower growing, native tree species may be able to take hold.

The total clearance of Native-dominated, young secondary forest follows a continued trend in the reduction of an increasingly scarce habitat type within Singapore's ecological context. Native-dominated, young secondary forests possess conditions that are most similar to Singapore's original ecoscape, serving as an important refuge for native flora and fauna. Thus, their removal is likely to have cumulative effects in this regard.

With previously established Importance, Magnitude, Permanence, Reversibility and Cumulativity scores, the final significance of this impact on Native-dominated, young secondary forest is expected to be a Moderate Negative Impact.

Exotic-dominated secondary forest

Exotic-dominated secondary forests were given an importance score of 3 in accordance with the justification listed in Table 4.17.

Whilst Exotic-dominated secondary forests regenerate at a quicker rate than Native-dominated secondary forests due to their composition of faster-growing exotic species, partial to full recovery of these habitats is still expected to take place in the order of years. Thus, the planned development is expected to result in largely irreversible changes.

Similarly, the impacts are deemed to be cumulative. Although Exotic-dominated secondary forests may technically be considered an inferior habitat type compared to its Native-

dominated counterparts, the scarcity of forest habitat as a whole across Singapore exacerbates the consequences of further habitat loss.

With previously established Importance, Magnitude, Permanence, Reversibility and Cumulativity scores, the final significance of this impact on Exotic-dominated secondary forest is expected to be a Moderate Negative Impact.

Grassland and Scrubland

Grasslands and Scrublands were given an importance score of 2 in accordance with the justification listed in Table 4.17.

The flora species that comprise most Grasslands and Scrublands are sun-loving, fast-growing species that can rapidly take over cleared land areas. Seed sources for such species are similarly abundant across Singapore's ecological landscape. Thus, the regeneration of Grasslands and Scrublands is frequently observed at an early stage along the course of vegetation succession when cleared areas are left alone. For these reasons, the changes caused by urban development to this habitat type are expected to be reversible.

The loss of Grassland and Scrubland habitat was also expected to have cumulative effects. Overall, the rarity of vegetated habitats within Singapore enhances the significance of each habitat patch.

With previously established Importance, Magnitude, Permanence, Reversibility and Cumulativity scores, the final significance of this impact on Scrublands and Grasslands are expected to be a Slight Negative Impact.

4.4.2.2 Injury or Mortality to Fauna

The complete clearance of pre-existing habitat within the Study Area is expected to conclude with the expulsion or dispatch of the vast majority of fauna species from the Study Area. However, the establishment of new high-rise buildings may lead to incidences of bird and wildlife collisions, particularly during the migratory season. Additionally, reflective surfaces of the buildings may disorient birds, further elevating the risk of strikes against building exteriors. This interaction may result in injury and mortality for the birds and other volant wildlife.

4.4.2.3 Loss of Ecological Connectivity

The notion of ecological connectivity describes the quality of the linkage between the site in question, amidst the broader network of other natural habitats as a whole. Thus, ecological connectivity is dependent on numerous metrics, beginning from the physical distances between the selected site and other natural areas, resource availability, microclimatic conditions and habitat suitability of connecting ecological corridors and may vary contextually at the level of differing taxonomic groups, insofar as forms of locomotion and territorial range may differ between them.

The loss of ecological connectivity may have complex consequences. For example, opting to develop a natural site with high innate ecological connectivity may avert the magnitude of deleterious consequences experienced by extant fauna present within the development footprint, as they may be able to relocate away from construction activities towards other connected suitable habitat. However, the loss of such sites may ultimately reduce the long-term survival of affected populations, which may have now become isolated into habitats with inadequate resources, where they could have previously moved between linked within the ecological network. In totality, evaluating the loss of ecological connectivity resultant

from planned development remains an important consideration and helps to shed light on the long-term outlook with a cascade of consequences on affected fauna, flora and habitat.

The quantification of ecological connectivity in this impact assessment will be encompassed within Magnitude scoring. Accordingly, the magnitude of a loss in ecological connectivity will be scored higher should the ecological connectivity of the development site be of good quality, and the converse is similarly true.

On the whole, the nearest distinctively separate patch of forest is that of Admiralty Forest, which remains separated from the Study Area by a road of approximately 70m in width. Besides this, the nearest forest patches are those proximal to the Sembawang Air Base and those found within the Central Catchment Nature Reserve (CCNR), which are approximately a considerable 2.5km and 3km away respectively. Furthermore, the Study Area remains separated from these natural sites by a dense matrix of urban development, including wide and heavily utilised roads surrounding the entire perimeter of the Study Area, as well as various residences, industrial facilities and other centres of human activity. For these reasons, the hypothetical ecological corridors connecting the Study Area with these adjacent sites have generally been deemed to be of poor quality. Nevertheless, the Study Area is more easily accessible to and may serve as a stepping-stone habitat for volant species. Further taxa-specific assessments are described and scored in the relevant subsections below.

Non-volant Mammals and Herpetofauna

The development of the site is expected to result in a slight to negligible loss of ecological connectivity for both non-volant mammals and herpetofauna. Having to rely on terrestrial locomotion, the presence of heavily utilised roads, mixture of urban development, along with the physical distance between suitable habitat patches would have translated to effectively impassable barriers to movement. Whilst the eventual development of the Study Area would contribute to an increase in the distance between the remaining habitat patches, these changes cannot be said to have resulted in an effective reduction in ecological connectivity, simply because the linkages between the Study Area and adjacent habitats were already close to a point of diminishing returns.

Similarly, the loss of ecological connectivity as a result of the development of the Study Area is expected to have non-cumulative effects for non-volant mammals and herpetofauna, since the Study Area was not a functional ecological corridor for these taxa in its pre-development condition.

Nevertheless, changes to the Study Area are expected to have permanent and non-reversible effects to ecological connectivity for these taxa due to creation of barriers to dispersal due to the development. The establishment of suitable ecological corridors necessitates mitigative steps to be taken within the Study Area. However, while this can be aided by substantive planting to the extraneous urban matrix directly connected to the Study Area, this has limited mitigative potential for non-volant mammals and herpetofauna due to the presence of surrounding roads and barriers.

With previously established Importance, Magnitude, Permanence, Reversibility and Cumulativity scores, the final significance of the loss of ecological connectivity on Herpetofauna and Mammals is expected to be a Slight Negative Impact.

Avifauna, Bats, Butterflies and Odonates

The development of the site is expected to result in a moderate loss of ecological connectivity for both Avifauna, Bats, Butterflies and Odonates. These taxa rely on flight for locomotion and are thus less encumbered by the presence of roads and vehicular traffic compared to their terrestrial counterparts. Thus, some degree of ecological connectivity may be said to be pertinently provided by the Study Area to these taxa.

Nevertheless, various facets and urban structures still function as barriers to movement and dispersal for volant fauna. The presence of urban development alters the suitability of habitat, resource availability and microclimatic conditions, alongside the threat of anthropogenic interference, thus hindering the free movement of volant fauna. Accordingly, an increase in the distance between suitable habitat as a result of the development of the Study Area, is likely to restrict the range of mobility in some species, as fewer stopover sites with suitable climatic conditions, refuges and other resources are removed. Specifically, the loss of ecological connectivity relating to the Study Area may obstruct the dispersal of the aforementioned taxa from the Central Catchment Nature Reserve to the fringing habitats of Admiralty Park and Mangroves, and vice versa. At the regional level, the Study Area appears to be patronised by various migratory species, suggesting that it may play a role in sheltering these species travelling along international migratory routes. Although the extent by which the Study Area is utilised is not specifically known, the development of the Study Area is expected to result in some degree of ecological connectivity loss for these species.

The loss of ecological connectivity is not expected to have cumulative effects for Avifauna, Bats, Butterflies and Odonates, although it is expected to be permanent since the clearance of the habitat from the Study Area is currently believed to be total. However, unlike for non-volant mammals and herpetofauna, the loss of ecological connectivity is expected to be reversible. Ecological connectivity may be restored through the retention of selected trees, as well as supplementary planting in an informed manner that provides suitable refuges for the range of volant fauna, as they reattempt to move between previously linked habitats. These measures will be further elaborated upon in Section 4.5.2.

With previously established Importance, Magnitude, Permanence, Reversibility and Cumulativity scores, the final significance of the loss of ecological connectivity to be a minor negative impact on Avifauna and Bats, whilst a slight negative impact is expected for Butterflies and Odonates.

4.5 Proposed Mitigation Measures

This section describes the range of mitigation measures typically utilised during both construction and post construction phases to reduce the magnitude of predicted impacts. As many mitigation measures affect multiple ecological receptors to different extents, the descriptions listed here are primarily prescriptive and qualitative. A quantification of the residual impacts following an adequate implementation of the proposed mitigation measures will be elaborated upon in Section 4.6.

4.5.1 Construction Phase

In light of the impacts described and assessed in Section 4.4.1, the following mitigation measures are recommended to reduce the magnitude of potential impacts to ecological receptors during the construction phase.

Pre-felling fauna inspections

Trees selected for imminent felling should be adequately marked and physically tagged in a clear and distinct manner. Pre-felling inspections should be performed on such trees with the assistance of a trained ecologist, to check for the presence of arboreal fauna, fledging avifauna and other pre-existing or erected microhabitats, such as bird nests, bee hives and tree burrows. Appropriate actions should then be undertaken in response to the findings. For example, planned works should be postponed if active bird nests are found on trees marked for felling, until further verification attempts ascertain that the nests are no longer occupied or utilised.

Transplantation of conservation-significant flora

Conservation-significant flora can be identified and earmarked for transplantation prior to the commencement of construction activities. The selection of conservation-significant flora specimens should reflect a number of considerations, including conservation priority, cultivated or natural provenance, size, maturity, and accessibility of the plant, as well as the specimen's health, which may go some way into determining whether a specimen will successfully survive the transplantation process. If found to be suitable, harvesting of fruits, seeds, saplings, propagules, stem and leaf cuttings should be considered in lieu of species characteristics, and conducted prior to the construction activity.

Wildlife Management, Protection and Monitoring Plan (including Wildlife Response and Rescue Plan)

A suitable Wildlife Management, Protection and Monitoring Plan is to be prepared prior to the commencement of construction or clearance activity. This plan should identify and flag out potential species of interest, including conservation significant species, species likely to be able to move across established hoardings, and potentially injurious species. The plan should indicate the staging and direction of vegetation clearance, denominate potential exit points or trapping points for wildlife, where they can subsequently be contained and relocated from the site. Accordingly, the plan should also encompass suitable Wildlife Response and Rescue protocols; these should dictate the procedures for the appropriate handling, trapping and relocation of errant wildlife, as well as contain relevant information for the employment of NParks Certified Animal Management Specialist to execute the aforementioned plan.

Planning and installation of hoarding

A suitable hoarding plan should be established prior to the commencement of construction or clearance activity. The placement of the hoarding should demarcate and define the planned construction area; and no modifications to the natural environment beyond the hoarding should be undertaken. The hoarding should be well-marked, with an installation depth of at least 300mm to prevent wild boars (*S. scrofa*) from entering or destabilising the hoarding structures through digging activity. Hoarding lines should be located at a distance away from any retained trees to prevent damage to the major roots of trees during the installation process, which may destabilise trees and result to them falling accidentally. Once satisfactorily installed, the structural integrity of the hoarding should be subject to regular inspections, ensuring that no changes to the hoarding or earthen foundations occur throughout the construction phase, which may allow various fauna to enter the development area through gaps or by digging.

Lighting Management Plan

Prior to commencement of construction works, a Light Management Plan (LMP) with illuminance layout plan (type of lighting and height of mounting), luminaire specifications and night work schedule shall be formulated. Lights operating at night should be of low wavelengths and narrow spectrum, pointed downwards and towards the interior of the site instead of resulting in spillage beyond the site boundary and into adjacent retained terrestrial habitats. Light shields can be installed for light fixtures near the site boundary to minimise light spillage into adjacent terrestrial habitats. All unnecessary lights should be turned off outside construction hours.

Prevention of fauna entrapment

Erosion Control Blankets (ECBs) can prove to be hazardous – becoming traps for ground-dwelling fauna such as snakes and lizards. To minimise the impact from fauna entrapment, the selection of ECBs should be limited to those made of fully biodegradable material. In addition, all ECBs and pits should be checked daily by on-site personnel, to minimise the likelihood of entrapping fauna, which can result in increased rates of injury or mortality over prolonged periods.

Wildlife Awareness Training

The presence of the Long-tailed macaque, Smooth-coated otters and Equatorial spitting cobras may pose a threat to human health and safety. Conversely, aggressive animals and other fauna that are generally perceived as a nuisance may be subjected to persecution from people working on site. The implementation of Wildlife Awareness Training aims to provides an overview of the potentially injurious or distasteful species on site, an educated assessment of their potential threat and alternative solutions to violence for the management of such individuals. In addition, such training will also provide information on preventative measures intended to reduce the occurrence of negative human-wildlife encounters. For example, prevent wild animals from scavenging on construction site, areas for food consumption, storage, and waste disposal should be demarcated and managed. The personnel should also be briefed on what to do should they encounter specific wild animals.

4.5.2 Post-Construction Phase

In light of the impacts described and assessed in Section 4.4.2, the following mitigation measures are recommended to reduce the magnitude of potential impacts to ecological receptors during the post-construction and operational phase.

Habitat creation and retention of mature trees

The retention of mature trees, if feasible, may be considered if the trees are of special interest by being functionally important (e.g. containing nesting sites for birds) or being of conservation significance. These considerations are especially relevant if mature trees are of a size and a maturity that makes transplantation logistically improbable. In addition, the location of the trees within the development footprint may guide decision making; large, mature trees found on the periphery of the site may be more liable for retention than those found within the central areas of the development, thereby obstructing the placement of future buildings.

Habitats may be created by planting green spaces with native plants to mimic natural environments. This amalgamation of vegetation typically could include plants of various forms to create habitat heterogeneity, as well as host plants and other relevant shrubbery for butterflies and other insects. This tiered planting approach improves habitat complexity, providing a vegetation structure and microclimatic conditions more akin to that of an actual natural habitat. Thus, more provisioning ecosystem services may be produced through tiered enhancement planting and is typically associated with increased species richness and utilisation. A selection of these vegetated niches may then be linked up, for example, by lining various walkways with a continuous sequence of these niches, to replicate the function of an ecological corridor.

Bird-safe implementations

A number of measures may be implemented to reduce the probability of bird strikes, an understated source of bird mortality. These measures can be generally classified based on two objectives – to reduce the reflectivity of building surfaces and to reduce the association of buildings with green spaces. Measures in the first class may include reducing the amount of glass panels lining the exterior surfaces of buildings, or increasing the opacity by using low reflectance glass, decals, blinds or external screens. Measures in the second class may include orientating buildings away from adjacent vegetation, placing indoor vegetation away from the glass exteriors or reducing the intensity of indoor illumination, thereby concealing the presence of vegetation and other continuous spaces when viewed through glass panels. Further details for bird safe buildings can be referenced through NParks' guidelines (https://www.nparks.gov.sg/biodiversity/urban-biodiversity/bird-safe-building-guidelines).

4.6 Residual Impact

4.6.1 Construction Phase

4.6.1.1 Injury or Mortality to Fauna

Avifauna, Herpetofauna and Mammals are expected to be main beneficiaries of the implemented mitigation measures where injury and mortality are concerned. For example, the conduct of pre-felling fauna inspections is likely to protect fledging birds and eggs, where they might have otherwise been killed during the vegetation clearance process. Similarly, checking and removing mammals and herpetofauna trapped under Erosion Control Blankets may provide a lease of life to these individuals. Nevertheless, other individuals are still expected to be directly injured or killed across a myriad of construction activities. On the whole, the residual impacts are likely to be slightly reduced with the implementation of the entire range of mitigation measures (Table 4.20).

4.6.1.2 Human-wildlife conflict

The impacts of human-wildlife conflict for both affected individuals and affected species may be ameliorated through the combined implementation of Wildlife Awareness Training, Wildlife Response and Rescue Protocol and Hoarding Plan. The former two measures will provide informed, alternative pathways of recourse where undesirable species of fauna come into close proximity with people. Meanwhile, the latter is expected to reduce the frequency of human-wildlife interactions as a whole. Together, these measures intend to reduce the rate by which violence is utilised on undesirable species, and by which human-initiated antagonism can in turn result in reprisals such as scratches, bites and envenomation.

However, a successful reduction of human-wildlife conflict impacts is ultimately dependent on the voluntary uptake of the suggested protocols. Accordingly, some species will inadvertently invoke repulsion in some individuals, which may result in injury and death to the animal in question. This behavioural diversity in individual conduct is likely to result in a more modest reduction of impacts than if responses were purely rational (Table 4.20).

4.6.2 Post-Construction Phase

4.6.2.1 Loss of avifauna

The loss of avifauna populations to collision events and bird strikes continues to be an understated and likely significant source of mortality in the post-construction phase. The implementation of bird-safe designs and measures have previously been touted to measurably reduce the injury and mortality rates of transient avifauna. Similar effects are expected to be replicated within the future development should the recommended measures by properly employed.

4.6.2.2 Loss of conservation significant flora

The loss of conservation significant flora may be substantively reduced if proper extraction, transplantation and relocation measures are undertaken. Contextually, transplantation and relocation attempts are expected to be especially rewarding, since the conservation significant flora found within Study Area did not have a particularly high abundance (102

specimens). Many of the conservation significant specimens here were also not especially large and were of growth forms that are suitable for transportation. These include the Critically Endangered *P. polycarpa*, Endangered *T. semipinnata,* and most specimens of other Vulnerable finds such as *A. splendens, C. latifolia* and *E. ferrugineus*. Thus, it might be concluded that relocation and transplantation efforts would be efficacious in the context of this development. However, the benefits of relocation and transplantation may ultimately be tempered by the ability of individual plants to adapt to their new environment. On average, relocation and transplantation measures are likely to dampen the extent of loss of conservation significant flora resultant from the eventual development of the Study Area.

4.6.2.3 Loss of ecological connectivity

The effects of lost ecological connectivity for volant fauna may be modestly benefitted by the retention of mature trees of functional importance (e.g., those selected as nesting sites or refuges), as well as the supplementary planting of other native flora, including shrubs and host plants. The micro-niches created along these nature ways may suffice simply as transient stopover points for volant fauna on the move between habitats on the Northern coast of Singapore and the Central Catchment Nature Reserve. However, these niches are unlikely to provide the same level of resources and connectivity as the original Study Area.

4.7 RIAM Summary

4.7.1 Construction Phase

Table 4.20 Summary of impact assessment for ecological impacts for the construction phase. The change in impact Magnitude following mitigation (if any), and the residual impact Significance is also shown. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score)

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures							With mitigation measures		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Loss of fauna	Avifauna	4	-2	3	3	2	-64	Minor negative	-1	-32	Slight negative
	Mammal	3	-3	3	3	2	-72	Minor negative	-2	-48	Minor negative
	Herpetofauna	2	-4	3	3	2	-64	Minor negative	-3	-48	Minor negative
	Butterflies	2	-2	3	3	3	-36	Slight negative	-1	-18	Slight negative
	Odonates	2	-2	3	3	2	-32	Slight negative	-1	-16	Slight negative
Loss of flora	Conservation significant flora	5	-4	3	2	2	-140	Major negative	-3	-105	Moderate negative
Human-wildlife conflict	Mammal	3	-4	2	3	2	-84	Moderate negative	-2	-42	Minor negative
	Herpetofauna	2	-4	2	3	2	-56	Minor negative	-3	-42	Minor negative
	Humans	3	-4	2	3	2	-84	Moderate negative	-2	-42	Minor negative

4.7.2 Post-Construction Phase

Table 4.21 Summary of impact assessment for ecological impacts for the post-construction phase. The change in impact Magnitude following mitigation (if any), and the residual impact Significance is also shown. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score)

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures							With mitigation measures		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Loss of vegetation and habitat	Native-dominated, young secondary forest	3	-4	3	3	3	-108	Moderate negative	-3	-81	Moderate negative
	Exotic-dominated secondary forest	3	-4	3	3	3	-108	Moderate negative	-3	-81	Moderate negative
	Scrubland	2	-4	3	2	3	-64	Minor negative	-3	-48	Minor negative
	Grassland	2	-4	3	2	3	-64	Minor negative	-3	-48	Minor negative
Injury or mortality to fauna	Birds and volant wildlife	3	-3	3	3	2	-72	Minor negative	-2	-48	Minor negative
Loss of ecological connectivity	Non-volant mammals	3	-1	3	3	2	-24	Slight negative	-1	-24	Slight negative
	Bats	3	-2	3	2	2	-42	Minor negative	-1	-21	Slight negative
	Avifauna	4	-2	3	2	2	-56	Minor negative	-1	-28	Slight negative
	Herpetofauna	2	-1	3	3	2	-16	Slight negative	-	-	Slight negative
	Butterfly	2	-2	3	2	2	-28	Slight negative	-1	-14	Slight negative
	Odonate	2	-2	3	2	2	-28	Slight negative	-1	-14	Slight negative

5 Air Quality

5.1 Applicable Legislation, Guidelines and Standards

Air quality in Singapore is governed by NEA Singapore Ambient Air Quality Targets (SAAQT) shown in Table 5.1 below. Baseline results will be compared against SAAQT limits.

Table 5.1 NEA Singapore Ambient Air Quality Targets

Pollutant	Averaging period	Target Limits
PM_{10}	24 hours	50 µg/m^3
	1 year	20 µg/m^3
$PM_{2.5}$	24 hours	25 µg/m^3
	1 year	10 µg/m^3
NO_2	1-hour	200 µg/m^3
	1 year	40 µg/m^3
CO	8 hours	10 mg/m^3
	1 hours	30 mg/m^3

Other than the SAAQT, below are the list of Applicable Acts, Regulations & Guidelines for air quality protection that will be referenced to for the analysis of the air quality impact assessment in this study.

- Environmental Protection and Management (Vehicular Emissions) Regulations, 2008
- Environmental Protection and Management (Air Impurities) Regulations, 2008
- Environmental Protection and Management (Off-Road Diesel Engine Emissions) Regulations, 2012
- Environmental Protection & Management (Prohibition on the Use of Open Fires) Order 2008
- Technical Memorandum Annex 12: Guidelines for Air Quality Assessment published by HK EPD
- Energy Conservation Act, 2014
- Guidance on the assessment of dust from demolition and construction, Institute of Air Quality Management (IAQM), 2016

The Environmental Protection and Management (Vehicular Emissions) Regulations, 2008 in Singapore focuses on controlling and reducing emissions from vehicles. It sets standards for vehicle exhaust emissions to mitigate air pollution, promoting environmental

sustainability. The regulations aim to enhance air quality and public health by enforcing emission standards for vehicles operating in Singapore.

Environmental Protection and Management (Off-Road Diesel Engine Emissions) Regulations, 2012 regulates all off-road diesel engines (e.g., cranes, excavators, power generators, etc) imported into Singapore must comply with the EU Stage II, US Tier II or Japan Tier I off-road diesel engine emission standards. This regulation is in place to ensure that exhaust emissions are controlled at source to meet air quality standards and do not contribute additional pollutants to the environment.

Guidance on the assessment of dust from demolition and construction by IAQM is an essential tool for evaluating the dust impact arising from various scales of demolition and construction activities. In the absence of construction and development plans at the time of writing, this guideline serves as a valuable resource for estimating dust impact and conducting air quality assessments.

5.2 Baseline Study

It is important to understand the existing environmental condition to allow informed assessment of the potential changes resulted from the development. The ambient air quality baseline study is hence designed to measure the baseline air quality pertaining to dust and other gaseous pollutants at the nearby sensitive receptors. Additionally, there is a wafer fabrication facility with emission stacks near the Project site, these stacks may release acidic gases that could potentially have adverse effects on both human health and the environment. To address this concern, measurements of acidic gases were also conducted near the factory to detect their presence in the existing environment.

Site surveys were conducted from 20 Jan 2023 to 10 Feb 2023 to measure the baseline condition for general air pollutants (PM_{10}, $PM_{2.5}$, NO_2, CO) and acidic gas (HCl, HF, HNO_2 and NH_3) and the results were used to establish the initial conditions that serve as a benchmark for evaluating any impact that may occur to the sensitive receptors and ambient air quality as a result of the construction and post-construction activities associated with the Project. The detailed of air quality baseline report are presented in Appendix F.

Detailed methodology and findings of primary data collection and review of secondary data are presented in this section.

5.2.1 Methodology

5.2.1.1 Desktop Study

Desktop study is carried out through the review of secondary data including previous environmental study reports, satellite imagery and maps, and relevant literatures. The secondary data enable the identification of sensitive receptors in the vicinity, as well as the existing emission sources in the area. The historical environmental study reports also provide information of the progressive air quality condition over the years.

Main references which involve air quality measurement within WNC area are listed below:

- RTS EIA (LTA, 2018)
- Air Quality Assessment for Proposed New Erection of an 8-Storey General Industry Development (Business 2) (JTC, 2022)

5.2.1.2 Field Survey

General Air Pollutant

Air quality measurements of PM_{10}, $PM_{2.5}$, NO_2 and CO are done at five (5) locations (A1 to A5) that are representative of sensitive receptors in the Project vicinity shown in Figure 5.1. The detailed location and duration of measurements is shown in Table 5.2 below.

PM_{10}, $PM_{2.5}$ were measured by air quality sensor adopting laser scattering method, and NO_2 and CO were by using electrochemical method.

Acidic Gas

Acidic gas sampling of HCl, HF, HNO_2 and NH_3 are done at one (1) location at A4 shown in Figure 5.1, to measure any impact due to the presence of stack emission located within the industrial area, north-east of Project site. The detailed location and duration of measurements is shown in Table 5.2 below.

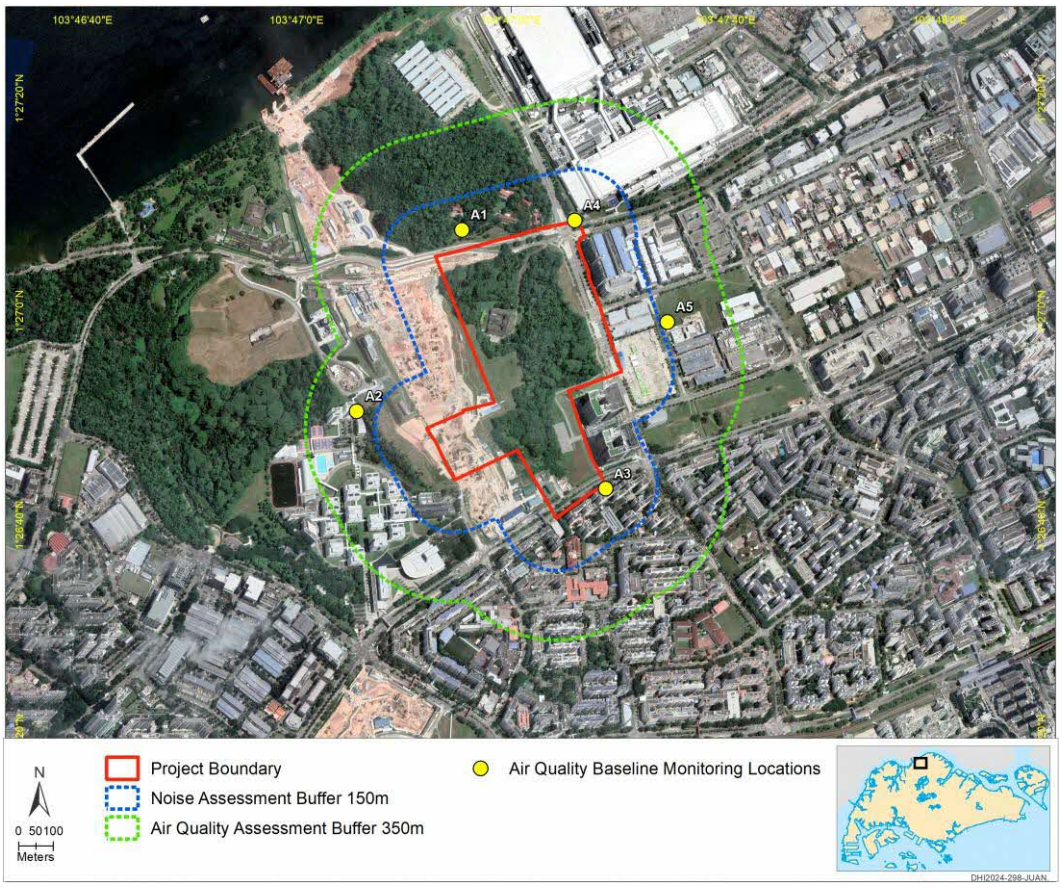


Figure 5.1 Air Quality Baseline Monitoring Locations (Satellite image as of 10 Mar 2022)

Table 5.2 Air quality monitoring period

Station	Location	Type of receptor	Monitoring Period	Parameters
A1 (Boarding House)	Turf between Admiralty Road West and Keramat Road	• Residential Areas • Fauna within secondary forest	20 Jan 2023 to 27 Jan 2023	PM_{10}, $PM_{2.5}$, NO_2 and CO
A2 (Republic Polytechnic)	Outside of Republic Polytechnic Xperiential Hub	• Educational Institutions	27 Jan 2023 to 03 Feb 2023	
A3 (HDB Blk 877)	HDB Block 877 Woodlands Ave 9, Singapore 730877	• Residential Areas • Healthcare Facilities	20 Jan 2023 to 27 Jan 2023	
A4 (Wafer Fab Industries)	Junction of North Coast Avenue and Admiralty Road West	• Industrial areas	27 Jan 2023 to 03 Feb 2023	PM_{10}, $PM_{2.5}$, NO_2 and CO
			31 Jan 2023 to 01 Feb 2023	HCl, HF, HNO_2 and NH_3
A5 (Industrial areas with workers dormitory)	Woodland Industrial Park E2	• Industrial areas	03 Feb 2023 to 10 Feb 2023	PM_{10}, $PM_{2.5}$, NO_2 and CO

5.2.2 Findings

5.2.2.1 Desktop Study

In view of the expected construction activities listed in Section 1.3.2, significant dust emission may be resulted from the site clearance, and blasting and excavation during land levelling and formation works. Air pollutants (e.g. NO_2 and CO) may be emitted from engines of the powered equipment to be used for the construction activities. The emission is regulated by NEA's regulation for Off-Road Diesel Engine Emissions.

The presence of acidic gas pollutants such as nitrogen dioxide (NO_2), Hydrogen Chloride (HCl), Hydrogen Fluoride (HF), Nitrous acid (HNO_2), and Ammonia (NH_3) could be generated from neighbouring industries and operations such as emission from wafer fabrication industries located north of the Project site. These common forms of acidic gas will be measured in the baseline study to understand the existing impact from neighbouring industries.

It is noted that ozone in ambient air is a secondary pollutant that is formed as a result of complex atmospheric chemistry dominated by regional levels of nitrogen oxides, volatile organic compounds and driven by sunlight. Hence, the related emissions of its precursor, NOx, is considered but ozone itself is not considered in this study.

Review of Previous Studies

Air quality measurements from previous studies within the vicinity of Project Site will be referenced and compared with current primary data collected for air quality baseline study. A brief summary of measurement results from previous studies is provided below:

Air Quality Assessment for Proposed New Erection of an 8-Storey General Industry Development (Business 2) (JTC, 2022)

Pre and post-construction air quality assessment was done at JTC Woodlands North Coast building (1 and 7 North Coast Avenue) measuring PM_{10}, $PM_{2.5}$, NO_2 and CO ambient levels. Pre-construction study was conducted from 29 Jun 2018 to 06 Jul 2018 and post-construction study was conducted from 04 Jan 2022 to 18 Jan 2022. Elevated readings were observed in post-construction for all pollutants which is expected due to the increase in human traffic, but all values did not exceed the SAAQTs guideline. Post-construction readings for PM_{10} range from 25 to 35 µg/m^3, $PM_{2.5}$ range from 13 to 17 µg/m^3 and CO range from 0 to 4 mg/m^3 for both 1-hour and 8-hour mean. As post-construction measured concentrations are generally in line with baseline concentrations, with regards to dynamic changes in road traffic over the years.

RTS EIA (LTA, 2018)

Ambient air quality monitoring was conducted at three (3) locations; Campus Heights Republic Polytechnic, Blk 870 Woodlands Street 81 and Micron Industries for a 24-hour period between 15 Dec 2016 to 21 Dec 2016 measuring PM_{10}, $PM_{2.5}$, NO_2, CO and O_3 ambient levels prior to the construction of RTS Link Phase 2. Results show that baseline particulate matter (PM_{10} and $PM_{2.5}$) was found to have exceeded SAAQT Long-term targets at Campus Heights Republic Polytechnic; and $PM_{2.5}$ was found to have exceedance at Blk 870 Woodlands St 81. All the other parameters were below the SAAQT guideline.

5.2.2.2 Field Survey

Air quality monitoring results conducted from 20 Jan 2023 to 10 Feb 2023 is presented below in Table 5.3. $PM_{2.5}$ and NO_2 at A4 were found to have exceeded the SAAQT limits. Exceedance of $PM_{2.5}$, NO_2 at A4 could be attribute to the vehicular traffic as it is located at the road junction of North Coast Avenue and Admiralty Road West.

Table 5.3 Results of baseline measurements of PM_{10}, $PM_{2.5}$, NO_2 and CO

Measurement Location / Limit	Results (µg/m^3)			Results (mg/m^3)	
	PM_{10} (24-hr mean)	$PM_{2.5}$ (24-hr mean)	NO_2 (1-hr mean)	CO (8-hr)	CO (1-hr)
SAAQT	**50**	**25**	**200**	**10**	**30**
A1 (Boarding House)	9.95	8.90	166.21	0.11	0.11
A2 (Republic Polytechnic)	11.47	10.24	169.39	0.05	0.05

Measurement Location / Limit	Results ($\mu g/m^3$)			Results (mg/m^3)	
	PM_{10} (24-hr mean)	$PM_{2.5}$ (24-hr mean)	NO_2 (1-hr mean)	CO (8-hr)	CO (1-hr)
A3 (HDB Blk 877)	9.92	8.86	190.45	0.11	0.11
A4 (Wafer Fab Industries)	32.79	27.87	214.19	0.05	0.05
A5 (Industrial areas)	16.78	15.46	196.08	0.01	0.01

Note: Values exceeding NEA's SAAQT limit are indicated in red.

Acidic gas monitoring results conducted from 31 Jan 2023 to 01 Feb 2023 is presented below in Table 5.4. Result shows acidic gas is not detected and since potential source of acidic gas is from the stack emission within the industrial area, other locations do not foresee the detection of acidic gas as well.

Table 5.4 Results of baseline measurements of HCl, HF, HNO_2 and NH_3

Location	Parameter	Total Air Volume Sampled (L)*	Results (ppb)	Detection Limit
A4 (Wafer Fab Industries)	**HCl**	4081	< 0.01	0.01 ppb
	HF	4081	< 0.01	
	HNO_2	4081	< 0.01	
	NH_3	4081	< 0.03	0.03 ppb

**Total air volume sampled is calculated based on the average flowrate throughout the monitoring period from 31 Jan 2023 to 01 Feb 2023.*

5.3 Impact Assessment Framework

Air quality impacts anticipated from the construction and post-construction phase of the development were evaluated in-line with the UK Institute of Air Quality Management's Guidance on the Assessment of Dust from Demolition and Construction (2016) which generally encompass the following stepwise procedures:

Step 1: Identification of relevant air quality sensitive receptors (ASRs), both social-economic and ecological, by setting a study boundary of 350 m for more detailed assessment (see Section 5.3.1.1)

Step 2: Assessing the risk of dust impacts from Project construction activities (see Section 5.4) via:

- **Step 2A**: determining the potential dust emission sources and magnitude, i.e., small, medium, large, based on estimated scale of the work and nature (see Table 5.7 and Section 5.4).

- **Step 2B**: defining the sensitivity of the relevant ASRs based on their exposure duration, site sensitivity and overall importance. The assessment of the sensitivity and importance of social-economic and ecological ASRs is guided by the matrices provided in Table 5.5.
- **Step 2C**: defining the risk of impacts based on the potential dust emission sources and magnitude as determined from Step 2A and the sensitivity of the ASRs from Step 2B. The magnitude of change in air quality is assessed based on the framework presented in Table 5.8.

Step 3: Prescribing site-specific mitigation measures to abate anticipated air quality impacts (see Section 5.5)

Step 4: Determining the significance of the residual impacts (see Section 5.6)

The assessments in step 2 are guided by the following matrices. IAQM framework ranks magnitude of change and sensitivity of receptors into 4 categories, i.e., negligible, small, medium and large in the former and negligible, low, medium and high in the latter. More granularity is present in DHI's RIAM framework, requiring some receptor-specific adaptations of the IAQM method as suggested below.

5.3.1 Importance Rating of Sensitive Receptors

Table 5.5 Evaluation Framework for Sensitivity and Importance of Air Quality Sensitive Receptors

Score	Generic Definition	Specific Criteria
5	Important to national/ international interests	• Social-economic receptors affected are specifically protected by national or international policies or legislation and are of significance at the regional or national scale.
4	Important to regional/national interests	• Social-economic receptors where more sensitive members of the public are exposed for eight hours or more in a day, e.g., hospital and care facilities
3	Important to areas immediately outside the local condition	• Social-economic receptors where members of the public are exposed for eight hours or more in a day, for example, residential properties and schools
2	Important only to the local condition (within a large direct impact area)	• Social-economic receptors where the people exposed are workers and they may be exposed for eight hours or more in a day, for example, office and shop workers
1	Important only to the local condition (within a small direct impact area)	• Social-economic receptors with transient exposure, e.g., recreational users of playgrounds, visitors to place of worship, etc.

5.3.1.1 Identified Sensitive Receptor and Importance

Air quality sensitive receptors (ASRs) that would be susceptible to potential impacts from the planned works that are located within the 350m radius of the Project boundary are identified and shown in Figure 5.2 below. Description of the receptors are shown in Table 5.6.

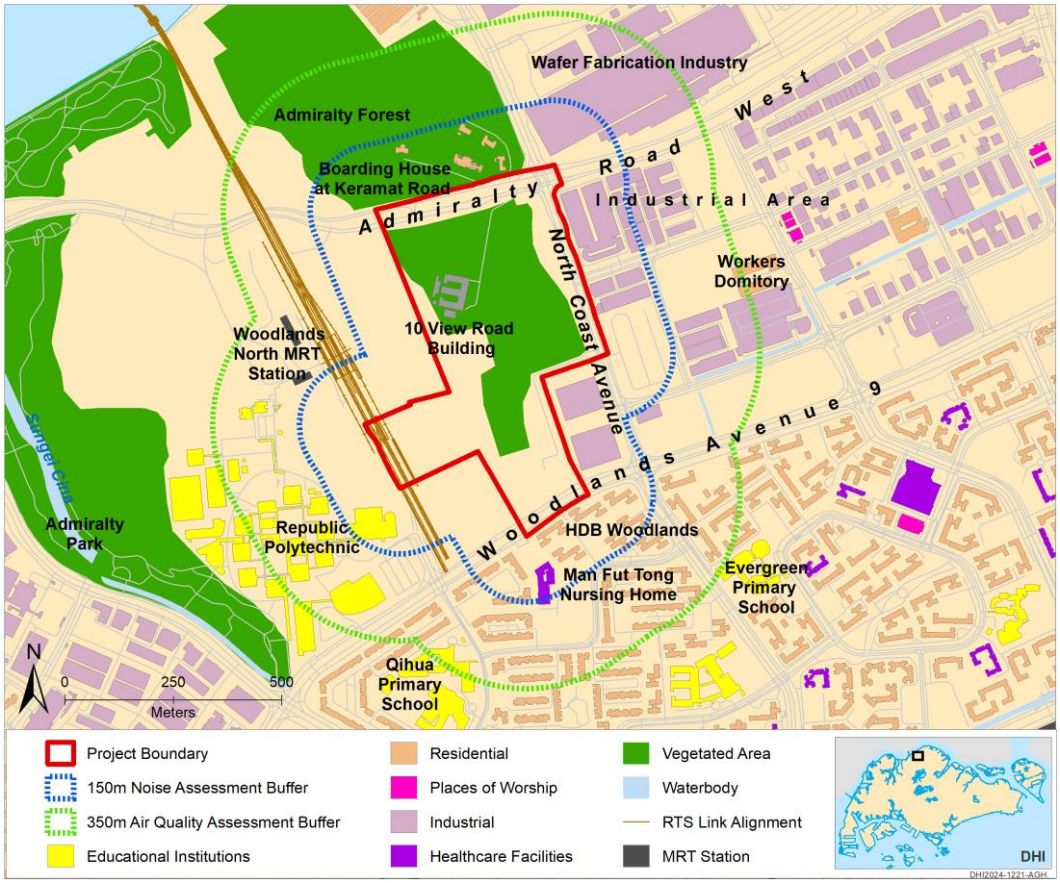


Figure 5.2 Air quality sensitive receptor identified within 350 m radius of Project boundary

Table 5.6 Identified sensitive receptors for air quality

Type of receptor	Description	Sensitivity	Importance Score
Residential areas	• Boarding house and colonial houses at Keramat Road and Dahan road, north of Project site • HDB residence along Woodlands Ave 9, Blk 749 to 757, Blk 807 to 810, Blk 816 to 818, Blk 822, Blk 838 to 848 and Blk 870 to 882 • Worker dormitory- Woodland Lodge One situated at Woodland Industrial Park E4, east of Project site.	Residents at these locations are expected to be exposed to the air emissions from Project site at least 8 hours a day.	3
Terrestrial fauna	• Faunas within Admiralty Forest	Fauna at these locations is expected to be exposed to the air emissions from Project site at least 8 hours a day.	3

Type of receptor	Description	Sensitivity	Importance Score
Educational institutions	• Republic Polytechnic (RP)	Students and staff at these locations are expected to be exposed to the air emissions from Project site at least 8 hours a day. For RP, only the carpark building is situated within the 150m boundary. Other main academic buildings are within the 150m to 300m radius and are mostly air-conditioned. Thus, sensitivity is relatively lower.	2
	• Qihua Primary School	Students and staff at these locations are expected to be exposed to the air emissions from Project site at least 8 hours a day. For Qihua Primary school, the compound is shielded by surrounding HDB blocks which serves to reduce its susceptibility to pollutant emissions from the Project site.	2
Healthcare facilities	• Man Fut Tong Nursing home	Residents at this location are expected to be exposed to the air emissions from Project site at least 8 hours a day. Residents of healthcare facilities are more sensitive and vulnerable to air quality impact.	4
Industrial areas	• Wafer fabrication industry • Industrial facilities along North Coast Ave	Aspects of these industries may have operational requirements pertaining to air intakes. Workers at these sites are exposed to air emissions resulting from their industrial activities. To ensure the health and safety of workers, it is imperative that they are provided with suitable PPE. Therefore, in the context of this EIA, these individuals are not categorized as sensitive receptors concerning air quality.	2

5.3.2 Magnitude of Change

According to IAQM's Guidance on the Assessment of Dust from Demolition and Construction, activities on construction sites that will potentially result in dust impact include demolition, earthworks, construction and trackout. Table 5.7 summarises the referenced definition of dust emission magnitude in relation to the estimated scale of construction activities.

Table 5.7 IAQM's Definition of Potential Dust Emission Magnitude

Type of Activity	Dust Emission Magnitude Classification Reference		
	Large	**Medium**	**Small**
Demolition	• Total building volume >50,000 m^3 • Potentially dusty construction material (e.g. concrete) • On-site crushing and screening [a] • Demolition activities >20 m above ground level	• Total building volume 20,000 m^3 - 50,000 m^3 • Potentially dusty construction material • Demolition activities 10-20 m above ground level	• Total building volume <20,000 m^3 • Construction material with low potential for dust release (e.g. metal cladding or timber) • Demolition activities <10 m above ground • Demolition during wetter months
Earthworks	• Total site area >10,000 m^2 • Potentially dusty soil type (e.g. clay, which will be prone to suspension when dry due to small particle size) • >10 heavy earth moving vehicles active at any one time • Formation of bunds >8 m in height • Total material moved >100,000 tonnes	• Total site area 2,500 m^2 - 10,000 m^2 • Moderately dusty soil type (e.g. silt) • 5-10 heavy earth moving vehicles active at any one time • Formation of bunds 4 m - 8 m in height • Total material moved 20,000 tonnes - 100,000 tonnes	• Total site area <2 ,500 m^2 • Soil type with large grain size (e.g. sand) • <5 heavy earth moving vehicles active at any one time • Formation of bunds <4 m in height • Total material moved <20,000 tonnes • Earthworks during wetter months
Construction	• Total building volume >100,000 m^3 • On site concrete batching [a] • Sandblasting	• Total building volume 25,000 m^3 - 100,000 m^3 • Potentially dusty construction material (e.g. concrete) • On site concrete batching [a]	• Total building volume <25,000 m^3 • Construction material with low potential for dust release (e.g. metal cladding or timber)
Trackout	• >50 heavy duty vehicle (HDV) (>3.5 tonnes) outward movements [b] in any one day [c] • Potentially dusty surface material (e.g. high clay content) • Unpaved road length >100 m	• 10-50 HDV outward movements [b] in any one day [c] • Moderately dusty surface material (e.g. high clay content) • Unpaved road length 50 m - 100 m	• <10 HDV outward movements [b] in any one day [c] • Surface material with low potential for dust release • Unpaved road length <50 m

[a] Mobile crushing equipment and concrete batching plants can be significant sources of dust. Professional judgement will be required to determine how the use of crushing and screening equipment or on-site concrete batching will affect the dust emission magnitude.

[b] A vehicle movement is a one-way journey, i.e. from A to B, and excludes the return journey

[c] HDV movements during a construction project vary over its lifetime, and the number of movements is the maximum not the average

The IAQM classification categorizes the magnitude of impacts into Low, Medium and High levels. In the RIAM framework, the magnitude of change is rated from a score of from 0 to -4. Adapting the magnitude in RIAM, the evaluation framework for assessing the magnitude of change in air quality for this EIA is presented in Table 5.8

Table 5.8 Evaluation Framework for Magnitude of Change in Air Quality

Score	IAQM Risk of Impacts Classification	Generic Definition	Specific Criteria
-4	Large	Major negative disadvantage or change	• Severe effects on air quality which are likely to be long lasting, typically widespread in nature and requiring significant intervention to return to baseline • Air quality is likely to routinely exceed national / international standards, guidelines or target levels
-3		Moderate negative disadvantage or change	• Potential effects on air quality which are likely to be long lasting, typically widespread in nature and requiring moderate intervention to return to baseline • Air quality is likely to approach or in danger of exceeding national / international standards, guidelines or target levels
-2	Medium	Minor negative disadvantage or change	• Short-term localised effects on air quality which are likely to return to equilibrium conditions within a short timeframe (hours or days at most) • Air quality is likely to be within national / international standards, guidelines or target levels
-1	Low	Slight negative disadvantage or change	• Short-term localised effects on air quality but likely to be highly transitory (lasting hours) and well within natural fluctuations • Air quality is likely to be well within national / international standards, guidelines or target levels
0	Negligible	No change	• Status quo

5.4 Prediction and Assessment of Impacts

To assess the potential impacts of construction dust emission, a semi-quantitative approach is adopted based on the UK Institute of Air Quality Management (IAQM)'s Guidance on the Assessment of Dust from Demolition and Construction, and further interrupted with RIAM (see evaluation framework in Section 5.3.2).

While emissions of pollutant such as nitrogen dioxide and hydrocarbons into the airshed can be resulted from the movement of heavy vehicles and powered machinery within the construction site, their contributions are expected to be regulated under the Environmental Protection and Management (Off-Road Diesel Engine Emissions) Regulations 2012 and with effect from 1 July 2012, all off-road diesel engines (e.g., cranes, excavators, power generators, etc) imported into Singapore must comply with the EU Stage II, US Tier II or Japan Tier I off-road diesel engine emission standards. Considering the above, potential impacts from these pollutants are expected to be managed by the relevant regulations and hence not further considered in the following assessment.

5.4.1 Construction Phase

The construction activities for the WNC development would be carried out in 4 Phases in general. As presented in Section 1.3.2.1, spatially the construction zoning will be divided into Area 1 – Southern area to the west of existing 1 & 7 North Coast industrial building, Area 2 – strip of vegetation in between WNC and RTS development, and future road / utilities diversion within existing RTS works boundary, Area 3 & 4 – central area and northern area of WNC, which are currently forested slope. Though a detailed construction programme is not available at this stage of assessment, given the existing land condition and terrain of the Project site, it is expected that land clearance, land preparation (involving earthworks) and infrastructure would be the major works for all areas. As Area 1 is currently an open space with parking lots, land clearance and land preparation works would be minor. Infrastructure would be the main works. For Area 2 and 3, on the other hand, include land clearance, land preparation and infrastructure would be the main works. Area 4 is under review due to the ongoing study for 10 View Road and surrounding area; therefore, the construction details and timeline of Area 4 cannot be confirmed at this stage. The impact assessment is based on MP2019 parameters in which the entire Project area would be cleared for development works. Other than the land preparation and infrastructure works, construction of buildings will eventually be carried out for future development in next stage. The potential impact from building construction, though not under the current infrastructure works, would also be assessed in this EIA for completeness.

With reference to the indicative Project timeline in Section 1.3, construction activities of the site will be divided and carried out in Areas as elaborated in the Table 5.9 below. The construction activities are categorised into earthworks, construction, trackout and demolition for assessment in accordance with IAQM's Guideline.

Table 5.9 Indicative construction area, timeline and the associated activities

Construction Areas	Estimated years of construction	Remarks
Area 1	2026 - 2032	• Earthworks (Land clearance and land preparation) • Construction activities for infrastructure works (roads, drains, sewer) • Construction activities for substructure and superstructure (future development) • Trackout
Area 2	2026 - 2030	• Earthworks (Land clearance and land preparation) • Construction activities for infrastructure works (roads, drains, sewer) • Construction activities for substructure and superstructure (future development) • Trackout

Construction Areas	Estimated years of construction	Remarks
Area 3	2026 - 2030	• Earthworks (Land clearance, land preparation, rock blasting and excavation) • Construction activities for infrastructure works (roads, drains, sewer) • Construction activities for substructure and superstructure (future development) • Trackout
Area 4[1]	2028 - 2035 (10 View Road Building under study)	• Earthworks (Land clearance, land preparation, rock blasting and excavation) • Construction activities for infrastructure works (roads, drains, sewer) • Construction activities for substructure and superstructure (future development) • Repurposing of Building/ Demolition of building structure (Under Study) • Trackout

[1] Area under study. Any works to start after Area 1 - 3

5.4.1.1 Dust Emission from Construction Activities

Potential dust impacts from Project construction phase were assessed in this subsection. For construction phase, dust emissions from construction processes, equipment, movement-related suspension and wind erosion from exposed surfaces are usually more significant as compared to the emissions of gaseous pollutants such as NO_2 and CO, given the engines operating on site are properly maintained and comply to NEA's regulations. Table 5.10 shows the major sources of dust emission during the construction phase.

Currently, the Project site is forested, and topography is elevated approximately 30-40m from the surrounding roads. Construction phase involves land clearance, site levelling, land preparation and infrastructure works. With reference to IAQM assessment guideline, the construction activities are generally classified into demolition, earthworks (site formation and levelling, excavation, and blasting), construction (foundation and superstructure), and trackout (transportation of dusty materials). Based on the scale of the proposed development, the potential dust impacts from these works are evaluated and the impact magnitude as classified using IAQM guideline is presented Table 5.11 and the subsequent subsections.

This section explains the air quality impact associated with different construction activities, and Section 5.7 specifically details the impact significance that each ASR is expected to experience, based on various construction activities and the characteristic of respective ASRs.

Table 5.10 Air pollutants source anticipated during the construction phase

Air Pollutant	Source of Emission
PM2.5, PM10	• Construction processes which involve disturbance of earth materials, such as land clearance, land preparation, infrastructure works, rock blasting, excavation, stockpiling, handling/transportation of materials • Movement of construction vehicles and equipment causing suspension of dust from exposed surface within construction site

Air Pollutant	Source of Emission
	• Fugitive dust due to wind action on open / exposed earth materials and stockpiles, and combustion of fuel

Table 5.11 Anticipated IAQM impact magnitude for the construction activities

Activities	IAQM Impact Magnitude	Description of expected scale of works
Demolition	Medium	• Total building volume 20,000 m^3 – 50,000 m^3 • Potentially dusty construction material (involve breaking of concrete) • Demolition activities 10-20 m above ground level
Earthwork	Large	• Total site area significantly >10,000 m^2, potentially dusty soil type • >10 heavy earth moving vehicles active at any one time • Total material moved significantly >100,000 tonnes
Construction	Medium	• Total building volume 25,000 m^3 – 100,000 m^3 • Potentially dusty construction material (e.g. concrete) • Potential on-site concrete batching
Trackout	Large	• >50 Heavy Duty Vehicles (HDV) (>3.5t) outward movements in any one day • Potentially dusty surface material (e.g. high clay content), • Unpaved road length >100 m

Demolition

Demolition refers to the controlled process of taking down existing structures and infrastructure, ensuring the safe and efficient removal of these elements to make way for new development. Demolition may include the dismantling of structures, the disposal of debris, and the clearing of the site to accommodate the upcoming construction activities.

Following the IAQM's definition of demolition, potential dust emission magnitude from the Demolition of existing structure at 10 View Road is classified as "Medium". This is based on a rough estimation demolition activities 10-20 m above ground level. Good demolition site management practices would therefore be required to mitigate dust emission from these activities if the 10 View Road Building is to be demolished.

Earthworks

Earthworks anticipated for WNC development include the processes of soil-stripping, ground-levelling via rock blasting, excavation, stockpiling, and landscaping. Given the current site condition and hilly terrain, significant volume of earth disturbing works due to site clearance and levelling for establishing the land will take place. Removal of existing vegetation and levelling of the hill via rock blasting will be the main activities.

Following the IAQM's definition of earthworks, potential dust emission magnitude from the Project site clearance and excavation works is classified as "Large". This is based on a rough estimation of more than 150,000 m^2 of the total work area and significant volume of rocks and earth materials would be generated from levelling of land. Good construction site management practices would be required to mitigate dust emission from these activities.

Construction

Construction of new infrastructure (road, drain, sewer etc.) would generate dust. The key issues when determining the potential dust emission magnitude during the construction phase include the size of the infrastructure, method of construction, construction materials, and duration of construction activities. After the completion of infrastructure works, the Project site will be passed on for future construction of substructure and superstructure, which will involve the use of potentially dusty materials, such as concrete, in a larger scale as compared to the construction of infrastructure works. Following the IAQM's definition of construction, a classification of "Medium" dust emission magnitude is assigned for the overall construction activities.

Trackout

It is expected that dust and dirt from the construction site, if unmanaged, will be transported onto the public road network, where it may accumulate and then re-suspended by vehicles using the network. Heavy duty vehicles (HDVs) when leaving the construction site may carry dusty materials with them and may then disperse onto the road. The Public Utilities Board (PUB) stipulates a stringent set of earth control measures for construction sites, including the requirement of wheel wash at the entrance of the construction site to minimize these effects. As the inventory list of anticipated construction vehicles and the number of trips is not available at the time of writing, this assessment is based on the scale and area of total work area, and has considered more than 50 HDV outward movements in a day along an unpaved road length more than 100 m. Following the IAQM's definition of impact from trackout activities, a classification of "Large" dust emission magnitude is assigned.

5.4.1.2 Air Quality Impact on Sensitive Receptors

Biodiversity in Admiralty Forest / within Project site

The Admiralty Forest is located to the north of Project site, with a dense patch of terrestrial forest. The fauna associated with these habitats would be potentially impacted by dust generated from the Project site.

The fringe of Admiralty Forest to the worksite is situated at a distance of approximately 100 meters from the northern boundary of the Project site. Notably, Admiralty Forest is separated from the Project site by Admiralty Road West, which is a bustling 4-lane road with a significant amount of vehicular traffic, including heavy vehicles that run throughout the entire day. Admiralty Road West serves as a crucial connection between the industrial area and the Woodlands Checkpoint, resulting in a high volume of vehicle movements along this thoroughfare.

The fauna within the edge of Admiralty Forest is already exposed to some levels of emissions from passing vehicles along Admiralty Road West. This implies that these species may have acclimated or adapted to such conditions.

Demolition

Biodiversity within Project site: A "Medium" classification of dust impact is expected from demolition of 10 View Road structures based on IAQM matrix. The demolition works will be restricted to the 10 View Road, which comprises a few low-rise buildings. The dust generated from the low-rise buildings is expected to be localised and settled within short timeframe. Thus, the dust emission from demolition works is expected to be localised and only affecting the fauna and flora in the immediate surrounding of the demolition area at 10 View Road, if the forest has not been cleared prior to the demolition works. Depending on the construction sequence, if the forest has been cleared and sensitive species have been translocated out from the Project site, no impact on biodiversity would be resulted.

Biodiversity in Admiralty Forest: The horizontal distance from the fringe of Admiralty Forest to the infrastructure at 10 View Road is approximately 220 meters. When demolition

activities generate dust emissions up on the hill, the extent of the dust dispersion is anticipated to be localized and will not cause significant impact at Admiralty Forest.

Considering the worst scenario, the biodiversity in the forest surrounding 10 View Road is anticipated to experience Slight negative impact from the demolition work, while no impact is expected at Admiralty Forest.

Earthwork

For earthwork and rock blasting activities, distance from the fringe of Admiralty Forest to the northern boundary of the Project site is approximately 100m and to the southern boundary of Project site is approximately 660m. The total earthwork area is estimated to be more than 150,000 m^2, which is significantly larger than the value outlined by IAQM's definition of "Large" dust impact from earthwork (Total site area >10,000 m^2). Though the construction works within the Project site will start progressively from south to north in general (refer to Table 5.9 for the construction sequence and years), it is anticipated that there will be concurrent earthworks in 2 or more Areas of development for certain duration of time. Given the extensive work area and the earthworks activities could spend for years, the dust emission from the earthworks is expected to be significant and would impose Minor negative impact on the biodiversity in Admiralty Forest.

Construction

For construction activities including construction of infrastructure under this Project, and construction of substructure and superstructure for future development, "Medium" classification of dust impact is expected based on IAQM matrix. The distance from the fringe of Admiralty Forest to the northern boundary of the Project site is approximately 100m. The future development design is not available at the moment; however, a significant building volume can be anticipated in view of the site area of approximately 27 ha. Consequently, Slight negative impact of dust is expected from the construction activities.

Trackout

For trackout activities, "Large" classification of dust impact is expected based on the IAQM matrix. Trackout dust, stemming from transporting earthwork and construction materials using HDV. The impact of trackout dust is expected to be more pronounced if the trackout route is planned along Admiralty Road West which is adjacent to the Admiralty Forest. Slight negative impact on the biodiversity in Admiralty Forest due to trackout.

Residential Areas

Within the 350-meter assessment buffer from the Project site, as outlined in Table 3.1 in Section 3.2.2, three (3) clusters of residential areas have been identified. Depicted in Table 5.6, with the largest number of residences in the south residing in HDBs along Woodlands Avenue 9. To the north, a small dwelling with a boarding house and colonial houses is situated at Keramat Road and Dahan Road. Near the eastern buffer boundary is the worker dormitory situated at Woodland Industrial Park E4. HDB residences along Woodlands Avenue 9 are separated from the Project site by Woodlands Avenue 9 itself. Similarly, residents at Keramat Road and Dahan Road are divided from the Project site by Admiralty Road West—a busy 4-lane road with substantial vehicular traffic.

Given their proximity to the Project boundary, residents of HDB along Woodlands Avenue 9 and Keramat Road, as well as Dahan Road, are more likely to experience greater impacts from the development activities within the Project site. However, it's noteworthy that the current state of these locations already exposes to the effects of passing vehicles.

Moreover, residents of the workers' dormitory are expected to be less affected by the development works. This is attributed to their distance from the Project site and partial shielding provided by the industrial building adjacent to the eastern Project boundary. Additionally, the dormitory is located within an industrial area, coupled with the presence of a nearby bus depot, further reduces sensitivity to any minor increases in air quality.

Demolition

Demolition activities for the infrastructure at 10 View Road are limited to Area 4 of the indicated Project timeline. The small dwellings on Keramat Road and Dahan Road are situated approximately 250 meters from the 10 View Road infrastructure, while the rest of the residential cluster is at least 550 meters away. Hence, impacts are only anticipated to affect residences in Keramat Road and Dahan Road. While dust emissions are expected during demolition, the dispersion of dust is foreseen to be localized and would be settled within short timeframe, due to the existing low-rise structure within the premise. Consequently, Slight negative impact could be resulted at the Keramat Road and Dahan Road premise, while no impact at the other residential receptors in the study area.

Earthworks

During earthworks and rock blasting activities, residents of Keramat Road, Dahan Road, and HDBs along Woodlands Avenue 9 are expected to be consistently exposed to dust from the Project site for 8 hours or more daily. The extensive earthwork area within Project site which is estimated to be more than 150,000 m^2, surpasses the IAQM's dust emission magnitude of "Large" impact due to earthworks. It's noteworthy that residents of the worker dormitory may experience slightly lower effects due to partial shielding from the adjacent industrial building and the dormitory's location in an industrial area, further reducing sensitivity to air quality changes. Consider the scale and timespan of earthworks, the dust impact on residents is assessed to be Minor negative.

Construction

Construction activities are expected to have “Medium” dust impact based on the IAQM matrix. The anticipated impact varies with the indicative phasing of development activities. Construction during Area 1 is likely to affect residents of the HDB cluster along Woodlands Avenue 9 more, while Area 3 will have impact at all three clusters. For Area 4, residents of Keramat Road and Dahan Road will be more affected. Slight negative impact of dust is expected from the construction activities.

Trackout

Trackout activities are expected to have “Large” dust impact as classified by the IAQM matrix. The dust, resulting from the movement of earthwork and construction materials using HDVs, may have negative impact on the health of residents for long duration of exposure. Residents are expected to spend long hours within their premises. Slight negative impact is anticipated from trackout.

Educational Facilities

Republic Polytechnic (RP) and Qihua Primary School (QHPS) are located within the 350-meter study buffer from the Project site. In the case of RP, only the car park building is situated within the 150m boundary, while the main academic buildings are predominantly within the 150m to 300m radius, most are air-conditioned and hence unlikely to be affected by air quality impacts caused by the Project. For QHPS, the compound is screened by surrounding HDB blocks at the southern boundary of Project site, reducing its susceptibility to dust emissions from the Project site.

Demolition

RP is located approximately 500 meters from the demolition site, while QHPS is situated around 775 meters away. No impact would be resulted from demolition works to the students and staff at both RP and QHPS.

Earthworks

During earthworks and rock blasting activities, the extensive earthwork area within Project site which is estimated to be more than 150,000 m^2, surpasses the IAQM's definition of “Large” dust impact from earthwork. Minor negative impact is expected from earthworks.

Construction

Construction activities are expected to have “Medium” dust impact based on the IAQM matrix. The anticipated impact varies with the indicative phasing of development activities due to the distances from the works. In general, Slight negative impact is anticipated from the construction activities.

Trackout

Trackout activities are expected to have “Large” dust impact, as classified by the IAQM matrix. The impact of trackout dust is expected to be more pronounced if the trackout route is planned adjacent to the respective receptors. However, both RP and QHPS are quite distanced from the Project site and potential trackout route. Slight impact is anticipated for the students and staff within the premises.

Healthcare Facilities

Man Fut Tong Nursing Home (MFTNH) is the sole healthcare facility identified within the 350-meter study buffer from the Project site. It is located approximately 115 meters from the southern boundary of the Project site. Given its role as a nursing home for the elderly, residents of healthcare facilities are particularly sensitive and vulnerable to the impacts on air quality.

Demolition

Man Fut Tong Nursing Home (MFTNH) is situated approximately 590 meters from the demolition site of 10 View Road. The expected dust impact resulting from the demolition is foreseen to be localized and no impact for the residents of the nursing home is expected.

Earthworks

During earthworks and rock blasting activities, the extensive earthwork area within Project site which is estimated more than 150,000 m^2, surpasses the IAQM's definition of “Large” impact from earthwork. Additionally, MFTNH is situated very close to the southern boundary and may be more affected by the earthworks conducted in Area 1 and Area 2. Moderate negative impact is anticipated for the residents in the nursing home due to the earthworks.

Construction

Construction activities are expected to have “Medium” dust impact based on the IAQM matrix. The anticipated impact varies with the indicative phasing of development activities. MFTNH is likely to be affected by the dust impact generated in Area 1 construction work due to its proximity to the work area. Minor negative impact is anticipated for the residents in the nursing home due to the construction activities.

Trackout

Trackout activities are expected to have “Large” dust impact as classified by the IAQM matrix. The dust, resulting from the movement of earthwork and construction materials using HDVs. MFTNH is likely to be affected by the dust impact generated from trackout in Area 1 and Area 2 construction work due to its proximity to the work areas. Minor negative impact is anticipated for the residents in the nursing home due to trackout.

Industrial Area

Wafer fabrication industry is situated adjacent to the eastern corner of northern boundary and industrial facilities along North Coast Ave is situated at eastern boundary of the Project site. Wafer fabrication industry may have operational requirement of air intakes and for the workers, it is noteworthy that workers at these sites are exposed to air emissions resulting from their industrial activities. To ensure the health and safety of workers, it is imperative that they are provided with suitable PPE. Therefore, in the context of this EIA, these individuals are not categorized as sensitive receptors concerning air quality.

Demolition

Demolition activities for the infrastructure at 10 View Road are limited to Area 4 for a short timeframe. Wafer fabrication industry is situated approximately 320 meters from the Project site, separated by Admiralty Road West. While dust emissions are expected during demolition, the dispersion of dust is foreseen to be localized. No impact is anticipated at the wafer fabrication industry due to demolition works.

Earthworks

During earthworks and rock blasting activities, wafer fabrication intakes are expected to be consistently exposed to dust from the Project site daily. The extensive earthwork area within Project site which is estimated more than 150,000 m^2, surpasses the IAQM's definition of “Large” impact from earthwork. Minor negative impact is anticipated.

Construction

Construction activities are expected to have “Medium” dust impact based on the IAQM matrix. The anticipated impact varies with the indicative phasing of development activities. Wafer fabrication industry is likely to be affected by the dust impact generated in Area 4 construction work due to its proximity to the Project site. Slight negative impact is anticipated.

Trackout

Trackout activities are expected to have “Large” dust impact as classified by the IAQM matrix. The dust, resulting from the movement of earthwork and construction materials using HDVs. The trackout dust impact only from Area 4 construction is anticipated to affect the wafer fabrication industry. Slight negative impact is anticipated.

5.4.2 Post-Construction Phase

It is noted that at the time of writing, operational stage development plan has not been established. Thus, post-construction phase impact assessment of the Project site was evaluated based on URA Master Plan 2019 parameters.

Types of proposed developments within the Project site will comprise commercial, Business 1 – White (B1-W) and Business 2 (B2) industries. The allowed land uses are mainly general and light industries and are expected to be mostly contained within the buildings. There is no planned permanent emission stack in the WNC development. Potential sources of emission are limited to the induced vehicular traffic in the area, and small exhaust emission from future businesses (from fuel powered equipment). The effects of which will be assessed qualitatively, based on the characteristics of the emissions and distance from relevant receptors.

Table 5.12 Air pollutants emitted by the development within the Project site

Air Pollutant	Source of Emission
Nitrogen oxides, NO_x	• Emissions from industrial process (if any), typically related to the use of fuel
PM2.5, PM10	• Emissions from induced vehicular traffic in the area

5.4.2.1 Post- Construction Phase Impact Assessment

WNC operations is expected to be general and light industries, which the potential emission from the operation is comparable to an integrated commercial building. There is no planned permanent emission stack, and the future operations are not expected to generate significant pollution. Other than the business operation in WNC, induced vehicular traffic commuting to the new development may cause increase in vehicular emission. However, consider that the future WNC area will also be supported by the railway development, and the area is currently bounded by main roads with heavy traffic. The potential change in air quality in the WNC area is thus not significant.

5.5 Proposed Mitigation Measures

5.5.1 Construction Phase

To address the air quality impact stemming from construction activities, a set of mitigation measures is proposed at source to minimise emission from the construction. General good site management practices shall be implemented, incorporating effective earth control measures throughout all stages of construction. General and activities specific measures are proposed below, and these collective strategies aim to significantly reduce airborne dust during construction, promoting a healthier air quality environment for both on-site workers and the surrounding community. Regular monitoring and adjustment of these measures will be integral to ensuring their continued effectiveness throughout the construction phase.

General measures:

- Planning of construction programme to minimize the area and duration of exposed surfaces, and to reinstate completed work areas as early as practical.
- Comply with relevant environmental regulations, including the Environmental Protection and Management Act and any other regulations and guidelines come into effect when the time of construction works commencement.
- Minimise the duration of bare earth exposure through careful planning of work sequence and schedule.
- If exposure of bare earth and stockpile of earth materials is needed on site, Erosion Control Blankets shall be used to cover the exposed surfaces to prevent wind erosion and wash off by rain.
- Adequate tarpaulin covers to be placed on-site in case of storm events.
- Plants and machineries used on site shall be properly and regularly inspected and maintained to control dust and air pollutants emission.
- Minimise dust emission from dusty activities, e.g. excavation and demolition, by water spraying and / or physical screening.
- To schedule activities with the potential for higher dust emissions, such as earthwork and demolition during periods of lower wind speeds to reduce the dispersion of airborne particles
- Wheel washing bay shall be provided, and all trucks / vehicles shall be washed before leaving the construction site.
- Minimize traffic delays caused by movement of construction vehicles by planning transport route and transport period that avoid congested areas and peak hours of road use.
- Installation and proper maintenance of dust screen, fencing or hoarding along construction site perimeters recommended to reduce dust deposition.
- Avoid burning of waste or other materials.

Demolition (if any):

- Employing dust barriers and screens around the demolition site.
- To keep the demolition period as short as possible.
- No crushing or screening of demolished construction material shall be performed on-site.

Earthworks:

- Prompt removal of excavated soil from the construction site to prevent prolonged exposure.
- To limit the height of stockpiles to control airborne dust.
- Earthworks to be conducted in stages.
- To cover any exposed earth areas not in immediate use with erosion control blankets.
- To compact or pave any exposed earth areas not in immediate use.

Construction:

- Installation of physical barriers to contain ground-level pollutants.
- Employing local exhaust ventilation systems.
- To prioritize the use of low volatile organic compound (VOC) construction materials for paints, adhesives, and sealants.
- To utilize emission-reducing construction equipment.
- Regular inspection and maintenance of construction equipment to control emissions.
- If concrete batching is carried out on site, the batching plant shall be placed away from the sensitive receptors.
- Use enclosed chutes and conveyors and covered skips wherever possible.
- Minimise drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate.

Trackout:

- Installation of trackout control mats at exit points complemented by wheel wash stations.
- Designing site exit points paved or stabilized surfaces to minimize the disturbance of loose soil.
- Enforcing lower speed limits within the construction site to ensure vehicles move within the site and exit gradually.
- Equipping all haul trucks transporting materials with covers to reduce dust emissions during transit.
- Regular maintenance and cleaning of road within site to promptly remove accumulated dust and debris minimizing the generation of dust.

5.5.2 Post-Construction Phase

The future operations of WNC will be characterized by the presence of general and light industries and commercial buildings, potential emission from the future businesses / processes are not expected to be intensive. The use of environmentally friendly technologies and energy-efficient systems in both industrial processes and office spaces will be encouraged to minimize air emissions.

Green spaces and landscaping will be integrated into the site design which can contribute to air quality improvement. Since the future operation as light industries is not expected to result in significant change in air quality in the area, no specific mitigation measures are recommended.

5.6 Residual Impact

5.6.1 Construction Phase

Through the implementation of a comprehensive set of air quality impact mitigation measures during the construction phase, the anticipated significance of air quality impacts associated with various activities is expected to be significantly reduced to minor or negligible levels. These measures, ranging from the use of dust control techniques, physical screening, and site management practices, are strategically designed to minimize dust emissions and dispersion to the surrounding environment. The residual impact after implementing these mitigation strategies is outlined in Section 5.7.

5.6.2 Post-Construction Phase

No residual impact is anticipated.

5.7 RIAM Summary

5.7.1 Construction Phase

Table 5.13 Summary of impact assessment for Air Quality impacts for the construction phase. The change in impact Magnitude following mitigation (if any), and the residual impact Significance is also shown. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score)

Activity	Sensitive Receptors	Predicted impacts without mitigation measures							With mitigation measures		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Earthworks	Terrestrial fauna (Admiralty Forest)	3	-4	2	2	2	-72	Minor negative impact	-2	-36	Slight negative impact
	Residential areas	3	-4	2	2	2	-72	Minor negative impact	-2	-36	Slight negative impact
	Educational institutions	2	-4	2	2	2	-48	Minor negative impact	-2	-24	Slight negative impact
	Healthcare facilities	4	-4	2	2	2	-96	Moderate negative impact	-2	-48	Minor negative impact
	Industrial areas	2	-4	2	2	2	-48	Minor negative impact	-2	-24	Slight negative impact
Demolition of 10 view road (if any)	Terrestrial fauna (Project site)	3	-2	2	2	2	-36	Slight negative impact	-1	-18	Slight negative impact
	Residential areas	3	-1	2	2	2	-18	Slight negative impact	0	0	No impact
	Educational institutions	2	0	2	2	2	0	No impact	-	-	No impact
	Healthcare facilities	4	0	2	2	2	0	No impact	-	-	No impact
	Industrial areas	2	0	2	2	2	0	No impact	-	-	No impact

Activity	Sensitive Receptors	Predicted impacts without mitigation measures							With mitigation measures		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Construction activities	Terrestrial fauna (Admiralty Forest)	3	-2	2	2	2	-36	Slight negative impact	-1	-18	Slight negative impact
	Residential areas	3	-2	2	2	2	-36	Slight negative impact	-1	-18	Slight negative impact
	Educational institutions	2	-2	2	2	2	-24	Slight negative impact	-1	-12	Slight negative impact
	Healthcare facilities	4	-2	2	2	2	-48	Minor negative impact	-1	-24	Slight negative impact
	Industrial areas	2	-2	2	2	2	-24	Slight negative impact	-1	-12	Slight negative impact
Trackout	Terrestrial fauna (Admiralty Forest)	3	-2	2	2	2	-36	Slight negative impact	-1	-18	Slight negative impact
	Residential areas	3	-2	2	2	2	-36	Slight negative impact	-1	-18	Slight negative impact
	Educational institutions	2	-1	2	2	2	-12	Slight negative impact	0	0	No impact
	Healthcare facilities	4	-2	2	2	2	-48	Minor negative impact	-1	-24	Slight negative impact
	Industrial areas	2	-2	2	2	2	-24	Slight negative impact	-1	-12	Slight negative impact

5.7.2 Post-Construction Phase

No significant change in air quality is predicted during the operation of future businesses (general and light industries) in WNC. Therefore, specific mitigation measures and residual impact is not relevant.

Table 5.14 Summary of impact assessment for Air Quality impacts for the post construction phase. The change in impact Magnitude following mitigation (if any), and the residual impact Significance is also shown. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score)

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures						
		I	M	P	R	C	ES	Impact Significance
Emission from WNC operation	Terrestrial fauna (Admiralty Forest)	3	0	2	2	2	0	No impact
	Residential areas	3	0	2	2	2	0	No impact
	Educational institutions	2	0	2	2	2	0	No impact
	Healthcare facilities	4	0	2	2	2	0	No impact
	Industrial areas	2	0	2	2	2	0	No impact

6 Airborne Noise

6.1 Applicable Legislation, Guidelines and Standards

The noise assessment criteria are based on the Singapore Construction Noise Regulations. The permissible construction noise limits for worksites from Monday to Saturday is shown in Table 6.1 below.

Table 6.1 Permissible construction noise limits for worksites - Source: Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2011

Monitoring Station	Worksite Operational Period			Parameter
	Day (07:00 – 19:00)	Evening (19:00 – 22:00)	Night (22:00 – 07:00)	
(a) Hospitals, schools, institutions of higher learning, homes for the aged sick etc.	60	50		$L_{eq\text{-}12hr,}$ dB(A)
	75	55	55	$L_{eq\text{-}5\ min,}$ dB(A)
(b) Residential buildings located less than 150 m from the construction site where the noise is being Emitted	75	-	-	$L_{eq\text{-}12hr,}$ dB(A)
	-	65	55	$L_{eq\text{-}1hr,}$ dB(A)
	90	70	55	$L_{eq\text{-}5\ min,}$ dB(A)(1)
	75	55	55	$L_{eq\text{-}5\ min,}$ dB(A)(2)
(c) Building (other than those in paragraphs (a) and (b))	75	65		$L_{eq\text{-}12hr,}$ dB(A)
	90	70	70	$L_{eq\text{-}5\ min,}$ dB(A)

Notes:
(1) Applicable maximum permissible noise levels where noise is being emitted on Mondays to Saturdays.
(2) Applicable maximum permissible noise levels where noise is being emitted on Sundays and public holidays.

According to NEA's directive, the maximum permissible noise levels for construction sites shall be adjusted by the addition of a correction factor to the higher of either the permissible noise level or the measured background noise level, to account for the existing background noise levels in the area. The correction factors correspond to the difference between the applicable permissible level, and the background noise level, and are presented in Table 6.2 below.

It should be noted that the correction factor is not to be used during the design and prediction phase. Instead, the intent of the correction factor is for use during assessment to account for background ambient noise levels.

Table 6.2 Correction factor - Source: Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2011

Difference between Permissible and Background Noise Levels dB(A)	Correction Factor dB(A)
Below 2	3
2 to less than 4	2
4 to less than 10	1
10 and above	0

In cases where a worksite occurs within 150 m of a sensitive land use, the regulations also impose restrictions upon the hours of the work of the site (unless an exception is approved by the Director-General of the NEA). Construction works are prohibited during the following periods:

- 2200 to 0700 on Monday to Saturday
- Sundays or Public Holidays

6.2 Baseline Study

Construction and development activities on the Project site will generate noise, which can contribute to noise pollution in the surrounding environment. Prolonged and excessive airborne noise can cause nuisance and have adverse effects on wildlife and human health such as increased stress levels and can disturb or disorient faunas in the adjacent forest north of Project site. Establishing baseline condition helps to understand the noise levels residence and faunas surrounding the Project site is currently exposed to, and compare to the predicted noise levels due to the development of WNC.

Methodology and findings of primary data collection and review of secondary data will be presented in this section.

6.2.1 Methodology

6.2.1.1 Desktop Study

Secondary data such as previous EIA report, satellite imagery, existing land use, and development activities assist in identifying the baseline monitoring location and provide comparison data for the primary data collected. Secondary data provides data of background noise condition in the area over the years considering with the on-going construction of RTS Link west of Project site and other future developments planned within the WNC area.

Previous studies of airborne noise within WNC area listed below have been reviewed.

- RTS EIA (LTA, 2018)

6.2.1.2 Field Survey

The baseline airborne noise survey comprises three (3) monitoring stations for 7-days continuous measurement. Monitoring locations shown in Figure 6.1 were selected to represent sensitive receptors shown in Table 6.3 located in close proximity or have line of site to the Project site.

Measurement was done over seven (7) consecutive days of monitoring, including weekdays and weekends. Additionally, spot measurement for a duration of 15 minutes was carried out to verify and provide observation on the site condition.

Table 6.3 Noise monitoring location

Station	Location	Type of receptor
N1	Turf between Admiralty Road West and Keramat Road	• Residential Areas • Fauna within secondary forest
N2	Outside of Republic Polytechnic Xperiential Hub	• Educational Institutions
N3	HDB Block 877 Woodlands Ave 9, Singapore 730877	• Residential Areas • Healthcare Facilities

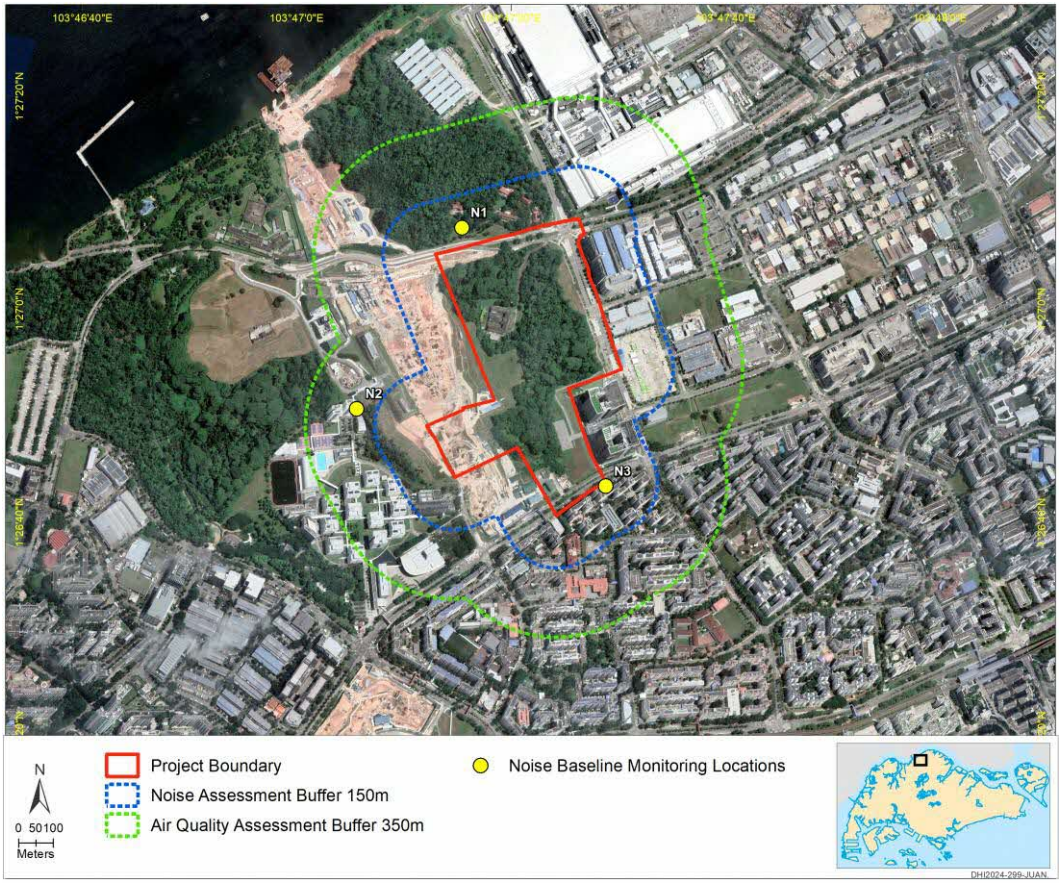


Figure 6.1 Noise Baseline Monitoring Locations (Satellite image as of 10 Mar 2022)

The noise measurements were carried out using NEA approved Type 1 sound level meters. The noise sensors were set up at 1.5m above the ground and away from a façade or any reflective surface. The baseline noise monitoring locations were also selected away from local noise sources such as mechanical plant, pumps or regular community activity.

Data recorded during periods of rain can increase the measured noise levels and therefore not representative of the noise sources of interest. As such, extraneous noise from the rain has been excluded from our assessment.

6.2.2 Findings

6.2.2.1 Desktop Study

In view of the expected construction activities listed in Section 2.3, significant airborne noise will be generated from the site clearance, blasting, excavation to level the land to designed level, mobilisation of equipment such as trucks, lorry crane, mobile cranes, and excavators into Project site and infrastructure works such as construction of roads, drains, sewer, utility service, buildings and landscaping works. Airborne noise is expected to be generated consistently throughout the development of the Project site.

Review of Previous Studies

Airborne noise measurements from previous studies within the vicinity of Project Site will be referenced and compared with current primary data collected for airborne noise baseline

study. Due to the confidentially and availability of the studies to the general public, please approach the respective agencies for detailed report information.

RTS EIA (LTA, 2018)

Baseline airborne noise monitoring was conducted at three (3) locations; Campus Heights Republic Polytechnic, Blk 871 Woodlands Street 81 and View Road Lodge from 09 Dec 2016 to 28 Dec 2016. Baseline measurements at each location were conducted for one week (weekdays and weekends) to record the noise levels over time periods of 12 hours (long term) and 1 hour and 5 minutes (short term).

Sources of potential airborne noise impacts during construction identified are trucks transporting spoil / equipment, traffic congestion caused due to inadequate lane compensation and traffic diversion during construction and powered mechanical equipment. In which similar activities will be anticipated during to the construction phase of WNC Project site.

$L_{eq\ 5mins}$ dB(A) (maximum values measured for the monitoring period) shown in Table 6.4 below was presented in the RTS EIA report and Campus Heights Republic Polytechnic and Blk 871 Woodlands Street 81 baseline noise levels exceeded NEA's construction limit occasionally, likely due to vehicular traffic and human activities. View Road Lodge experience a lower ambient noise level, as it is surrounded by forest and the premise has restricted access.

Table 6.4 Noise monitoring location

Station	Measurement period	$L_{eq\ 5min}$ dB(A)		
		Day (07:00 – 19:00)	Evening (19:00 – 22:00)	Night (22:00 – 07:00)
NL01: Admiralty Forest / Boarding house	9 to 16 Dec 2016	76 (90)	69 (70)	70 (70)
NL02: Block 871, Woodlands	20 to 27 Dec 2016	79 (90)	79 (70)	71 (55)
NL03: Campus Heights, Republic Polytechnic (RP)	20 to 27 Dec 2016	78 (75)	76 (55)	73 (55)

Note:

1. Bracket values indicate relevant NEA's construction noise limit

2. Values exceeding NEA's construction noise limits are indicated in red.

3. Maximum values measured for the monitoring time period were presented in RTS EIA.

6.2.2.2 Field Survey

Air borne noise monitoring results conducted from 17 Jan 2023 to 27 Jan 2023 is presented below in Table 6.5. The detailed of noise baseline report are presented in Appendix G.

Noise levels at N3 exceeded NEA's construction noise limits for evening (22:00 – 7:00) and N1 and N3 exceeded NEA's construction noise limits for night (22:00 – 7:00) likely due to the proximity to main roads. Republic Polytechnic experience lower background noise level when compared to Admiralty Forest and HDB Woodlands.

Table 6.5 Results of baseline measurements of ambient noise level

Monitoring Station	Measured Noise Level $L_{eq\text{-}5min}$ (dB)		
	Day (07:00 – 19:00)	Evening (19:00 – 22:00)	Night (22:00 – 07:00)
N1 – Admiralty Forest / Boarding house	61 (90)	60 (70)	59 (55)
N2 – Republic Polytechnic	54 (75)	53 (55)	52 (55)
N3 - HDB Woodlands Blk 877	64 (75)	63 (55)	60 (55)

Note:

1. Bracket values indicate relevant NEA's construction noise limit

2. Values exceeding NEA's construction noise limits are indicated in red.

3. Average values measured for the monitoring time period were presented.

A 15-minutes attended noise measurements were carried out on 27 Jan 2023 at the noise monitoring locations to understand the noise environment at the sensitive receptors.

Table 6.6 15-minute attended noise measurement results

Location	$L_{Aeq\text{-}15\ mins}$ dB(A)	Time	Description
N1 – Admiralty Forest / Boarding house	59	10:23	The overall noise environment at this monitoring location during the attended measurement period was dominated by frequent traffic from Admiralty Road West and insects. Construction noise from the TE1 was audible at this location but not dominating the noise environment.
N2 – Republic Polytechnic	60	11:24	The overall noise environment at this monitoring location during the attended measurement period was dominated by local activities such as people talking, vehicles movement to carpark.
N3 - HDB Woodlands Blk 877	63	12:06	The overall noise environment at this monitoring location during the attended measurement period was dominated by frequent traffic noise from Woodlands Avenue 9. On some occasions, children noise were audible.

6.3 Impact Assessment Framework

6.3.1 Importance Rating of Sensitive Receptors

The type and sensitivity of Noise Sensitive Receptors (NSRs) would be similar to ASRs. The assessment can be referred to Section 5.3.1.

6.3.1.1 Identified Sensitive Receptors

The noise sensitive receivers within the 150m survey corridor of the Project site are evaluated in accordance with the general description of sensitivity in Table 5.5 for ASRs, and the importance scores are summarised in Table 6.7. The noise sensitive receivers are also illustrated in Figure 6.2.

Table 6.7 Summary of Noise Sensitive Receptors

Rec ID	Description	Receiver Type	Important Score
N01	Micron Semiconductor Asia Pte Ltd	Industrial	2
N02	Harvest @ Woodlands	Industrial	2
N03	Woodlands E-Terrace	Industrial	2
N04	7 North Coast Building	Industrial	2
N05	1 North Coast Building	Industrial	2
N06	876, 877, 878 Woodlands Avenue 9	Residential	3
N07	870, 871, 872 Woodlands Avenue 9	Residential	3
N08	Man Fut Tong Nursing Home	Healthcare	4
N09	Republic Polytechnic	Educational	2
N10	Admiralty Forest	Fauna	3
N11	Boarding House at Keramat Road	Residential	3

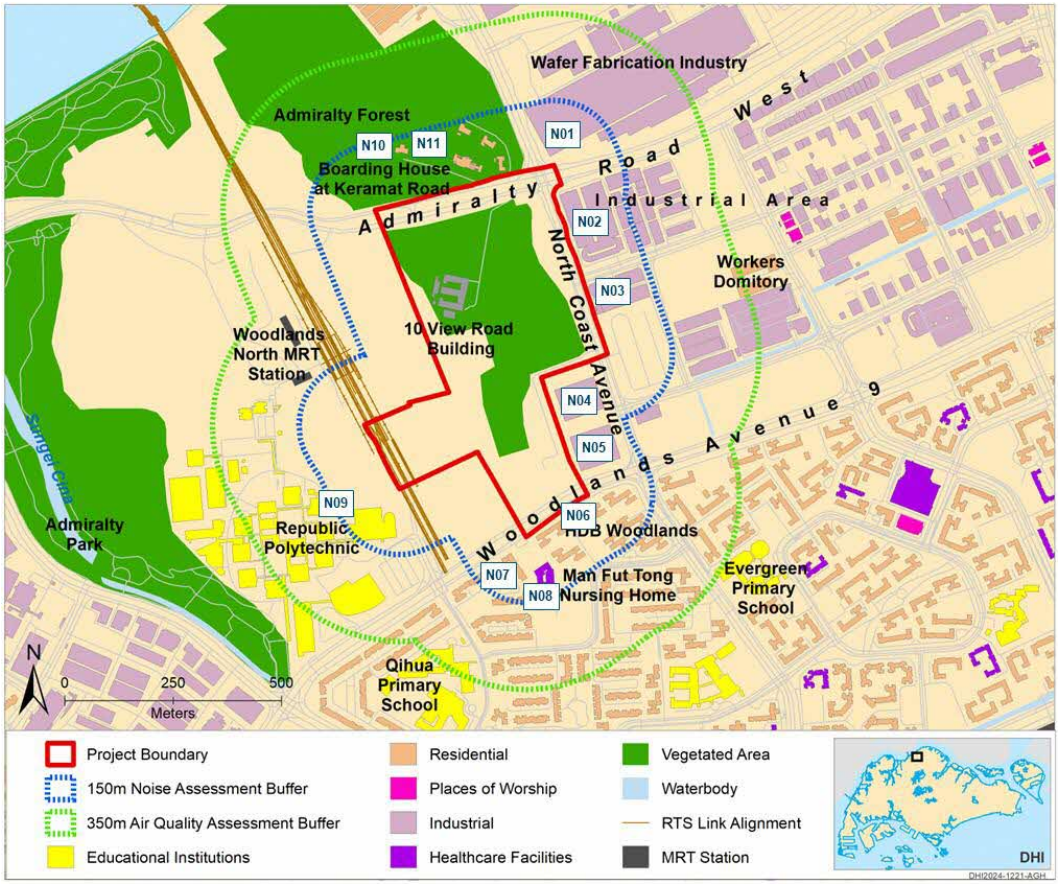


Figure 6.2 Location of Noise Sensitive Receptors

6.3.2 Magnitude of Change

To assess the magnitude of noise impact to the NSRs (human receptors), the predicted noise levels are compared with the NEA's guideline on construction noise limits stated in Table 6.1. The resulting exceedance is interpreted and categorised into different significance levels as described in Table 6.8. The thresholds presented takes guidance from the Fundamentals of Acoustics adopted by WHO which indicate a change in sound pressure level of 3 dB is just perceptible to the human ear and that of 5 dB is clearly noticeable (Hansen, 1951).

For terrestrial and freshwater fauna receptors, there are no specific guidelines or thresholds stipulated globally or in Singapore, partly because the effects of noise on most fauna species are poorly understood (Larkin *et al.* 1996, Brown 2001), hence guidance is taken from relevant organisations, literature, and expert judgement. For example, The Nature Conservancy (2015) recommends noise levels to be ideally as low as 55 dB within 100 m from source to protect sensitive animal species. Other studies have suggested that higher noise levels of around 68 dB may reduce birds' foraging ability and eventually lead them to avoid and abandon the habitat (Ortega, 2012). For acoustic pollution impacts specific to aquatic fauna and habitats, a noise level above 60 dB is accepted to induce behavioural changes in freshwater fauna and temporary changes in population patterns (Kunc et al., 2016). Given that different species have varied tolerance to anthropogenic noise and noise levels (Parris and Schneider, 2008), and taking into account the concentration of anthropogenic noise sources (expressway traffic, wafer fab industry, schools) that characterise this Study Area, a noise level of 60 dB is taken as the threshold for fauna receptors in this Study, above which detectable changes are predicted.

The evaluation of impact magnitude for airborne noise-sensitive human and fauna receptors are presented in Table 6.8.

Table 6.8 Evaluation Framework for Magnitude of Change in noise level for human and fauna receptors. Where multiple criteria result in multiple possible scores, the more conservative score (higher Magnitude) is adopted in evaluating the Magnitude of Change.

Score	Generic Criteria	Specific Criteria	
		Human Receptors	Fauna Receptors
-4	Major negative disadvantage or change	• Predicted noise level at NSR exceeded the limit by more than 10 dBA	• Predicted noise level exceeded 85 dBA, likely resulting in death or injury of fauna receptors
-3	Moderate negative disadvantage or change	• Predicted noise level at NSR exceeded the limit by between 5 to 10 dBA • Or predicted noise level at NSR cause an increase of greater than 10 dBA as compared to baseline level	• Predicted noise level cause an increase of greater than 10 dBA as compared to baseline level • Or predicted noise level of 75-85 dBA, resulting in evident physiological and anatomical changes, and low survivability and biological fitness of fauna populations
-2	Minor negative disadvantage or change	• Predicted noise level at NSR exceeded the limit by between 3 to 5 dBA • Or predicted noise level at NSR cause an increase of up to 10 dBA as compared to baseline level	• Predicted noise level cause an increase of up to 10 dBA as compared to baseline level • Or predicted noise level of 65-75 dBA, resulting in significant behavioural changes in fauna (change in feeding patterns, predator-prey interactions, reduced ability to maintain territories and increased aggression between individuals)
-1	Slight negative disadvantage or change	• Predicted noise level at NSR exceeded the limit by between 1 to 3 dBA • Or predicted noise level at NSR cause an increase of up to 5 dBA as compared to baseline level	• Predicted noise level cause an increase of up to 5 dBA as compared to baseline level • Or predicted noise level of 60-65 dBA, resulting in temporary/recoverable shifts in fauna behaviour (e.g., change in vocalisation pattern or avoidance of areas with acoustic pollution), which are not expected cause a substantial change in species population
0	No change	• Predicted noise level at NSR exceeded the limit by up to 1 dBA • Predicted noise level at NSR cause an increase of up to 3 dBA as compared to baseline level	• Predicted noise level cause an increase of up to 3 dBA as compared to baseline level • Or predicted noise level below 60 dBA, with no changes in fauna behaviour or populations expected

6.4 Prediction and Assessment of Impacts

6.4.1 Noise Modelling (Construction Phase)

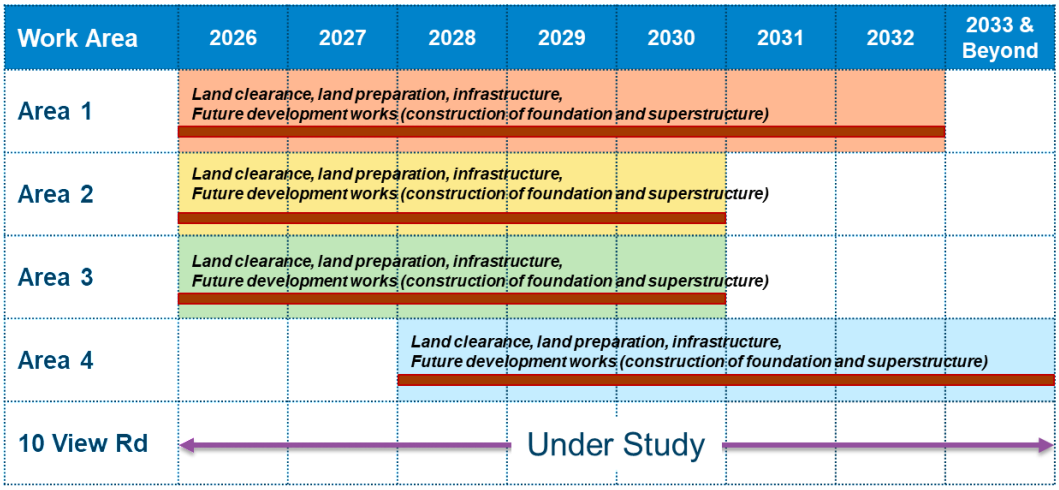
The SoundPLAN noise simulation software, Version 9.0 was used to predict noise generated from the equipment anticipated to be used during construction. The software adopts the widely used international standard ISO 9613-2 (ISO, 1996) and the model assumes hemispherical propagation from all noise sources at 0.5m over a ground surface.

The purpose of the modelling was to determine an indicative noise level of the equipment likely to be used during the construction phase; to allow for a screening of the potential noise impacts; and appropriate planning of mitigation implementation.

6.4.1.1 Construction Scenarios

The detail planning of construction programme is not available at this stage. The estimated timeline associated with various construction activities at different working areas is shown in Table 6.9. Area 4 is under review due to the ongoing study for 10 View Road and surrounding area. The impact assessment is based on MP2019 parameters in which the entire Project area would be cleared for development works.

Table 6.9 Timeline associated with various construction activities at different working areas



The following construction scenarios were modelled to represent the construction activities. The anticipated construction equipment for the land preparation and infrastructure works, and the building construction for future development is provided in Table 6.10. Though the construction and development for Area 4 is under study and any works in Area 4 would be carried out after Area 1 – 3, it is conservatively assumed that construction activities in Area 1 – 4 are carried out concurrently in the model simulation.

- Scenario 1 – Land clearance, land preparation and infrastructure work. As the study area is distributed over a varying topography, it is likely that the construction equipment for earthworks removal will be located at higher ground elevations, which may impact the noise sensitive receivers. It is assumed the land clearing activities will be carried out at Area 1 to Area 4 concurrently.
- Scenario 2 – Future development works carried out at Area 1 to Area 4. Typically pilling works, RC works, steel works and reinstatement works are the noisiest

construction activities. It is assumed that the construction activities will be carried out at at Area 1 to Area 4 concurrently.

Table 6.10 Anticipated construction equipment and its sound power level for each phase and stage of works

Stages	Modelled Construction Equipment	Sound power level per equipment (From BS 5228)
Land clearance and land preparation – Earth works	Bulldozer x 2	113 dB(A)
	Tracked Excavator x 4	103 dB(A)
	Dumper x 2	107 dB(A)
	Generator x 1	93 dB(A)
Infrastructure – Road, drains, sewer, utilities works	Dumper x 3	107 dB(A)
	Breaker mounted on wheeled backhoe x 1	120 dB(A)
	Excavator x 3	103 dB(A)
	Generator x 1	93 dB(A)
Construction of substructure and superstructure (future development)	Excavator x 2	93 dB(A)
	Dumper x 2	107 dB(A)
	Bored Piling Rig x 3	112 dB(A)
	Mobile Crane x3	98 dB(A)
	Concrete mixer x 3	104 dB(A)
	Concrete pump x 3	106 dB(A)
	Breaker mounted on wheeled backhoe x 1	120 dB(A)
	Generator x 1	93 dB(A)

6.4.1.2 Selected Noise Sensitive Receptors

According to the noise regulations by NEA, all occupiable buildings around a construction site are defined as noise sensitive receptors. All buildings within 300 m from the site were modelled and were selected for the prediction of noise levels 1 m from their façade in accordance with the *Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2011*. Buildings were modelled to act as screens and reflective surfaces for the acoustic model.

6.4.1.3 Model Assumptions for the Pre-Mitigation Run

The following assumptions were made for the initial model run:

- No mitigation was implemented for the modelled equipment at the pre-mitigation stage.

- Typical single layer sheet metal hoardings around construction sites were not modelled as these thin hoardings typically do not have sufficient mass, rigidity, or construction quality to serve as an effective noise barrier.
- For this assessment, the noise sources were assumed to be located in close proximity to key work locations within the construction site boundary. Sources are assumed to be operating at 100% at all time periods.
- The number of construction equipment used in the model were determined based on the size of the site and the type of construction activity provided. Note that actual construction methodology, positioning and number of construction equipment may vary from the modelled scenarios and can only be determined by the Contractor.
- Façade correction was modelled to account for the reflective noise from building facades.
- The predicted noise level parameter is based on $L_{eq,\ 12hrs}$ dB(A).

6.4.1.4 Noise Modelling Results – Unmitigated Scenarios

The predicted construction noise levels at the noise sensitive receptors are summarized in Table 6.11.

Table 6.11 Summary of Predicted Construction Noise Levels (Unmitigated Scenario)

Receiver ID	Type of Receivers	Predicted Noise Levels, Leq_{-12hr} dB(A)		Noise Criteria – Leq_{-12hr}, dB(A)
		Scenario 1	Scenario 2	
N01	Industrial	61	66	75
N02	Industrial	66	70	75
N03	Industrial	67	70	75
N04	Industrial	70	75	75
N05	Industrial	72	**79**	75
N06	Residential	70	75	75
N07	Residential	66	70	75
N08	Healthcare	**61**	**68**	60
N09	Educational	57	**62**	60
N10	Fauna	**67**	**72**	60
N11	Residential	67	72	75

Scenario 1 - Land clearance, land preparation and infrastructure work

The evaluation of construction noise impact magnitude at the noise sensitive receptors due to land clearance, land preparation and infrastructure work are summarised in Table 6.12. Grid noise contour presented in Figure 6.3.

The noise levels due to land clearance, land preparation and infrastructure works are predicted to comply with the daytime noise criteria at all receptors with exception of N14-Forest and N15-Nursing Home, which are predicted to exceed the noise criteria by 7dB and 1 dB, respectively.

Table 6.12 Evaluation of Construction Noise Impact Magnitude for Scenario 1 (Unmitigated Scenario)

Receiver ID	Type of Receivers	Predicted Noise Levels – Leq_{-12hr}, dB(A)	Noise Criteria – Leq_{-12hr}, dB(A)	Impact Evaluation	Magnitude Score
N01	Industrial	61	75	Predicted noise level at NSR within noise limit	0
N02	Industrial	66	75	Predicted noise level at NSR within noise limit	0
N03	Industrial	67	75	Predicted noise level at NSR within noise limit	0
N04	Industrial	70	75	Predicted noise level at NSR within noise limit	0
N05	Industrial	72	75	Predicted noise level at NSR within noise limit	0
N06	Residential	70	75	Predicted noise level at NSR within noise limit	0
N07	Residential	66	75	Predicted noise level at NSR within noise limit	0
N08	Healthcare	**61**	60	Predicted noise level at NSR exceeded the limit by between 1 to 3 dBA	-1
N09	Educational	57	60	Predicted noise level at NSR within noise limit	0
N10	Fauna	**67**	60	Predicted noise level of 65-75 dBA, potentially resulting in significant behavioural changes in fauna	-2
N11	Residential	67	75	Predicted noise level at NSR within noise limit	0

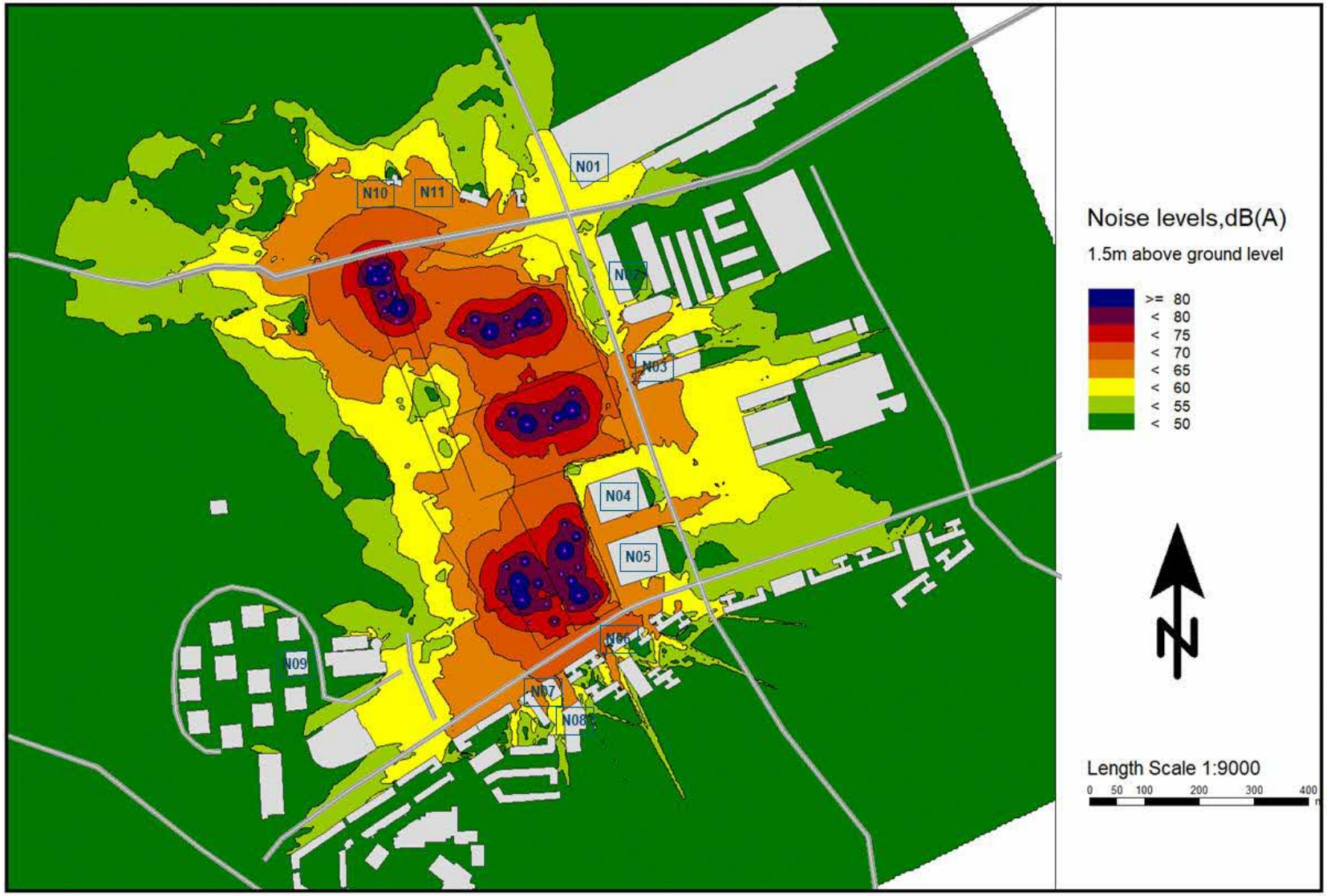


Figure 6.3 Scenario 1 – Grid Noise Contour for Land Clearance, Land Preparation and Infrastructure Work

Scenario 2 - Future development works – Construction of substructure and superstructure

The evaluation of construction noise impact magnitude at the noise sensitive receptors due to scenario 2 future development works is summarised in Table 6.13. Grid noise contour is also presented in Figure 6.4.

The noise levels due to scenario 2 are predicted to comply with the daytime noise criteria at all receptors with the exception of N07 (Industrial), N13 (Educational), N14 (Admiralty Forest) and N15 (Nursing Home).

Table 6.13 Evaluation of Construction Noise Impact Magnitude for Scenario 2 (Unmitigated Scenario)

Receiver ID	Type of Receivers	Predicted Noise Levels – Leq_{-12hr}, dB(A)	Noise Criteria – Leq_{-12hr}, dB(A)	Impact Evaluation	Magnitude Score
N01	Industrial	66	75	Predicted noise level at NSR within noise limit	0
N02	Industrial	70	75	Predicted noise level at NSR within noise limit	0
N03	Industrial	70	75	Predicted noise level at NSR within noise limit	0
N04	Industrial	75	75	Predicted noise level at NSR within noise limit	0
N05	Industrial	**79**	75	Predicted noise level at NSR exceeded the limit by between 1 to 3 dB	-1
N06	Residential	75	75	Predicted noise level at NSR within noise limit	0
N07	Residential	70	75	Predicted noise level at NSR within noise limit	0
N08	Healthcare	**68**	60	Predicted noise level at NSR exceeded the limit by between 5 to 10 dB	-3
N09	Educational	**62**	60	Predicted noise level at NSR exceeded the limit by between 1 to 3 dB	-1
N10	Fauna	**72**	60	Predicted noise level of 65-75 dB, resulting in significant behavioural changes in fauna	-2
N11	Residential	72	75	Predicted noise level at NSR within noise limit	0

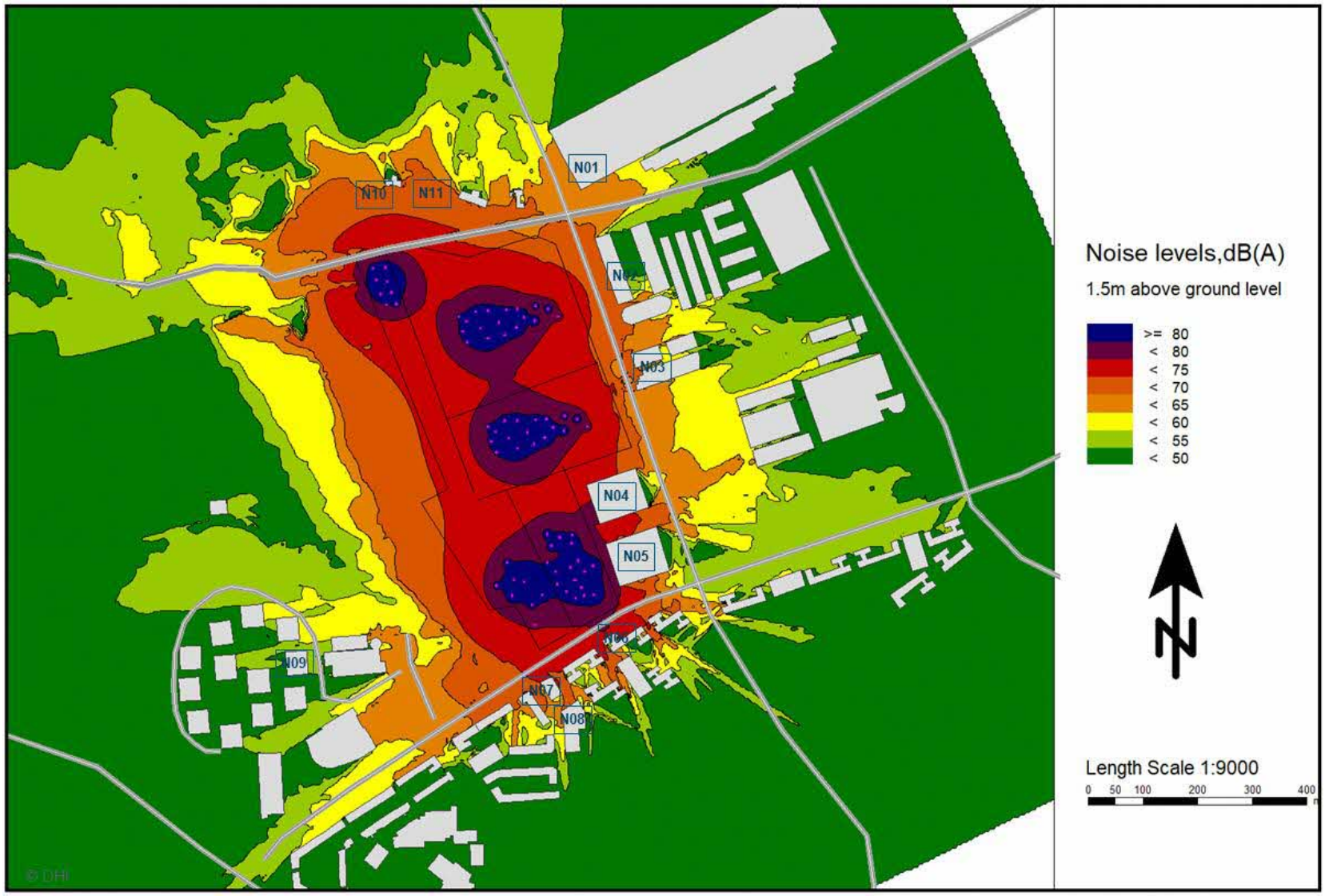


Figure 6.4 Scenario 2 – Grid Noise Contour for Future Development Works – Construction of Substructure and Superstructure

6.4.2 Construction Phase Impact Assessment (Unmitigated)

Based on the assessment results from the above section, considered the predicted noise level at receptors and their sensitivity, it is predicted that there will be a slight to moderate negative impact to the identified receptors due to the predicted activities:

- Land clearance, land preparation and infrastructure work (Area 1 to Area 4)
    - Minor impact on terrestrial fauna (up to 67 dB(A))
    - Slight impact to healthcare facilities (up to 61 dB(A))
- Future development works – Construction of substructure and superstructure (Area 1 to Area 4)
    - Minor impact on terrestrial fauna (up to 72 dB(A))
    - Moderate impact to healthcare facilities (up to 68 dB(A))
    - Slight impact to educational facilities (up to 62 dB(A))
    - Slight impact to industries facilities (up to 79 dB(A))

6.4.3 Post-Construction Phase Impact Assessment (Unmitigated)

At the time of writing, the operational stage development plan has not been established. Therefore, the post-construction phase impact assessment of the Project site was evaluated based on URA Master Plan 2019 parameters.

Types of proposed developments within the Project site will comprise commercial, Business 1 – White (B1-W) and Business 2 (B2) industries. The allowed land uses are mainly general and light industries and are expected to be mostly contained within the buildings. It is also worth noting that any new development shall be designed to achieve the NEA Boundary Noise Limits at the site boundary of the development. As such, it is anticipated that any noise impact from the operation of the future WNC business could be managed through a thoughtful design.

6.5 Proposed Mitigation Measures

6.5.1 Construction Phase

The noise impact from the construction activities should be mitigated at source, if possible, in order to meet the construction noise limits specified by NEA. Good site practices and noise management can be expected to considerably reduce the pre-construction and construction noise impact. The following recommendations present best practice measures for the control of noise:

- Select equipment with low noise emissions (More details will be elaborated in Section 6.5.1.1)
- Prior to commencement of construction works, install hoarding and noise barriers along project boundary (More details will be elaborated in Section 6.6.1).
- Inspect and maintain vehicles and mechanical plants in good effective working order and operate in a manner to minimise noise emissions

- Keep compressor, generator and engine compartment doors close and plant turned off when not in use.
- Machines in intermittent use will be shut down or throttled down to a minimum during periods between works
- Precaution and care when unloading vehicles to avoid un-necessary noise.
- Limit the timing of the use of heavy machineries (e.g. cranes, excavators, generators) to minimise noise emission, in particular early morning and evening hours when animals are more active. Where alternatives are available, only equipment and vehicles that emit lower noise levels are to be used.
- Where necessary, retrofitting silencer or enclosure on machine engines and exhaust to reduce noise emission.
- Use site terrain, material stockpiles and suitable work locations to screen work locations and maximise the distance between work activities and the nearest noise sensitive receptors
- Manage project vehicles to not wait or queue up with engines running at the entrance to the site access
- Inspect heavy machines regularly identifying maintenance issues which generate excessive noise and carry out maintenance as required
- Construction personnel to be trained in noise-reduction behaviours such as reducing the drop height of materials.
- Daily toolbox briefing should include reminders on the need to implement noise-reduction behaviours
- All construction personnel should be educated about sensitive ecological nature of work areas before commencing the work

6.5.1.1 Source Controls

Source controls for specific equipment are highly recommended as they are typically the most effective measures for reducing noise levels. A summary of some possible mitigation measures that should be considered is provided in Table 6.14.

Table 6.14 Possible Control Mitigation Measures

Plant	Source of noise	Mitigation	Noise Reduction (from BS 5228)
Hammer Drive Piling Equipment	Pneumatic/diesel hammer or steam winch vibrator driver	Enclose hammer head and top of pile in acoustic screen	5 to 10 dB
	Sheet pile	Acoustically dampen sheet steel piles to reduce levels of resonant vibration	
	Impact on pile	Use resilient pad (dolly) between pile and hammer head. Packing needs to be kept in good condition	

Plant	Source of noise	Mitigation	Noise Reduction (from BS 5228)
	Crane cables, pile guides and attachments	Careful alignment of pile and rig	
	Power units or base machine	Fix more efficient sound reduction equipment or exhaust. Acoustically dampen panels and covers. When intended by the manufacturer, engine panels need to be kept closed. Use acoustic screens when possible	
Earth moving plant: • Bulldozer • Compactor • Crane • Dump truck • Dumper • Excavator • Grader • Loader • scraper	Engine	Fit more efficient exhaust sound reduction equipment Manufacturers' enclosure panels need to be kept closed	5 to 10
Compressors and generators	Engine Compressor or generator body shell	Fit more efficient exhaust sound reduction equipment Manufacturers' enclosure panels need to be kept closed Acoustically dampen metal casing	Up to 10
	Total Machine	Erect acoustic screen between compressor or generator and noise-sensitive area. When possible, line of sight between top of machine and reception point needs to be obscured.	Up to 10
		Enclose compressor or generator in ventilated acoustic enclosure	Up to 20
Pneumatic concrete breaker, rock drills and tools	Tool	Fit suitably designed muffler or sound reduction equipment to reduce noise without impairing machine efficiency Ensure all leaks in air line are sealed	Up to 15
	Bit	Use dampened bit to eliminate ringing	

Plant	Source of noise	Mitigation	Noise Reduction (from BS 5228)
	Total machine	Erect acoustic screen between compressor or generator and noise-sensitive area. When possible, line of sight between top of machine and reception point needs to be obscured.	Up to 10
		Enclose breaker or rock drill in portable or fixed acoustic enclosure with suitable ventilation	Up to 20
Rotary drills, diamond drilling and boring	Drive motor and bit	Use machine inside acoustic shed with adequate ventilation	Up to 15
Riveters	Impact on rivet	Enclose work area in acoustic shed	Up to 15
Pumps	Engine pulsing	Use machine inside acoustic enclosure with allowance for engine cooling and exhaust	Up to 20
Concrete mixers	Cleaning	Do not hammer the drum	
Materials handling	Impact of material	Do not drop materials from excessive heights. Screen dropping zones, especially on conveyor systems. Line chutes and dump trucks with a resilient material.	Up to 15

6.5.1.2 Path Controls – Portable Noise Barriers

Portable noise barriers are highly recommended as a path control to be implemented for noisy activities carried out in a localised area within the worksite (e.g. roadworks due to road diversion, construction of temporary POB, etc.). It is estimated in the British Standard BS 5228-1:2009+A1:2014 that, when implemented well, such barriers are able to reduce broadband noise egress levels of shielded construction plant by up to 10 dB. To increase their effectiveness, portable noise barriers should be deployed as close as possible to noise sources.

6.5.1.3 Path Controls – Site Noise Barrier

Noise reduction achieved through a combination of the controls above may not be sufficient to meet statutory limits. It is anticipated that temporary noise barriers located near the site boundary may be required to protect the noise sensitive receptors. These noise barriers are able to serve as site hoarding. Indicative dimensions and locations required have been determined through further modelling in SoundPLAN 9.0 and are presented in Section 6.6.

Noise Barrier Materials

The primary function of a noise barrier is to shield receptors from excessive noise generated by construction activities. The effectiveness of a noise barrier is determined by parameters such as its relative position between source and receiver, its height as well as its material, which determines properties such as sound transmission loss and sound absorption.

6.6 Residual Impact

The following subsections provide a summary of the post-mitigation model findings for each scenario and any further recommendations.

6.6.1 Construction Phase

6.6.1.1 Model Assumptions for Post – Mitigation Model

Indicative dimensions and locations required for the noise barrier have been determined through further modelling in SoundPLAN 9.0.

It is noted that at this stage of the Project, the location of equipment within the respective worksites, the number of equipment, and individual sound power level for the equipment are indicative only and will be subject to change depending on the detailed construction programme. In addition to the modelling assumptions for the pre-mitigation run (Section 6.4.1.3), noise modelling to determine dimensions of barriers were undertaken based on the following assumptions:

- Noisy activities will be prohibited during the evening and night periods due to the proximity of residential NSRs within 150 m of the worksite. The mitigation option was therefore modelled to meet the day criteria.
- The source control (e.g. local mitigation measures) will be reduced by 5dB.
- Noise barrier walls facing the noise sources will be absorptive with minimum absorptive coefficient of Noise Reduction Coefficient (NRC) 0.7.
- The extent and height of the noise barrier wall is as detailed in Figure 6.5.
- Transmission Loss (TL) through the noise barriers were not considered in the model i.e. barriers are assumed to have sufficiently high TL.

The noise barrier modelled in the simulations (Figure 6.5) represent the minimum height required to mitigate the predicted construction noise to acceptable levels at the surrounding receptors. However, it is noted that NEA has issued a new requirement mandating the installation of a 6-meter noise barrier along the entire perimeter of selected construction sites, specifically those within 75 meters of sensitive premises (e.g., school, institution of higher learning, home for the aged sick or residential building). Since the Project development is subject to this new requirement when it takes effect on 01 April 2025, the noise barrier in accordance with the specifications will be required and is shown in Figure 6.6. The contractor is required to comply with these regulations.

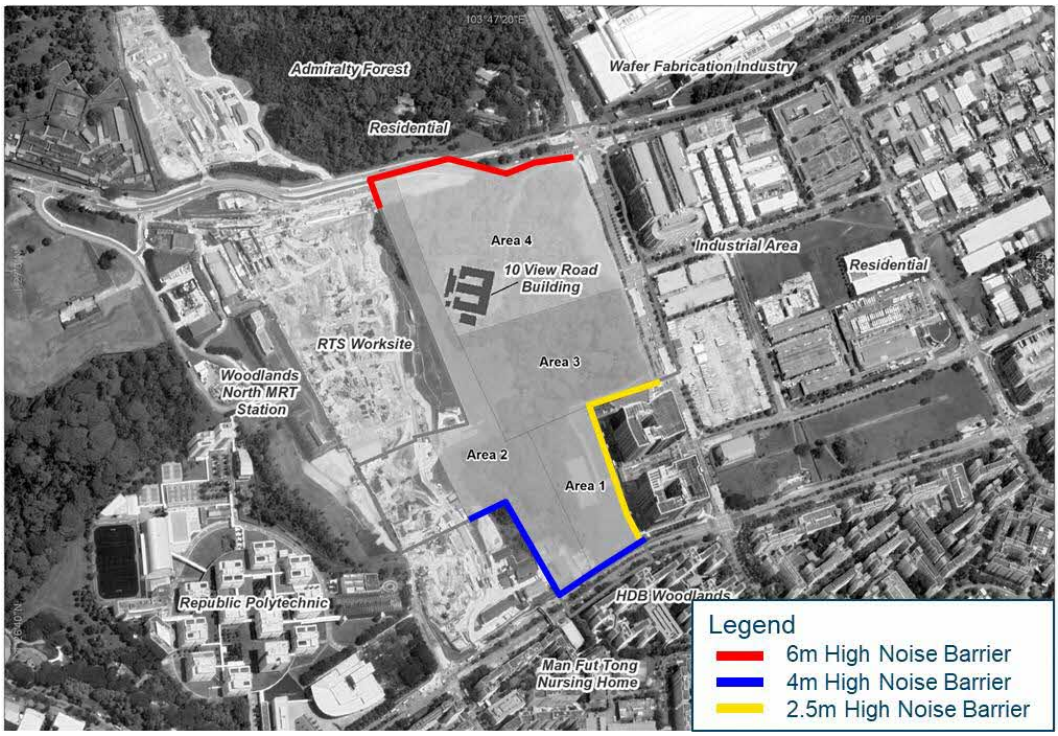


Figure 6.5 Noise Barrier Height and Extent use in noise modelling

Figure 6.6 Noise Barrier Height and Extent Based on Specifications of Perimeter Noise Barriers (NEA, 2024)

6.6.1.2 Noise Modelling Results (Mitigated)

The predicted construction noise levels at the noise sensitive receptors for Scenario 1 and 2 after implementing the proposed mitigation measures are summarized in Table 6.15.

Based on the modelling results, the predicted noise level for terrestrial fauna at Admiralty Forest (Receiver ID - N10) is below the assessment criteria, the physical presents of construction activities such as movement of equipment and vehicles may cause additional disturbance to the fauna. As a result, the magnitude scoring has been slightly adjusted for a more conservative assessment. A slight negative impact on the terrestrial fauna is considered after mitigation, with the summary of the residual impact outlined in Section 6.7.

Table 6.15 Summary of Predicted Construction Noise Levels (Mitigated Scenario)

Receiver ID	Type of Receivers	Predicted Noise Levels, Leq_{-12hr} dB(A)		Noise Criteria – Leq_{-12hr}, dB(A)
		Scenario 1	Scenario 2	
N01	Industrial	56	60	75
N02	Industrial	61	64	75
N03	Industrial	62	64	75
N04	Industrial	65	69	75
N05	Industrial	67	73	75
N06	Residential	65	69	75
N07	Residential	61	64	75
N08	Healthcare	56	59	60
N09	Educational	50	56	60
N10	Fauna	59	60	60
N11	Residential	59	75	75

Scenario 1 - Land clearance, land preparation and infrastructure work

The evaluation of construction noise impact magnitude at the noise sensitive receptors due to land clearing, land preparation and infrastructure work after implementing the proposed mitigation measures is summarised in Table 6.16. Grid noise contour is also presented in Figure 6.7.

The noise levels due these works are predicted to comply with the daytime noise criteria at all receptors.

Table 6.16 Evaluation of Construction Noise Impact Magnitude for Scenario 1 (Mitigated Scenario)

Receiver ID	Type of Receivers	Predicted Noise Levels – Leq_{-12hr}, dB(A)	Noise Criteria – Leq_{-12hr}, dB(A)	Impact Evaluation	Magnitude Score
N01	Industrial	56	75	Predicted noise level at NSR within noise limit	0
N02	Industrial	61	75	Predicted noise level at NSR within noise limit	0
N03	Industrial	62	75	Predicted noise level at NSR within noise limit	0
N04	Industrial	65	75	Predicted noise level at NSR within noise limit	0
N05	Industrial	67	75	Predicted noise level at NSR within noise limit	0
N06	Residential	65	75	Predicted noise level at NSR within noise limit	0
N07	Residential	61	75	Predicted noise level at NSR within noise limit	0
N08	Healthcare	56	60	Predicted noise level at NSR within noise limit	0
N09	Educational	50	60	Predicted noise level at NSR within noise limit	0
N10	Fauna	59	60	Predicted noise level at NSR within noise limit	0
N11	Residential	59	75	Predicted noise level at NSR within noise limit	0

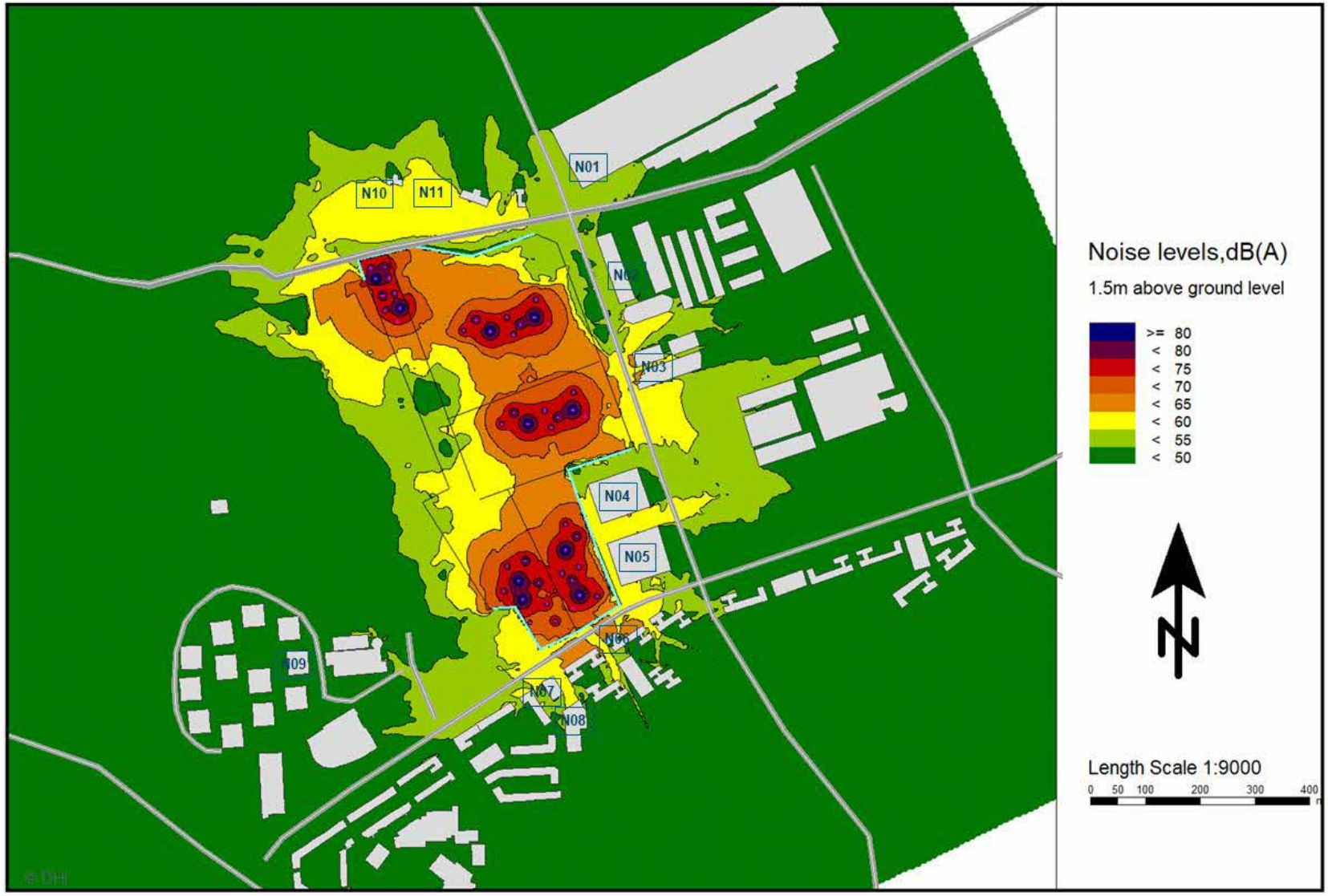


Figure 6.7 Scenario 1 – Grid Noise Contour for Land Clearance, Land Preparation and Infrastructure Work with Proposed Mitigation Measures

Scenario 2 - Future development works – Construction of Substructure and Superstructure

The evaluation of construction noise impact magnitude at the noise sensitive receptors due to scenario 2 future development works after implementing the proposed mitigation measures is summarised in Table 6.17. Grid noise contour is also presented in Figure 6.8.

The noise levels due to scenarios 2 are predicted to comply with the daytime noise criteria at all receptors.

Table 6.17 Evaluation of Construction Noise Impact Magnitude for Construction Works for New Buildings (Mitigated Scenario)

Receiver ID	Type of Receivers	Predicted Noise Levels – Leq_{-12hr}, dB(A)	Noise Criteria – Leq_{-12hr}, dB(A)	Impact Evaluation	Magnitude Score
N01	Industrial	60	75	Predicted noise level at NSR within noise limit	0
N02	Industrial	64	75	Predicted noise level at NSR within noise limit	0
N03	Industrial	64	75	Predicted noise level at NSR within noise limit	0
N04	Industrial	69	75	Predicted noise level at NSR within noise limit	0
N05	Industrial	73	75	Predicted noise level at NSR within noise limit	0
N06	Residential	69	75	Predicted noise level at NSR within noise limit	0
N07	Residential	64	75	Predicted noise level at NSR within noise limit	0
N08	Healthcare	59	60	Predicted noise level at NSR within noise limit	0
N09	Educational	56	60	Predicted noise level at NSR within noise limit	0
N10	Fauna	60	60	Predicted noise level at NSR within noise limit	0
N11	Residential	60	75	Predicted noise level at NSR within noise limit	0

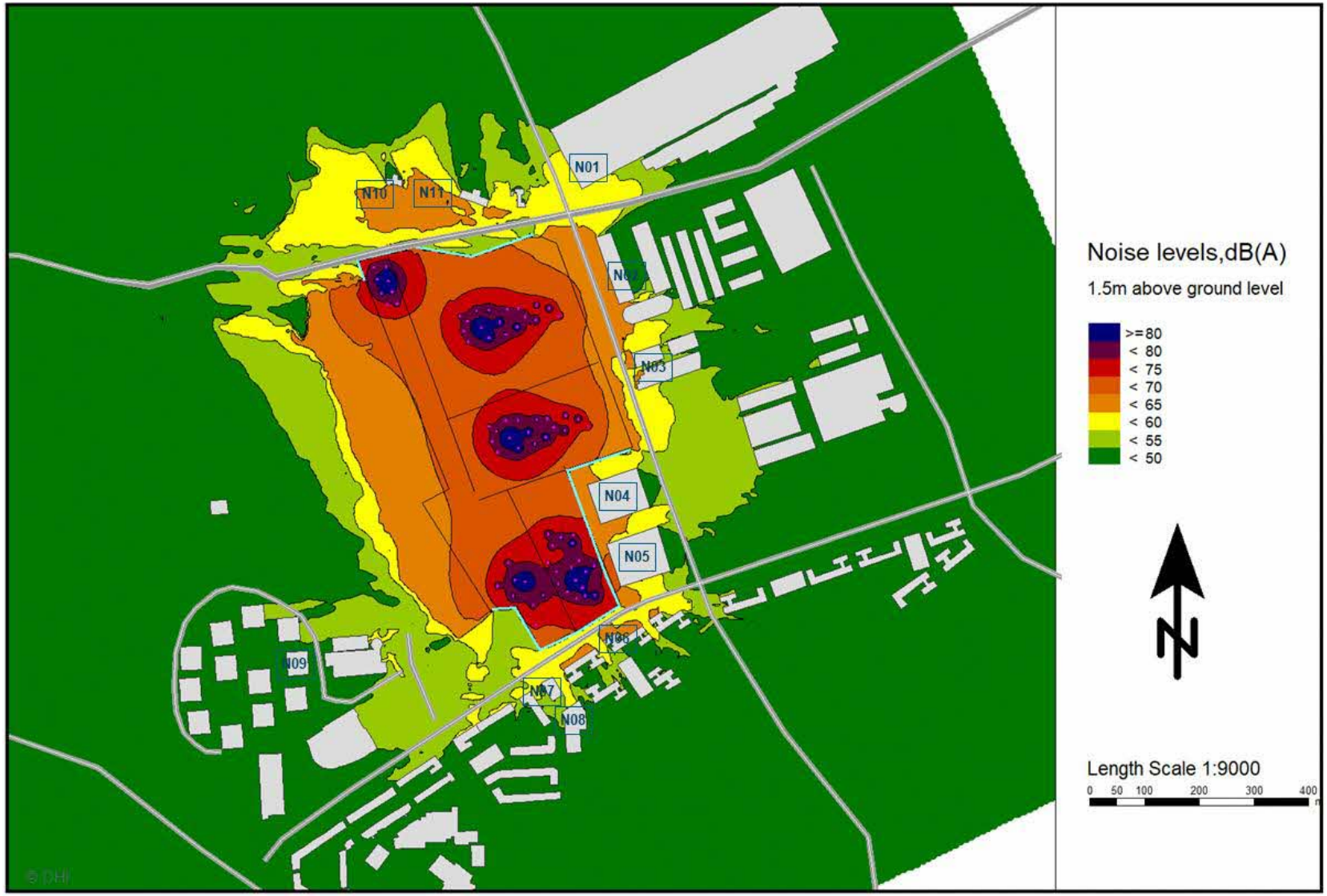


Figure 6.8 Scenario 2 – Grid Noise Contour for Future Development Works – Construction of Substructure and Superstructure with Proposed Mitigation Measures

6.6.2 Post-Construction Phase

Depending on the noise sources e.g. plant room, ventilation louvres, or other heavy machines to be used in the future businesses, mitigation measures may be implemented to reduce the noise impact to the surrounding receivers. These may include noise barriers, selection of quieter equipment, acoustic louvres and installation of silencers. These shall be considered in the future detailed design for the development.

Through the implementation of noise mitigation measures during the operational phase such as noise barriers, installation of silencers and acoustic louvres etc, it is anticipated that the significance of noise impacts will be reduced to slight or negligible levels.

6.7 RIAM Summary

6.7.1 Construction Phase

Table 6.18 Summary of impact assessment for Noise impacts for the construction phase. The change in impact Magnitude following mitigation (if any), and the residual impact Significance is also shown. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score)

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures							With mitigation measures		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Scenario 1 Land clearance, Land preparation and infrastructure work	Terrestrial fauna (Admiralty Forest)	3	-2	2	2	3	-42	Minor negative impact	-1	-21	Slight negative impact
	Residential areas	3	0	2	2	3	0	No impact	-	-	-
	Educational institutions	2	0	2	2	3	0	No impact	-	-	-
	Healthcare facilities	4	-1	2	2	3	-28	Slight negative impact	0	0	No impact
	Industrial areas	2	0	2	2	3	0	No impact	-	-	-
Scenario 2 Future development works – Construction of substructure and superstructure	Terrestrial fauna (Admiralty Forest)	3	-2	2	2	3	-42	Minor negative impact	-1	-21	Slight negative impact
	Residential areas	3	0	2	2	3	0	No impact	-	-	-
	Educational institutions	2	-1	2	2	3	-14	Slight negative impact	0	0	No impact
	Healthcare facilities	4	-3	2	2	3	-84	Moderate negative impact	0	0	No impact
	Industrial areas	2	-1	2	2	3	-14	Slight negative impact	0	0	No impact

6.7.2 Post-Construction Phase

At the time of writing, the operational stage development plan has not been established. Based on the consideration that, the future businesses are mainly general and light industries, and are expected to be mostly contained within the buildings. Also, any new development shall be designed to achieve the NEA Boundary Noise Limits at the site boundary of the development. With a proper design, the potential noise impact during the post-construction phase of the development is considered negligible.

Table 6.19 Summary of impact assessment for Noise impacts for the construction phase. The change in impact Magnitude following mitigation (if any), and the residual impact Significance is also shown. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score)

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures						
		I	M	P	R	C	ES	Impact Significance
Noise emission from WNC operation	Terrestrial fauna (Admiralty Forest)	3	0	2	2	3	0	No impact
	Residential areas	3	0	2	2	3	0	No impact
	Educational institutions	2	0	2	2	3	0	No impact
	Healthcare facilities	4	0	2	2	3	0	No impact
	Industrial areas	2	0	2	2	3	0	No impact

7 Ground Vibration

7.1 Applicable Legislation, Guidelines and Standards

Singapore does not have any national criteria that relates to ground vibration.

Vibration criteria from human comfort have been based on the guidance of British Standards. These have been used for many projects and are summarised:

- BS6472-1:2008 Guide to evaluation of human exposure to vibration in buildings – Part 1: Vibration sources other than blasting
- BS 5228-2 2009: Code of practice for noise and vibration control on construction and open sites – vibration

Vibration impact on sensitive equipment is typically assessed against the Vibration Criterion (VC) curves in the ASHRAE 2019 Handbook. Note that the ASHRAE curves originated from the ISO 2631.2:1989 standard. These vibration curves are provided in Figure 7.1 for reference.

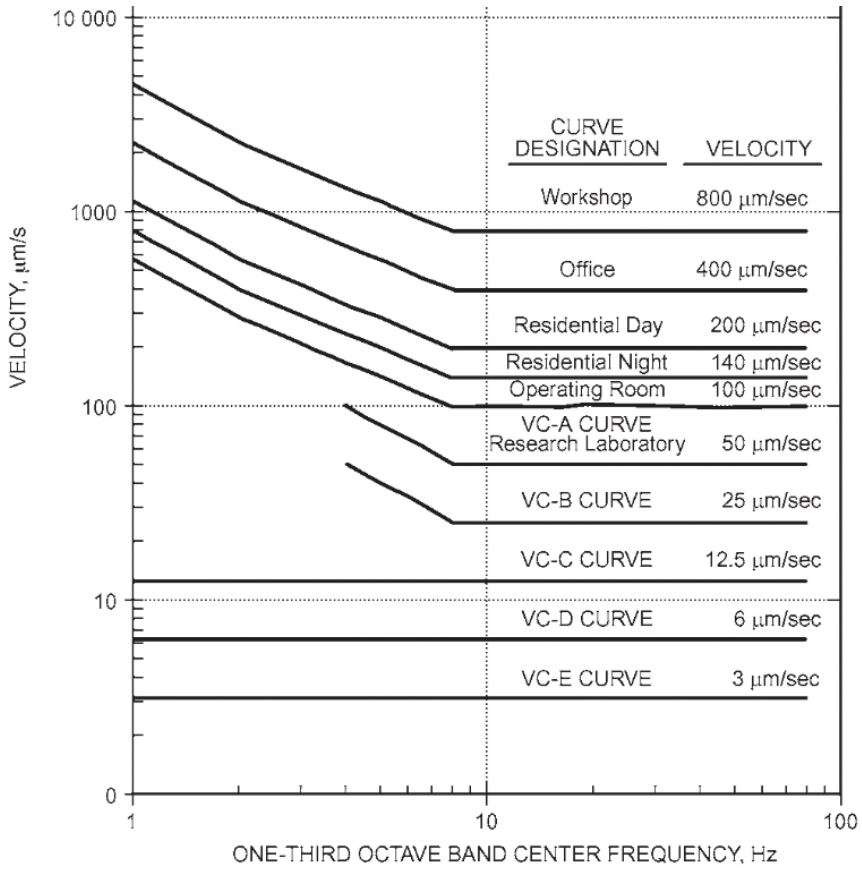


Figure 7.1 ASHRAE 2019 Building vibration criteria for vibration measured on building structure

7.2 Baseline Study

Vibrations generated from heavy equipment and machinery used during construction can have adverse effects on the surrounding environment and human health. Ground vibrations are a form of environmental pollution that can cause structural damage to buildings and sensitive infrastructures, and also disrupt the ecosystem. The establishment of a baseline condition helps to determine the current levels of ground vibrations in the surrounding environment before the development activities commence.

Methodology and findings of primary data collection and review of secondary data will be presented in this section.

7.2.1 Methodology

7.2.1.1 Desktop Study

Secondary data

Secondary data such as previous EIA report, satellite imagery, existing land use, and development activities assist in identifying the baseline air monitoring location and provide comparison data for the primary data collected. Secondary data provides an overview of the progressive air quality condition over the years considering with the on-going construction of RTS Link west of Project site and other future developments planned within the WNC area.

Previous studies of ground vibration within WNC area listed below have been reviewed.

- RTS EIA (LTA, 2018)

7.2.1.2 Field Study

The baseline ground vibration monitoring will comprise of four (4) vibration monitoring stations for 2-day continuous measurements over a 48-hour period of vibration shown in Table 7.1. Monitoring locations shown in Figure 7.2 were selected to represent sensitive receptors located in close proximity to the Project site. The measurements will be in the form of maximum peak particle velocity (PPV) in Transverse, Vertical and Longitudinal direction, and its corresponding frequency. The detailed of ground vibration baseline report are presented in Appendix H.

Table 7.1 Ground vibration monitoring location

Station	Location	Type of receptor	Monitoring Period
V1	Turf between Admiralty Road West and Keramat Road	• Residential Areas • Fauna within secondary forest	31 Mar 2023 to 02 Apr 2023
V2	Outside of Republic Polytechnic Xperiential Hub	• Educational Institutions	06 Jan 2023 to 09 Jan 2023
V3	HDB Block 877 Woodlands Ave 9, Singapore 730877	• Residential Areas • Healthcare Facilities	06 Jan 2023 to 08 Jan 2023

Station	Location	Type of receptor	Monitoring Period
V4	Junction of North Coast Avenue and Admiralty Road West	• Industrial areas	13 Jan 2023 to 16 Jan 2023

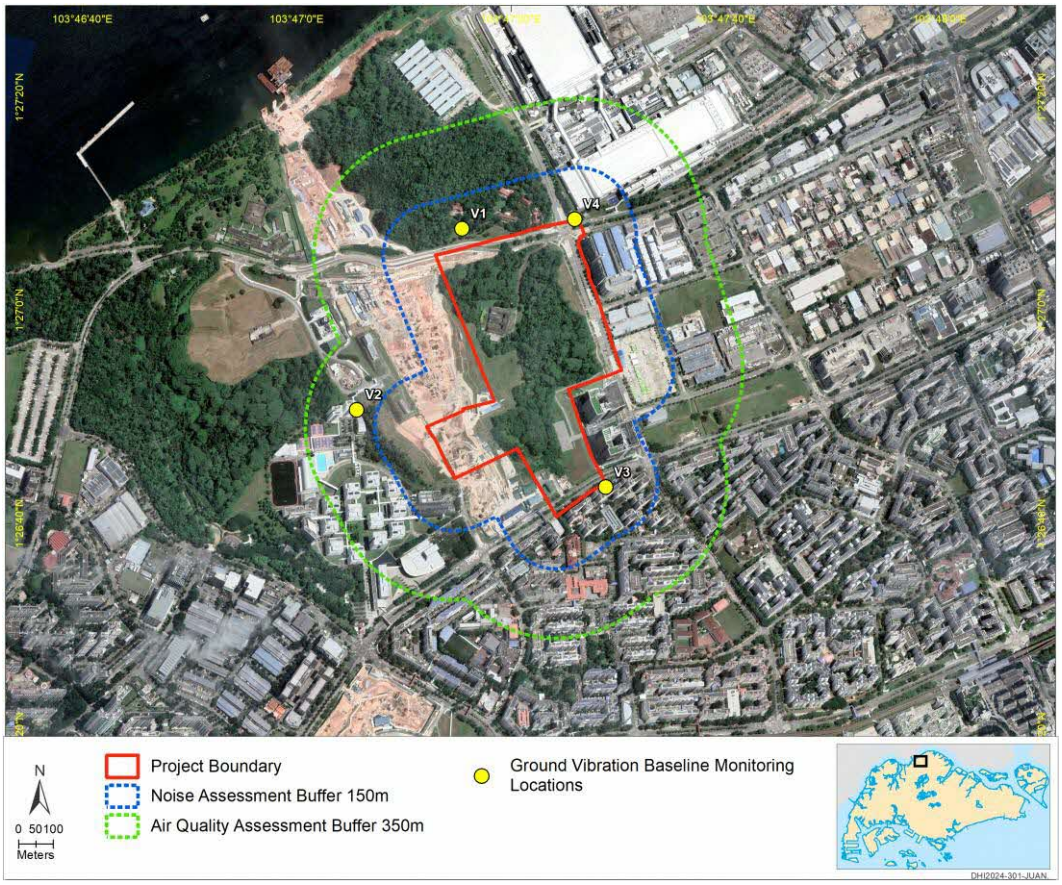


Figure 7.2 Ground Vibration Baseline Monitoring Locations (Satellite image as of 10 Mar 2022)

7.2.2 Findings

7.2.2.1 Desktop Study

In view of the expected construction activities listed in Section 2.3, ground vibration could be generated from the site clearance, blasting, excavation to level the land to designed level, mobilisation of equipment such as trucks, lorry crane, mobile cranes, and excavators into Project site and infrastructure works such as construction of roads, drains, sewer, utility service, buildings and landscaping works. However, vibration is expected to be contained within the Project site.

Review of Previous Studies

Vibration measurements from previous studies within the vicinity of Project Site will be referenced and compared with current primary data collected for airborne noise baseline study. Due to the confidentially and availability of the studies to the general public, please approach the respective agencies for detailed report information.

RTS EIA (LTA, 2018)

A short term baseline vibration survey was undertaken 8 July 2016 during the morning peak period. During the time, the highest vibration event was a maximum peak particle velocity of 0.36 mm/s. Magnitude of this level would be imperceptible to humans and given the relatively large distance between the construction site and identified receptors, the expected vibration levels during the day are classified as imperceptible at all receptors.

7.2.2.2 Field Study

Site surveys were conducted as per Section 7.2.1.2 to measure the baseline condition and the results were used to establish the initial conditions. Continuous measurements of triaxial movement in PPV were recorded for at least 2 days at each location, and the 95th percentile of the PPV in mm/s are presented to remove the outliers which could be due to physical disturbance by passerby and wildlife. The results are presented below.

Table 7.2 Results of baseline measurements of ground vibration level

Monitoring Station	Vibration level (PPV, mm/s)
V1 – Admiralty Forest / Boarding house	0.45 mm/s
V2 – Republic Polytechnic	0.35 mm/s
V3 - HDB Woodlands / Man Fut Tong Nursing Home	0.66 mm/s
V4 – Sensitive industry	0.55 mm/s

7.3 Impact Assessment Framework

7.3.1 Importance Rating of Sensitive Receptors

The type and sensitivity of Vibration Sensitive Receptors (VSRs) would be similar to ASRs. The assessment can be referred to Section 5.3.1.

7.3.1.1 Identified Sensitive Receptors and Importance

The vibration sensitive receivers with the 300 m survey corridor of the Project site are summarized in Table 7.3. The vibration sensitive receivers are also illustrated in Figure 7.3.

Table 7.3 Summary of Vibration Sensitive Receivers

Receiver ID	Description	Receiver Type
V01	Micron Semiconductor Asia Pte Ltd	Industrial (Sensitive) / Office
V02	Harvest @ Woodlands	Industrial
V03	Woodlands E-Terrace	Industrial
V04	7 North Coast Building	Industrial
V05	1 North Coast Building	Industrial
V06	876, 877, 878 Woodlands Avenue 9	Residential
V07	870, 871, 872 Woodlands Avenue 9	Residential
V08	Man Fut Tong Nursing Home	Healthcare
V09	Republic Polytechnic	Educational
V10	Admiralty Forest	Fauna
V11	Boarding House at Keramat Road	Residential

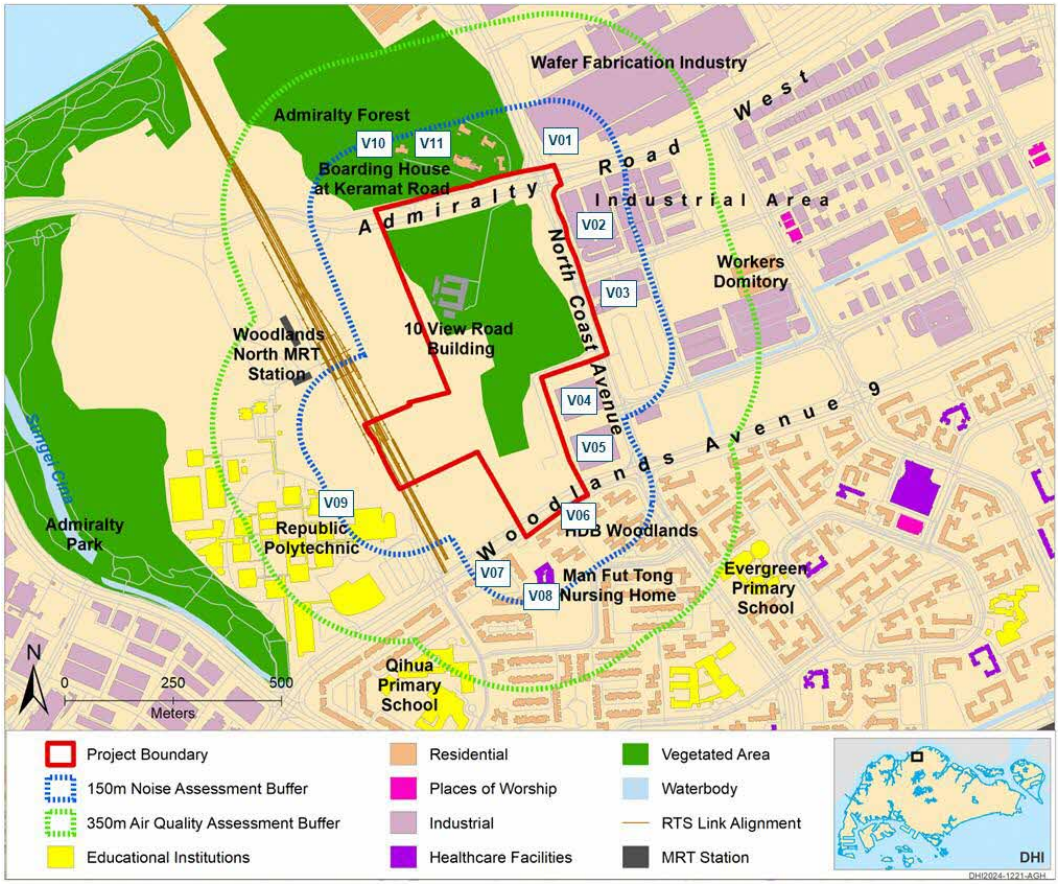


Figure 7.3 Location of Vibration Sensitive Receivers

7.3.2 Magnitude of Change

Vibration criteria for human comfort have been based on the guidance of British Standards BS 5228-2 (2009) and ASHRAE Handbook (2023).

BS 5228-2 (2009) provides simple criteria in terms of the overall peak particle velocity (PPV). PPV is a parameter that only considers the overall level of the vibration source. The proposed impact criteria for vibration (PPV) are outlined in Table 7.4 below.

From our experience on construction vibration loggers, majority of vibration equipment available in the market are in PPV. PPV may be used to set the trigger level on the vibration monitoring loggers during construction.

Table 7.4 Proposed Impact Criteria for Human Comfort Vibration (PPV)

Vibration Level (PPV)	Effect
0.14 mm/s	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.
0.3 mm/s	Vibration might be just perceptible in residential environments.
1.0 mm/s	It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.
10 mm/s	Vibration is likely to be intolerable for any more than a very brief exposure to this level in most building environments.

ASHRAE Handbook (2019) provides more comprehensive vibration criteria in terms of the root mean square (RMS) and in one-third octave bands. These are also known as the vibration criterion (VC) curves and are provided in Figure 7.1. Based on our past project experience on wafer fabrication facilities, it is understood that the vibration criteria for such facilities are in the range of VC-B to VC-D. The proposed vibration criteria for Micron Semiconductor is provided in Table 7.5 and is based on the more stringent criteria. VC-D.

Table 7.5 ASHRAE Vibration Criterion for vibration sensitive receiver(s)

Receiver	Vibration Criteria
Micron Semiconductor Asia Pte Ltd (Wafer Fabrication Plant)	VC-D

The BS6472 (2008) criteria uses the Vibration Dose Value (VDV) metric, which is a more complicated parameter and is based on both the level and the duration of assessment during day and night periods. The VDV criteria is not recommended for this assessment as the duration of each construction activity during the day and night period are not known at this stage. In addition, the VDV parameter is not commonly measured on site during construction and will not be comparable to vibration data measured.

Table 7.6 Evaluation Framework for Magnitude of Change in Vibration Level for Human and Fauna Receptors

Score	Generic Criteria	Specific Criteria	
		Human Receptors	Fauna Receptors
-4	Major negative disadvantage or change	> 10 mm/s PPV	
		• Vibration is likely to be intolerable for any more than a very brief exposure to this level in most building environments.	• Affects entire population or a significant part of it causing a substantial decline in abundance or change in and recovery of the population (or another dependent on it) is not possible either at all or within several generations due to natural recruitment
-3	Moderate negative disadvantage or change	1 to 10 mm/s PPV	
		• It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.	• Effect causes a substantial change in abundance or reduction in distribution of a population over one or more generations but does not threaten the long-term viability or function of that population, or any population dependent on it
-2	Minor negative disadvantage or change	0.3 to 1 mm/s PPV	
		• Vibration might be just perceptible in residential environments.	• Effect does not cause a substantial change in the population of the species, or other species dependent on it
-1	Slight negative disadvantage or change	< 0.3 mm/s PPV	
		• < 0.3 mm/s PPV	• Effect is within the normal range of natural variation accustomed to by the population of the species
0	No impact	• Status quo	• Status quo

7.4 Prediction and Assessment of Impacts

7.4.1 Construction Vibration Modelling Methodology

Limited studies have been published on vibration due to mechanised constructions in various topologies. One of the largest studies published was from the UK Transport Research Laboratory (TRL), undertaken by Dr David Hiller (now Arup UK), and G Crabb in 2000. Arup has referred to Hiller and Crabb's (2000) research paper for this assessment.

The vibration propagation path assumption is illustrated in Figure 7.4. It shows that vibration propagates from the construction activity though the soil, into the building and to the receiver. For this assessment, the vibration levels have been predicted at the 2nd storey of the receiver to represent worst case vibration levels. Vibration levels typically attenuates as the vibration propagates to the higher storeys of a building and are amplified due to suspended slabs.

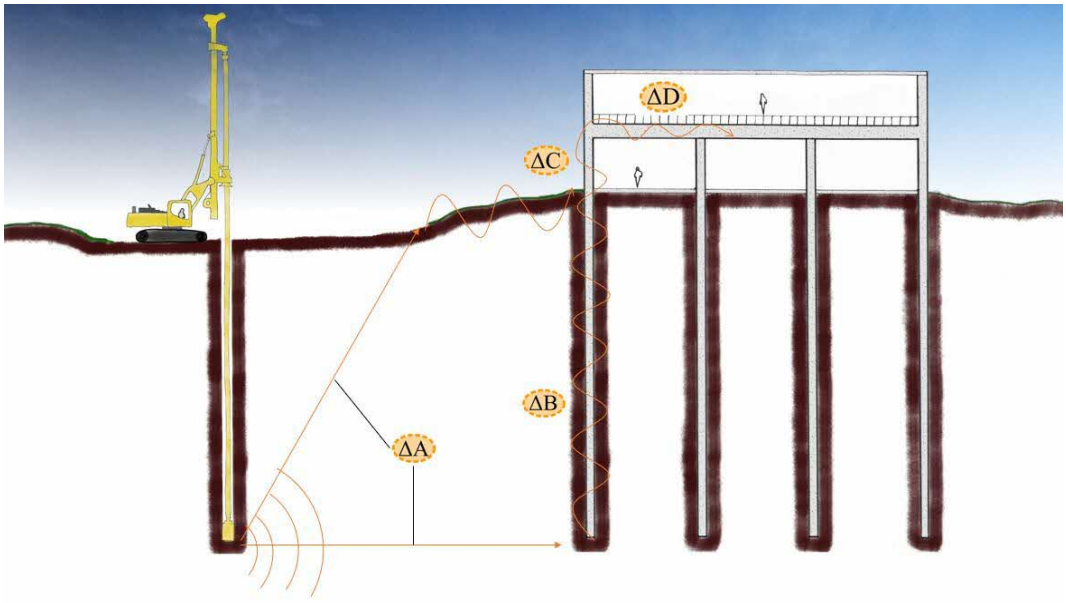


Figure 7.4 Conceptual Sketch Demonstrating the Vibration Propagation Path

The diagram in Figure 7.5 outlines the correction factors that are applied in the model to simulate the propagation path from the vibration source to the building floor slab. Each correction factor is explained further in the following sections.

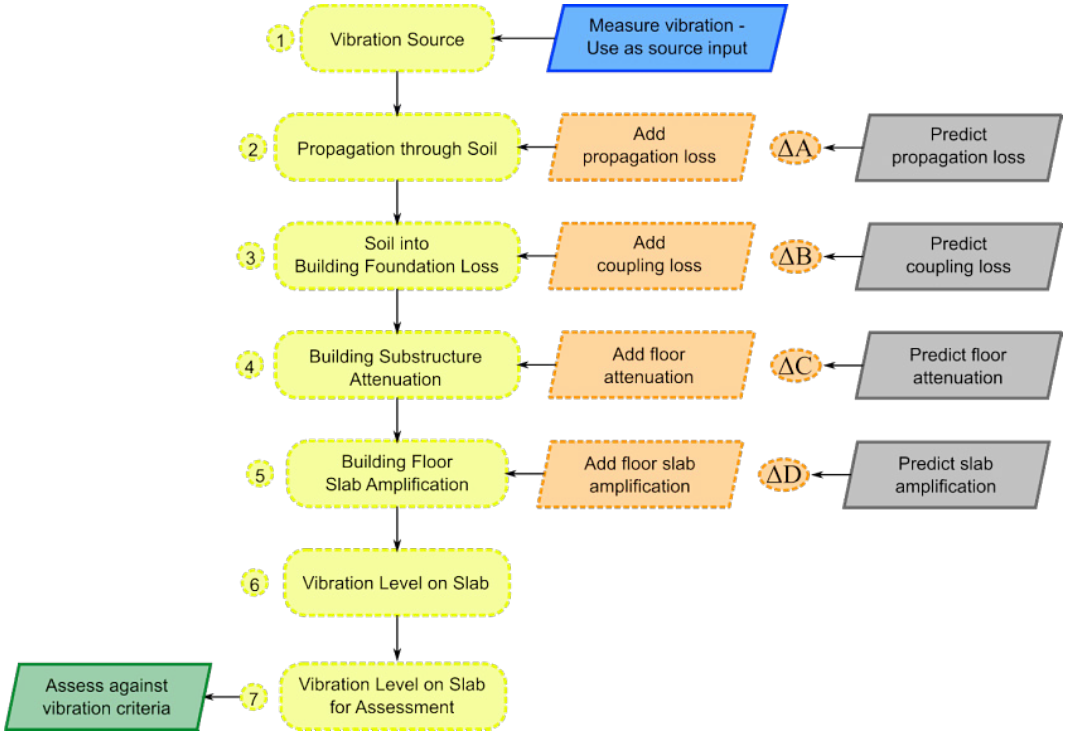


Figure 7.5 Vibration Assessment Methodology

Geometric Propagation Loss Through Soil, ΔA

As described in Hiller and Crabb (2000), the calculation of vibration at the receiver includes consideration of a geometric loss and damping loss. It was also noted that the range of distance with which civil engineering works are concerned is relatively small compared with geophysical seismic distances, and typically only a few wavelengths of the disturbance occur between source and receiver. Therefore, the equation for the geometric loss is provided below considering that the damping loss is negligible.

$$v_b = v_a \left(\frac{r_a}{r_b}\right)^{\gamma}$$

Where:

v_a is the vibration level known at location a

v_b is the vibration level known at location b

r_a is the distance from the source at location a

r_b is the distance from the source at location b

γ is the geometric propagation loss term

In this project, r_a and r_b refer to the horizontal distance from vibration source to each respective location.

Building Foundation Loss, ΔB

The building foundation loss is associated with the vibration in the ground transferring into the building structure. The amount of energy transfer and the spectrum of the vibration attenuation due to the building depend strongly on the building structure and type of foundation.

Nelson (1998) provided some typical values for attenuation from soil into buildings, generally referred to as “coupling loss”. Nelson provides attenuation losses from soil into Large Masonry Buildings on Piles, which is considered appropriate for this study.

Building Substructure Attenuation, ΔC

Generally speaking, it is expected that there will be small losses in levels as the vibration travels up the building. These floor-to-floor losses were converted into one-third octave centre band frequencies in this study. An attenuation of 1 dB is considered for frequencies below 31.5 Hz.

Building Floor Slab Amplification, ΔD

With respect to amplification of the building structure, this depends on the type of floor slab under consideration. For a slab on grade, the slab will be very well damped and also the mass of the earth below helps to reduce any potential amplification of the structure. For raised slabs (i.e. floor slabs which are not located at grade), additional amplification of certain frequencies will typically occur. This is due to the slab vibrating between its structural supports and can lead to significant amplification at its natural frequency (resonance). The natural frequency will be controlled by various factors including the thickness, spacing of supports, depth of beams, column spacing and materials. For these reasons, it is generally considered to be best practice to locate vibration sensitive equipment on the ground floor (1st story) using a slab on grade. Arup has adopted the typical amplification spectra from Nelson (1998) for typical raised concrete floor slabs.

Wafer fabrication facilities

In Arup’s experience, wafer fabrication facilities are generally built with sensitive equipment located on the 2nd story (or higher) so that connections to supporting mechanical plant

equipment can be provided from below. Therefore, due to the vibration sensitive nature of the equipment, the slabs must be specially built to avoid otherwise potentially severe amplification. Therefore, wafer fabrication slabs are generally constructed using very stiff waffle slab construction with closely spaced deep beams (typically 500–1000 mm deep) in both directions, creating a slab with high stiffness and mass. Such a slab may have a resonant frequency in the range of 20–30 Hz, considerably higher than those in typical commercial buildings. Due to the high mass and stiffness of these slabs, there is also likely to be reduced amplification of the slab compared with a conventional concrete slab construction. Amplification in this range may be quite low. Arup has assumed a 2 dB amplification in the 20–30 Hz.

It has been assumed that future wafer fabrication facilities use a waffle slab type construction as described above.

7.4.2 Construction Phase

Vibration measurements were previously conducted by Arup at various locations in Singapore in response to different construction activities. The vibration measurement data was utilized as the input for predicting vibrations.

An assessment has been carried out for major vibration-generating construction activities in granite. These include:

Demolition of 10 View Road (if any)

- Breaker

Construction activities

- Construction of buildings
    - Bored piling
    - Diaphragm wall construction (D-wall construction)
- Construction of roads
    - Breaker
    - Milling

There is an ongoing study for 10 View Road and surrounding area. The impact assessment is based on MP2019 parameters in which the entire Project area would be cleared for development works. Hence potential impact from demolition works is considered.

The predicted vibration levels due to bored piling are expected to result in a Slight negative impact at two of the vibration sensitive receivers – 1 and 7 North Coast Building. The vibration levels are predicted to exceed 1.0 mm/s at the higher end of the predicted range. According to BS 5228-2 (also reproduced in Table 7.4), it is likely that these vibration levels can cause complaint but can be tolerated if prior warning is given.

Similarly, it is predicted that the higher end of the range of vibration levels for few ecological and residential sensitive receiver locations, including Admiralty Forest, Boarding House at Keramat Road, and HDB Woodlands Avenue Block 876, will result in a Slight negative impact with PPV of 0.3 - 0.41 mm/s due to bored piling. According to BS 5228-2, vibration of this level might just be perceptible in residential environments.

Vibration levels at the industrial premises to the east of the Project site is predicted to be up to 0.42 – 0.64 mm/s at the higher end. With the relatively higher background vibration levels anticipated at industrial premises, workers at these locations are expected to be adapted to the background vibration levels and less sensitive to the change caused by the construction works at the Project site.

Mitigation measures such as carrying out the construction works further away from the vibration sensitive receivers and using low vibration construction techniques are recommended and discussed further in Section 7.5.

7.4.2.1 Bored Piling

The predicted construction vibration levels at the vibration sensitive receivers due to bored piling are summarized in Table 7.7 and Table 7.8.

Table 7.7 Predicted Construction Vibration due to Bored Piling (PPV)

Receiver ID	Description	Predicted Vibration (mm/s, PPV)	Magnitude Score
V01	Micron Semiconductor Asia Pte Ltd (Office)	< 0.3	-1
V02	Harvest @ Woodlands	0.13 – 0.42	-2
V03	Woodlands E-Terrace	0.20 – 0.64	-2
V04	7 North Coast Building	0.39 – 1.25	-3
V05	1 North Coast Building	0.39 – 1.25	-3
V06	876, 877, 878 Woodlands Avenue 9	0.13 – 0.42	-2
V07	870, 871, 872 Woodlands Avenue 9	0.13 – 0.42	-2
V08	Man Fut Tong Nursing Home	< 0.3	-1
V09	Republic Polytechnic	0.13 – 0.42	-2
V10	Admiralty Forest	0.13 – 0.42	-2
V11	Boarding House at Keramat Road	0.13 – 0.42	-2

Table 7.8 Predicted Construction Vibration due to Bored Piling (ASHRAE Vibration Criteria Curves)

Receiver ID	Description	Vibration Criteria (ASHRAE Vibration Criteria Curves)	Predicted Vibration (ASHRAE Vibration Criteria Curves)
V01	Micron Semiconductor Asia Pte Ltd (Industrial-Sensitive)	VC-D	< VC-D

7.4.2.2 Diaphragm Wall Construction

The predicted construction vibration levels at the vibration sensitive receivers due to diaphragm wall construction are summarized in Table 7.9 and Table 7.10.

Table 7.9 Predicted Construction Vibration due to Diaphragm Wall Construction (PPV)

Receiver ID	Description	Predicted Vibration (mm/s, PPV)	Magnitude Score
V01	Micron Semiconductor Asia Pte Ltd (Office)	< 0.3	-1
V02	Harvest @ Woodlands	0.13 – 0.41	-2
V03	Woodlands E-Terrace	0.20 – 0.62	-2
V04	7 North Coast Building	0.39 – 1.22	-3
V05	1 North Coast Building	0.39 – 1.22	-3
V06	876, 877, 878 Woodlands Avenue 9	0.13 – 0.41	-2
V07	870, 871, 872 Woodlands Avenue 9	0.13 – 0.41	-2
V08	Man Fut Tong Nursing Home	< 0.3	-1
V09	Republic Polytechnic	0.13 – 0.41	-2
V10	Admiralty Forest	0.13 – 0.41	-2
V11	Boarding House at Keramat Road	0.13 – 0.41	-2

Table 7.10 Predicted Construction Vibration due to Diaphragm Wall Construction (ASHRAE Vibration Criteria Curves)

Receiver ID	Description	Vibration Criteria (ASHRAE Vibration Criteria Curves)	Predicted Vibration (ASHRAE Vibration Criteria Curves)
V01	Micron Semiconductor Asia Pte Ltd (Industrial-Sensitive)	VC-D	< VC-D

7.4.2.3 Breaker

The predicted construction vibration levels at the vibration sensitive receivers due to breaker activities are summarized in Table 7.11 and Table 7.12.

Table 7.11 Predicted Construction Vibration due to Breaker Activity (PPV)

Receiver ID	Description	Predicted Vibration (mm/s, PPV)	Magnitude Score
V01	Micron Semiconductor Asia Pte Ltd (Office)	< 0.3	-1
V02	Harvest @ Woodlands	< 0.3	-1
V03	Woodlands E-Terrace	< 0.3	-1
V04	7 North Coast Building	< 0.3	-1
V05	1 North Coast Building	< 0.3	-1
V06	876, 877, 878 Woodlands Avenue 9	< 0.3	-1
V07	870, 871, 872 Woodlands Avenue 9	< 0.3	-1
V08	Man Fut Tong Nursing Home	< 0.3	-1
V09	Republic Polytechnic	< 0.3	-1
V10	Admiralty Forest	< 0.3	-1
V11	Boarding House at Keramat Road	< 0.3	-1

Table 7.12 Predicted Construction Vibration due to Breaker Activity (ASHRAE Vibration Criteria Curves)

Receiver ID	Description	Vibration Criteria (ASHRAE Vibration Criteria Curves)	Predicted Vibration (ASHRAE Vibration Criteria Curves)
V01	Micron Semiconductor Asia Pte Ltd (Industrial-Sensitive)	VC-D	< VC-D

7.4.2.4 Milling

The predicted construction vibration levels at the vibration sensitive receivers due to milling activities are summarized in Table 7.13 and Table 7.14.

Table 7.13 Predicted Construction Vibration due to Milling Activity (PPV)

Receiver ID	Description	Predicted Vibration (mm/s, PPV)	Magnitude Score
V01	Micron Semiconductor Asia Pte Ltd (Office)	< 0.3	-1
V02	Harvest @ Woodlands	< 0.3	-1
V03	Woodlands E-Terrace	< 0.3	-1
V04	7 North Coast Building	< 0.3	-1
V05	1 North Coast Building	< 0.3	-1
V06	876, 877, 878 Woodlands Avenue 9	< 0.3	-1
V07	870, 871, 872 Woodlands Avenue 9	< 0.3	-1
V08	Man Fut Tong Nursing Home	< 0.3	-1
V09	Republic Polytechnic	< 0.3	-1
V10	Admiralty Forest	< 0.3	-1
V11	Boarding House at Keramat Road	< 0.3	-1

Table 7.14 Predicted Construction Vibration due to Milling Activity (ASHRAE Vibration Criteria Curves)

Receiver ID	Description	Vibration Criteria (ASHRAE Vibration Criteria Curves)	Predicted Vibration (ASHRAE Vibration Criteria Curves)
V01	Micron Semiconductor Asia Pte Ltd (Industrial-Sensitive)	VC-D	< VC-D

7.5 Proposed Mitigation Measures

7.5.1 Construction Phase

Based on the ground vibration predicted in Section 7.4.2, there are two vibration sensitive receivers (i.e., V6 and V7) that would result in “moderate” magnitude of change during bored piling and diaphragm wall construction. To reduce this magnitude of change, it is recommended that construction works be carried out at a minimum distance of 25 m and 30 m from the receivers when conducting bored piling and diaphragm wall construction, respectively. If buffer cannot be achieved, prior warning shall be given to the 1 & 7 North Coast building users.

Low vibration construction techniques (e.g. use non-vibratory equipment to avoid / minimise the impact of casing insertion during bored piling) are recommended to be implemented in the construction contracts.

It is also recommended that the Best Practicable Means in line with the British Standard BS5228-2:2009 be implemented during the construction stage. This will include the following as appropriate:

- The Contractor shall propose and justify effective, feasible and site-specific mitigation measures and conditions to minimise vibration and comply with the criteria. Mitigation measures shall be in the order of the following hierarchy of controls:

  a) Elimination

  b) Substitution

  c) Engineering control

  d) Administrative control

- Photographs, drawings and specifications for all mitigation measures shall be provided, where applicable.
- Careful selection of plant, construction methods and programming. Only plant conforming to relevant national or international standards, directives and recommendations on vibration emissions will be used.
- All equipment used on site shall be regularly maintained and shall be operated in a manner that minimises vibration as far as is practicable.
- Damaged plant and equipment shall not be used.
- Equipment not in use shall be shut down to reduce the amount of vibration generated by idling motors.

It should be recognized that the application of human response criteria, rather than conservative damage criteria, could significantly prolong project durations. This could lead to an increase in complaints and unreasonable cost implications. In these circumstances, careful action by the developer, including negotiation, public relations and property surveys might result in agreed levels of vibration in excess of those suggested in this assessment.

7.5.1.1 Bored Piling

The predicted construction vibration levels at the vibration sensitive receivers V04 and V05 due to bored piling at a buffer distance of 25 m are summarized in Table 7.15.

Table 7.15 Predicted Construction Vibration due to Bored Piling with Buffer Distance of 25 m (PPV)

Receiver ID	Description	Predicted Vibration (mm/s, PPV)	Magnitude Score
V04	7 North Coast Building	< 1.0	-2
V05	1 North Coast Building	< 1.0	-2

7.5.1.2 Diaphragm Wall Construction

The predicted construction vibration levels at the vibration sensitive receivers V04 and V05 due to diaphragm wall construction at a buffer distance of 30 m are summarized in Table 7.16 .

Table 7.16 Predicted Construction Vibration due to Diaphragm Wall Construction with Buffer Distance of 30 m (PPV)

Receiver ID	Description	Predicted Vibration (mm/s, PPV)	Magnitude Score
V04	7 North Coast Building	< 1.0	-2
V05	1 North Coast Building	< 1.0	-2

7.5.2 Post-Construction Phase

The future industrial uses in this area will be mostly general and light industries. Also, the sensitive receptors are separated from the Project site by existing main roads with busy traffic, which contributed to the background vibration at the sensitive receptors. Though machineries may be deployed subjected to the industries' need, large-scale heavy equipment which may cause significant vibration transmitting to the surrounding receptors is unlikely. In case large machines which may cause significant vibration is used, the business operator can consider mitigation measures such as setting back the vibration equipment away from the receivers, installing vibration isolators, placing the equipment on a slab-at-grade or stiff structure on case-by-case basis.

7.6 Residual Impact

7.6.1 Construction Phase

By setting back the construction activities away from the receptors as recommended, whereby bored piling will be carried out at a minimum of 25 m and for D-wall construction at a minimum of 30 m as a mitigation measure, vibration levels at V04 and V05 are predicted to remain below 1.0 mm/s, reducing the impact significance to Slight Impact.

Breaker and milling activities are not presented in RIAM summary in Section 7.7.1, as the assessment focuses on the highest vibration-generating activities. Both milling and breaker have negligible impact with vibration levels below 0.3mm/s.

7.6.2 Post-Construction Phase

The future general and light industries are not expected to cause significant vibration impact at the sensitive receptors in the vicinity of the Project site. Furthermore, with the installation of vibration isolators or carefully locating the vibration generating activities away from the receptor, it is anticipated that the significance of vibration impact will be negligible.

7.7 RIAM Summary

7.7.1 Construction Phase

Table 7.17 Summary of impact assessment for Vibration impacts for the construction phase. The change in impact Magnitude following mitigation (if any), and the residual impact Significance is also shown. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score)

Activity	Sensitive Receptors	Predicted impacts without mitigation measures							With mitigation measures		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Demolition of 10 view road (If any)	Fauna (Admiralty Forest)	3	-1	2	2	2	-18	Slight negative impact	-	-	Slight negative impact
	Residential areas	3	-1	2	2	2	-18	Slight negative impact	-	-	Slight negative impact
	Educational institutions	2	-1	2	2	2	-12	Slight negative impact	-	-	Slight negative impact
	Healthcare facilities	4	-1	2	2	2	-24	Slight negative impact	-	-	Slight negative impact
	Industrial areas (1 & 7 North Coast Building)	2	-1	2	2	2	-12	Slight negative impact	-	-	Slight negative impact
	Industrial areas	2	-1	2	2	2	-12	Slight negative impact	-	-	Slight negative impact
Construction activities (Bored pilling and D-wall construction)	Fauna (Admiralty Forest)	3	-2	2	2	2	-36	Slight negative impact	-	-	Slight negative impact
	Residential areas	3	-2	2	2	2	-36	Slight negative impact	-	-	Slight negative impact
	Educational institutions	2	-2	2	2	2	-24	Slight negative impact	-	-	Slight negative impact
	Healthcare facilities	4	-1	2	2	2	-24	Slight negative impact	-	-	Slight negative impact

Activity	Sensitive Receptors	Predicted impacts without mitigation measures							With mitigation measures		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
	Industrial areas (1 & 7 North Coast Building)	2	-3	2	2	2	-36	Slight negative impact	-2	-24	Slight negative impact
	Industrial areas	2	-1	2	2	2	-12	Slight negative impact	-	-	Slight negative impact

7.7.2 Post-Construction Phase

Table 7.18 Summary of impact assessment for Vibration impacts for the post-construction phase. The change in impact Magnitude following mitigation (if any), and the residual impact Significance is also shown. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score)

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures						
		I	M	P	R	C	ES	Impact Significance
Vibration from WNC operation	Fauna (Admiralty Forest)	3	0	2	2	2	0	No impact
	Residential areas	3	0	2	2	2	0	No impact
	Educational institutions	2	0	2	2	2	0	No impact
	Healthcare facilities	4	0	2	2	2	-24	No impact
	Industrial areas (1 & 7 North Coast Building)	2	0	2	2	2	0	No impact
	Industrial areas	2	0	2	2	2	0	No impact

8 Light

Light pollution generally refers to the encroachment of artificial light into unlit areas, which include residential districts and in particular nature areas, where nocturnal and crepuscular wildlife may be impacted. Sources of light pollution vary widely and can consist of public (street) and residential (domestic) lighting, construction and architectural lighting, and lighting from public and private vehicular transportation. These pollution sources can occur throughout the different phases of the Project. Ancillary and/or auxiliary lighting installed for facilities during the construction and operational/commissioning phases of the Project, for instance, may impact the ecological and behavioural patterns of fauna species adjacent to the site. This section presents the applicable legislation, standards and guidelines, baseline ambient light levels, prediction and assessment of the significance of light pollution impacts generated during the Project's operation phase, as well as recommendation of suitable mitigation measures and the residual impacts.

8.1 Applicable Legislation, Guidelines and Standards

There are currently no legislations or regulations for light pollution in Singapore that pertain to ecological receptors and impacts. Nonetheless, international organisations such as the Institution of Lighting Professionals (ILP, 2013) and Buglife: The Invertebrate Trust (Bruce-White and Shardlow, 2011) advocate considering the potential for light pollution impacts on wildlife as part of the scoping process for EIAs. While the assessment of light pollution impacts on fauna and human receptors is gradually gaining traction in EIAs conducted in Singapore, the quantification of baseline ambient light levels was rarely conducted in these EIAs. Moreover, among the few studies where baseline ambient light levels were quantified, they were typically limited to readings taken from a single timepoint instead of time-series data logged over weeks. Therefore, the baseline ambient light study conducted in this EIA can be viewed as contributing to knowledge gaps.

8.1.1 Local Guidelines

The Land Transport Authority (LTA) of Singapore provides guidelines on illuminance levels for public street lighting (LTA, 2019). The LTA guidelines are presented in Table 8.1.

Table 8.1 LTA Guidelines for public street lighting.

Road Lighting Levels		
Type of Roads	**Minimum Average Illuminance (at floor level)**	
Expressway and Major Road	20 lux	
Expressway and Major Road conflict area	1.5x (e.g. 30 lux)	
Minor and Residential Road	10 lux	
Minor and Residential Road conflict area	1.5x (e.g. 15 lux)	
Footpath Lighting Levels		
Type of Footpath	**Minimum Average Illuminance (at floor level)**	**Uniformity**
Alongside with public streetlights (without dedicated footpath lightings)	5 lux	NA
Footpath (with dedicated footpath lightings)	10 lux	0.25

While not entirely related to light spill, NParks in 2022 released 'Bird-Safe Building Guidelines' which include proposed mitigation measures for reducing light spill, preventing bird strikes and entrapment within illumination zones; particularly for nocturnal birds and night-flying migratory birds (NParks, 2022). Some of the proposed mitigation measures include:

- Lighting design that minimizes light spill (I.e., shielded and downward pointing lighting)
- Internal features such as automated blinds and curtains that still allow for light transmission
- Use of treated glass to reduce light transmission
- Application of external features onto glass, such as decals and stickers
- Use of automated lighting controls to reduce indoor lighting at night, which in turn mitigates bird strikes by night-flying birds

8.1.2 Guidelines in Other Countries

Australia

Guidelines pertaining to light pollution for wildlife are present in other countries. For instance, the Australian government in 2020 developed the National Light Pollution Guidelines for Wildlife including Marine Turtles, Seabirds and Migratory Shorebirds (Department of the Environment and Energy Australia, 2020). The latter was subsequently updated in May 2023 (Department of the Environment and Energy Australia, 2023). In particular, the Guidelines provide a framework that includes best practises for lighting design that accounts for wildlife and nature areas. Some of the recommendations are as follows:

- Always using Best Practice Lighting Design to reduce light pollution and minimise the effect on wildlife.
- Undertaking an Environmental Impact Assessment for effects of artificial light on listed species for which artificial light has been demonstrated to affect behaviour, survivorship or reproduction.
- Checklist for Artificial Light Management.
- These Guidelines provide technical information to inform the management of artificial light for Australia's *Environment Protection and Biodiversity Conservation Act (1999)* (EPBC Act).

United Kingdom

In the United Kingdom, applicable guidelines on lighting impacts on wildlife are developed by various non-governmental organisations, with notable examples being the Bat Conservation Trust and Buglife: The Invertebrate Conservation Trust. The *Interim Guidance: Recommendations to help minimise the impact artificial lighting* (Bat Conservation Trust, 2014) provides recommendations to help minimise the impact of artificial lighting on wildlife, including:

- Usage of narrow spectrum light sources to lower the range of species affected by lighting
- Usage of light sources that emit minimal ultra-violet light
- Avoid white and blue wavelengths of the light spectrum to reduce insect attraction and where white light sources are necessary, they should be of a warm / neutral colour temperature <4,200 Kelvin (K) in order to manage the blue short wave length content
- Lights used should have a peak wavelength higher than 550 nm

These recommendations are also concurred by the guidelines published by Buglife (2011), which has further details and recommendations that are more specific to invertebrates, which form the base of terrestrial food webs and hence have knock-on effects across the trophic levels.

A UK professional engineering institution – the Institution of Lighting Professionals, has published a guidance note on the evaluation of lighting impacts, including on wildlife, in Environmental Impact Assessments (ILP, 2013).

8.2 Baseline Study

To obtain an understanding of the ambient light levels at the Project site prior to the construction phase, baseline data are required. This section details the data collection methods and findings from the baseline study.

8.2.1 Methodology

To date, there have not been historical ambient light studies nor data relevant to the Project site. To establish baseline data, a baseline light survey with three ambient light monitoring locations was conducted. Each survey location was chosen to represent sensitive receptors across various categories, as well as the possibility of experiencing altered lighting conditions during the construction and operational phase of the development.

Measurements of ambient light intensity (lux levels) was continuously logged on a 5-minute interval over a 14-day period covering both weekdays and weekends, from 6-19 January 2023, using HOBO Pendant Temperature/Light Data Logger MX2202 (ONSET, Bourne, MA, USA) (Figure 8.1). The light sensors on the loggers were oriented on the horizontal plane facing upwards for standardisation. Lux level data is then summarised and presented in tabular and temporal (time-series) graphical form.

Baseline lux level measurements was processed to obtain the mean daily values, and the mean daily maximum and minimum values, and mean nocturnal (defined as the time period from 2000h to 0600h) values at each monitoring station to facilitate the evaluation of existing light pollution levels.

Figure 8.1 HOBO Pendant MX2202 Temperature and Light Data Logger deployed during the baseline study.

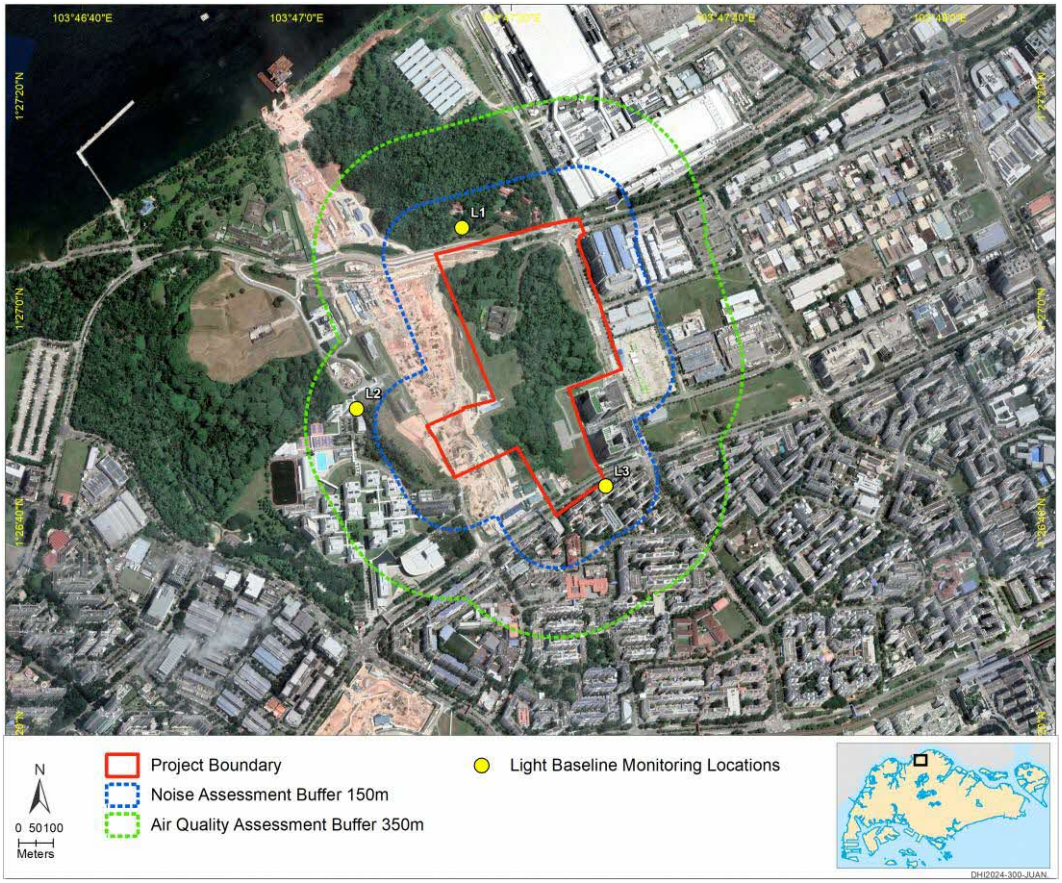


Figure 8.2 Deployment locations of micro-loggers (HOBO MX2202) for ambient light baseline (Satellite image as of 10 Mar 2022)

The three (3) measurement locations were chosen at the nearest ecological and human sensitive receptors from the Project site. The Project footprint and buffer zones of 150m are indicated in Figure 8.2, and the three dataloggers and the representing sensitive receptors are listed in Table 8.2.

Table 8.2 Receptors sensitive to changes in ambient light at each baseline ambient light measurement location.

Baseline ambient light location ID	Sensitive Receptors
L1	• Residents at Keramat Road • Fauna within Admiralty forest
L2	• Residents at Republic Polytechnic Hostel
L3	• Residents at Woodlands Avenue 9 • Residents at Man Fut Tong Nursing Home

8.2.2 Findings

During the day, L2 recorded the highest daily maximum and mean light levels, followed by L1 and L3 (Table 8.3; Figure 8.3). The micro-loggers that were deployed at locations L1 and L2 were open areas that were relatively unsheltered, whereas L3 is sheltered by the

buildings of HDB residential apartments at times during the day. The contrasting daytime ambient light levels across the three sites generally reflects the availability of shade cast by adjacent structures or vegetation cover.

Ambient light levels during the night exhibited a general absence of light pollution, with L3 having the highest levels (≈ 5 lux) (Table 8.3), which was expected due to the site being a residential area with street lighting turned on throughout nocturnal hours. Graphical illustrations for day and night light levels are shown in Figure 8.3 & Figure 8.4.

The mean nocturnal ambient light levels recorded at L1 and L2 were negligible (Table 8.3), indicating little to no light pollution, and reflecting the rapid decay of nocturnal ambient light levels with distance from artificial light sources, e.g. L2 was located approximately 20 m from the nearest light street lighting and yet recorded a mean nocturnal ambient light level of close to 0 lux. Whereas the mean light level recorded at L3 was ≈ 5 lux, which is in line with LTA's street lightning guidelines for public footpaths (Table 8.1). The latter level recorded is likely due to the presence of artificial lighting adjacent to the datalogger.

Table 8.3 Ambient Light Levels Recorded at Light-Sensitive Receptors.

Light Level Statistics (Mean)	Mean (Lux)		
	L1	L2	L3
Daily maximum light level	84711.9	95592.6	61032.4
Daily mean light level	14192.9	16091.3	6266.8
Nocturnal* mean light level	0.0177	0.0206	4.978
Daily minimum light level	0	0	4.7

* Nocturnal hours from 2000h-0600h

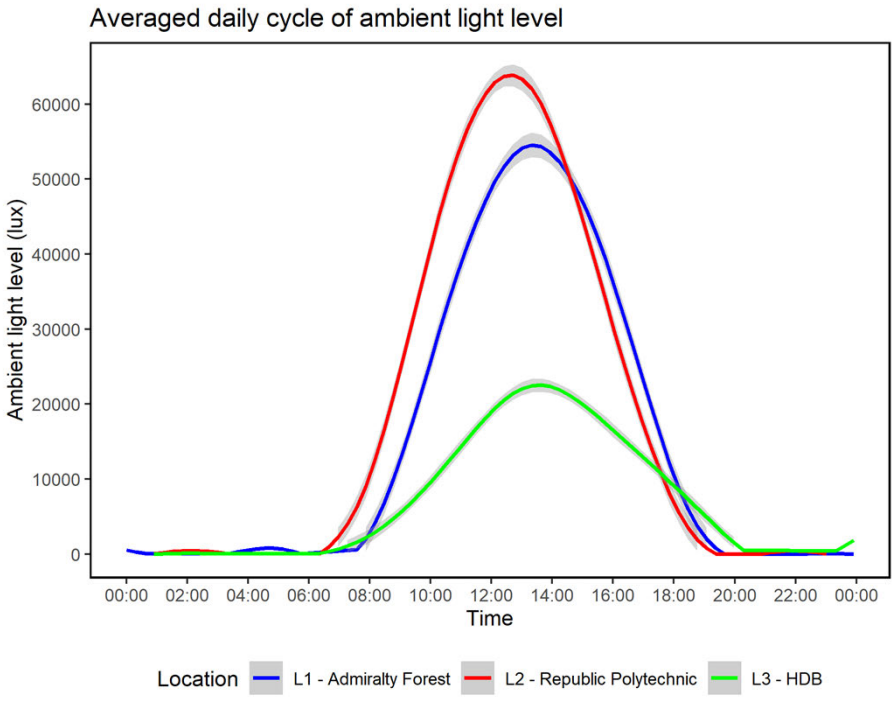


Figure 8.3 Averaged daily diurnal cycle of ambient light level.

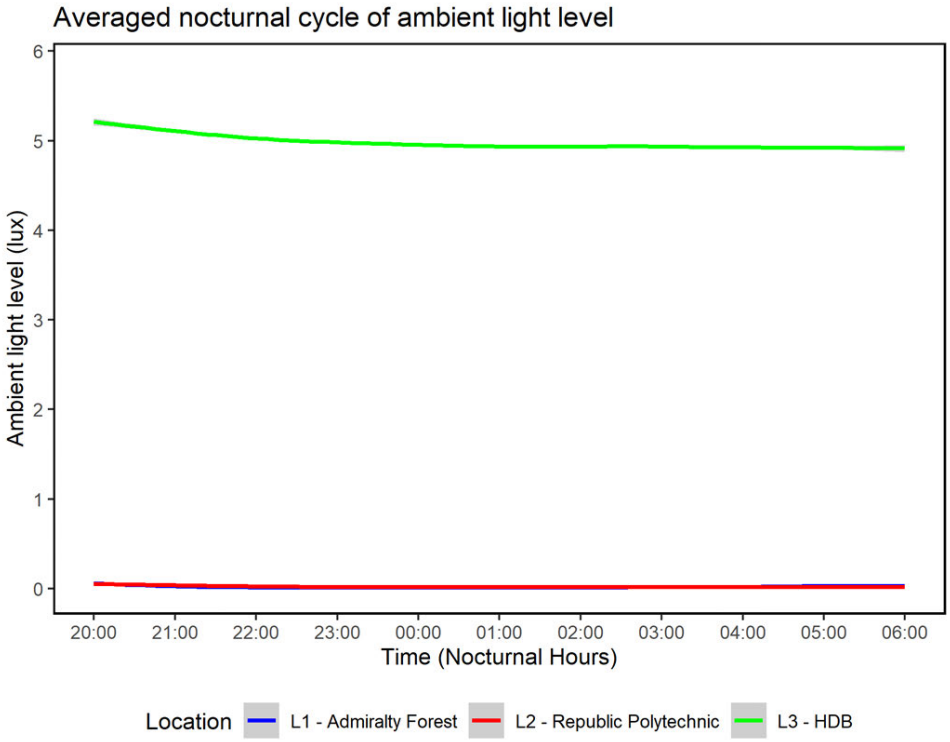


Figure 8.4 Averaged nocturnal cycle of ambient light level.

8.3 Impact Assessment Framework

8.3.1 Importance Rating of Sensitive Receptors

The evaluation framework for importance of sensitive receptors and magnitude of change defined for the lighting impact assessment is presented in Table 8.4.

Table 8.4 Evaluation Framework for Importance of Light-Sensitive Receptors

Score	Socio-economic	Ecological
5	• Locations where light-sensitive activities such as sleep are of high importance by the more sensitive members of the public, e.g., hospitals and polyclinics • Locations with existing very low ambient light levels	• Locations where the receptors affected are specifically protected by national or international policies or legislation and are of high importance at the regional or national scale, e.g., fauna (nocturnal and crepuscular fauna) in Nature Reserves, Nature Areas, ASEAN Heritage Park • Populations mainly residing deep within forests, not urban-adapted and highly susceptible to ALAN
4	• Locations where more sensitive members of the public are exposed for eight hours or more in a day, e.g., residential care homes	• Locations where the receptors affected are of moderate importance at the regional or national scale, e.g., fauna in forested sites outside of

Score	Socio-economic	Ecological
	• Locations with existing low ambient light levels	designated nature reserves and nature areas • Populations mainly residing within forests and not urban-adapted
3	• Locations where light-sensitive activities such as sleep are of moderate importance by the members of the public, e.g., private residential, and dormitories • Locations with existing moderate ambient light levels • Locations where members of the public are exposed for eight hours or more in a day, e.g., residential properties and schools	• Locations where the receptors affected are important for the functioning and integrity of adjacent habitats, e.g., green corridors, biodiversity buffer area • Fauna accustomed to existing urban night lighting, but minor impacts are expected • Locations where the receptors affected contain specific species or taxa that are sensitive to ambient light levels
2	• Locations where the people exposed are workers and they may be exposed for eight hours or more in a day, for example, office, industrial and shop workers	• Locations where the receptors affected are with limited biodiversity and ecological value, e.g., grasslands and shrubland • Fauna populations accustomed to existing night lighting, but slight disturbances are still expected
1	• Receptors with transient exposure, for example recreational users of parks and playgrounds	• Locations where the receptors affected are with little to no biodiversity value, e.g., managed turf

8.3.1.1 Identified Sensitive Receptors and Importance

The identified sensitive receptors were further post stratified into two main receptors, namely fauna (biodiversity) and humans (socio-economic) and. The receptors were then accorded their respective importance scores based on Table 8.4 above, with justifications described in Table 8.5 below.

The sensitive receptors were identified based on the planned development, which excludes the existing area within the Project site.

Table 8.5 Relevant Light-Sensitive Receptors

Category	Ambient light sensitive receptor	Importance Score	Justification
Fauna	Terrestrial fauna at Admiralty Forest	3	• Wildlife is known to be sensitive to light levels, especially nocturnal species. Light pollution and excessive artificial light at night (ALAN) can therefore exert negative impacts on them.

Category	Ambient light sensitive receptor	Importance Score	Justification
			• The presence of bats (pollinators), owls (nocturnal predators) and non-volant mammals like civets (seed dispersers) within the Project site would therefore be affected by ambient levels.
Socio-economic	Hostel residents at Admiralty Forest HDB and Man Fut Tong Nursing Home Residents of Republic Polytechnic Hostel	3	• Hostel residents will spend a significant amount of time in their rooms, especially after work hours. • Students from the polytechnic are likely to be exposed as well. • Nursing home residents are likely to be residing within their premises for eight hours or more in a day, making them susceptible to excessive light pollution. • However, there are existing lighting within the compound and adjacent to it. Nonetheless, light pollution and excessive ALAN can therefore exert negative impacts on them.

8.3.2 Magnitude of Change

Table 8.6 Evaluation Framework for Magnitude of Change in Lighting

Score	Generic Criteria	Specific Criteria
-4	Major negative disadvantage or change	**General** • Predicted night lighting levels to be significantly higher than existing levels for an extended duration throughout the night **Biodiversity** • Populations are irretrievably compromised due to ALAN • High likelihood of behavioural changes within populations, and their extirpation from the current habitat **Socio-economic** • Residents are severely disturbed by visible lights • Excessive lights directly visible inside any room in the house leading to sleep disorder and other related health issues • High likelihood that residents will regularly lodge complaints to Authorities about excessive light trespass
-3	Moderate negative disadvantage or change	**General** • Predicted night lighting levels to be significantly higher than existing levels for a long duration throughout the night **Biodiversity**

Score	Generic Criteria	Specific Criteria
		• Populations are moderately disturbed due to ALAN • Moderate likelihood of behavioural changes within populations, and their extirpation from the current habitat • Discernible and fundamental changes to existing light levels, that would disturb populations **Socio-economic** • Residents are notably disturbed by visible lights and are likely to file complaints with the local authorities • Obtrusive light trespass and glare are present inside any room within the house, thereby affecting their quality of life • Sleep quality may be affected without window coverings
-2	Minor negative disadvantage or change	**General** • Predicted night lighting levels to be slightly higher than existing levels for a long duration throughout the night **Biodiversity** • Populations experience minor disturbance due to ALAN, but not to the extent that the overall condition of the populations are impaired in the long term • Low likelihood of behavioural changes within populations, and their extirpation from the current habitat **Socio-economic** • Residents are mildly disturbed by the visibility of lights within their homes, and may experience discomfort
-1	Slight negative disadvantage or change	**General** • Predicted night lighting levels to be slightly higher than existing levels for a short duration throughout the night **Biodiversity** • Populations experience slight disturbances due to ALAN • Very low likelihood of behavioural changes within populations, and their extirpation from the current habitat **Socio-economic** • Residents may notice the visibility of lights within their homes, but is unlikely to cause discomfort
0	No change	**General** • Little to no perceptible change to the night lighting conditions assessed as compared to the existing levels **Biodiversity** • Little to no disturbances on populations • Negligible likelihood of behavioural changes within populations, and their extirpation from the current habitat **Socio-economic** • Residents not affected nor disturbed by visibility of lights

8.4 Prediction and Assessment of Impacts

8.4.1 Construction Phase

8.4.1.1 Light Nuisance from Construction Site during Night-Time Works Residents

The Project footprint is situated in area adjacent to an educational institution and sizeable residential housing district, which serve as the main socio-economic receptors. The construction lighting from the Project may therefore affect these receptors.

Certain approved construction activities are carried out during night-time at the adjacent RTS work site. For this Project, although no night works have been planned thus far, auxiliary lighting for safety and industry purposes may still be required, further exacerbating the impacts of light spill into the nearby residential areas. This may have a negative impact to the circadian clock of residents', which is a 24-hour day/night cycle that has an influence on physiological activities. Difficulties adjusting the circadian clock can result in affects to people who rotate shifts or work at night, and delayed sleep–phase syndrome, in which people fall asleep late at night and struggle to wake up in time for work, school, or social engagements.

With reference to Table 8.6, the magnitude of the change is expected to be minor as the majority of the residents from the HDB along Woodlands Avenue 9 are already exposed to relatively high light levels, and changes to these levels due to Project activities are expected to be minimal. Overall, the duration of the impact is expected to be temporary in nature during the construction phase and is mitigable with proper lighting management, such as curtains, blinds and tinted windows, which are often already installed in households throughout Singapore.

The impact severity due to light nuisance from construction activities of the proposed Project to the nearby residents is therefore considered to be non-permanent, recoverable, non-cumulative and thus, the overall significance of this impact is considered to be slight negative.

Biodiversity

Artificial lighting at night (ALAN) can have adverse impacts on the ecosystem. The heightened presence of ALAN disrupts the circadian rhythms of animals and alters the day-night cycle for plants. This disruption may result in increased predation by diurnal carnivores on nocturnal animals, exhaustion for insects drawn to artificial light, disorientation and disturbance in foraging patterns for birds, as well as changes to the disturbance in foraging, communication, reproduction, and migratory patterns of various animals (Rich & Longcore, 2006; Falcón et al. 2020).

Exposure to ALAN can disorient birds and increase their exposure risks to predation (McLaren et al. 2018). It can also repel wildlife from passageways and corridors (Bliss-Ketchum et al. 2016), as well as light-adverse bats from their usual feeding grounds and travel pathways (Pauwels et al. 2019). Fireflies, which utilise bioluminescent signals for communication, is only able to achieve this process in the absence of ambient light (Longcore & Rich, 2004). Light pollution impacts the foraging behaviours of animals like fruit bats, leading to decreased activity and foraging in artificially illuminated regions. Given that fruit bats serve vital ecological roles as seed dispersers and pollinators, their diminished foraging activities could result in the decline of the pollination and seed-dispersal services they typically offer (Lewanzik & Voigt, 2014). These cumulative changes may lead to downstream impacts on ecosystem functions.

The planned construction works would expose the southern part of Admiralty Forest to potential light spill, thereby affecting the fauna residing within it. However, given the urban nature of the areas surrounding the forest, the fauna residing within Admiralty Forest are likely to be accustomed to some level of night lighting levels, particularly near the edge of the forest.

Thus, with reference to Table 8.6, the magnitude of the change is expected to be minor The duration of the impact is expected to be temporary in nature during the construction phase and is controllable with proper lighting management through EMMP.

Therefore, the impacts are deemed to be non-permanent, recoverable, non-cumulative, and thus, the overall significance of this impact is considered slight negative.

8.4.2 Post-Construction Phase

8.4.2.1 Light Nuisance from Future Building Operation

Residents

During the operational stage, source of light impacts will be derived from the operation of the proposed development where installation of artificial lightings is required to illuminate the associated ancillary and related facilities. There will therefore be an increased light source emission from the operation of the commercial buildings, new covered linkways, walkways, pedestrian overhead bridge, etc., and these fixtures would be permanent.

Considering an increase of light source emission from the pre-development ambient lighting conditions, the nature of impact from the proposed development is anticipated to be negative. In reference to Table 8.6, the magnitude of the change from the anticipated increased illuminance however is not expected to cause any significant impacts to nearby residential premises or care facilities is expected to be slight as the illuminance from commercial developments are typically designed to be localised to reduce spill light impacts on the nearby residential premises. Moreover, the existing public street lighting, residential lighting, commercial lighting and RTS construction lighting are light sources that residents are likely accustomed to. The overall potential light impacts are deemed to be permanent, irrecoverable, non-cumulative, but the overall significance of this impact is considered slight negative.

Biodiversity

The nature of light impacts on the terrestrial fauna in Admiralty Forest is anticipated to be negative in the long term given that the illuminance of the surrounding area is increased with the proposed development.

Fauna around the periphery of the Project site are already exposed to light spill emanating from existing lighting fixtures along the public roads and residential buildings in the vicinity, therefore the in incremental light pollution would result in minor disturbances to fauna, but have a very low likelihood of behavioural changes to populations. Further, it is likely that fauna receptors in the vicinity have developed some level of acclimatisation to their disturbed surroundings.

With reference to Table 8.6, the magnitude of the change is expected to be slight due to localised illuminance at the proposed development, and fauna utilizing the Nature Ways and forest edges have typically adapted to urban lightings. The potential light impacts are deemed to be permanent, irrecoverable, non-cumulative, and therefore the overall significance of this impact is considered minor negative.

Table 8.7 Evaluation of Lighting Impact During Construction Without Mitigation Measures. I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures						
		I	M	P	R	C	ES	Impact Significance
Light nuisance from construction night works (short term)	Residents	2	-1	2	2	2	-12	Slight negative
	Fauna	3	-2	2	2	2	-36	Slight negative
Light nuisance from future building operation (long term)	Residents	2	-1	3	2	2	-14	Slight negative
	Fauna	3	-2	3	2	2	-42	Minor negative

8.5 Proposed Mitigation Measures

8.5.1 Construction Phase

Table 8.8 Mitigation measures to ameliorate impacts of light pollution.

Hierarchy	Mitigation Measures
Avoidance	• Avoiding use of lighting that is not needed • Avoid construction works during night hours as much as practicable • Illumination with a high UV component should be avoided to reduce impacts on insects
Minimisation	• Checklist for Artificial Light Management / Night Works Management Plan • Lights should be pointed downwards and towards the interior of the site instead of resulting in spillage beyond the site boundary and into adjacent retained forest area. Shields can be installed for light fixtures near the site boundary to minimise light spillage into adjacent forest habitats • If needed outside operating hours, low lux level lighting with light shields shall be used along pathways, paved areas and in areas where public access cannot be prevented. • Where possible and safe, use motion sensor to activate lighting for less frequently accessed areas • Where possible and safe, have light sources be lower than the perimeter hoarding height • Lights operating at night should be of low wavelengths and narrow spectrum (Figure 8.5) • Limiting light intensity to the minimum possible levels while not compromising on safety requirements (Figure 8.6) • Managing the direction of light emissions, i.e. light should not be directed towards forest habitats (Figure 8.5) • Ensure all unnecessary lights are turned off at the end of any night works

Hierarchy	Mitigation Measures
	• When directing light sources, be aware of reflective surfaces that could reflect the directed light to sensitive areas • Site lighting locations should be reviewed regularly to ensure minimal impacts to surrounding terrestrial fauna receptors
Restoration	• N.A.
Offsets	

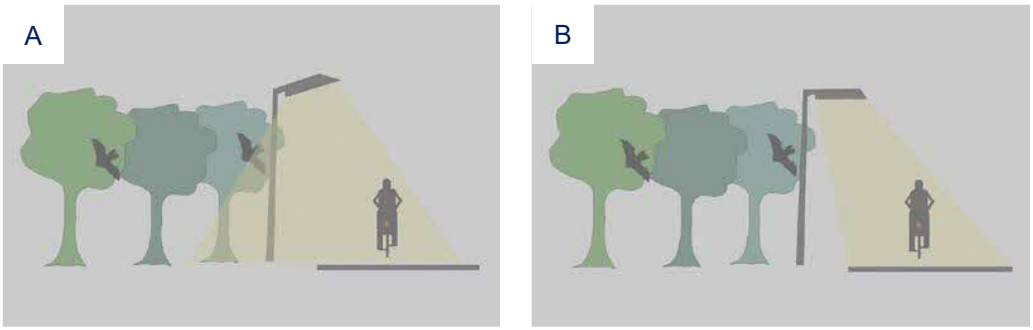


Figure 8.5 Best lighting practices to minimise/avoid light trespass. (A) Conventional design that results in light spillage towards adjacent forest habitat. (B) Shielded and angled lighting that focuses the light cone only on the area where is it needed (Adapted from Voigt et al. 2018).

Figure 8.6 Best lighting practices (Adapted from Mont-Mégantic International Dark Sky Reserve).

Should nightworks be required, a Night Works should be developed as part of the Construction EMMP prior to the commencement of works. This should detail the implementation plan for mitigation measures set out in Table 8.8, including layouts and designs of lights used, durations and activities which require night lighting, and roles and responsibilities pertaining to lighting management.

8.5.2 Post-Construction Phase

Table 8.9 Mitigation measures to ameliorate impacts of light pollution.

Hierarchy	Mitigation Measures
Avoidance	• Same proposed measures as in Table 8.8
Minimisation	• General measures same as proposed measures as in Table 8.8
	BCA Green Mark Certification Scheme • The Project site is part of the Woodlands Regional Centre, a government land sales (GLS) site (URA, 2023) • As part of the 2nd Green Building Masterplan, Green Mark certification (either Platinum or Gold^{PLUS} rating) is necessitated for any new development that fall under GLS programmes (BCA, 2023) • Prescribed Green Mark ratings have to be obtained before TOP/CSC can be granted • The Health & Wellbeing section of the Green Mark certification comprises the criteria 'HW2.2 Circadian Rhythm' which acknowledges the importance of the circadian rhythm in both humans and animals; as well as how light exposure impacts the latter. The following criteria are part of HW2.2's assessment matrix: • Views to Outside • Quality of Artificial Lighting • Circadian Lighting System • Additionally, lighting should adhere to MOM's minimum safety requirements for works to be performed at night: • SS 531 – 2: 2008: Code of Practice for Lighting of Work Places • SS 531 – 3: 2008: Lighting Requirements for Safety and Security of Outdoor Work Places
	Landscape Excellence Assessment Framework (LEAF) Certification to recognize the current best practices in landscape design and management. Lighting within and surrounding the development shall be designed with the following aspects in mind, in line with the LEAF assessment criteria: • Accessibility • Biodiversity Conservation • Community Wellbeing & Engagement • Design & Landscaping • Environmental Sustainability • Maintenance
Restoration	**BCA Green Mark Certification Scheme** • The Resilience section of the Green Mark certification programme allows for points to be scored via • 'RE3.1 Buildings in Nature' natural planting, which involves achieving a high Green Plot Ratio (GnPR), planting palette that comprises of >50% native species, and provision of 'wild landscape areas'

Hierarchy	Mitigation Measures
Offsets	• 'RE3.2 Natural Climate Solutions' involves the restoration of habitats (i.e., external tree planting and/or additional natural landscaping within building area) • Restoration of natural habitats, and native planting palette is recommended to be weaved into overall design plan, taking into account abovementioned pointers relating to lighting (e.g., setting of dark buffers) which can be considered as offsets for the increased light outputs from the overall development

8.6 Residual Impact

8.6.1 Construction Phase

Through the implementation of a night works management plan during the construction phase, the anticipated significance of light spillage and ALAN impacts associated with the various construction activities is expected to be reduced to slight or negligible levels. These measures, ranging from the use of light shields, low wavelength and narrow spectrum lights to the incorporation of wildlife-friendly lighting designs, are strategically designed to minimize light spill and ALAN. The cumulative effect of employing these mitigation strategies is outlined in Section 8.7.

8.6.2 Post-Construction Phase

Through the implementation of green building design via the Green Mark Certification scheme, which includes (but is not limited to) eco-friendly lighting technologies, efficient and sustainable energy usage, as well as biodiversity restoration and offsets (via landscaping and planting to restore dark buffers), the anticipated significance of light spill and ALAN impacts is anticipated to be minimized from minor to slight or negligible levels. The cumulative effect of employing these mitigation strategies is outlined in Section 8.7.

8.7 RIAM Summary

Summary RIAM table below for the construction phase, after mitigation measures (Table 8.10).

Table 8.10 Summary of impact assessment for ecological impacts for the construction phase. The change in impact Magnitude following mitigation (if any), and the residual impact Significance is also shown. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score)

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures							With mitigation measures		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Light nuisance from construction night works (short term)	Residents	3	-1	2	2	2	-18	Slight negative	0	0	No impact
	Fauna	3	-2	2	2	2	-36	Slight negative	-1	-18	Slight negative

Summary RIAM table below for post-construction phase, after mitigation measures (Table 8.11).

Table 8.11 Summary of impact assessment for ecological impacts for the post-construction phase. The change in impact Magnitude following mitigation (if any), and the residual impact Significance is also shown. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score)

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures							With mitigation measures		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Light nuisance from future building operation (long term)	Residents	3	-1	3	2	2	-21	Slight negative	0	0	No impact
	Fauna	3	-2	3	2	2	-42	Minor negative	-1	-21	Slight negative

9 Microclimate (Ambient Air Temperature)

The Urban Heat Island (UHI) effect is a phenomenon where the warmth (temperature) of both the atmosphere and surfaces in cities (urban areas) compared to their non-urbanized (rural) surroundings distinctly differ (Voogt, 2004) — due to heat being trapped within cities. Heat islands are caused by rapid and extensive urbanization, when man-made buildings and paved surfaces store heat during the day and then release it slowly during the evening, keeping urban localities hotter than its surrounding areas. These driving factors thereby create a climate where metropolitan city centres experience markedly higher temperatures as compared to their rural counterparts. In Singapore, a temperature difference of up to 7°C between urban and less built-up areas during the night has been documented through various studies and acknowledged by government agencies as the basis to develop mitigation techniques (SG101, 2022).

The UHI effect exerts impacts on human health, animal life, social events, tourism, water availability and business performance. The rise in temperature thus causes increased energy consumption (via air-conditioners), which inadvertently creates a vicious cycle of a warming urban climate. Cities experiencing the UHI effect also face increased vulnerabilities to heat waves from climate change. The impacts of heat waves are more pronounced in the tropics and affect outdoor workers. In serious events, heat waves do cause human mortality and should therefore be taken into consideration during environmental impact assessments.

Separately, the microclimatic environment (hereafter ‘microclimate’) of ecological communities is another parameter that can also be influenced by the UHI effect. In particular, edge-related forest effects arising from urbanisation impose negative impacts on forest communities, whereby forests 50-100m of edges experience greater fluctuations in light, temperature, and humidity levels during the day (Pohlman et al. 2009). As a result of these changes in microclimatic conditions, forest edges are typically drier and hotter that forest interiors, leading to increased tree mortality, canopy gaps, and a greater propensity for disturbance-adapted plants (e.g. weeds, vines & pioneer species) to grow and proliferate.

The multi-fold impacts of the UHI effect and microclimate on both human and ecological receptor therefore warrant their review during impact assessment.

9.1 Applicable Legislation, Guidelines and Standards

There are currently no legislations/regulations for the potential of developments to alter microclimatic conditions, in particular ambient air temperature, pertaining to ecological receptors.

9.1.1 Human Thermal Comfort Indices

Several metrics/indices for human thermal comfort, however, have been proposed and utilised in varying degrees. The overarching concept can be labelled as outdoor thermal comfort (OTC), with four main models identified by Dzyuban et al. (2022), that include the Universal Thermal Climate Index (UTCI), Perceived Temperature (PTj), Physiologically Equivalent Temperature (PET), and rational Standard Effective Temperature (SET).

In Singapore, the metric used for recent local studies was the Physiologically Equivalent Temperature (PET)[1]. Heng and Chow (2019) evaluated acceptable OTC ranges in Singapore Botanical Gardens, by analysing PET against thermal perception survey responses from 1,508 park goers. The estimated neutral temperature, where respondents experience neither heat nor cold stress, was deemed to be approximately 26.2°C; acceptable temperatures, when only slight heat or cold stress is experienced, ranged between 21.6°C and 31.6°C; and preferred ('ideal') temperature for all respondents is 24.2°C.

However, as only ambient air temperatures (see Section 9.2.1) were recorded during this study[2], only arbitral comparisons and qualitative assessments of ambient air temperature are made here. References to, and comparisons with international/local standards and guidelines are made as well.

9.1.2 International Guidelines on Heat and Health

The Intergovernmental Panel on Climate Change (IPCC) Report (2023) projected future temperature changes due to climate change impacts. In particular, risk of species losses (in percentage value %) and heat-humidity risks to human health (in daily mean surface temperature that) were used as metric to assess the potential risks and impacts of climate change (Figure 9.1).

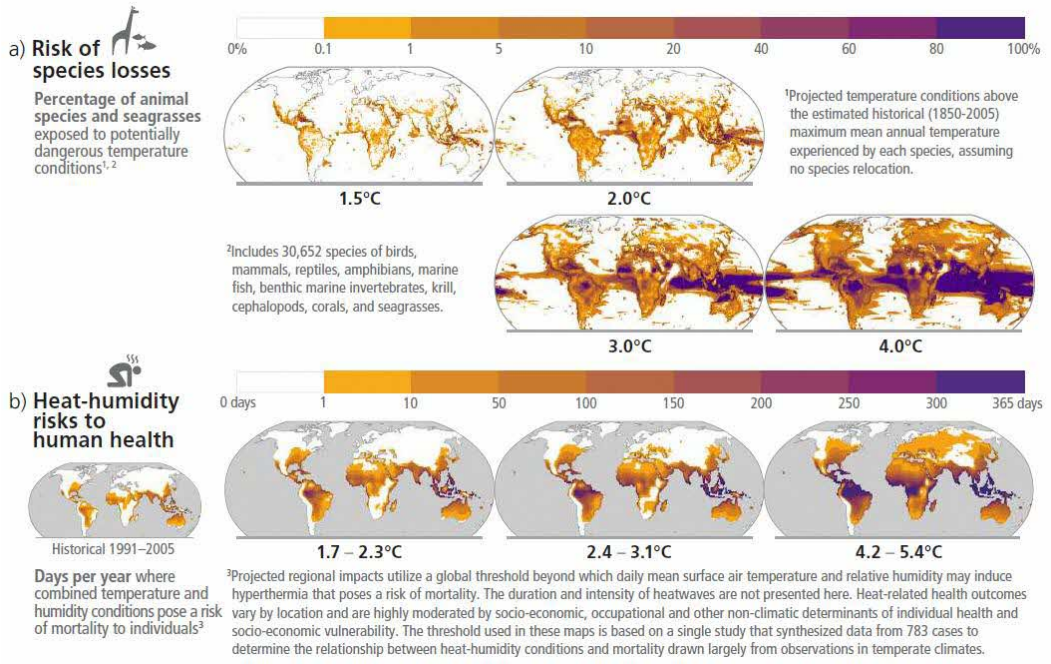


Figure 9.1 Projected risks and impacts of climate change on natural and human systems at different global warming levels (GWLs) relative to 1850-1900 levels (Source: IPCC Report, 2023).

Heatwaves that previously occurred once every decade in a climate with minimal human interference is projected to occur 4.1 times more frequently with 1.5°C of global warming,

[1] PET is 'the equivalent (air) temperature of an isothermal reference environment with a water vapour pressure of 12 hPa (50% at 20 °C) and light air (0.1 m s−1), at which the heat balance of a reference person is maintained with core and skin temperature equal to those under the conditions being assessed'.

[2] Other parameters such as humidity, wind velocity and globe temperature are required for PET, as demonstrated by Chow et al. (2016).

5.6 times with 2°C, and 9.4 times with 4°C. The intensities of these heatwaves are also projected to increase by 1.9°C, 2.6°C, and 5.1°C respectively (IPCC, 2023).

Additionally, both the World Health Organisation (WHO) (2018) and the United Nations Environment Programme (UNEP) (2021) further noted that extreme heat can have increasingly serious effects beyond ≥ 35°C, compounded further by high humidity (Zhang et al. 2011).

The United States Environmental Protection Agency (USEPA) also lists out how heat islands impact and compromise human health and comfort:

- *Older adults* – People within this group are among the most vulnerable to extreme heat events. Many physiological, psychological, and socioeconomic factors contribute to this danger. Older adults are more likely to be in poor health, to be less mobile and more isolated, to be more sensitive to high heat, and to live on reduced incomes (Gamble et al. 2013).
- *Young children* – People within this group tend to be more susceptible to extreme heat due to their small size and other characteristics. Children's more rapid breathing rates relative to body size, time spent outdoors, and their developing respiratory systems raise their chances of aggravated asthma and other lung diseases caused by ozone air pollution and smog, which usually increases during heat waves (US Climate Change Science Program, 2008).
- *Populations with low-income* – People within this group are at greater risk of heat-related illnesses due to poor housing conditions, including lack of air conditioning and small living spaces, and inadequate resources to find alternative shelter during a heat wave (US Climate Change Science Program, 2008).
- *People who spend their working hours outdoors* – People within this group are more prone to conditions such as heat exhaustion and heat stroke. They have higher exposures to ozone air pollution and heat stress, especially if work tasks involve heavy exertion.
- *People in poor health* – People within this group includes those with chronic conditions, disabilities, mobility constraints, and those taking certain medications, who are vulnerable to extreme temperatures. People with diabetes, physical impairments, and cognitive deficits are especially at risk during heat waves (US Climate Change Science Program, 2008).

9.1.3 Local (Singapore) Guidelines

In Singapore, the highest daily temperature of 37°C was recorded in Ang Mo Kio recently in May 2023, matching what was recorded in Tengah in 1983 (Woon, 2023). However, assessments of heat impacts on humans have to be localised and account for local climates (Dzyuban et al. 2022).

In particular, the Meteorological Service Singapore defines a heat wave occurrence, when the daily maximum temperature[3] is ≥ 35°C for three consecutive days, and the daily mean temperature[4] throughout the period is ≥ 29°C.

[3] Based on the daily maximum temperature and daily mean temperature averaged across three designated stations with long-term temperature records. Daily maximum temperature is defined as the highest temperature recorded for the day.

[4] Daily mean temperature is defined as the average of the hourly temperatures recorded for the day.

The impact assessment framework presented in Section 9.3 therefore makes reference to the international and local guidelines described above, and was fine-tuned for the Project with the local context taken into consideration.

9.2 Baseline Study

As historical data/studies on microclimate and ambient air temperature for the Project site were lacking, a 2-week baseline monitoring regime was implemented here.

9.2.1 Methodology

Microclimate represented by ambient air temperature was measured to obtain a representative baseline against which the magnitude of change in ambient air temperature during the Project's operation phase can be evaluated. It is known that vegetation and forest within urban area can reduce the UHI effect, via cooling capacity from transpiration, trapping moisture, and providing shade. The baseline ambient air temperature was measured across a forest-urban gradient – within the forest interior, at forest edge habitats, and within built-up areas.

Ambient air temperature was recorded using micro-data loggers with temperature accuracy of <±0.5°C – HOBO MX2202 (ONSET, Bourne, MA, USA). Each iButton logger was enclosed within a white PVC housing designed to shield against direct solar radiation but permit airflow, hence enhancing the reliability of temperature measurements. Each iButton logger was positioned at a standardised height of 1.5 m above the ground level (Figure 9.3). Temperature readings were taken at intervals of 5 minutes.

Ten (10) MX2202 loggers were deployed over a 18-day period (3 to 20 February 2023) to capture the spatial and temporal heterogeneities of ambient temperature. The locations were chosen to maximise the coverage across the various existing ground cover classes, i.e., forest interior and edge habitats, residential areas, built-up areas facing forest habitats and roads, and JTC business buildings (Figure 9.2). This broad coverage across ground cover classes provided sufficient data points for predicting future ambient air temperatures during the Project's operation stage.

Baseline microclimatic measurements of ambient temperature were processed to obtain the mean daily values, and the mean daily maximum and minimum values, to facilitate the evaluation of the urban heat island effect. Data is presented in tabular and temporal (time-series) graphical form. The point data obtained was also interpolated to create heat maps of existing temperatures for ease of visualisation.

Table 9.1 Relevant Sensitive Receptors and the respective land cover class represented by each temperature logger deployed.

Temperature Logger	Land Cover Class
M1	Building adjacent to forest
M2	Low rise building surrounded by forest
M3	Forest edge adjacent to another forest fragment (separated by road)
M4	Forest edge adjacent to buildings
M5	Forest interior > 50m from edge

Temperature Logger	Land Cover Class
M6	Open turf / ground
M7	Forest interior < 50m from edge
M8	JTC building adjacent to major road
M9	JTC building zone adjacent to urban areas
M10	HDB residential blocks adjacent to major road and JTC buildings

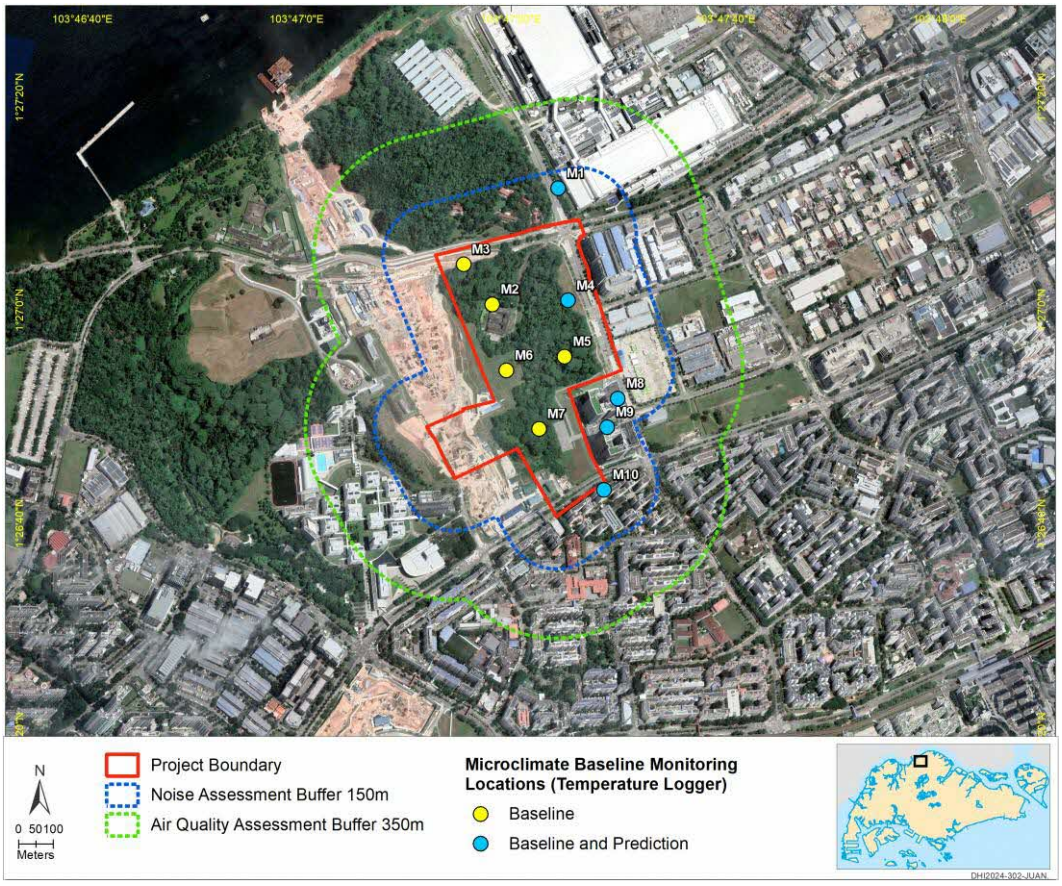


Figure 9.2 Deployment locations of temperature loggers, distributed to cover the various ground cover classes (e.g. forest interior, forest edge, grassland, roads, and buildings) (Satellite image as of 10 Mar 2022)

Figure 9.3 Dataloggers deployed at Project site, from a forest to urban gradient (From left to right: M5 – Forest interior, M4 – Forest edge & M9 – JTC building).

9.2.2 Findings

The temperature data exhibited a clear pattern across the forest-urban gradient, with the greatest divergence across survey locations observed in daily maximum temperatures, followed by daily mean temperatures (Table 9.2, Figure 9.4).

Overall, areas with open conditions resulted in highest daily maximum temperatures, reflecting the strong driver of solar irradiation on the land and hence air temperature. This was most evident at location M6, which was an open turf entirely devoid of canopy cover or other shading structures. In contrast, locations within forest interior conditions (M5 and M7) recorded the lowest daily maximum temperatures, reflecting both the shading effect provided by the canopy cover and evapotranspiration cooling from the multi-tiered vegetation.

Urbanised land cover was observed to exhibit elevated mean nocturnal temperatures that were marked greater than temperature in the forest interior, which could be the result of the Urban Heat Island effect. Specifically, > 2°C of divergence in daytime temperatures between forest interior and urban areas; and > 1°C of divergence in nocturnal temperatures, which points towards the presence of the UHI effect at JTC buildings (M9 & M10).

Table 9.2 Mean temperature dataloggers deployed across Project site. Values highlighted in red show the greatest value, blue indicates the lowest.

Land-cover Category	Location	Mean Temperature (°C)			
		Daily Minimum	Daily Mean	Daily Maximum	Nocturnal*
Forest interior	M5	23.80	25.93	29.48	24.94
	M7	24.00	26.56	31.40	25.20
Forest edge	M3	23.97	27.54	36.74	25.25
	M4	23.76	27.47	35.64	25.23
Semi-urban	M2	23.92	27.35	36.36	25.14
	M6	23.79	27.76	37.27	24.96
Urban	M1	24.44	27.68	35.50	25.76
	M8	24.79	27.64	33.46	26.01
	M9	24.41	27.34	34.55	25.67

Land-cover Category	Location	Mean Temperature (°C)			
		Daily Minimum	Daily Mean	Daily Maximum	Nocturnal*
	M10	24.65	27.44	33.92	25.90

** Nocturnal temperatures from 2000h-0600h*

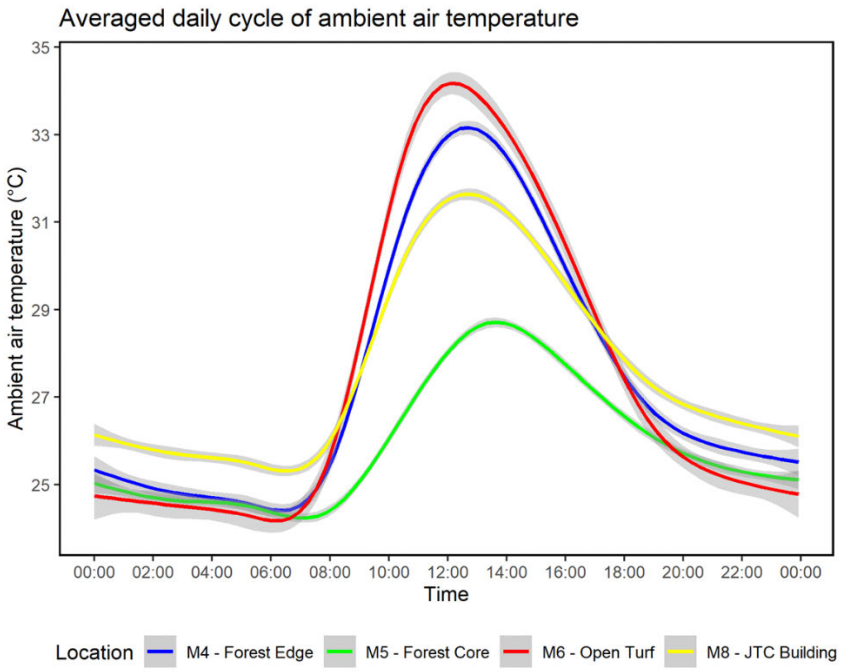


Figure 9.4 Graph of averaged daily cycle of ambient air temperature, for different land-cover categories (dataloggers M4, M5, M6 & M8).

For a better overall illustration of the ambient temperatures across the Project site, a heat map showing the distribution of temperature levels is shown in Figure 9.5 below. A divergence of > 1.7°C in daily mean temperatures was observed.

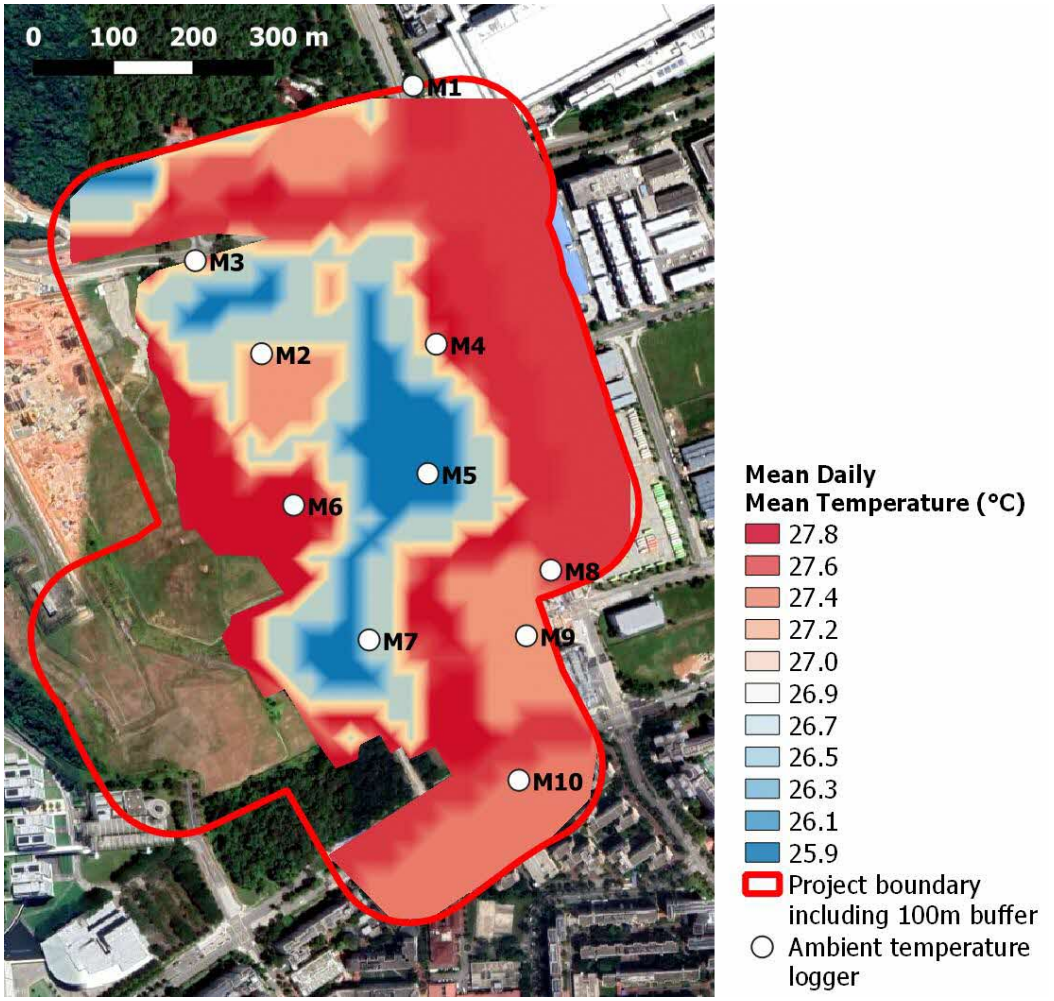


Figure 9.5 Heat map of mean daily temperatures across the Project Site. The construction area for RTS is excluded from the heat map interpolation.

Forest interior (M5) which is > 50m away from forest edge, has the lowest daily mean, daily maximum and nocturnal ambient temperature. For deviation in ambient air temperatures across the Project site, urban and semi-urban sites exhibited markedly higher deviation from forest interior in daily mean, daily maximum and nocturnal temperatures (Table 9.3), where a divergence of > 7°C was recorded in the mean daily maximum temperatures.

However, it is worth noting that the data collection period fell during abnormally cool temperatures during tail end of NE monsoon, which means that the general ambient temperature and any UHI effect may be underestimated.

Table 9.3 Δ Mean temperature across Project site. Values highlighted in red show the greatest value, blue indicates the lowest.

Land-cover Category	Location	Δ Mean Temperature (°C)^			
		Δ Daily Minimum	Δ Daily Mean	Δ Daily Maximum	Δ Nocturnal*
Forest interior	M5	0.04	-	-	-
	M7	0.24	0.62	1.91	0.26
Forest edge	M3	0.22	1.60	7.25	0.31
	M4	-	1.54	6.16	0.29
Semi-urban	M2	0.16	1.41	6.87	0.21
	M6	0.04	1.83	7.79	0.02
Urban	M9	0.65	1.41	5.07	0.73
	M10	0.90	1.51	4.44	0.96
	M8	1.04	1.70	3.98	1.07
	M1	0.68	1.74	6.01	0.83

** Nocturnal hours from 2000h-0600h*

^ The dashes (-) refer to the lower bound value from which Δ is calculated

Additionally, the mean daily temperature for the month of February 2023 was retrieved from the Meteorological Service Singapore and used as a reference (Figure 9.6). From which, it can be seen that the approximate mean daily temperature for the Project site was approximately between 26.0°C to 26.5°C during that period.

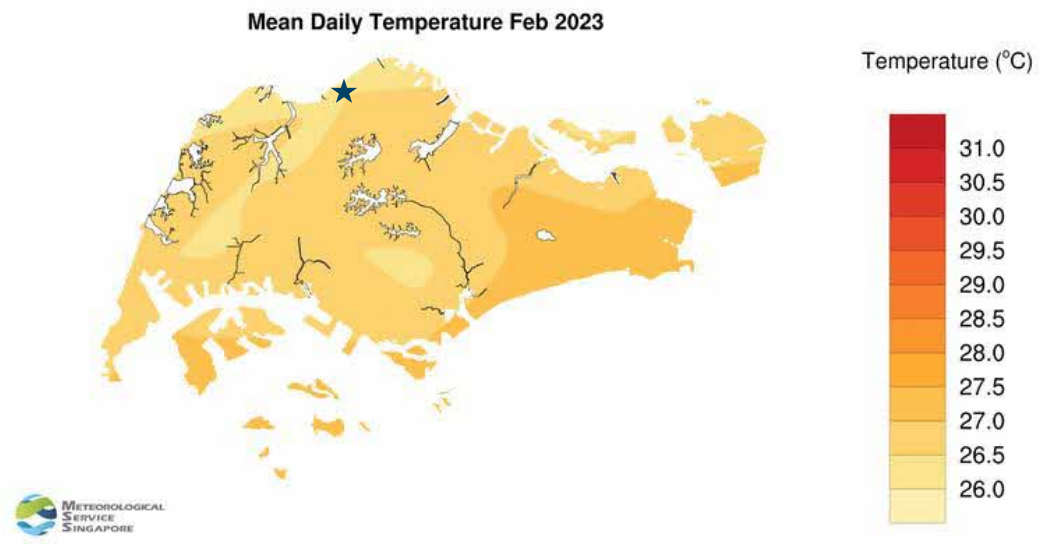


Figure 9.6 Mean daily temperature for February 2023. The blue star is an indicative location of the Project site (Source: Meteorological Service Singapore, 2023).

Season fluctuations are also prominent factor whereby during the baseline period of February 2023, the mean temperature was lower compared to the annual monthly mean temperature. This variation is highlighted in Figure 9.7, with data retrieved from the Meteorological Service Singapore used as a reference.

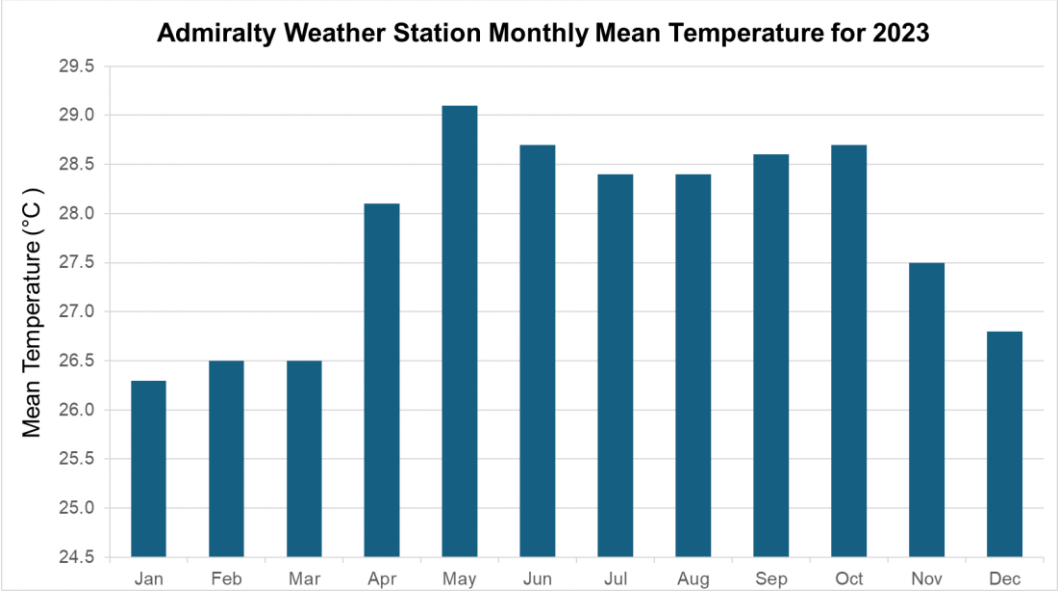


Figure 9.7 Mean monthly temperature for 2023. (Data source: Meteorological Service Singapore, 2023).

9.3 Impact Assessment Framework

9.3.1 Importance Rating of Sensitive Receptors

The evaluation framework for importance of sensitive receptors and magnitude of change defined for the ambient air temperature impact assessment is presented in Table 9.4.

Table 9.4 Evaluation Framework for Importance of Temperature-Sensitive Receptors

Score	Socio-economic	Ecological
5	• Locations where temperature-sensitive activities are of high importance by the more sensitive members of the public, e.g., hospital/polyclinics • Locations where residents are highly susceptible to potential heatwaves and heat strokes that entail may be fatal • Locations with existing very low ambient temperature levels and very high green coverage – which would experience significant changes in ambient temperature levels if development were to occur	• Locations where the receptors affected are specifically protected by national or international policies or legislation and are of high importance at the regional or national scale, e.g., fauna (such as sea turtles & migratory birds) in Nature Reserves, Nature Areas, ASEAN Heritage Park • Locations where the microclimate impacts of edge effects and/or habitat loss would be highly detrimental to the threatened flora and fauna that reside within and/or adjacent to it
4	• Locations where more sensitive members of the public are exposed for eight hours or more in a day, e.g., residential care homes • Locations where residents are susceptible to potential heatwaves and heat strokes that entail may be fatal • Locations with existing low ambient temperature levels and high green coverage	• Locations where the receptors affected are of moderate importance at the regional or national scale, e.g., fauna in forested sites outside of designated nature reserves and nature areas • Locations where the microclimate impacts of edge effects and/or habitat loss would be highly detrimental to the threatened flora and fauna that reside within and/or adjacent to it
3	• Locations where temperature-sensitive activities are of moderate importance by the members of the public, e.g., private residential, and dormitories • Locations with existing moderate ambient temperature levels that correspond with daily meteorological service readings • Locations where members of the public are exposed for eight hours or more in a day, e.g., residential properties and schools	• Locations where the receptors affected are important for the functioning and integrity of adjacent habitats, e.g., green corridors, biodiversity buffer areas • Locations where the receptors affected contain specific species or taxa that are sensitive to ambient temperature levels, but are able to withstand and/or adapt to changes
2	• Locations where the people exposed are workers and they may be exposed for eight hours or more in a day, for example, office, industrial and shop workers	• Locations where the receptors affected are with limited biodiversity and ecological value, e.g., grasslands and shrubland

Score	Socio-economic	Ecological
1	• Receptors with transient exposure, for example recreational users of parks and playgrounds	• Locations where the receptors affected are with little to no biodiversity value, e.g., managed turf

9.3.1.1 Identified Sensitive Receptors and Importance

The identified sensitive receptors were post-stratified into two main categories, namely fauna (biodiversity) and human (socio-economic) receptors. Based on the ratings described in Table 9.4 above, the importance scores for each receptor and the justifications are presented in Table 9.5 below.

The sensitive receptors were identified based on the planned development, which excludes the existing area within the Project site.

Table 9.5 Sensitive receptors and their assigned importance score.

Category	Ambient air temperature sensitive receptor	Importance Score	Justification
Fauna	Terrestrial fauna at Admiralty Forest	3	• Wildlife is known to be sensitive to ambient air temperature levels, especially nocturnal species. Changes in temperatures can therefore exert negative impacts on them. • The habitat is within and adjacent to a wildlife corridor/biodiversity buffer area. • Additionally, the presence of herpetofauna within the Project site would therefore expose them to potential impacts due to changes in ambient air temperature levels.
Human	Hostel residents at Admiralty Forest HDB and Man Fut Tong Nursing Home Residents of Republic Polytechnic Hostel	4	• Hostel residents will spend a significant amount of time in their rooms, especially after work hours. • Furthermore, nursing home residents are likely to be residing within their premises for eight hours or more in a day, making them susceptible to excessively high ambient air temperatures. • Students from the polytechnic are likely to be exposed as well. • Nonetheless, ambient air temperature can therefore exert negative impacts on them.

9.3.2 Magnitude of Change

As there have been no established frameworks for assessing ambient air temperature impacts for EIA purposes (as described in Section 9.1), DHI developed a qualitative assessment matrix based on the RIAM approach, via a combination of desktop studies and literature review, with the Project's site characteristics taken into consideration.

Table 9.6 Evaluation Framework for Magnitude of Change in Ambient Air Temperature

Score	Generic Criteria	Specific Criteria
-4	Major negative disadvantage or change	**Biodiversity** • Populations are irretrievably compromised due to significant changes in ambient air temperatures • High likelihood of behavioural changes within populations, and their extirpation from current habitat **Socio-economic** • Residents are severely disturbed by changes in ambient air temperatures • Significant changes ambient air temperatures inside any room in the house leading to sleep disorder and other related health issues
-3	Moderate negative disadvantage or change	**Biodiversity** • Populations are moderately disturbed due to changes ambient air temperature levels • Moderate likelihood of behavioural changes within populations, and their extirpation from the current habitat • Discernible and fundamental changes to ambient air temperature levels, that would disturb populations **Socio-economic** • Residents are notably disturbed by changes in ambient air temperature levels • Sleep quality may be affected
-2	Minor negative disadvantage or change	**Biodiversity** • Populations experience minor disturbance due to changes in ambient air temperature levels, but not to the extent that the overall condition of the populations are impaired in the long term • Low likelihood of behavioural changes within populations, and their extirpation from the current habitat **Socio-economic** • Residents are mildly disturbed by changes in ambient air temperature levels within their homes, and may experience discomfort
-1	Slight negative disadvantage or change	**Biodiversity** • Populations experience slight disturbances due to changes in ambient air temperature levels • Very low likelihood of behavioural changes within populations, and their extirpation from the current habitat

Score	Generic Criteria	Specific Criteria
		Socio-economic • Residents may notice the changes in ambient air temperatures within their homes, but is unlikely to cause discomfort
0	No change	**Biodiversity** • Little to no disturbances on populations • Negligible likelihood of behavioural changes within populations, and their extirpation from the current habitat **Socio-economic** • Residents not affected nor disturbed by ambient air temperatures within their homes

9.4 Prediction and Assessment of Impacts

9.4.1 Overall Impacts throughout the Project and Operational Phase

9.4.1.1 Long term changes in Ambient Air Temperatures from Building Operation

Residents

We can expect the conversion of forest cover to buildings and urbanised surfaces to raise the ambient temperatures and lower humidity, given the reduction in evapotranspiration and the associated cooling capacity. The elevated ambient temperatures will be most pronounced during night hours, when trapped heat is slowly released from urban structures, leading to an urban heat island effect.

Existing residents at Woodlands Avenue 9 and Admiralty Road West will be most vulnerable to elevated ambient temperatures and the UHI effect, given their proximity to the loss of forest cover and the presence of new buildings. However, the overall Project area is highly-urbanised, with the presence of residential and industrial buildings, as well as the RTS site surrounding the Project area. Changes to ambient air temperatures levels are therefore expected in the long term, but residents are unlikely to be experience discomfort.

Furthermore, the UHI effect can be mitigated through the adoption of design guidelines to maximise thermal comfort. For instance, new buildings within the Project development site can be orientated to reduce thermal heat gain on the façade. Vertical greenery can also be planted to minimise heat gain on the building façade. Nature-friendly landscaping can also be interspersed throughout the development footprint, to further ameliorate the UHI effect.

Therefore, the impacts are deemed to be permanent, but recoverable, non-cumulative, and thus, the overall significance of this impact is considered slight negative.

Biodiversity

Clearance of the secondary forest will introduce edge effects that perturbs habitat microclimate, resulting in heightened risks of parasitism or disease, predation risks, elevated temperatures, reduced humidity, increased wind speeds, and increased light availability. Increased wind speeds at the newly exposed forest edge will likely increase the susceptibility of trees to wind-induced damage and treefalls, and consequently elevated tree mortality. Adverse microclimatic conditions would also result in higher risks of drying

out and subsequent fire risk. Studies on forest fragmentation have reported increased tree mortalities up to 300 m deep from a forest edge, and reduced humidity up to 100 m deep (Laurance et al., 2018).

Alterations in microclimatic conditions, and in turn forest structure dynamics, can have substantial and long-term impacts on the faunal communities that inhabit the forests, as many of the species have adapted to specific microclimates that exist within the forest structures. For instance, herpetofauna are known to be sensitive and susceptible to changes in temperature and humidity levels. Some species like the Malayan Water Monitor *Varanus nebulosus* are unable to regulate their own body temperatures and are therefore susceptible to the prevailing microclimatic conditions. Moreover, critical activities such as foraging and mating are closely tied to suitable temperature and moisture regimes. Altered microclimates may thus result in reproductive failure and mortality (Olson & Saenz, 2013).

Notwithstanding the potential impacts of edge effects mentioned above, the southern part of Admiralty Forest will be exposed to the Project development and future building operation. However, given that the southern Admiralty Forest is already exposed to the existing RTS site, as well as the lodging/residential buildings along Keramat and Dahan Roads — the main Admiralty Road West segregating the Project development site from the forest — existing edge effects are likely to be present. The fauna within Admiralty Forest are also likely to be urban-adapted and acclimatised to the surroundings. That said, the loss of habitat from the Project development and future building operation therefore exerts long term impacts, but will be mitigatable via native planting and reforestation efforts within the development, as well as along existing and planned Nature Ways.

Therefore, the impacts are deemed to be permanent, but recoverable, non-cumulative, and thus, the overall significance of this impact is considered slight negative.

Table 9.7 Assessment of Impact Significance without and with mitigation measures (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score)

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures						
		I	M	P	R	C	ES	Impact Significance
Long term ambient temperature change from building operation	Residents	4	-1	3	3	2	-32	Slight negative
	Fauna	3	-1	3	2	2	-21	Slight negative

9.5 Proposed Mitigation Measures

9.5.1 Overall Project duration and Post-Construction Phase

Table 9.8 Mitigation measures to ameliorate impacts of changes to ambient air temperatures.

Hierarchy	Mitigation Measures
Avoidance	• N.A.

Hierarchy	Mitigation Measures
Minimisation	**BCA Green Mark Certification Scheme** • As mentioned in Table 8.8, the development footprint falls under the GLS programme, thereby necessitating the developer to engage in and obtain the Green Mark Certification by BCA • Apart from Resilience criteria RE3.1 and RE3.2 mentioned above, it is also recommended for the following criteria to be fulfilled: • 'RE1.2a Outdoor Thermal Comfort' involves environmental modelling of the Project footprint to illustrate that outdoor thermal comfort is maintained or improved, and that the UHI effect minimised or reduced • Practicable mitigation measures to ameliorate the UHI effect should also be identified and implemented • This can be achieved via appropriate material selection, fine-tuning the landscape (both hardscape, softscape) and appropriately designing building surfaces • 'RE1.2b Urban Heat Island Mitigation' involves the adoption and implementation of UHI mitigation measures which can include: • The creation of green and blue spaces for landscaping and roof (e.g., rooftop garden and/or farm) • Use of roofing materials/coatings/cool paints with high Solar Reflectance Index (SRI) > 40 • Provision of unshaded hardscape areas with SRI > 39 (this includes unshaded carparks, internal roads, plazas, and pedestrian walkways) • Additionally, the Health & Wellbeing section of the Green Mark Certification also entails relevant mitigation measures that the developer can implement. The relevant criteria include: • 'HW1.3a Thermal Comfort', for non-airconditioned areas, is assessed via one of these three performance routes: (i) Thermal Comfort Simulation, (ii) Effective Cross Ventilation, and (iii) Prescriptive Performance • 'HW2.1 Access to Nature' is assessed via the following pointers (non-exhaustive): I. Provision of accessible planted sky terraces, rooftop gardens and courtyards, II. Fixed indoor planting distributed at key common areas, III. Placement of natural elements and used of mixed textures in common areas etc., IV. If indoor greenery is absent or inaccessible, the design of the common areas should have visual access to greenery • A combination of the aforementioned strategies to mitigate ambient air temperature is recommended. • In particular, a mix of natural landscaping (i.e., nature-based/natural climate solutions), with innovative green building design for both indoor and outdoor spaces would serve to regulate, and possibly lower outdoor ambient air temperatures • Benefits apply to both biodiversity and humans
Restoration	
Offsets	

Hierarchy	Mitigation Measures
	Landscape Excellence Assessment Framework (LEAF) Certification to recognize the current best practices in landscape design and management. Future development shall be designed with the following aspects in mind, in line with the LEAF assessment criteria: • Accessibility • Biodiversity Conservation • Community Wellbeing & Engagement • Design & Landscaping • Environmental Sustainability • Maintenance Additionally, future development should be carefully designed and planned by taking reference to the LEAF assessment for development criteria such as: • Green Plot Ratio of the Entire Site and Green Buffer & Peripheral Planting Verge • Ground Level Landscaped Area • Catchment of Runoff • Percentage of Native Plants Species Used • Quantity of Native Species Planted • Percentage of Retained Mature Trees On Site • Percentage of Auto-Irrigation

9.6 Residual Impact

9.6.1 Overall Project duration and Post-Construction Phase

Through the implementation of a comprehensive set of design mitigation measures during the post-construction phase via the BCA Green Mark certification, which includes (but is not limited to) eco-friendly building technologies (e.g., efficient HVAC and lighting systems), efficient and sustainable energy usage, as well as green building design and landscaping strategies, the anticipated significance of ambient air temperature impacts is anticipated to be minimized to slight or negligible levels. The residual impact after employing these mitigation strategies is outlined in Section 9.7.

9.7 RIAM Summary

Summary RIAM table below for the overall Project during and post-construction phase, after mitigation measures (Table 9.9).

Table 9.9 Summary of impact assessment for ecological impacts for the overall Project. The change in impact Magnitude following mitigation (if any), and the residual impact Significance is also shown. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score)

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures							With mitigation measures		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Overall ambient temperature increase from future building operation (long term)	Residents	3	-1	3	2	2	-21	Slight negative	0	0	No impact
	Fauna	3	-1	3	2	2	-21	Slight negative	0	0	No impact

10 Soil and Groundwater

This section outlines the potential environmental impact related to soil and groundwater during the construction phase of the Project. Substantial amount of earth material is expected to be excavated and removed from the Project site. The assessment comprises the potential impact due to handling of any contaminated soil and groundwater from the Project site, and the potential impact of contamination caused by the construction activities.

10.1 Applicable Legislation, Guidelines and Standards

Relevant Legislation and standards that governed the study of soil and groundwater contamination issues in Singapore are listed below:

- Environmental Protection and Management Act (2013), regulating the discharge of trade effluent, oil chemical, sewage or other pollution onto land
- SS 593:2013 Code of Practice for Pollution Control (COPPC) provides guidance on managing land pollution, remediating contaminated sites, and ensuring proper storage and prevention of accidental releases of oils and chemicals
- An Environmental Site Assessment/Environmental Baseline Study are legally required as part of Jurong Town Council (JTC) lease agreements

10.2 Baseline Study

10.2.1 Methodology

The baseline study was conducted through a literature review of historical land use, an assessment of the soil investigation report from JTC, and an analysis of the aerial topography survey to evaluate the baseline conditions of the site.

- Section 1.3.1.1 has detailed the land use history
- Soil Investigation and Rock Mapping Works for Woodlands North Coast Phase 2 (JTC, 2020)

An aerial topography survey was conducted by YJP Surveyors Pte Ltd on the 12 Aug 2023, Figure 10.2 illustrates the topography of the Project site. The detailed of topography survey are presented in Appendix I.

10.2.2 Findings

Land Use History

With reference to the findings of land use history in Section 1.3.1.1, it is evident that the Project site has undergone various phases of land use since the early records dating back to 1924. Similar to a native and untouched habitat, the potential for soil and groundwater contamination is considered minimal. This is attributed to the site's historical uses, which include agricultural cultivation, concrete reservoirs, serving as a location for a mental institution, and functioning as a dormitory which is outlined in Table 10.1 below.

Despite the historical use of the land as a hospital, the likelihood of occurrence for contaminated hospital waste and biohazardous waste is minimal as it was a mental

institute. Additionally, the absence of industrial activities like factories in the recorded land use history further reduces the risk of soil and groundwater pollution in the area.

Table 10.1 Land use history summary

Year	Land use history	
	Vegetated area	Northern edge
1924s	Rubber and pineapple plantations (Figure 1.4A; Figure 1.5A)	No information
1936	No change	A reinforced concrete reservoir, known as Batu Rimau was built for the British Army (Figure 1.5B)
1941	No change	Rimau Offices and Accommodation, Command centre for the British Army
1966	Plantations were abandoned, spontaneous bush and grassland vegetation took over Project site (Figure 1.4B)	No change
1975	No change	Rimau Offices and Accommodation was converted into View Road premise, a government-owned mental institution
2001	No change	View road institution converted to dormitory
2009	Some of the vegetation in the south was cleared for the construction of industrial buildings. Industrial buildings were demolished by 2015. (Figure 1.6A; Figure 1.6B)	No change
2011	No change	View Road dormitory ceased operation
2016 – present	Some of the vegetation in the south-west area was cleared for the construction of Woodlands North MRT station and RTS Link. (Figure 1.6B; Figure 1.6C; Figure 1.6D)	No change

Geology and Topography

The Project site area lies within the geological formation of Bukit Timah Granite as shown in Figure 10.1. The topography of the site is elevated from the surrounding (Figure 10.2), and the future development will involve slope cutting to level off the area. The change in geology and topography of the Project site due to the development will be evaluated and described, through literature review of the existing geological composition and historical site investigation and geological survey reports.

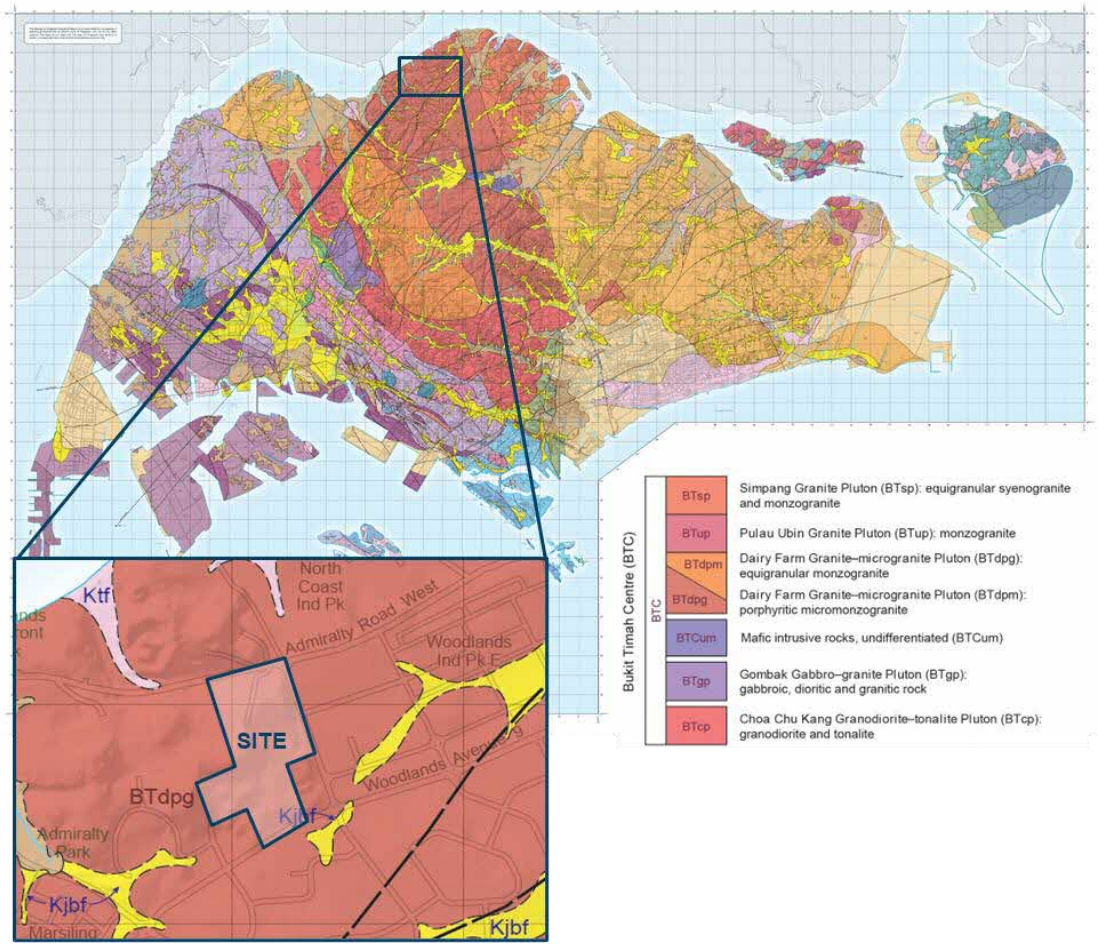


Figure 10.1 The approximate site location on the Geological Map extracted from the "Geology Map of Singapore" published by DSTA, 2021

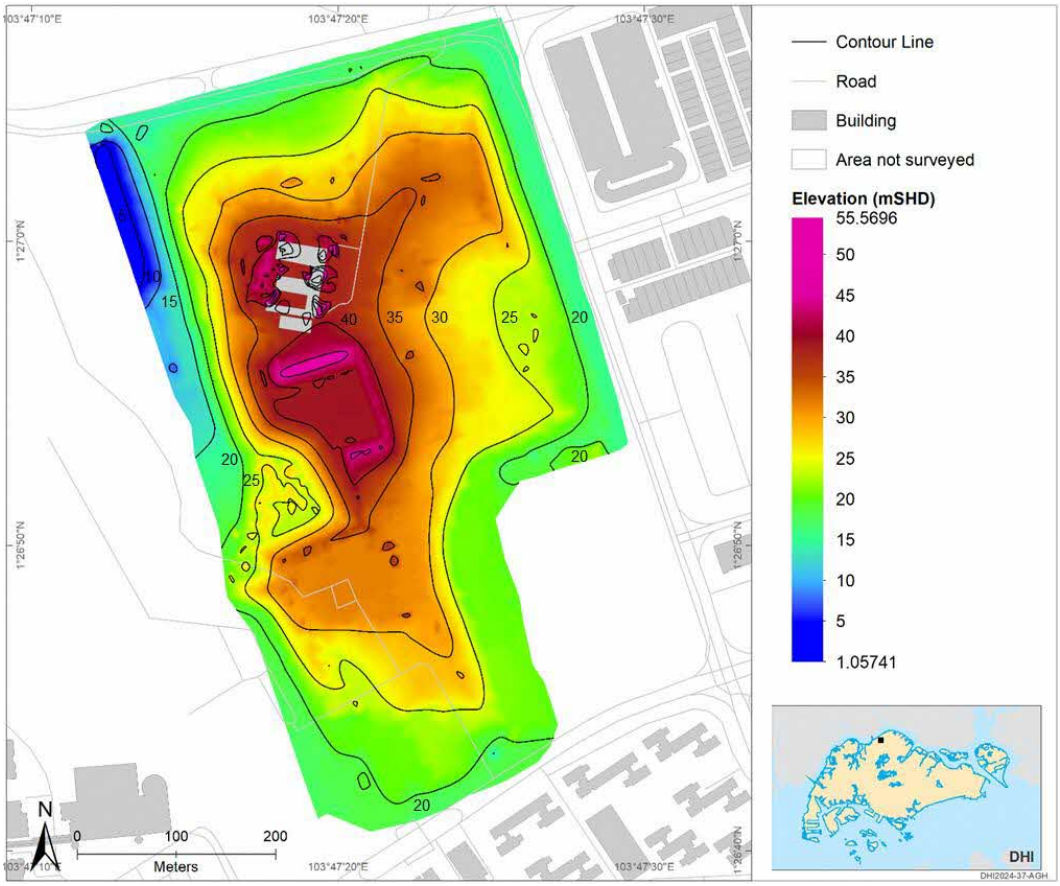


Figure 10.2 Topography of Project Site

Soil investigation

Review of past soil investigation report shows that based on the borehole data, visual classification and laboratory tests results, the underlying sub-soils within Project site can be divided into reconstituted ground and Bukit Timah Granite.

Fourteen (14) boreholes were drilled in 2019 at the Project site indicated in Figure 10.3. However, chemical tests were only carried out at three (3) boreholes to determine the chemical characteristics of the underlying subsoil. pH value, organic content and total sulphate content were tested for **BH-b, BH-d** and **BH-n**. Laboratory results show that pH ranged between 7.51 to 7.78, sulphate (as SO3) content ranged between 0.025 g/L to 0.05 g/L and organic contents were all below detection limit of 0.10% (w/v). pH measured were within the typical range (pH 6 to 8.5) for groundwater and sulphate content was way below the USEPA standard for sulphate in drinking water (concentration of below 0.25 g/L). Given that the organic content in all three (3) measured boreholes was below the detection limit, no signs of contamination was observed, it can be concluded that the soil and groundwater at the Project site was unlikely to be contaminated by previous land use activities.

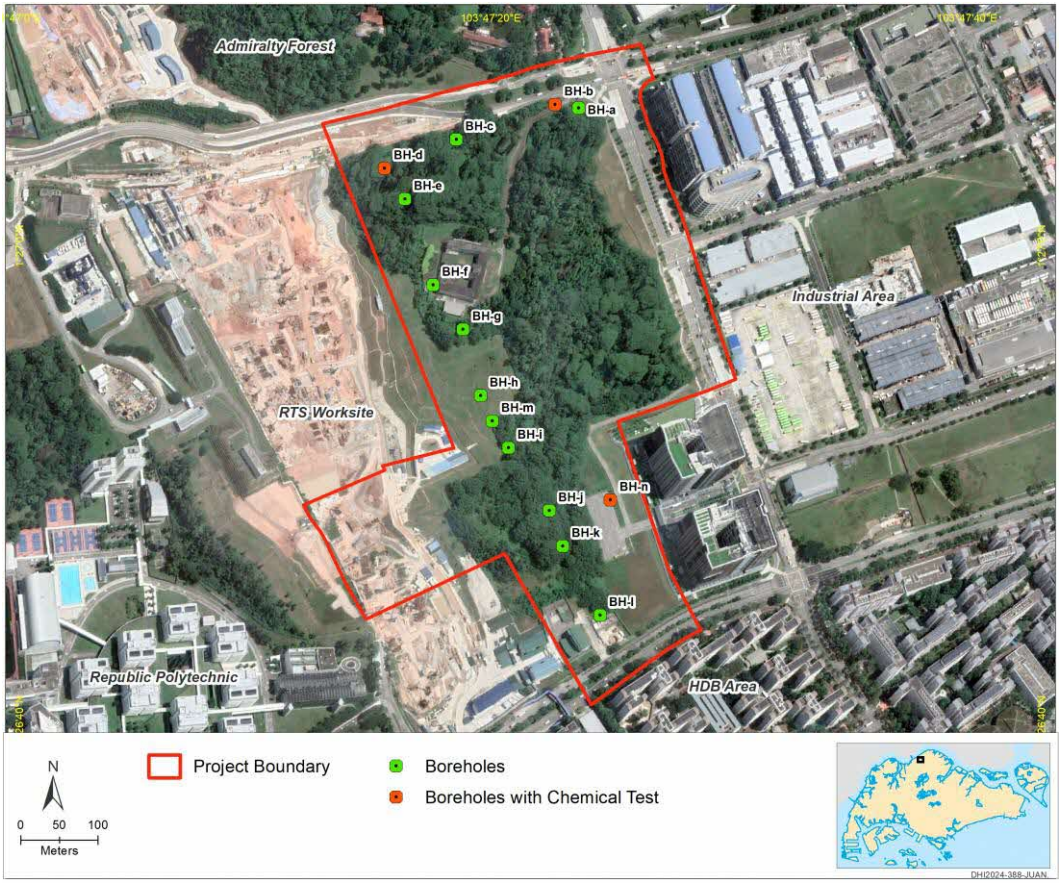


Figure 10.3 Borehole locations for soil investigation (Satellite image as of 10 Mar 2022)

10.3 Impact Assessment Framework

10.3.1 Importance Rating of Sensitive Receptors

The potential impact related to soil and groundwater contamination within the Project site, is expected to affect the environment itself. Hence the receptor considered for this assessment is the Project site and the immediate surrounding. Given the absence of any receiving water bodies within the Project site, it is anticipated that the potential impact arising from contaminated soil and groundwater will not significantly extend beyond the confines of the Project area. The general framework for the evaluation of importance of receptors is presented in Table 10.2.

Table 10.2 Evaluation of Importance of Soil and Groundwater Receptors

Score	Generic Definition	Specific Criteria
5	Important to national/international interests	Receptors specifically protected by national or international policies or legislation and are of significance at the regional or national scale, e.g. designated Nature Reserves, Nature Areas, ASEAN Heritage Park
4	Important to regional/national interests	Receptor locations where human or wildlife populations are readily exposed to soil and groundwater and are dependent on

Score	Generic Definition	Specific Criteria
		the soil and groundwater resources for economical or biological support to sustain the population
3	Important to areas immediately outside the local condition	Receptor locations where the groundwater resource is an important water supply, and is currently used, but there is capacity and / or adequate opportunity for alternative sources of comparable quality.
2	Important only to the local condition (within a large direct impact area)	Receptor locations accessible by general public where exposure is transient, for example public footpath, playing fields, parks.
1	Important only to the local condition (within a small direct impact area)	Receptor locations with limited access and where exposure is transient, for example private premises.

The construction activities for Project site, if not managed properly could potentially cause contamination of the soil and groundwater within the work area, and could spill to the immediate surrounding environment. The receptor, i.e. the Project site in this case is considered to have limited access to public during construction. Hence the potential impact is unlikely to affect the surrounding human and ecological receptors. Thus, the importance of the Project site to potential impact on soil and groundwater is given the score of 1.

Human receptors (workers) within the Project site are not considered as sensitive receptors, as they shall be equipped with proper personal protective equipment (PPE), undergo regular safety training, and coupled with adhering to proper construction practices.

Nevertheless, in the event of a significant spillage or leakage of chemicals , or if excavated soil is mishandled or illegally dumped outside the Project site, there is a potential risk of impacting the immediate community surrounding the Project site, including passersby. Therefore, the immediate community is assigned an importance score of 1 in case of an unforeseen incident.

10.3.2 Magnitude of Change

The evaluation framework to assess magnitude of change for soil and groundwater quality is presented in Table 10.3.

Table 10.3 Evaluation Framework for Magnitude of Change in Soil and Groundwater Quality

Score	Generic Criteria	Specific Criteria
-4	Major negative disadvantage or change	• Extremely high concentration of contamination affecting an extensive area / volume of soil and groundwater, and may lead to significant ecological and human health implications
-3	Moderate negative disadvantage or change	• Significant concentrations of contamination affecting a substantial portion of area / volume of the soil and groundwater in the area, leading to noticeable environmental impact

Score	Generic Criteria	Specific Criteria
-2	Minor negative disadvantage or change	• Elevated concentration of contamination, causing localised impact on soil and groundwater which is confined to specific areas, but can be remediated in time during construction
-1	Slight negative disadvantage or change	• Low concentration and localized contamination, which can be easily managed / treated by confinement / dilution, and is not expected to cause significant environmental and health implication
0	No change	• Not detectable contamination

10.4 Prediction and Assessment of Impacts

10.4.1 Construction Phase

10.4.1.1 Release of Contaminants from Contaminated Soil

The WNC development would involve levelling of the existing hill, which is anticipated to undergo extensive excavation and huge amount of spoil materials will be generated. If the excavated soil materials are contaminated, it is possible for the contaminants to be leach out when being handled on-site or off-site after disposal. Review of soil investigation report and land use history (refer to Section 10.2) indicates that highly polluting activities leading to contamination of the existing soil layer within the Project site is unlikely. Most of the area within the Project site has been vegetated for decades, despite the changes and successions of the vegetation composition over the years. The only man-made features are the current 10 View Road premise and the access road leading to it. According to historical articles, the premises was used as command centre and accommodation for the British Army in the 1930s, and was used as government-owned rehabilitation institution after the withdrawal of British Army in 1970s till 2001. As the site was mainly used for accommodation and rehabilitation, polluting activities which could cause soil and groundwater contamination is unlikely. Hence the likelihood of release of contaminants from the excavated spoil materials during construction is low.

While the review of historical land use and previous soil investigation reports does not indicate significant soil and groundwater contamination within the Project site, it is imperative to ensure that spoil materials disposed at the staging ground managed by NEA or other agencies, adhere to specified physical and chemical criteria mandated by relevant agencies. If any excavated materials are contaminated or failing the relevant disposal criteria, the handling and temporary stockpiling of such materials on site may pose the risk of leaching of contaminant to the surrounding environment. Any excavated materials are expected to be temporarily stockpiled on site and be treated / transported out of the site for disposal timely. The exposure time of excavated materials is expected to be short and mainly stay within the work area.

Provided proper construction management practices are implemented, potential impact on soil and groundwater quality within the Project site and the surrounding environment due to the release of contaminants from contaminated soil and groundwater are expected to be localised, if any. Any issues are likely to be remediated promptly during the construction process and stay confined within the construction site. The potential impact on soil and groundwater within Project site is considered to be slight negative.

However, in the event of a significant spillage or leakage of chemicals, or if excavated soil is mishandled or illegally dumped outside the Project site, there is a potential risk of impacting the immediate community surrounding the Project site, including passersby. Although the impact may only occur incidentally, it's crucial to emphasize that any such occurrence would pose a risk to the nearby community. Therefore, it is essential to maintain vigilance and adhere to proper handling and disposal procedures to minimize the potential impact.

10.4.1.2 Contamination of Soil and Groundwater due to Mishandling of Chemicals/ Materials

During construction, chemicals and hazardous industrial materials may be used and stored on site. Any uncontained leakage and spillage may be released into the soil. The extent to which these compounds migrate is determined by soil conditions and groundwater depth. Factors associated with the construction activities that may contribute to soil and groundwater contamination include the following:

- Fuel, oil and lubricant spillages and leaks from vehicles and machinery used during construction
- Inappropriate storage, use and disposal of hazardous chemicals/materials

Chemicals such as fuel, oil, and lubricants are commonly present on construction sites for refuelling, repairing, and maintaining equipment or vehicles throughout all phases of construction. The release of these chemicals into the soil and groundwater can occur due to leaks or spills from on-site storage, mishandling, or drips from vehicles or equipment. If not effectively contained, such chemical spills may lead to soil and groundwater contamination. Inadequate earth management and mishandling of excavated material could further contribute to a decline in soil and groundwater quality.

As part of standard practices on the Project site, chemicals and hazardous materials are to be stored in designated areas equipped with shelter and bunded secondary containment to prevent accidental spills from seeping into the soil and groundwater or spreading extensively. Site workers should undergo training to handle these chemicals properly as well. Given the frequent use and persistent storage of chemicals on site throughout the prolonged construction period, occasional accidental spills may occur, causing localized impacts that require cleanup. Proper earth control measures (EMCs) are also crucial to prevent additional contamination from excavated earth and discharged groundwater. Thus, the potential impact on soil and groundwater contamination is considered to be slight negative.

10.4.1.3 Surface runoff

The construction phase is expected to involve significant vegetation removal across the Project area, resulting in extensive areas of exposed soil. During wet weather events, surface runoff at the Project site is expected to be more significant compared to other sites, primarily due to the site's topography. The sloped terrain increases both the speed and volume of water flow, leading to a higher potential for surface runoff. In the absence of effective ECMs, this runoff could adversely impact the immediate community surrounding the Project site leading to waterlogging, and sedimentation. Implementing proper ECMs is crucial to prevent excessive soil erosion and the transport of loose material from the project site. Based on the analysis, the potential impact on immediate community surrounding the Project site is assessed as slight negative.

10.4.2 Post-Construction Phase

Based on URA Masterplan 2019 parameters, general and light industries with potential activities such as manufacturing, restaurants, repair and servicing storage of chemicals and oil, and production could be a potential source of contaminant released into the environment when mishandled during the operational phase. If the leakage or spill is not contained and treated promptly, contamination of soil and groundwater could be resulted.

Factors associated with the post-construction activities that may contribute to soil and groundwater contamination includes the following:

- Chemical usage: Fuel and oil leaks from industries during operational phase
- Storage practices: Inappropriate storage, use and disposal of hazardous chemicals/ materials
- Waste generation and disposal: Generation and mishandling of industrial and toxic waste from manufacturing, printing, and production processes

With proper post-construction phase management measures such as regular monitoring and inspection of the premises and proper waste management practices, no significance impact to soil and groundwater from the activities associated with post-construction phase is considered.

10.5 Proposed Mitigation Measures

10.5.1 Construction Phase

Slight negative impacts are anticipated on the quality of soil and groundwater within and around the Project site during the construction phase. Mitigation measures have been recommended to safeguard against issues such as surface runoff and the accidental release of chemicals. Details of these measures can be found in Table 10.4.

Table 10.4 Proposed Soil and Groundwater Impact Mitigation Measures by Hierarchy Type

Mitigation Hierarchy	Mitigation Measures
Avoidance	• Contractor to strictly avoid usage and storage of chemicals beyond the construction site
Minimization	• Contractor to prepare a soil management and disposal plan to define the proper storage and disposal of soil and excavated materials, especially for contaminated soil if any. Testing and remediation plan should be included to ensure the spoil materials meet the receiving facility requirement (dumping ground or other disposal facilities). • Groundwater from dewatering should undergone ECM treatment and tested to be complied with discharge limits before discharging into public drain. • Contractors should analyze the possible inhalation and cutaneous consequences to site workers exposed to contaminated soil and/or groundwater, and to provide proper personal protective equipment (PPE) to site workers, such as boots, rubber gloves, and googles. • Chemicals shall be stored at designated sheltered areas, with secondary containment. Spill kit and relevant Material Safety Data Sheet (MSDS) for the stored chemicals shall be provided in the storage area. • For the transportation of hazardous compounds, a notification or tracking system as well as a transportation emergency response plan are required • Appropriate material for toxic waste storage containers, and occasional leak tests conducted on these containers to notify for accidental spills • Clearance of surface vegetation should be done in stages to reduce the amount of surface runoff and erosion • 100% Biodegradable Erosion Control Blankets should be installed wherever bare earth is exposed • Soil and material stockpiles should be covered with tarpaulin when not in use • Proper erosion and sediment control measures should be implemented by engaging a Qualified Erosion Control Professional (QECP) to design and implement an Earth Control Measures (ECM) plan • Turf cover should be established during reinstatement of the work site to minimize soil erosion • After rain events, earth control measures in the Area are to be inspected and maintained over the course of construction • Tarpaulins mats (in adequate quantities) should be on standby on site during site clearance and excavation works. In the event of heavy rainfall, exposed soil and stockpiles are to be covered as soon as possible to prevent overflow of silty discharge

Mitigation Hierarchy	Mitigation Measures
Restoration	• In case any spillage occurs, the contractor shall immediately contain and clean up the spill. If extensive contamination is caused, proper disposal and treatment shall be carried out.
Offsets	• Nil

10.5.2 Post-Construction Phase

During the post-construction phase, implementing proactive and diligent mitigation measures is crucial to safeguard soil and groundwater quality. Regular monitoring and inspection of these conditions are essential to promptly identify any issues, especially in the event of potential chemical mishandling from the general and light industries.

To prevent soil degradation, ongoing maintenance of soil erosion control practices, such as vegetative cover and sedimentation basins, is imperative. Moreover, ensuring the judicious use of chemicals and fertilizers, coupled with adherence to proper waste disposal protocols, contributes significantly to maintaining a healthy soil and groundwater environment.

10.6 Residual Impact

10.6.1 Construction Phase

By employing a range of mitigation measures during construction phase, the expected significance of residual soil and groundwater impacts is anticipated to be considerably minimized. These measures, including a detailed soil management and disposal plan, ECM treatment for dewatering groundwater, and strict chemical storage protocols, aim to effectively address and mitigate potential risks. No residual impact is anticipated with proper implementation of mitigation measures.

10.6.2 Post-Construction Phase

Through the implementation of proactive management measures during operation, the anticipated residual impact on soil and groundwater quality is expected to be negligible levels. Rigorous monitoring and inspection protocols, especially regarding potential chemical mishandling from the future businesses operators, remain integral. Ongoing maintenance of soil erosion control practices, coupled with judicious chemical and fertilizer use and proper waste disposal, ensures a sustained, healthy soil and groundwater environment. Overall, strict compliance with these generic good practices is vital for ensuring the long-term resilience and quality of soil and groundwater during the post-construction phases.

10.7 RIAM Summary

10.7.1 Construction Phase

Table 10.5 Summary of impact assessment for Soil and Groundwater impacts for the construction phase. The change in impact Magnitude following mitigation (if any), and the residual impact Significance is also shown. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score)

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures							With mitigation measures		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Release of Contaminants from Contaminated Soil	Project site	1	-2	2	2	2	-12	Slight negative	-1	-6	No impact
	Immediate community surrounding the Project site	1	-1	2	2	2	-6	No impact	-	-	No impact
Contamination of Soil and Groundwater due to Mishandling of Chemicals	Project site	1	-2	2	2	2	-12	Slight negative	-1	-6	No impact
Surface Runoff	Immediate community surrounding the Project site	1	-2	2	2	2	-12	Slight negative	-1	-6	No impact

10.7.2 Post-Construction Phase

Table 10.6 Summary of impact assessment for Soil and Groundwater impacts for the post construction phase. The change in impact Magnitude following mitigation (if any), and the residual impact Significance is also shown. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score)

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures							With mitigation measures		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Contamination of Soil and Groundwater due to Mishandling of Chemicals	Project site	1	-1	2	2	2	-6	No impact	-	-	No impact
	Immediate community surrounding the Project site	1	-1	2	2	2	-6	No impact	-	-	No impact

11 Landscape and Visual Aesthetics

This section includes the applicable guidelines for Landscape and Visual Aesthetics Impact Assessments (LVIA) and baseline study of the Project area. Qualitative LVIA was carried out to identify the current status of aesthetically appealing areas around the Project site, and to evaluate the visual impacts during both the construction and operational phases.

This section will be taking reference to the guidelines outlined in Annex 18 of the Hong Kong Environmental Protection Department's Environmental Impact Assessment Ordinance Technical Memorandum. This guidance focuses on predicting and assessing the significance of the effects a new development may have on landscape character and visual amenity. It emphasizes the importance of considering community perceptions and aspirations regarding landscape features. The assessment approach varies depending on the nature of the issues, relying on judgment and preferences.

11.1 Applicable Legislation, Guidelines and Standards

Currently there are no legislation or standards in Singapore for landscape and visual aesthetics impact assessment. Thus, evaluation of LVIA for the Project site will be based on the guidelines provided below:

- IEMA Guidelines for Landscape and Visual Impact Assessment Third Edition
- Hong Kong Environmental Protection Department's Environmental Impact Assessment Ordinance Technical Memorandum Annex 18

11.2 Baseline Study

The baseline assessment includes desktop study and site reconnaissance on the 17 Oct 2022.

11.2.1 Methodology

The baseline review for the LVIA assessment integrated satellite image analysis site reconnaissance carried out on 17 Oct 2022. Satellite imagery provided a comprehensive overview of the study area, enabling the identification of landscape features and land use patterns. Concurrently, on-site observations allowed for a ground-level assessment, capturing details not discernible from satellite images alone. This combined approach aimed to ensure a thorough understanding of the existing visual landscape, laying the foundation for a comprehensive evaluation of potential impacts during the assessment process.

11.2.2 Findings

Based on the satellite image, current landscape features and character of the Project site are forested area with an unoccupied 3-storey building at 10 View Road and some cleared land plots as seen in Figure 11.1.

It is noteworthy that, Project site is isolated, surrounded by active roads; Admiralty Road West in the north, North Coast Avenue in the East, Woodlands Avenue 9 in the south and active construction work of RTS in the west shown in Figure 11.2.

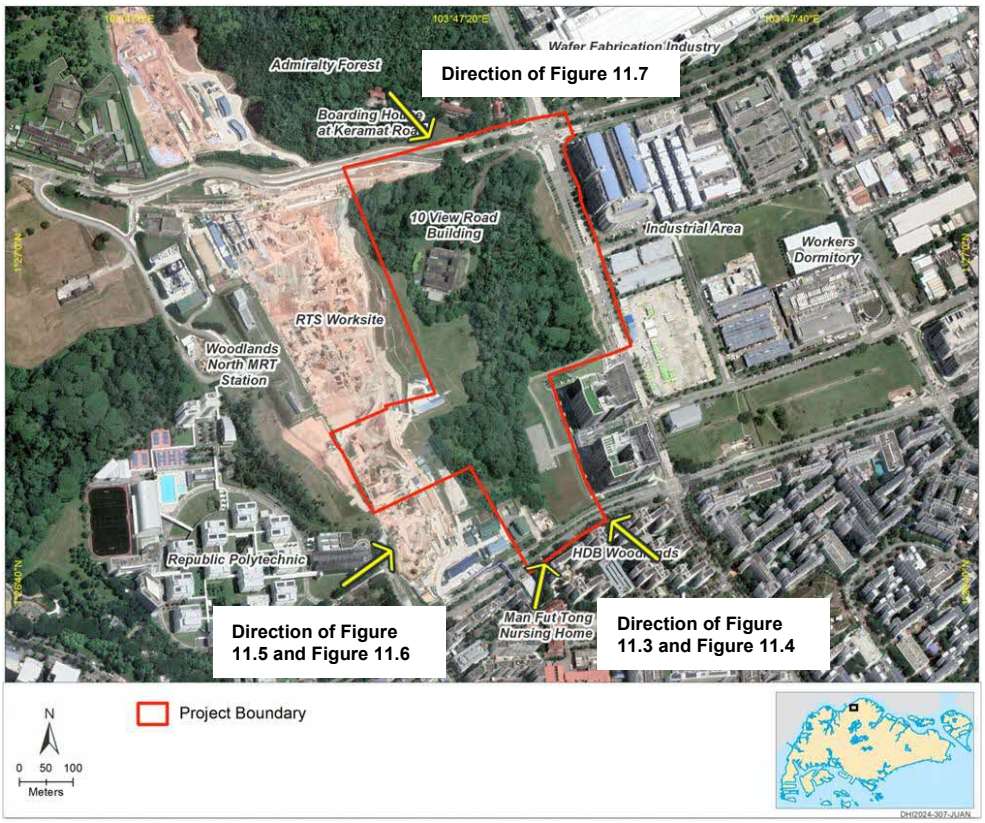


Figure 11.1 View angles to the Project site (Satellite image as of 10 Mar 2022)

Figure 11.2 Current site condition. Project site bounded by active road and construction site (Satellite image as of 10 Mar 2022)

Based on the on-site observations, residents of the HDB residing at 4th storey and above along Woodland Ave 9 (Figure 11.3), students and employees of Republic Polytechnic at higher grounds (Figure 11.5) have an unobstructed sight of view to the Project site. Residents of boarding house along Admiralty Road West (Figure 11.7) experience a limited view of the Project site, with tall vegetation obstructing their line of sight.

Passerby at ground level along Woodlands Ave 9 have partial view of the Project site as some of the perimeters of the Project site is blocked by hoarding due to the on-going RTS construction (Figure 11.4).

Passerby at ground level at Republic Polytechnic do not have a clear line of sight to the Project site as the perimeter of the Project site as it is entirely blocked by hoarding due to the on-going RTS construction (Figure 11.6).

Currently, residents and passerby of boarding house along Admiralty Road West have a clear view to the Project site, however once the Project site construction hoarding is installed, it is expected that the view will be completely obstructed for the passerby and partially obstructed for the residents as the Admiralty Forest adjacent to Project site is slightly elevated and residents are at a higher ground.

Figure 11.3 View of Project site for residents residing at higher levels of the HDB along Woodland Ave 9, taken on 17 Oct 2022

Figure 11.4 View of project site for residents and passerby of the along Woodland Ave 9 at ground level taken on 17 Oct 2022

Figure 11.5 View of Project site for students and employee of Republic Polytechnic from RP carpark at higher levels, taken on 17 Oct 2022

Figure 11.6 View of students, employee and passerby of Republic Polytechnic from RP carpark at ground levels, taken on 17 Oct 2022

Figure 11.7 View of Project site for residents of boarding house and passerby along Admiralty Road West at ground level taken on 17 Oct 2022

11.3 Impact Assessment Framework

11.3.1 Importance Rating of Sensitive Receptors

The evaluation of importance of visual impact sensitive receptors is presented in Table 11.1.

Table 11.1 Evaluation Framework for Sensitivity and Importance of Visual Impact Sensitive Receptors

Score	Generic Definition	Specific Criteria
5	Important to national/ international interests	• Social-economic receptors which will be observing landscapes featuring nationally or internationally significant heritage or landmarks with heightened importance. (eg: landscape safeguarded by pertinent national or international policies and legislation) • In these settings, the appreciation of the surrounding scenery will be profoundly influenced by the alteration of the landscape.
4	Important to regional/national interests	• Social-economic receptors where more sensitive members of the public are exposed for eight hours or more in a day, e.g., hospital and care facilities. • In these settings, the frequent appreciation of the surrounding scenery is inherent, given the significant time spent within these spaces and also demands for more visual comfort of the surrounding.
3	Important to areas immediately outside the local condition	• Social-economic receptors where members of the public are exposed for eight hours or more in a day, for example, residential properties. • In these settings, the frequent appreciation of the surrounding scenery is inherent, given the significant time spent within these spaces.
2	Important only to the local condition (within a large direct impact area)	• Social-economic receptors where the people exposed for eight hours or more in a day, for example schools. • In these settings, the limited view or appreciation of the surrounding scenery is inherent.
1	Important only to the local condition (within a small direct impact area)	• Social-economic receptors with transient exposure, e.g., visitors to place of worship, office and shop workers etc. • In these settings, the appreciation of the scenery is constrained by the brief duration of their presence or their work demands during those hours.

11.3.1.1 Identified Sensitive Receptors and Importance

Table 11.2 Identified sensitive receptors for visual impact

Receptor	Description	Importance
Boarding house at Keramat Road	• Residence boarding house will have frequent appreciation of the scenery of the Project site. However, they have a partial view of the Project site due to the presence of tall vegetation obstructing some of their perspective.	2

Receptor	Description	Importance
	• Visual impacts during construction activities. • Development can be seen but would comprise a minor component in the view.	
HDB residence along Woodlands Ave 9 (Blk 749 to 757, Blk 807 to 810, Blk 816 to 818, Blk 822, Blk 838 to 848 and Blk 870 to 882)	• Residence of HDB will have frequent appreciation of the scenery of the Project site. • Visual impacts during construction activities. • Development can be seen but would comprise a moderate component in the view.	3
Republic Polytechnic	• Students of Republic Polytechnic will have limited opportunities to appreciate the scenery of the Project site, given their attendance in indoor classrooms and the demands of their class schedules. • Visual impacts during construction activities.	2
Industrial areas	• Workers will have limited opportunities to appreciate the scenery of the Project site, given their work demand.	1

11.3.2 Magnitude of Change

The assessment will be evaluating the visibility of the development's components. 'Visibility' refers to the degree to which specific activities can be seen from neighbouring areas, considering factors such as the number of viewers, the duration of visibility, viewing distance (proximity to construction/project operations), type of view / landscape character, and the context of the view. In this study, the general classifications of visibility are outlined broadly in accordance with the evaluation framework below.

Table 11.3 Evaluation Framework for Magnitude of Change in Visual Impact

Score	Generic Definition	Specific Criteria
-4	Major negative disadvantage or change	• Extensive and transformative alterations that fundamentally reshape the landscape character, resulting in a significant and permanent deviation in nature from its original state.
-3	Moderate negative disadvantage or change	• Significant modifications that have a noticeable impact on the landscape, potentially leading to changes in its visual aesthetics and landscape character for a considerable area.
-2	Minor negative disadvantage or change	• Noticeable alterations that may affect specific portions of the landscape, but the overall integrity and character are still largely preserved.

Score	Generic Definition	Specific Criteria
-1	Slight negative disadvantage or change	• Small-scale modifications that are generally subtle and may not significantly alter the overall appearance or functionality of the landscape.
0	No change	• Landscape character remains unchanged, or change into comparable functionality. • No noticeable change.

11.4 Prediction and Assessment of Impacts

11.4.1 Construction Phase

There is an ongoing study for 10 View Road and surrounding area. The impact assessment is based on MP2019 parameters in which the entire Project area would be cleared for development works. The landscape character of the Project site will be changed completely from existing forest and vegetation to bare land / construction site during the construction phase. This impact comprises extensive vegetation removal, and the visibility of construction activities involving continuous movement of equipment and materials. Although the Project site will be enclosed from the public with hoarding provisions, individuals residing on higher floors may still have an unobstructed or partial view of the ongoing construction work.

The transition in landscape character during the construction phase will change from a forested area to a dynamic construction site, featuring a variety of different works and constructed buildings. The previously tranquil forest scene will give way to a bustling environment with numerous activities and movements throughout the entire construction phase.

The alteration of the visual landscape of the Project site during the construction phase is anticipated to cause major change to all visual sensitive receptors. The entire area, estimated to be 27.7 ha will undergo clearance and transformation into an active construction site, following the proposed timeline outlined in Section 1.3.2.1. Despite the phased approach to construction, significant disruption to the current visual aesthetic of the Project site is unavoidable due to the extensive nature of the transformation. The visual change to all receptors is expected to be temporary and reversible after the construction is completed, however, the impact from construction is expected to last for years.

11.4.2 Post-Construction Phase

The post-construction phase of the Project, the once-forested landscape will undergo a profound transformation into a modern built-up area, characterized by high-rise industrial buildings. The visual setting will evolve from a natural environment to a dynamic industrial and commercial hub. The landscape character is expected to experience a complete change in nature, comprises permanent loss of large portion of forested habitat and change into multiple concrete buildings in an urban setting. Landscape features such as planters and streetscape plantations will be integrated into the development area. However, the Project site will still be dominant by hardscape. This transformation is predicted to have multifaceted and minor to moderate impacts on the surrounding community.

11.5 Proposed Mitigation Measures

11.5.1 Construction Phase

The recognition of the need for landscape and visual impact mitigation during the construction phase underscores a commitment to responsible and sustainable construction practices. Construction activities inherently have the potential to disrupt the natural landscape and visual aesthetics of an area, affecting both the environment and the communities that reside nearby. As such, implementing effective measures described below to minimize these impacts is not a regulatory requirement in many cases, but a conscientious response to the preservation of the surrounding ecosystem and the well-being of local communities. By proactively addressing landscape and visual concerns, development projects can enhance their overall sustainability, contribute to a positive relationship with the community, and ensure a harmonious integration with the existing environment.

- Installation of hoarding around the Project boundary, minimizing visual disruption for surrounding areas.
- Employing visually appealing barriers or hoardings that blend with the surroundings, ensuring a more aesthetic appearance during development.
- Strategically planning construction activities and site layout to minimizes visual obtrusiveness. This includes strategic positioning of structures, equipment, and storage areas to reduce visibility from sensitive viewpoints.
- Implementing effective dust control measures during earthwork and construction activities helps maintain a clean and visually pleasing site environment.
- Choosing construction materials and colours that harmonize with the existing environment, reducing the visual contrast between the construction site and its surroundings.
- Introducing temporary landscaping features to softens the visual impact of construction activities, enhancing the aesthetics of the site.
- Regular removal of construction debris, maintaining a tidy site and prevent dumping construction waste or materials outside of Project site to minimizes visual clutter and enhances the overall appearance of the site and the surrounding environment.
- Proper management of construction site lighting reduces light pollution, mitigating visual impacts during nighttime construction activities.

11.5.2 Post-Construction Phase

As the built environment takes its final form, the need to address and mitigate landscape and visual effects becomes crucial in fostering a sustainable and aesthetically pleasing community. This phase is characterized by opportunities to enhance the visual integration of structures with the environment, reinstate disrupted areas to their original conditions as much as possible via the mitigation measures as shown below.

- Landscaping design:
  - Implementing a thoughtful landscaping design that incorporates greenery on buildings, especially those facing initial forest views.

- The use of skyrise greenery in building design enhances the overall visual integration with the surroundings.
- Minimizing the use of extensive glass materials helps reduce reflections and minimize bird strikes.

- Tree Planting Efforts:
  - To offset tree felling works during the construction phase.
  - Planting of trees and shrubs along the built structures, associated facilities, and road networks to enhance overall greenery efforts with the surrounding environment.
- BCA Green Mark Certification:
  - The built environment, which includes both the buildings and surrounding landscape architecture, is recommended to be designed with the Green Mark Certification in mind.
  - Refer to Section 8.5 for detailed description of Green Mark Certification Scheme.
- Landscape Excellence Assessment Framework (LEAF)
  - Certification to recognize the current best practices in landscape design and management. Future development shall be designed with the following aspects in mind, in line with the LEAF assessment criteria:
    - Accessibility
    - Biodiversity Conservation
    - Community Wellbeing & Engagement
    - Design & Landscaping
    - Environmental Sustainability
    - Maintenance
  - Additionally, future development should be carefully designed and planned by taking reference to the LEAF assessment for development criteria such as:
    - Green Plot Ratio of the Entire Site and Green Buffer & Peripheral Planting Verge
    - Ground Level Landscaped Area
    - Catchment of Runoff
    - Percentage of Native Plants Species Used
    - Quantity of Native Species Planted
    - Percentage of Retained Mature Trees On Site
    - Percentage of Auto-Irrigation

11.6 Residual Impact

11.6.1 Construction Phase

Employing a robust set of mitigation measures during construction phase will significantly minimizes anticipated residual impacts on the landscape and visual aspects. Measures include hoarding installation, strategic planning of activities, and the use of visually appealing barriers. These efforts align with responsible and sustainable construction practices, emphasizing the Project's commitment to environmental preservation and community well-being. The visual impact during construction phase is expected to be reduced to slight impact.

11.6.2 Post-Construction Phase

Opportunities in the post-construction phase allow for the visual reinstatement of disrupted site which will reduce the residual impact to slight to minor levels. Key measures include thoughtful landscaping design, reduced use of extensive glass materials, tree planting to enhance greenery efforts with the surrounding environment. These strategies align with the goal of creating a sustainable and aesthetically pleasing community in the final form of the built environment.

11.7 RIAM Summary

11.7.1 Construction Phase

Table 11.4 Summary of impact assessment for Visual impacts for the construction phase. The change in impact Magnitude following mitigation (if any), and the residual impact Significance is also shown. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score)

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures							With mitigation measures		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Alterations to current landscape from forest to construction site	Boarding house at Keramat Road	2	-4	2	2	2	-48	Minor negative impact	-2	-24	Slight negative impact
	HDB residence along Woodlands Ave 9	3	-4	2	2	2	-72	Minor negative impact	-2	-36	Slight negative impact
	Republic Polytechnic	2	-4	2	2	2	-48	Minor negative impact	-2	-24	Slight negative impact
	Industrial areas	1	-4	2	2	2	-24	Slight negative impact	-2	-12	Slight negative impact

11.7.2 Post-Construction Phase

Table 11.5 Summary of impact assessment for visual impacts for the post-construction phase. The change in impact Magnitude following mitigation (if any), and the residual impact Significance is also shown. (I = Importance; M = Magnitude; P = Permanence; R = Reversibility; C = Cumulative; ES = Environmental Score)

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures							With mitigation measures		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Alterations to current landscape from forest to future developments	Boarding house at Keramat Road	2	-4	3	3	2	-64	Minor negative impact	-2	-32	Slight negative impact
	HDB residence along Woodlands Ave 9	3	-4	3	3	2	-96	Moderate negative impact	-2	-48	Minor negative impact
	Republic Polytechnic	2	-4	3	3	2	-64	Minor negative impact	-2	-32	Slight negative impact
	Industrial areas	1	-4	3	3	2	-32	Slight negative impact	-2	-16	Slight negative impact

12 Construction Waste & Vector Proliferation

The inappropriate management, storage and disposal of construction wastes generated during the construction process has the potential to result in various forms of environmental contamination, with downstream effects such as degradation of soil quality, shifts in flora and fauna composition towards pest or nuisance species. Poorly managed construction wastes may also have adverse effects on people in proximity, causing acute illnesses/injury and in severe circumstances, resulting in chronic conditions.

12.1 Applicable Legislation, Guidelines and Standards

National environmental management requirements that are applicable to the management and control of environmental pollution and vector proliferation are found in several Acts, Regulations and Guidelines, as listed in Table 12.1.

Table 12.1 Applicable acts, regulation and guidelines for environmental pollution and vector control

Environmental Aspect	Applicable Acts, Regulations & Guidelines
Waste management and environmental pollution	• Environmental Public Health Act (2002) • General Waste Collection Regulations (2000) • Toxic Industrial Wastes Regulations (2000) • Specified Construction Sites Order (2021)
Vector control	• Control of Vectors and Pesticides Act (2002)

Environmental Public Health Act

The Environmental Public Health Act (EPHA) enacted in 2002 embodies the parent regulatory framework that governs the management of waste produced through commercial, industrial and personal activity. Several regulations under this parent act are of relevance to the range of waste expected to be produced during the construction process.

The General Waste Collection Regulations pertains to the management of most forms of non-hazardous waste, including the obligations for both the producers and collectors of such waste products.

The Toxic Industrial Waste Regulations, in turn, stipulates the bounds by which hazardous or toxic wastes may be generated, managed and disposed. A catalogue of wastes classified as “Toxic Industrial Wastes” similarly falls within the purview of these regulations, and may include a variety of sludges, chemicals and solvents. Specific requirements necessitate the appointment of licensed toxic industrial waste companies for the management, treatment and disposal of such wastes.

The Specified Construction Sites Order represents a more recent obligation for site occupiers to manage potential environmental damage through the appointment of a licensed Environmental Control Officer, who is legally required to monitor, assess and mitigate the extent of environmental damage.

Control of Vectors and Pesticides Act

The Control of Vectors and Pesticides Act functions as the governing set of guidelines for the for the control of vectors; and through this prevent the proliferation of vector-propagated diseases, such as Dengue Fever, the Zika Virus and Murine Typhus, amongst a whole

range of other infectious diseases. The Act regulates the formal licensing of official NEA approved Vector Control Operators and workers, and controls the legal availability of toxicants and repellents intended for use in vector control.

12.2 Impact Assessment Framework

12.2.1 Importance Rating of Sensitive Receptors

Score	Generic Definition	Specific Criteria
-4	Important to national/international interests	• Receptors specifically protected by national or international policies or legislation and are of significance at the regional or national scale, e.g. designated Nature Reserves, Nature Areas, ASEAN Heritage Park
-3	Important to regional/national interests	• Receptor locations where human or wildlife populations are readily exposed to the construction environment and are dependent on the soil and groundwater resources for economical or biological support to sustain the population
-2	Important to areas immediately outside the local condition	• Receptor locations where the construction environment is utilised in distant, but not within the immediate proximity. Adequate opportunities are available for the utilization of alternative sources of comparable quality.
-1	Important only to the local condition (within a large direct impact area)	• Receptor locations accessible by general public where exposure is transient, for example public footpath, playing fields, parks.
0	Important only to the local condition (within a small direct impact area)	• Receptor locations with limited access and where exposure is transient, for example private premises.

Construction waste

The pollutive effects of construction waste during the construction phase are expected to influence all the environment as a whole in and around the vicinity of the Project Site. Downstream receptors from this process may broadly include the construction personnel, and the various flora and fauna identified within the Study Area. An assessment of the impacts associated with environmental pollution and construction activities to flora and fauna have been discussed in Section 4.4. Thus, this section will focus on their effects on construction personnel.

Since construction personnel are typically equipped with suitable personal protective equipment, have undergone safety training and are managed in accordance to established protocols and practices, their susceptibility to the effects of construction waste and pollution is expected to be minimal. Thus, construction personnel will be given an importance score of 1.

Vector Proliferation

The proliferation of vectors and associated spreading of diseases would be similarly expected to mainly affect the construction personnel operating within the Study Area. Whilst the effects of construction waste are often warded off by suitable preventative measures, additional opportunities are available to affect construction workers, particularly during their personal and rest time, during which, personnel are often left in proximity to the site, but to their own devices. In these respects, the importance score of construction personnel is raised to 2.

An additional receptor has been identified with respect to the proliferation of vectors. Residents living in adjacent homes, and workers working in the various commercial and industrial facilities surrounding the Study Area are likely recipients of such impacts. Relevant vectors, such as mosquitoes, flies and rats are likely able to successfully escape the construction bounds of the Study Area, and move into these aforementioned adjacent areas. Thus, an importance score of 2 has been similarly attributed to these individuals.

12.2.2 Magnitude of Change

Table 12.2 Evaluation Framework for Magnitude of Change in Environmental Pollution

Score	Generic Definition	Specific Criteria
-4	Major negative disadvantage or change	• Production and retention of waste material that is of at least intermediate toxicity, resulting in potentially chronic or substantive impacts on health and quality of environmental receptors i.e., release of asbestos, heavy metals, and radioactive material • Effects of environmental pollution are essentially permanent; pollutive effects may be mitigated but not resolved, resulting in the disequilibrium of affected environmental receptors
-3	Moderate negative disadvantage or change	• Production and retention of waste material that is of mild toxicity, resulting in potentially acute impacts on health and quality of environmental receptors • Effects of environmental pollution necessitate dedicated removal, resulting in the disequilibrium of affected environmental receptors if left without intervention
-2	Minor negative disadvantage or change	• Production and retention of waste material that is of indiscernible toxicity, but may be associated with reduced quality of environmental receptors, and long-lasting irritation or discomfort in human receptors i.e., microplastic release, loose ashes, oils and sludges • Effects of environmental pollution benefit from intentional removal, to reduce the duration and extent of pollutive effects
-1	Slight negative disadvantage or change	• Production and retention of waste material that may produce temporary mild irritation, discomfort, or annoyance in human receptors i.e., accidental spillage of organic waste • Effects of environmental pollution are temporary, and self-resolving
0	No change	• Status quo

12.3 Prediction and Assessment of Impacts

12.3.1 Construction Phase

An assortment of natural and artificial wastes are expected to be produced as a consequence of the construction process. Whilst the production of wastes is generally unavoidable, the management of waste has traditionally been unproblematic within the context of Singapore's developments. Thus, the magnitude of impacts associated with waste-based environmental pollution is generally classed as Minor.

Similarly, conditions created by the construction process that may be conducive to the proliferation of various pests and vectors are generally also adequately controlled and managed by standard practices utilised in Singapore. Accordingly, the magnitude of impacts associated with the presences and diseases spread by vectors have been deemed to be Minor.

Both the generation of wastes and propagation of vectors is expected to be limited to the duration and scale of the construction process. Thus, waste-linked environmental pollution and vector-linked impacts have been deemed to be both temporary and reversible.

The subsections below briefly describe categories of waste, vectors and their associated impacts.

Cut and felled vegetation

A large quantity of vegetation is expected to be removed and felled during the clearance of habitat from the Study Area. Improperly managed stockpiles of rotting vegetation may be a source of fouling, function as refuges for pests and zoonotic vectors and may pose a fire hazard, especially under dry and hot conditions.

Excavated earth and substrata

The levelling of the Study Area through excavation and blasting works is expected to result in large volumes of loose substrata and earth. Improperly managed excavated earth may result in significant off gassing, and excessive sedimentation of both adjacent roads and drainage cisterns as a result of surface runoff.

Miscellaneous Waste

Miscellaneous waste include scrap food, litter and debris associated with human activities in and about the construction site. The improper management and disposal of these miscellaneous wastes may become a significant source of odour, windblown litter, soil and water fouling, as well as sustenance for various vectors and pests.

Construction Waste

Extraneous waste is expected to be generated through inefficiencies in the construction process. This may consist of broken concrete, scrap metal, wood such as planks, boards and pallets, as well as various plastic material such as packaging, wrapping and sheets. The degradation of these materials has the potential to release various toxicants, irritants and dusts into the surrounding environment. For example, various plastic products may be broken down into microplastics, whose effects on the soil and water quality, as well as animal and human health remain unknown. Similarly, the corrosion of metal-based products may suffuse the environment with excessive concentrations of heavy metal ions, which may then have a myriad of downstream effects on environmental acidification, nutrient balance, beyond generally being inherently toxic.

Hazardous Waste

Hazardous waste is likely to arise as a result of chemical usage during the construction process. Broad categories of such hazardous waste include various lubricants, solvents,

colouring agents and contaminated water, amongst other synthetic or artificial chemical agents.

The inherent toxicity in these chemical agents are expected to pose a range of downstream effects on both environmental and human health, potentially shifting the equilibrium of ecosystems past points of functionality and afflicting human receptors with a host of acute and chronic ailments. Various hazardous wastes may also be highly flammable, such as those that may be classed as hydrocarbons.

Mosquito breeding

Stagnant water pools suitable for mosquito breeding are a frequent consequence of construction related activities. These pools may form as a result of ditches, holes and other recessed areas that fill up during periods of heavy rainfall, or can be formed through improper storage of equipment and machinery in a manner that allows for the retention of water. The potential proliferation of mosquitoes may preliminarily function as an annoyance but can also secondarily result in the dissemination of serious diseases amongst construction workers operating within the development area, as well as residents and passers-by to the general Woodland's North Coast vicinity. These diseases include Dengue, Chikungunya, Zika and Encephalitis, all of which have been recorded in Singapore.

Vector Proliferation

The accumulation of domestic and food waste material, if poorly managed, can provide other vector species, such as rodents, flies and cockroaches, with easy access to food and shelter. The breeding of these other vectors generally results in consternation and a sense of unease, although other food-borne diseases may also be spread as a result.

12.3.2 Post-Construction Phase

The cessation of construction activities in the post-construction phase, alongside the integration of proper waste management and drainage systems should result in a quotidian level of environmental pollution. Thus, no environmental pollution from waste management or vector related impacts is expected and will be assessed in relation to the post-construction phase.

12.4 Proposed Mitigation Measures

12.4.1 Waste Management

The management of construction waste broadly falls into three categories: Reduction, Reuse and Disposal. The order of these options is aligned with a hierarchy of priorities; impacts should be and would be most effectively mitigated through a reduction in the generation of construction wastes as a whole, before considering reusing suitable material. Finally, the proper disposal of unusable construction wastes through licensed waste collection and disposal contractors remains the last choice of recourse. These options should be encapsulated within a waste management plan appropriately devised during the pre-construction phase, stipulating the procedures for the management, recycling and disposal of waste in an environmentally friendly and sustainable manner.

Table 12.3 Aspects and mitigation measures employed for proper waste management

Aspect	Details
Reduction	• Accurate pre-construction planning for logistical and material requirements, with an emphasis of having reasonable, but not excessive margins. • Earth Control Measures such as the deployment of Erosion Control Blankets of should be employed to prevent sources of environmental pollution from escaping into adjacent waterways, reservoirs and substrata.
Reuse	• Timber/wood from cut vegetation can be recovered for use in the wood industry as far as possible. • Surplus excavated material and inert wastes (soil, broken rock etc.) shall be reused within project site as backfill, landscaping, erosion control and restoration features wherever practicable. • Scrap metals (e.g., welding rods, end caps, off-cuts etc.) can be recovered and sent for recycling as scrap.
Dispose	• Chemical toilet facilities/ septic tank system with collection of accumulated waste for off-site disposal by a licensed general waste collector. • Other inert general waste will be collected and disposed through licensed waste collector. • General refuse generated on-site must be stored in enclosed bins separate from construction and hazardous wastes. A licensed general waste collector shall be employed by the Contractor to remove general refuse, on a daily or every second day basis to minimise odour, pest, and litter impacts. • All non-hazardous wastes that are generated must be handled and disposed of in accordance with the requirements of the EPHA and the EPH (General Waste Collection) Regulations. • Any hazardous wastes that are generated must be handled and disposed of in accordance with the requirements of the EPHA and the EPH (Toxic Industrial Wastes) Regulations.

12.4.2 Vector Control

Mitigative measures intended to impede the proliferation of vectors begin with the implementation of an appropriate vector control plan during the pre-construction phase. The design and implementation of such a plan typically falls within the purview of the environmental consultant and NEA approved vector control operator. The standard aspects and relevant responsibilities of a vector management plan and team are detailed in Table 12.4 and Table 12.5.

Mosquito breeding

Table 12.4 Aspects and mitigation measures employed to prevent mosquito breeding

Aspect	Details
Prevention	• Orderliness and organisation should be maintained within the construction site; debris, litter and waste should be removed promptly • Air-handling units are to be situated under shelter, and equipped with an overflow pipe to allow for the draining of rainwater • Construction material and equipment to be stored at an elevated position to prevent the accumulation of stagnant water • Potential receptacles for water storage, including various pails, containers, corrugated plastic/metal sheets, are to be kept indoors and away from accidental exposure to rainfall • Puddles should be drained or emptied promptly • Holes and ditches should be filled, covered, or levelled to prevent the accidental accumulation of water
Monitoring	• Daily checks should be conducted for mosquito breeding, including aforementioned receptacles, alongside the presence of larvae • Weekly checks of NEA's dengue cluster map should be performed to reassess this risk to construction workers • Noticeable increases in the number of vectors should be reported to the NEA for investigation
Mitigation*	• Repellents and insecticides are to be applied into stagnant water weekly

**Thermal fogging cannot be carried out within 100m of Admiralty Forest*

Proliferation of other vectors

Table 12.5 Aspects and mitigation measures employed to prevent the proliferation of other vectors such as rodents and cockroaches

Aspect	Details
Prevention	• Proper sanitation and cleanliness should be maintained at all times, particularly around the living quarters of construction personnel • Food and sanitary waste should be disposed of in covered bins, and regularly cleared out from the site to proper waste disposal facilities • Edibles shall be adequately stored within rodent-proof storage such as sealed containments and elevated at least 60cm above ground
Monitoring	• Daily site inspections should be conducted to check for the presence of rodent burrows on a weekly basis • Noticeable increases in the number of vectors should be reported to the NEA for investigation
Mitigation	• Identified active burrows should be treated with rodenticides for at least three consecutive days or until all rats are dead, and sealed with compacted earth

12.4.3 Post-Construction Phase

Since no impacts were identified to have been relevant to the post-construction phase, and accordingly, no mitigation measures will be suggested.

12.5 Residual Impact

The residual impacts were evaluated using the RIAM method (Table 12.6) with due consideration that the recommended mitigation measures are implemented by the Contractor. The residual impacts are likely to be in the band of slight negative to no impact and considered acceptable.

12.6 RIAM Summary

Table 12.6 Evaluation Framework for Magnitude of Change in Environmental Pollution

Predicted Impact	Sensitive Receptors	Predicted impacts without mitigation measures							With mitigation measures		
		I	M	P	R	C	ES	Impact Significance	M	ES	Residual Impact Significance
Pollution from construction wastes	Project site and surrounding environment	1	-2	2	2	2	-12	Slight negative impact	-1	-6	No impact
Vector Proliferation	Project site and surrounding communities	2	-2	2	2	2	-24	Slight negative impact	-1	-12	Slight negative impact

13 Environmental Management and Monitoring Plan

This section outlines the monitoring and management measures that are recommended for the Development.

13.1 Objectives

The Environmental Management and Monitoring Plan (EMMP) constitutes a methodical strategy aimed at reducing environmental impacts and overseeing the execution of these alleviation measures. Its purpose is to ensure that the Project is implemented without causing unacceptable adverse effects on the site and its surrounding environment. Additionally, the EMMP serves as a valuable tool for evaluating the effectiveness of implemented mitigation measures in minimizing and maintaining potential project-related impacts at acceptable levels throughout the construction phase.

13.2 EMMP Roles and Responsibilities

For the implementation and sustained success of the EMMP, there are many different parties that must commit to ensure that the impacts to ecology and environment of the Project's construction activities will be mitigated to the lowest practicable level, with on-going monitoring designed to maintain this optimum level of mitigation for the duration of the proposed Developments.

13.2.1 Employer

It will be the responsibility of the Employer to ensure implementation of the EMMP by the Contractors or any third party during the construction periods of the Project. References within the EMMP to the "Employer" are to JTC as the proposed Developing Agency. References to the "Contractor" are to the main contractors for the construction phase and also include any sub-contractors under their purview.

13.2.2 Employer's Environmental Team

13.2.2.1 EMMP Consultant

JTC will engage an EMMP Consultant independently from Contractor construction contracts. The EMMP consultant shall formulate an EMMP that covers all proposed construction activities during the Development. This EMMP shall consider construction methodologies and activities and shall serve as a plan to implement the mitigation measures covered in this EIA.

The EMMP Consultant is responsible for conducting regular inspections of the site to monitor Contractor's implementation of EMMP measures, and audit of environmental monitoring data provided by the Contractor. Where audit findings highlight a nonconformance, there will be an investigation and appropriate corrective action taken. All environmental audits will be clearly documented and filed internally. The EMMP Consultant is responsible for the overall quality and effectiveness of the EMMP, organising the EMMP audits and provision of comment clarifications and presentations when required with stakeholders and authorities.

Biodiversity Specialists (Ecologist and Arborist)

The EMMP Consultant's team shall include a sufficiently experienced Ecologist to conduct a pre-clearance wildlife inspection and prepare wildlife management protocols as and when required by the relevant Authorities. The Ecologist is responsible for ensuring wildlife encountered during pre-clearance inspections are reported to the EMMP consultant and advising the EMMP consultant on further actions to mitigate fauna injury or mortality.

The EMMP consultant's team shall also include shall also a sufficiently experienced ISA-certified Arborist to conduct pre-felling inspection of trees, and ensure that appropriate tree protection measures are implemented for retained trees directly adjacent to the Project footprint.

The EMMP Consultant will be responsible for developing and training the Contractor and any sub-contractors in compliance with the EMMP, and incidents of human-wildlife conflicts.

13.2.3 Contractor

The Contractor shall be responsible for establishing an Environmental Team that comprises different environmental specialists to work with the regulatory authorities in Singapore to comply with regulations, policies and guidelines related to environmental affairs. The Contractor shall coordinate with EMMP Consultant (independently engaged by employer) and comply with the EMMP developed by the EMMP consultant. The Contractor shall ensure that all staff are familiar with the relevant parts of the EMMP.

While the EMMP sets out the requirements for environmental management during the construction phase, and the responsibilities for meeting them, the details of the actions to be taken in order to implement each aspect of the EMMP will need to be developed and specified by the Contractor in method statements. These method statements demonstrate how compliance with the requirements of the EMMP is to be achieved. These method statements need to be submitted to the EMMP Consultant and Employer for approval and distribution to relevant regulatory authorities as appropriate.

The Contractor will also be responsible for the provision and installation of all monitoring instruments required under the EMMP specifications, together with the necessities to ensure smooth operation and accurate data and results, such as power supply, mounting, protective or weather-proof casing. The data from the monitoring instruments shall be shared with the EMMP Consultant for EMMP monitoring requirements.

The Contractor will be responsible for developing and training staff in Emergency Management Procedures that cover potential incidents such as spills and leaks.

13.2.4 Contractor's Environmental Team

Environmental Control Officer

The Contractor shall engage at least one full-time Environmental Control Officer (ECO) for the construction phase of the development. The ECO shall be registered with the Commissioner of Public Health and discharge the duties set out in the Code of Practice for ECO. The ECO will contribute to devising practicable implementation plans for outlined mitigation measures and conduct daily site inspection in the following main areas: control of disease-bearing vectors and rodents; proper management and disposal of solid waste and liquid waste; control of noise and dust pollution; drainage control; general housekeeping; earth control measures; and silt control.

At least three weeks before construction works commencement, the ECO will submit an Environmental Control Program. After works commence a Site Environmental Control

Report (SECR) should be submitted every 2 weeks to the Contractor. The report shall be made available for inspection on demand by the Director-General of Public Health or any Public Health Officer. The Environmental Control Program SECR shall contain the information required by the Singapore Code of Practice for Environmental Control Officers.

Environmental Specialists

The Contractor will also be responsible where applicable to appoint Qualified Erosion Control Professional (QECP) (as required by PUB), Earth Control Measures Officer (ECMO), NEA-licensed Pest Control Officer (PCO), NParks Certified Animal Management Specialist, Tree Felling Contractor with ISA-certified Arborist, Landscape/Horticultural Contractor (if required), SINGLAS accredited laboratory, and licence waste collectors to implement the EMMP requirements.

Any environmental specialist or company engaged by the Contractor to undertake the works under the CEMMP, must be adequately experienced. Equipment or instruments used must be maintained and calibrated at manufacturer recommended frequencies. All the certifications, accreditation and quality assurance records must be gathered and documented if and when required by the Contractor.

NParks Certified Animal Management Specialist

The Contractor shall engage an NParks Certified Animal Management Specialist that can be mobilised immediately when the EMMP consultants advise that relocation of fauna is necessary and feasible during the earthworks stage of the construction to capture and relocate wildlife of concern encountered during the pre-felling investigation by the Ecologist. The Animal Management Specialist must be a third-party contractor that has been given approval from the Director-General of Wildlife Management to conduct specific activities that are restricted by the Wildlife Act. The EMMP consultants will advise the Contractor as and when relocation is necessary and feasible.

13.3 Impact Mitigation and Monitoring

This section presents some key impact management measures and the monitoring regime recommended for the pre-construction and construction phase of the Development. Subsections below listed out the brief description of the key EMMP measures.

Additionally, post-construction stage monitoring will solely aim to restore the site to its pre-construction condition as closely as possible. It will not involve monitoring the impact from the operations.

13.3.1 Environmental Impacts Register

Environmental Aspect	Description of Receiver		Description of Potential Impact		Proposed Mitigation Measures	Implementation Agent	Residual Impact Significance	Proposed Monitoring Requirement	Reporting Requirements
	Receiver	Importance / Sensitivity	Impact	Impact Significance					
Ecology	Native-dominated, young secondary forest	Moderate	Loss of vegetation and habitat	Moderate negative	• Conservation-significant tree/flora species, if present, should be considered for salvaging or transplanting. • Habitat creation should be attempted by replanting green spaces with native plants to mimic natural environments. The retention of mature trees fringing the development footprint should also be considered to retain the functionality of these habitats.	• Contractor/ECO • EMMP Consultant • Arborist/flora specialist • Fauna specialist	Moderate negative	• Contractor's arborist/flora and fauna specialists to formulate a monitoring plan taking into consideration proposed mitigation measures and the Contractor's detailed work schedule. • Periodic monitoring of retained trees' health and vigor to determine if health and vigor of trees at proximity to the development is being impaired by construction. • Monthly wildlife visual assessment to check for Contractor's compliance and that no animal entrapments within the work site. • EMMP Consultant to conduct monthly site inspection ensure environmental mitigation measures have been effectively implemented by the Contractor. • Contractor to conduct daily visual inspection of hoardings to ensure they are functioning and no wildlife entrapment. • Contractor to ensure all on-site staff are familiar with wildlife response protocol. • ECO to record any wildlife encounters (injured, trapped, mortality).	• Pre-felling Inspection Report • Monthly Wildlife Inspection Report • Monthly Tree Inspection Report • Monthly Environmental Performance Report • Wildlife encounter records
	Exotic-dominated, secondary forest	Moderate		Moderate negative			Moderate negative		
	Scrubland/ Grassland	Low		Minor negative			Minor negative		
	Non-volant mammals	Moderate	Loss of ecological connectivity	Slight negative			Slight negative		
	Bats	Moderate		Minor negative			Slight negative		
	Avifauna	High		Minor negative			Slight negative		
	Herpetofauna	Low		Slight negative			Slight negative		
	Butterflies	Low		Slight negative			Slight negative		
	Odonates	Low		Slight negative			Slight negative		
	Birds and volant wildlife	Moderate	Injury or mortality to fauna	Minor negative	• Bird-safe measures should be implemented to reduce the probability of bird strikes in accordance with NParks guidelines.		Minor negative		
	Mammals	Moderate	Loss of fauna	Minor negative	<u>Wildlife Management, Protection and Monitoring Plan</u> • An appropriate Wildlife Management, Protection and Monitoring Plan should be designed and implemented. • Staging and directional vegetation clearance, denominate temporary work zoning and potential trapping points for wildlife, where they can subsequently be contained and relocated from the site. • Detail procedures for the handling, trapping and relocation of such individuals in accordance with NParks guidelines. The plan should also include relevant information for NParks certified Animal management specialists, who will be responsible for executing said plan.		Slight negative		
	Avifauna	High		Minor negative			Minor negative		
	Herpetofauna	Low		Minor negative			Minor negative		
	Butterflies	Low		Slight negative			Slight negative		
	Odonates	Low		Slight negative			Slight negative		

Environmental Aspect	Description of Receiver		Description of Potential Impact		Proposed Mitigation Measures	Implementation Agent	Residual Impact Significance	Proposed Monitoring Requirement	Reporting Requirements
	Receiver	Importance / Sensitivity	Impact	Impact Significance					
					• Regular fauna inspections within the construction site to detect any fauna injury or fauna in distress early. <u>Pre-felling fauna inspection</u> • Prior to tree felling works, inspections for the presence of arboreal fauna and bee/hornet/wasp hives and bird nests are to be conducted. Tree felling works are to continue only after the safe removal/relocation of the mentioned fauna or fauna habitats. <u>General construction site management</u> • An appropriate hoarding plan should be designed and implemented to prevent the entry of wildlife into the construction site and reduce the occurrence of injuries and mortality. The hoarding should be at least 300mm embedded into the ground. • 100% Biodegradable Erosion Control Blankets are to be used and regularly inspected, to minimise the likelihood of fauna entanglement. • Formulation of Lighting Management Plan in case of night works, to avoid spillage of artificial night lighting towards Admiralty forest.				
	Conservation significant flora	Very high	Loss of flora	Major negative	• Conservation-significant tree/flora species, if present, should be considered for salvaging or transplanting. • Tree protection zone (TPZ) shall be demarcated and maintained in accordance with NParks guideline for any retain trees within and at the edge of the works boundary.		Moderate negative		
	Mammal	Moderate	Human-wildlife conflict	Moderate negative	• The Contractor is required to designate areas for food consumption and storage that will not be easily accessible by fauna. Rubbish bins with weighted lids are also to be provided to minimise the possibility of wildlife foraging. • The Contractor is required to develop and implement a Wildlife Response and Management Plan, to spell out the required actions, communication, and reporting needed to handle any wildlife encounters • Wildlife Awareness training to be conducted to demonstrate correct approaches to encounters with injurious or stray wildlife.		Minor negative		
	Herpetofauna	Low		Minor negative			Minor negative		
	Humans	Moderate		Moderate negative			Minor negative		
Air Quality	Terrestrial fauna (Admiralty Forest)	Moderate	Earthworks	Minor negative	<u>General construction site management:</u> • Planning of construction programme to minimize the area and duration of exposed surfaces, and to reinstate completed work areas as early as practical.	• Contractor/ECO • EMMP Consultant • Contractor PRO	Slight negative	• Daily visual inspection and housekeeping by Contractor of any abnormal emissions. • ECO to conduct site inspection and to submit a	• ECO Site Environmental Control Report • Online air quality monitoring data
			Demolition of 10 view road (if any, on fauna	Slight negative			Slight negative		

Environmental Aspect	Description of Receiver		Description of Potential Impact		Proposed Mitigation Measures	Implementation Agent	Residual Impact Significance	Proposed Monitoring Requirement	Reporting Requirements
	Receiver	Importance / Sensitivity	Impact	Impact Significance					
			within Project site only)		• Comply with relevant environmental regulations, including the Environmental Protection and Management Act and any other regulations and guidelines come into effect when the time of construction works commencement. • Minimise the duration of bare earth exposure through careful planning of work sequence and schedule. • If exposure of bare earth and stockpile of earth materials is needed on site, Erosion Control Blankets shall be used to cover the exposed surfaces to prevent wind erosion and wash off by rain. • Adequate tarpaulin covers to be placed on-site in case of storm events. • Plants and machineries used on site shall be properly and regularly inspected and maintained to control dust and air pollutants emission. • Minimise dust emission from dusty activities, e.g. excavation and demolition, by water spraying and / or physical screening. • To schedule activities with the potential for higher dust emissions, such as earthwork and demolition during periods of lower wind speeds to reduce the dispersion of airborne particles. • Wheel washing bay shall be provided, and all trucks / vehicles shall be washed before leaving the construction site. • Minimize traffic delays caused by movement of construction vehicles by planning transport route and transport period that avoid congested areas and peak hours of road use. • Installation and proper maintenance of dust screen, fencing or hoarding along construction site perimeters recommended to reduce dust deposition. • Avoid burning of waste or other materials. <u>Mitigation measures for Demolition</u> (if any): • Employing dust barriers and screens around the demolition site. • To keep the demolition period as short as possible. • No crushing or screening of demolished construction material shall be performed on-site. <u>Mitigation measures for earthworks:</u> • Prompt removal of excavated soil from the construction site to prevent prolonged exposure. • To limit the height of stockpiles to control airborne dust.			site environmental control report to the occupier of the construction at each site inspection every 2 weeks. • EMMP Consultant to conduct monthly site inspection ensure environmental mitigation measures have been effectively implemented by the Contractor. • Conduct continuous air quality monitoring at following locations to monitor for any significant dust impact: ○ A1: Admiralty Forest ○ A2: HDB Blk 877 Woodlands Ave 9	• Monthly Environmental Performance Report
			Construction activities	Slight negative			Slight negative		
			Trackout	Slight negative			Slight negative		
			Emission from WNC operation	No impact			No impact		
	Residential areas	Moderate	Earthworks	Minor negative			Slight negative		
			Demolition of 10 view road (if any)	Slight negative			No impact		
			Construction activities	Slight negative			Slight negative		
			Trackout	Slight negative			Slight negative		
			Emission from WNC operation	No impact			No impact		
	Educational institutions	Low	Earthworks	Minor negative			Slight negative		
			Demolition of 10 view road (if any)	No impact			No impact		
			Construction activities	Slight negative			Slight negative		
			Trackout	Slight negative			No impact		
			Emission from WNC operation	No impact			No impact		
	Healthcare facilities	High	Earthworks	Moderate negative			Minor negative		
			Demolition of 10 view road (if any)	No impact			No impact		
			Construction activities	Minor negative			Slight negative		

Environmental Aspect	Description of Receiver		Description of Potential Impact		Proposed Mitigation Measures	Implementation Agent	Residual Impact Significance	Proposed Monitoring Requirement	Reporting Requirements
	Receiver	Importance / Sensitivity	Impact	Impact Significance					
			Trackout	Minor negative	• Earthworks to be conducted in stages. • To cover any exposed earth areas not in immediate use with erosion control blankets. • To compact or pave any exposed earth areas not in immediate use. <u>Mitigation measures for construction activities:</u> • Installation of physical barriers to contain ground-level pollutants. • Employing local exhaust ventilation systems. • To prioritize the use of low volatile organic compound (VOC) construction materials for paints, adhesives, and sealants. • To utilize emission-reducing construction equipment. • Regular inspection and maintenance of construction equipment to control emissions. • If concrete batching is carried out on site, the batching plant shall be placed away from the sensitive receptors. • Use enclosed chutes and conveyors and covered skips wherever possible. • Minimise drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate. <u>Mitigation measures for trackout:</u> • Installation of trackout control mats at exit points complemented by wheel wash stations. • Designing site exit points paved or stabilized surfaces to minimize the disturbance of loose soil. • Enforcing lower speed limits within the construction site to ensure vehicles move within the site and exit gradually. • Equipping all haul trucks transporting materials with covers to reduce dust emissions during transit. • Regular maintenance and cleaning of road within site to promptly remove accumulated dust and debris minimizing the generation of dust.		Slight negative		
			Emission from WNC operation	No impact			No impact		
	Industrial areas	Low	Earthworks	Minor negative			Slight negative		
			Demolition of 10 view road (if any)	No impact			No impact		
			Construction activities	Slight negative			Slight negative		
			Trackout	Slight negative			Slight negative		
			Emission from WNC operation	No impact			No impact		
Airborne Noise	Terrestrial fauna (Admiralty Forest)	Moderate	Land clearance, Land preparation and infrastructure work	Minor negative	<u>General construction site management:</u> • Comply with relevant environmental regulations, including the Environmental Protection and Management Act and any other regulations and guidelines come into effect when the time of construction works commencement. • Prepare a Construction Noise Management Plan, to establish pre-construction baseline monitoring,	• Contractor/ECO • EMMP Consultant • Contractor PRO	Slight impact	• Contractor to formulate a Noise Management Plan to monitor and mitigate noise emissions according to construction schedule. • ECO conduct daily visual inspection of the noise barrier integrity and	• ECO Site Environmental Control Report • Online noise monitoring data • Grievance records • Monthly Environmental
			Future development works – Construction of	Minor negative			Slight impact		

Environmental Aspect	Description of Receiver		Description of Potential Impact		Proposed Mitigation Measures	Implementation Agent	Residual Impact Significance	Proposed Monitoring Requirement	Reporting Requirements
	Receiver	Importance / Sensitivity	Impact	Impact Significance					
			substructure and superstructure		plan for monitoring during the construction phase, and procedure for complaint handling. • Select equipment with low noise emissions. • Prior to commencement of construction works, install noise barriers along project boundary. • Inspect and maintain vehicles and mechanical plants in good effective working order and operate in a manner to minimise noise emissions. • Keep compressor, generator and engine compartment doors close and plant turned off when not in use. • Machines in intermittent use will be shut down or throttled down to a minimum during periods between works. • Precaution and care when unloading vehicles to avoid unnecessary noise. • Limit the timing of the use of heavy machineries (e.g. cranes, excavators, generators) to minimise noise emission, in particular early morning and evening hours when animals are more active. Where alternatives are available, only equipment and vehicles that emit lower noise levels are to be used. • Where necessary, retrofitting silencer or enclosure on machine engines and exhaust to reduce noise emission. • Use site terrain, material stockpiles and suitable work locations to screen work locations and maximise the distance between work activities and the nearest noise sensitive receptors. • Manage project vehicles to not wait or queue up with engines running at the entrance to the site access • Inspect heavy machines regularly identifying maintenance issues which generate excessive noise and carry out maintenance as required. • Construction personnel to be trained in noise-reduction behaviours such as reducing the drop height of materials. • Daily toolbox briefing should include reminders on the need to implement noise-reduction behaviours. • Maintain a complaints procedure to log and track response to complaints received from public. <u>Mitigation measures for source control:</u> • Use of quieter construction equipment as much as possible. • Control of noise sources at the source from construction site – Analyse construction inventory list and check equipment causing high noise levels.			performance of the machinery. • ECO to conduct site inspection and to submit a site environmental control report to the occupier of the construction at each site inspection every 2 weeks. • EMMP Consultant to conduct monthly site inspection ensure environmental mitigation measures have been effectively implemented by the Contractor. • Conduct continuous noise monitoring at the nearest affected NSRs to show compliance with the maximum allowable limits stated in the EPM (Control of Noise at Construction Sites) Regulations. ○ N1: Admiralty Forest ○ N2: HDB Blk 877 Woodlands Ave 9 ○ N3: Man Fut Tong Nursing Home	Performance Report
			Noise emission from WNC operation	No impact			No impact		
	Residential areas	Moderate	Land clearance, Land preparation and infrastructure work	No impact			No impact		
			Future development works – Construction of substructure and superstructure	No impact			No impact		
			Noise emission from WNC operation	No impact			No impact		
	Educational institutions	Low	Land clearance, Land preparation and infrastructure work	No impact			No impact		
			Future development works – Construction of substructure and superstructure	Slight negative			No impact		
			Noise emission from WNC operation	No impact			No impact		
	Healthcare facilities	High	Land clearance, Land preparation and infrastructure work	Slight negative			No impact		
			Future development works –	Moderate negative			No impact		

Environmental Aspect	Description of Receiver		Description of Potential Impact		Proposed Mitigation Measures	Implementation Agent	Residual Impact Significance	Proposed Monitoring Requirement	Reporting Requirements
	Receiver	Importance / Sensitivity	Impact	Impact Significance					
			Construction of substructure and superstructure		The equipment with lower noise level shall be prioritised. • Deploy localised portable noise barriers to screen the noisy activities, e.g. breaking of hard materials, engines <u>Recommendations for noise barrier:</u> • 6m Noise Barrier of minimum Sound Transmission Class (STC) 20 are proposed to be erected along the works boundary.				
			Noise emission from WNC operation	No impact			No impact		
	Industrial areas	Low	Land clearance, Land preparation and infrastructure work	No impact			No impact		
			Future development works – Construction of substructure and superstructure	Slight negative			No impact		
			Noise emission from WNC operation	No impact			No impact		
Ground Vibration	Terrestrial fauna (Admiralty Forest)	Moderate	Demolition of 10 View Road (if any)	Slight negative	• Construction works be carried out at a minimum distance of 25 m and 30 m from 7 North Coast building and 1 North Coast building when conducting piling activities. • Low vibration construction techniques (e.g. use non-vibratory equipment to avoid / minimise the impact of casing insertion during bored piling) are recommended to be implemented in the construction contracts. • Avoid impact pile driving where possible; alternatively, bore piling or the use of a sonic or vibratory pile driver causes lower vibration levels and should be used instead. • Avoid construction works during night hours, as the sensitivity to vibration of residential receptors increases at night. • Operate earth-moving and other vibration-inducing equipment as far away from vibration-sensitive receptors as possible. • Wherever possible, substitution with less intrusive equipment/method or isolation of vibration source should be considered. • All equipment used on site shall be regularly maintained and shall be operated in a manner that	• Contractor/ECO • EMMP Consultant	Slight negative	• ECO to ensure environmental control measures for vibration are implemented. • EMMP Consultant to conduct monthly site inspection ensure environmental mitigation measures have been effectively implemented by the Contractor.	NA
			Construction activities	Slight negative			Slight negative		
			Vibration from WNC operation	No impact			No impact		
	Residential areas	Moderate	Demolition of 10 View Road (if any)	Slight negative			Slight negative		
			Construction activities	Slight negative			Slight negative		
			Vibration from WNC operation	No impact			No impact		
	Educational institutions	Low	Demolition of 10 View Road (if any)	Slight negative			Slight negative		
			Construction activities	Slight negative			Slight negative		

Environmental Aspect	Description of Receiver		Description of Potential Impact		Proposed Mitigation Measures	Implementation Agent	Residual Impact Significance	Proposed Monitoring Requirement	Reporting Requirements
	Receiver	Importance / Sensitivity	Impact	Impact Significance					
			Vibration from WNC operation	No impact	minimises vibration as far as is practicable; damaged equipment should not be used. • Equipment not in use shall be shut down to reduce the amount of vibration generated by idling motors. • Maintain a complaints procedure to log and track response to complaints received from public.		No impact		
	Healthcare facilities	High	Demolition of 10 View Road (if any)	Slight negative			Slight negative		
			Construction activities	Slight negative			Slight negative		
			Vibration from WNC operation	No impact			No impact		
	Industrial areas	Low	Demolition of 10 View Road (if any)	Slight negative			Slight negative		
			Construction activities	Slight negative			Slight negative		
			Vibration from WNC operation	No impact			No impact		
Light	Residents	Moderate	Light nuisance from construction night works (Short-term)	Slight negative	• Avoiding use of lighting that is not needed. • Avoid construction works during night hours as much as practicable. • Illumination with a high UV component should be avoided to reduce impacts on insects. • Checklist for Artificial Light Management / Night Works Management Plan. • Lights should be pointed downwards and towards the interior of the site instead of resulting in spillage beyond the site boundary and into adjacent retained forest area. Shields can be installed for light fixtures near the site boundary to minimise light spillage into adjacent forest habitats. • If needed outside operating hours, low lux level lighting with light shields shall be used along pathways, paved areas and in areas where public access cannot be prevented. • Where possible and safe, use motion sensor to activate lighting for less frequently accessed areas. • Where possible and safe, have light sources be lower than the perimeter hoarding height. • Lights operating at night should be of low wavelengths and narrow spectrum. • Limiting light intensity to the minimum possible levels while not compromising on safety requirements. • Managing the direction of light emissions, i.e. light should not be directed towards forest habitats. • Ensure all unnecessary lights are turned off at the end of any night works.	• Contractor/ECO • EMMP Consultant	No impact	• Night work operations are subjected to approval by the TAs and ECO needs to develop a separate night works management plan and conduct regular site inspection. • ECO to ensure environmental control measures for nocturnal lighting are implemented during the night works. • ECO to document the night-works activities. • EMMP Consultant to conduct monthly site inspection ensure environmental mitigation measures have been effectively implemented by the Contractor.	• Monthly Environmental Performance Report
			Light nuisance from future building operations (Long-term)	Slight negative			No impact		
	Fauna	Moderate	Light nuisance from construction night works (Short-term)	Slight negative			Slight negative		
			Light nuisance from future building operations (Long-term)	Minor negative			Slight negative		

Environmental Aspect	Description of Receiver		Description of Potential Impact		Proposed Mitigation Measures	Implementation Agent	Residual Impact Significance	Proposed Monitoring Requirement	Reporting Requirements
	Receiver	Importance / Sensitivity	Impact	Impact Significance					
					• When directing light sources, be aware of reflective surfaces that could reflect the directed light to sensitive areas. • Site lighting locations should be reviewed regularly to ensure minimal impact to surrounding terrestrial fauna receptors. <u>For planning and design of the future development:</u> • Future development should be carefully designed in line with the Landscape Excellence Assessment Framework (LEAF) criteria.				
Microclimate	Residents	Moderate	Overall ambient temperature increase from future building operations (Long-term)	Slight negative	<u>For planning and design of the future development:</u> • To conform to GLS programme, and obtain Green Mark certification by BCA. • To conduct environmental modelling of the project footprint to illustrate that outdoor thermal comfort is maintained or improved, and that the UHI effect minimised or reduced. • To implement measures in accordance with Green Mark Certification guidelines • Future development should be carefully designed in line with the Landscape Excellence Assessment Framework (LEAF) criteria.	• Engineering design team for future development	No impact	NA	NA
	Fauna	Moderate		Slight negative			No impact		
Soil and Groundwater	Project site	Negligible	Release of Contaminants from Contaminated Soil (Short-term)	Slight negative	• Contractor to strictly avoid usage and storage of chemicals beyond the construction site. • Contractor to prepare a soil management and disposal plan to define the proper storage and disposal of contaminated soil, if any. Testing and remediation plan should be included to ensure the spoil materials meet the receiving facility requirement (dumping ground or accredited toxic waste disposal facilities). • Groundwater from dewatering should undergone ECM treatment and tested to be complied with discharge limits before discharging into public drain. • Contractors should analyze the possible inhalation and cutaneous consequences to site workers exposed to contaminated soil and/or groundwater, and to provide proper personal protective equipment (PPE) to site workers, such as boots, rubber gloves, and googles. • Chemicals shall be stored at designated sheltered areas, with secondary containment. Spill kit and relevant Material Safety Data Sheet (MSDS) for the stored chemicals shall be provided in the storage area.	• Contractor/ECO • EMMP Consultant	No impact	• ECO to conduct daily visual inspection of the site to identify potential contamination. • ECO to conduct site inspection and to submit a site environmental control report to the occupier of the construction at each site inspection every 2 weeks. • EMMP Consultant to conduct monthly site inspection ensure environmental mitigation measures have been effectively implemented by the Contractor.	• ECO Site Environmental Control Report • Monthly Environmental Performance Report
			Contamination of Soil and Groundwater due to Mishandling of Chemicals (Short-term)	Slight negative			No impact		
			Contamination of Soil and Groundwater due to Mishandling of Chemicals (Long-term)	No impact			No impact		
		Negligible	Release of Contaminants from	No impact			No impact		

Environmental Aspect	Description of Receiver		Description of Potential Impact		Proposed Mitigation Measures	Implementation Agent	Residual Impact Significance	Proposed Monitoring Requirement	Reporting Requirements
	Receiver	Importance / Sensitivity	Impact	Impact Significance					
	Immediate community surrounding the Project Site		Contaminated Soil (Short-term)		• For the transportation of hazardous compounds, a notification or tracking system as well as a transportation emergency response plan are required. • Appropriate construction material for toxic waste storage containers, and occasional leak tests conducted on these containers to notify for accidental spills. • In case any spillage occurs, the contractor shall immediately contain and clean up the spill. If extensive contamination is caused, proper disposal and treatment shall be carried out. • Clearance of surface vegetation should be done in stages to reduce the amount of surface runoff and erosion • 100% Biodegradable Erosion Control Blankets should be installed wherever bare earth is exposed • Soil and material stockpiles should be covered with tarpaulin when not in use • Proper erosion and sediment control measures should be implemented by engaging a Qualified Erosion Control Professional (QECP) to design and implement an Earth Control Measures (ECM) plan • Turf cover should be established during reinstatement of the work site to minimize soil erosion • After rain events, earth control measures in the Area are to be inspected and maintained over the course of construction • Tarpaulins mats (in adequate quantities) should be on standby during site clearance and excavation works, to ensure that exposed soil and stockpiles are covered and prevent overflow of silty discharge				
			Surface Runoff (Short-term)	Slight impact			No impact		
			Contamination of Soil and Groundwater due to Mishandling of Chemicals (Long-term)	No impact			No impact		
Landscape and Visual Aesthetics	Boarding house at Keramat Road	Low	Alterations to current landscape from forest to construction site	Minor negative	<u>General construction site management:</u> • Strategically planning construction activities and site layout to minimizes visual obtrusiveness. This includes strategic positioning of structures, equipment, and storage areas to reduce visibility from sensitive viewpoints. • Installation of hoarding around the Project boundary, minimizing visual disruption for surrounding areas. • Employing visually appealing barriers or hoardings that blend with the surroundings, ensuring a more aesthetic appearance during development. • Choosing construction materials and colours that harmonize with the existing environment, reducing the visual contrast between the construction site and its surroundings.	• Contractor/ECO • EMMP Consultant • Engineering design team for future development	Slight negative	• ECO to ensure daily housekeeping to maintain site tidiness. • EMMP Consultant to conduct monthly site inspection ensure environmental mitigation measures have been effectively implemented by the Contractor.	NA
			Alterations to current landscape from forest to future developments	Minor negative			Slight negative		
	HDB residence along Woodlands Ave 9	Moderate	Alterations to current landscape from forest to construction	Minor negative			Slight negative		

Environmental Aspect	Description of Receiver		Description of Potential Impact		Proposed Mitigation Measures	Implementation Agent	Residual Impact Significance	Proposed Monitoring Requirement	Reporting Requirements
	Receiver	Importance / Sensitivity	Impact	Impact Significance					
			site (Short-term)		• Implementing effective dust control measures during earthwork and construction activities helps maintain a clean and visually pleasing site environment. • Introducing temporary landscaping features to softens the visual impact of construction activities, enhancing the aesthetics of the site. • Regular removal of construction debris, maintaining a tidy site and prevent dumping construction waste or materials outside of Project site to minimizes visual clutter and enhances the overall appearance of the site and the surrounding environment. <u>For planning and design of the future development:</u> • Implementing a thoughtful landscaping design that incorporates greenery on buildings, especially those facing initial forest views. • The use of skyrise greenery in building design enhances the overall visual integration with the surroundings. • Minimizing the use of extensive glass materials helps reduce reflections and minimize bird strikes. • To conduct Tree Planting efforts to offset tree felling works during the construction phase and planting of trees and shrubs along the built structures, associated facilities, and road networks to enhance overall greenery efforts with the surrounding environment. • To design the built environment in accordance with the BCA Green Mark Certification. • Future development should be carefully designed in line with the Landscape Excellence Assessment Framework (LEAF) criteria.				
			Alterations to current landscape from forest to future developments (Long-term)	Moderate negative			Minor negative		
	Republic Polytechnic	Low	Alterations to current landscape from forest to construction site (Short-term)	Minor negative			Slight negative		
			Alterations to current landscape from forest to future developments (Long-term)	Minor negative			Slight negative		
	Industrial areas	Negligible	Alterations to current landscape from forest to construction site (Short-term)	Slight negative			Slight negative		
			Alterations to current landscape from forest to future developments (Long-term)	Slight negative			Slight negative		

Environmental Aspect	Description of Receiver		Description of Potential Impact		Proposed Mitigation Measures	Implementation Agent	Residual Impact Significance	Proposed Monitoring Requirement	Reporting Requirements
	Receiver	Importance / Sensitivity	Impact	Impact Significance					
Construction waste	Project site and surrounding environment	Low	Pollution from construction wastes	Slight negative	• Accurate pre-construction planning for logistical and material requirements, with an emphasis of having reasonable, but not excessive margins. • Earth Control Measures such as the deployment of Erosion Control Blankets of should be employed to prevent sources of environmental pollution from escaping into adjacent waterways, reservoirs and substrata. • Timber/wood from cut vegetation can be recovered for use in the wood industry as far as possible. • Surplus excavated material and inert wastes (soil, broken rock etc.) shall be reused within project site as backfill, landscaping, erosion control and restoration features wherever practicable. • Scrap metals (e.g., welding rods, end caps, off-cuts etc.) can be recovered and sent for recycling as scrap. • Chemical toilet facilities/ septic tank system with collection of accumulated waste for off-site disposal by a licensed general waste collector. • Other inert general waste will be collected and disposed through licensed waste collector. • General refuse generated on-site must be stored in enclosed bins separate from construction and hazardous wastes. A licensed general waste collector shall be employed by the Contractor to remove general refuse, on a daily or every second day basis to minimise odour, pest, and litter impacts. • All non-hazardous wastes that are generated must be handled and disposed of in accordance with the requirements of the EPHA and the EPH (General Waste Collection) Regulations. • Any hazardous wastes that are generated must be handled and disposed of in accordance with the requirements of the EPHA and the EPH (Toxic Industrial Wastes) Regulations.	• Contractor/ECO • PCO • EMMP Consultant	No impact	• Contractor to conduct daily visual inspection of the construction site to prevent generation of hazardous waste. • Contractor to conduct daily housekeeping to keep the construction site clean and tidy. • ECO to monitor and record all outgoing construction wastes to be transported licensed toxic industrial waste collector for hazardous wastes. • ECO to conduct site inspection and to submit a site environmental control report to the occupier of the construction at each site inspection every 2 weeks. • EMMP Consultant to conduct monthly site inspection ensure environmental mitigation measures have been effectively implemented by the Contractor.	• ECO Site Environmental Control Report • Waste manifest record • Monthly Environmental Performance Report

Environmental Aspect	Description of Receiver		Description of Potential Impact		Proposed Mitigation Measures	Implementation Agent	Residual Impact Significance	Proposed Monitoring Requirement	Reporting Requirements
	Receiver	Importance / Sensitivity	Impact	Impact Significance					
Vector Proliferation	Project site and surrounding communities	Low	Vector Proliferation	Slight negative	• Orderliness and organisation should be maintained within the construction site; debris, litter and waste should be removed promptly. • Proper sanitation and cleanliness should be maintained at all times, particularly around the living quarters of construction personnel. • Food and sanitary waste should be disposed of in covered bins, and regularly cleared out from the site to proper waste disposal facilities. • Edibles shall be adequately stored within rodent-proof storage such as sealed containments and elevated at least 60cm above ground. • Air-handling units are to be situated under shelter, and equipped with an overflow pipe to allow for the draining of rainwater. • Construction material and equipment to be stored at an elevated position to prevent the accumulation of stagnant water. • Potential receptacles for water storage, including various pails, containers, corrugated plastic/metal sheets, are to be kept indoors and away from accidental exposure to rainfall. • Puddles should be drained or emptied promptly. • Holes and ditches should be filled, covered, or levelled to prevent the accidental accumulation of water. • Daily checks should be conducted for mosquito breeding, including aforementioned receptacles, alongside the presence of larvae. • Daily site inspections should be conducted to check for the presence of rodent burrows on a weekly basis. • Weekly checks of NEA's dengue cluster map should be performed to reassess this risk to construction workers. • Noticeable increases in the number of vectors should be reported to the NEA for investigation. • Repellents and insecticides are to be applied into stagnant water weekly. • Identified active burrows should be treated with rodenticides for at least three consecutive days or until all rats are dead, and sealed with compacted earth. • Thermal fogging cannot be carried out within 100m of Admiralty Forest.	• Contractor/ECO • Vector control vendor • EMMP Consultant	Slight negative	• Contractor to form in-house vector control team to conduct daily check for mosquitoes breeding. • ECO to conduct site inspection and to submit a site environmental control report to the occupier of the construction at each site inspection every 2 weeks. • EMMP Consultant to conduct monthly site inspection ensure environmental mitigation measures have been effectively implemented by the Contractor.	• ECO Site Environmental Control Report • Monthly Environmental Performance Report

13.3.2 Contract-Specific EMMP

Prior to commencement of construction works, the Contractor shall work with the appointed EMMP Specialist to formulate a Contract-specific EMMP (CEMMP) based on their planned construction works details. The CEMMP shall make reference to the mitigations and monitoring as recommended in this EIA.

The following components shall be covered in Contract-Specific EMMP:

- Project Description
- Project Team
- Environmental Objectives
- Environmental Management and Mitigation Measures
- Environmental Monitoring
- Biodiversity Monitoring
- Health and Safety
- EMMP Documents and Reporting
- Change Management and Review

The CEMMP document will contain the following management and monitoring plans to achieve the environmental objectives of the EMMP:

- Flora and Arboriculture Management and Monitoring Plan
- Wildlife Management, Protection and Monitoring Plan (including Wildlife Response and Rescue Plan)
- Water Pollution Control and Monitoring Plan
- Noise Management and Monitoring Plan
- Air Pollution Control and Monitoring Plan
- Waste Management and Monitoring Plan
- Ground-borne Vibration Management and Monitoring Plan
- Soil and Groundwater Management and Monitoring Plan
- Earth Control Measures Plan
- Light Management and Monitoring Plan
- Vector Control Plan

13.3.3 Pre-construction Phase

Flora

The Development Agency will consult NParks on salvaging of plants of conservation and concern, as well as the retention of mature trees (if any) prior to construction works. The locations of conservation-significant flora species recorded during the baseline survey should be verified by a certified arborist / flora specialist, and individuals suitable for transplanting or sapling salvaging should be identified and clearly tagged. Additionally, mature trees potentially earmarked for retention as part of the urban ecoscape shall be assessed for tree health, vigour, structural stability, alongside a qualitative evaluation of its contribution to ecological function before final decisions regarding retention are undertaken. For conservation-significant flora species not suitable for transplanting, harvesting of fruits, seeds, saplings, propagules or stem and leaf cuttings can be carried out.

Tree Protection Zones

For any tree to be retained within or at the edge of the works boundary, a tree protection zone (TPZ) refers to a specified area that protects the entire tree including the roots system, trunk, and crown, and should be maintained to protect the trees throughout the period of construction.

Before the commencement of clearance works, a certified arborist shall conduct an assessment to identify suitable trees for retention along the boundary of the worksite. Selected trees should have a Tree Protection Zone (TPZ) recommended based on site utilisation plans and developed in accordance with the Guidelines on Greenery Provision and Tree Conservation for Developments (NParks, 2023b). The TPZ aims to minimise the impact of construction activities on trees, including but not limited to mechanical injury to roots, trunks and branches due to contact with equipment, materials, debris or other activities. It also aims to minimise soil compaction, which results in poor functioning of roots, and changes in soil levels that can cut off or suffocate roots.

Figure 13.1the general protection radius required based on the respective girth of retained trees. However, the TPZ size may still vary depending on both the crown and root spread which may render the need for larger tree protection zones, particularly for trees with a girth exceeding 2m.

Minimum Protection Zone from the Centre of a Tree

Girth (m)	Minimum Protection Zone
≤1.0m	2.0m
>1.0m but ≤1.5m	3.0m
>1.5m but ≤2.0m	4.0m
>2.0m	5.0m

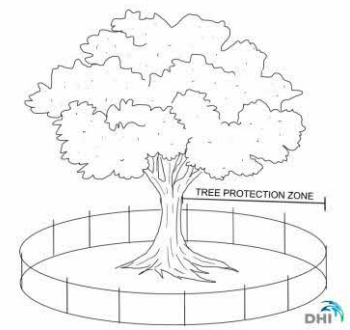


Figure 13.1 General guideline for minimum protection zone (radius) (NParks, 2023) and depiction of TPZ set up.

The following specifications extracted from NParks (2023b) shall be adhered to for construction work carried out within and outside of the TPZ.

Inside TPZ:

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

Outside TPZ:

- If major roots are encountered during excavation, the applicant may like to seek advice from a certified arborist, as cutting of major roots may affect the stability of the tree. Where possible, alternative proposals should be explored to avoid the need to cut the roots.

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

The TPZs should be set up at the start of the construction phase and should not be encroached upon in the course of any works. The certified arborist shall provide monthly checks on the integrity and conditions of the TPZs and report any findings to the appointed environmental control officer (ECO) for rectification and follow-up, which will be documented in the monthly Environmental Performance Report.

Fauna

A Wildlife Management Plan shall be devised by the assigned ecologist and/or EMMP consultant, dictating the appropriate handling, trapping and translocation protocols to be undertaken in line with NParks regulations, should errant wildlife be spotted within active developmental areas. The plan shall also include relevant contacts of NParks Certified Animal Management Specialists who may be utilised in the execution of any wildlife rescue and relocation processes.

Staged and Directional Clearance

The Project site comprises more than 20ha of vegetated area. Prior to any vegetation clearance, embedded perimeter hoardings are to be installed along the works boundary for fully enclose the Project area, so as to prevent animals running onto the roads which may cause injury and casualty of wildlife, as well as human-wildlife conflict. Vegetation will be cleared in stages, starting from the southern area bounded by Woodlands Avenue 9, towards the northern area bounded by Admiralty Road. This is to allow avifauna to move towards the Admiralty Forest in the north. An indicative plan is shown in Figure 13.2 below.

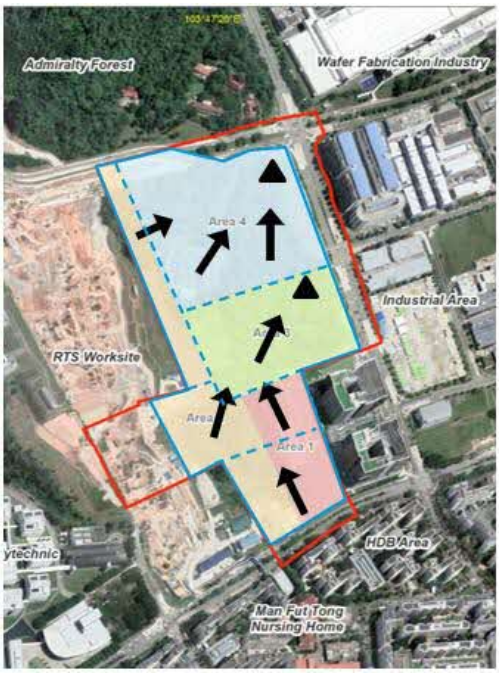


Figure 13.2 Indicative direction for site clearance, and potential trapping points

Directional site clearance shall be carried out to funnel wildlife towards planned points, where they will be captured and released in other suitable habitats in consultation with NParks. For more effective animal management, vegetation clearance, wildlife trapping, and translocation exercises will take place sequentially in smaller subsections of the Project area. These subsections will be demarcated by temporary hoarding, to prevent animals from moving into the larger forested area. The Contractor shall develop a detailed site clearance plan, and propose the corresponding hoarding plan, including temporary hoardings for wildlife trapping based on the future construction plan. A registered Wildlife Management Company shall be engaged for the trapping and relocation of animals within the Project site. The site clearance and wildlife management plan shall be submitted as part of the CEMMP to NParks for approval prior to works commencement.

For Wild boar found within the Project site during the pre-construction or construction stage, NParks is to be notified as soon as possible at nparks_wildlife_management@nparks.gov.sg for advice and subsequent action. An approved Animal Management Specialist must also be engaged to trap and remove individuals, the process of which may take about 4 to 8 weeks.

Pre-felling Wildlife Inspection

Prior to any vegetation clearance, camera traps shall be placed in each zone prior for 5 days, to observe the type of animals present on site. This will allow the Animal Management Specialist to devise suitable trapping methods for animals found within the site.

Pre-felling wildlife inspections shall be conducted by the appointed Ecologist before the clearance of each area. The Ecologist shall also survey for any fauna species, with an emphasis on arboreal fauna, fledging avifauna and other pre-existing or erected microhabitats, such as bird nests, bee hives and tree burrows. In the case where active bird nests are found, the Contractor is to wait for the chick to fledge before the tree is felled. Other observances are to be reported to the Contractor and Consultant to plan for specific management approaches prior to clearance.

Wildlife Response and Rescue Protocol

Even after completing pre-felling fauna inspections and directional clearance, there remains a possibility that animals could enter the site and become trapped, especially those that burrow or climb. For this reason, the EMMP Consultant, informed by their ecologist, should develop a Wildlife Response and Rescue Protocol. If any fauna are found within the working areas, all construction activities must cease immediately, and the Wildlife Response and Rescue Plan should be implemented.

Environmental Baseline Survey

Contractors shall conduct baseline surveys for air and noise quality before commencing the proposed work. Continuous monitoring of air quality and noise should be carried out for a duration of at least one (1) week. The proposed mitigation measures and monitoring requirements are detailed in the Environmental Impact Register in Section 13.3.1.

13.3.4 Construction Phase

Construction stage monitoring entails regular inspection to register excessive environmental impact and allow prompt follow up actions in case of environmental non-conformance. Monitoring by means of instrumental data collection and visual inspections, shall be employed by the Contractor's ECO to ensure environmental management and mitigation measures are effectively implemented on-site.

In the event where works need to be carried out during nighttime (after 7 pm), a Light management plan shall be prepared by the Contractor, which includes the plan for the

specifications and locations of proposed artificial night lighting, to ensure no excessive light spill towards Admiralty Forest and the residential areas surrounding the Project site

The EMMP Consultant shall carry out monthly inspection to ensure proper implementation of EMMP measures and its effectiveness. The consultant shall also inspect the perimeter of permanent hoarding around the site to ensure there are no gaps or defects where ground dwelling wildlife can enter the cleared site area where extensive construction work would have begun. Recommendations shall be made if any of the mitigation or management measures are found inadequate. In the circumstances where any trees are to be retained within the site or adjacent to it, an Arborist shall be engaged to carry out monthly monitoring and assess the health of the retained trees.

Continuous dust and noise monitoring at the nearby sensitive receptors shall be carried out to detect any excessive impacts, and to evaluate if the mitigation measures implemented by the Contractor is effective and adequate. The proposed mitigation measures and monitoring requirements are detailed in the Environmental Impact Register in Section 13.3.1.

13.4 Non-Compliance and Remedial Action

In the event of non-compliance of the Contractor with the requirements of the EMMP, the following process is recommended:

- The Employer to issue a notice of non-compliance to the Contractor, stating the nature and magnitude of the contravention.
- The Contractor to provide the Employer with a written statement describing remedial actions to be taken to rectify the non-compliance and expected results of the actions.
- The Contractor to correct the non-compliance within a period that is stipulated by the Employer, to provide the Employer with documented evidence of the completed remedial actions and obtain the Employer's approval for closure of the non-compliance notice.

If the Contractor fails to remedy the non-compliance within the predetermined timeframe or if the non-compliance gives rise to physical environmental damage, the Employer may take action (e.g. impose a penalty, require specific remedial action to be undertaken or stop work) based on the conditions of contract.

13.5 Feedback Management

The Contractor will establish a feedback management process to ensure that any complaints or feedback received from stakeholders are appropriately recorded, investigated, and resolved where required throughout the Developments. The main components of the feedback process will include:

- Prompt acknowledgement and response to stakeholder complaints, keeping them informed of the progress and outcomes
- Accurate records of complaints, investigations and outcomes are maintained
- Resolution within a specified timeframe (proposed four weeks)
- An escalation mechanism in the event that complaint cannot be resolved by the Developer(s) within the specified timeframe

- Assign responsibility and accountability to individual(s) such as Public Relations Officer (PRO) within the Developer(s) for administering the feedback procedure
- Government Agencies to be kept informed of complaints, where required.

13.6 Management of Change

Deviations from the scope of work might occur during execution of the Developments. Change is an inevitable part of the development, so managing and reviewing change during the execution phase is an important factor in success of the Developments. The overall aim of the EMMP is to ensure that environmental management is implemented, and its performance monitored. This means there must be scope for corrective action to be taken if required. It may be necessary to make modifications to the EMMP over the course of the Developments when:

- Unanticipated environmental impacts are identified that require additional mitigation
- When mitigation proposed proves ineffective or unable to be implemented
- When the Developments change in a way that is substantially different to that described in the EIA (e.g. internal changes initiated by the project team, external changes initiated by the Developer; or external changes that are a result of third-party stakeholders)

The overall responsibility for the management of change to the EMMP during construction and operation phase rests with the Employer in consultation with the relevant specialists and/or technical agencies where required. The steps for managing change to the EMMP are as follows:

- Identify and describe unanticipated impacts, ineffective mitigation or changes in the Developments construction or operation that require updates to the EMMP
- Suggest mitigation to manage the identified issues
- Concerns/issues could, for example, be highlighted in site inspection reports or progress calls with the Developer(s) on an ongoing basis
- Review and update the EMMP in consultation with the relevant specialists and/or technical agencies
- Record recommended corrective action in a Minutes of Meeting.

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