Document No: DOC/9175/DES/DR/6004/E

Contract 9175

Advance Engineering Study for the Proposed Downtown Line 2 Extension and a New Station on Existing North-South Line

Environmental Study Report
Biodiversity and Hydrology Study Report

Design Stage: Preliminary

Submitted by:
AECOM Singapore Pte Ltd

Submitted to:
Land Transport Authority

14 January 2025

Volume 1 of 5

DOCUMENT/DRAWING TECHNICAL VERIFICATION AND REVISION RECORD

PROJECT NAME	Contract 9175 - Advance Engineering Study for the Proposed Downtown Line 2 Extension and a New Station on Existing North-South Line							
PROJECT NO.	AECOM 60649989TR				FILE		1110	
*DOC/~~DWG~~ NO.	DOC/9175/DES/DR/6004/E				DATE OF FIRST ISSUE		19 August 2022	
*DOC/~~DWG~~ TITLE	Environmental Study (ES) Report Biodiversity and Hydrology Study Report							
DESIGN STAGE	Pre-Concept		Concept		Preliminary	X	Tender	

REV. No.	DATE OF ISSUE/REV.	DESCRIPTION	PREPARED/DESIGNED	CHECKED	APPROVED
-	19/08/22	First Submission	HHL / SYT / MYY / YEG / CKL / GRU / TRJ	JAG / NHT	STP
A	11/10/22	Second Submission	HHL / SYT / MYY / YEG / CKL / GRU / TRJ	JAG / NHT	STP
B	04/08/23	Third Submission	HHL / SYT / MYY / GRU / TRJ	JAG	JYY
C	11/12/23	Fourth Submission	HHL / GRU / TRJ	JAG	JYY
D	24/09/24	Fifth Submission	KAM / TTR	JAG	JYY
E	14/01/25	Sixth Submission	KAM / TTR	JAG	JYY

* Delete as Appropriate

This report is prepared for the **Land Transport Authority of Singapore** and is given for its sole benefit in relation to and pursuant to Contract 9175 – Advance Engineering Study for the Proposed Downtown Line 2 Extension and a New Station on Existing North-South Line and may not be disclosed to, quoted to or relied upon by any person other than the nominated persons of the **Land Transport Authority of Singapore** without our prior written consent.

No person other than **Land Transport Authority of Singapore** into whose possession a copy of this report comes may rely on this report without our express written consent and the **Land Transport Authority of Singapore** may not rely on it for any purpose other than as described above.

Contents

List of Figures

List of Tables

List of Appendices

List of Abbreviations

Acronym	Definition
ACMV	Air-conditioning and mechanical ventilation
AES	Advance Engineering Study
ALAN	Artificial lighting at night
ALARP	As Low As Reasonably Practicable
AM	Anti-Mosquito
APCP	Air Pollution Control Plan
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASR	Air sensitive receptor
BAT	Best Available Techniques
BCA	Building and Construction Authority
BIA	Biodiversity Impact Assessment
BIOME	NParks BIOME Biodiversity and Environment Database System
BKE	Bukit Timah Expressway
BOD_5	Biochemical Oxygen Demand
BS	British Standard
BTG	Bukit Timah Granite
CCK	Choa Chu Kang
CCNR	Central Catchment Nature Reserve
CCS	Central Control System
CCTV	Closed-circuit television
COC	Chemicals of Concern
COD	Chemical Oxygen Demand
COPPC	SS 593: Code of Practice for Pollution Control, 2013
CS	Conservation Significance
CT	Contractor
CUGE	Centre for Urban Greenery and Ecology
CVPA	Control of Vectors and Pesticides Act
DGPS	Differential Global Positioning System
DIV	Dutch Intervention Value
DO	Dissolved Oxygen
DSTA	Defence Science and Technology Agency
DTL	Downtown Line
DTL2e	Downtown Line 2 extension
EBS	Environmental Baseline Survey
ECB	Erosion control blanket
ECM	Earth Control Measures
ECO	Environmental Control Officer
ECP	Erosion Control Plan
ES	Environmental Study
EM	Environmental Manager
EMMP	Environmental Management and Monitoring Plan

Acronym	Definition
EPMA	Environmental Protection and Management Act
ERSS	Earth Retaining Stabilisation Structures
ERP	Emergency Response Plan
ERT	Emergency Response Team
FTA	Federal Transport Administration
GBN	Ground-borne Noise
GBV	Ground-borne Vibration
GPS	Global Positioning System
GSE	Gas Sensitive Electrochemical
GTM	Global Tide Model
HDB	Housing and Development Board
HLUS	Historical Land Use Study
IAQM	UK Institute of Air Quality Management
ISA	International Society of Arboriculture
ISO	International Organization for Standardization
IUCN	International Union for Conservation of Nature and Natural Resources
JTC	JTC Corporation (formerly Jurong Town Corporation)
KTM	Keretapi Tanah Melayu
LTA	Land Transport Authority
MCCY	Ministry of Culture, Community and Youth
MIC	Maximum Instantaneous Charge
MLS	Marchwood Laboratory Services Pte Ltd
MMF	Mono-Molecular Film
MND	Ministry of National Development
MOH	Ministry of Health
MOM	Ministry of Manpower
MOTIV	Modelling of Train Induced Vibration
MRT	Mass Rapid Transit
MSDS	Material Safety Data Sheet
MSL	Mean sea level
NAAQS	National Ambient Air Quality Standards
NAS	National Archives of Singapore
NBSAP	National Biodiversity Strategy and Action Plan
NEA	National Environment Agency
NHB	National Heritage Board
NIA	Noise Impact Assessment
NParks	National Parks Board
NRFF	New Rail Financing Framework
NSL	North South Line
NSR	Noise sensitive receiver
NTU	Nephelometric Turbidity Units
NUS	National University of Singapore
NVS	Noise and Vibration Study

Acronym	Definition
OPS	Operating Performance Standard
PAH	Polycyclic Aromatic Hydrocarbons
PAVA	Public Address Voice Alarm
PCP	Professional Certification Programme
PHILMINAQ	Mitigating Impact from Aquaculture in the Philippines
PIE	Pan-Island Expressway
PME	Powered mechanical equipment
POC	Potential of contamination
PPV	Peak particle velocity
PRO	Public Relation Officer
PSI	Pollution Standards Index
PUB	Public Utilities Board
QECP	Qualified Erosion Control Professional
QP	Qualified Professional
RMS	Root Mean Square
RTO	Resident Technical Officer
SAAQT	Singapore Ambient Air Quality Targets
SCDF	Singapore Civil Defence Force
SDS	Safety Data Sheet
SHE	Safety, Health and Environmental
SI	Soil Investigation
SIDS	Silty Imagery Detection System
SING	Singapore Botanic Gardens' Herbarium
SLA	Singapore Land Authority
SLM	Sound Level Meter
SMWQ	Singapore Marine Water Quality
SO	Superintending Officer
SOP	Standard Operation Procedure
SPL	Sound Pressure Levels
SRDB	Singapore Red Data Book
SVOC	Semi-Volatile Organic Compounds
SWO	Stop Work Order
TAQMMS	Telemetric Air Quality Monitoring and Management System
TBM	Tunnel boring machine
TDS	Total Dissolved Solids
TIA	Traffic Impact Assessment
TIW	Toxic Industrial Waste
TN	Total Nitrogen
TOC	Total Organic Carbon
TOR	Terms of Reference
TP	Total Phosphorus
TPH	Total Petroleum Hydrocarbons
TPZ	Tree Protection Zone

Acronym	Definition
TSS	Total Suspended Solids
UHI	Urban Heat Island
UK	United Kingdom
UNECE	United Nations Economic Commission for Europe
URA	Urban Redevelopment Authority
USEPA	United States Environmental Protection Agency
UXO	Unexploded ordinances
VCO	Vector Control Operator
VCT	Vector Control Technical
VCW	Vector Control Worker
VOC	Volatile Organic Compounds
VSR	Vibration sensitive receptor
WHO	World Health Organisation
WSHO	Workplace Safety and Health Officer
WSQ	Workforce Skills Qualifications

Glossary of Terms

Acronym	Definition
Above ground Project Footprint/ Operational Footprint	Above ground footprint of the station, potential future infrastructure, vehicular bridge and pedestrian linkbridge which will remain as permanent above ground features during operational stage of Contract 9175
Access Roads	Access roads are considered up to 500 m from the access point of the construction worksite area
Airborne Noise	Sound that is transmitted by the air e.g., speech. The term airborne noise and noise are used interchangeably in this report and mean the same
Air Pollution Control Plan	Plan implemented to ensure implementation of air mitigation measures
Arboricultural Survey	Assessment of tree — is the cultivation, management, and study of individual trees, shrubs, vines, and other perennial woody plants. It involves the assessment of trees by certified arborists, in addition to the mapping of trees using a Differential Global Positioning System (DGPS).
Baseflow	This scenario/ case represents the original worksites status at the time of writing of the approved Inception Report, before being optimised with feedback from the impact assessment team or due to other design constraints as part of usual development of design.
Biodiversity Study Area or Study Area (Biodiversity)	Forested area identified in the vicinity of the Project to be studied for its biodiversity value as defined by LTA for the purpose of this ES.
dB(A)	A-weighted sound pressure levels (dB) – weighted to human hearing frequencies
Catchment Delineation	Based on topographic and river network information, the water catchment boundary to any required (usually gauged) point on the river network is defined by applying GIS tools to an appropriate digital elevation model.
Commissioning Phase	This phase is a short transitional period specified for EMMP purpose, where environmental monitoring works are proposed and to be conducted by the Contractor before handing over to the rail operator in operational phase.
Construction worksite/ Construction area/ Construction footprint	Construction areas where surface impacts may occur due to construction footprint at above ground level e.g., all areas excluding the underground tunnels.
Construction Phase	A period where works are being carried out at the designated construction worksites. This includes the common activities at early stage of the construction phase (i.e., road and utilities diversion, site clearance, temporary worksite establishment, monitoring instrumentation installation), main construction phase (e.g., launch/ retrieval works, tunnel boring works, superstructure and station construction etc.) and the end/late stage of the construction phase (i.e., general landscaping and finishing works).
Coverage-based rarefaction and extrapolation sampling curves	Computes diversity estimates for rarefied and extrapolated samples with sample completeness (as measured by sample coverage) up to an appropriate coverage. This type of sampling curve plots the diversity estimates with respect to sample coverage. (Hsieh et al, 2019)
Cryptogenic	Species with unknown origin.
Demolition	Any activity involved with the removal of an existing structure (or structures). This may also be referred to as de-construction, specifically when a building is to be removed a small part at a time.
Dilapidation Studies	Studies to analyse impacts when a building/infrastructure/geological area is being demolished
Earthworks	This involves excavating material, haulage, tipping and stockpiling. This may also involve site levelling and landscaping
Emission Sources (Air Section)	Sources of air emissions for different activities such as earthworks, construction, trackout and demolition

Acronym	Definition
Entire Alignment	Entire alignment: refers to both the DTL2e underground rail alignment and potential future infrastructure, unless it is specified otherwise in the report context
Exotic Species	Plant or animal species introduced into an area where they do not occur naturally, non-native species.
Ex-situ	Testing is carried out offsite, or away from the natural location.
Ground Absorption Factor Ref: SoundPLAN	This factor is given to describe the noise propagation with respect to ground effect. For example, G = 0 describes a 100% hard ground such as asphalt, water or industrial sites; G=1 describes 100% soft ground such as fields, forests or grass
Heavy Duty Vehicle	Heavy duty vehicles defined as vehicles with a gross weight greater than 3.5 tonnes
Hydrology	The study concerned with the properties of the earth's water, and especially its movement in relation to land.
In-situ	Testing is carried out in the original place
ISO 9613-2:1996	Is the standard describing "Acoustics – Attenuation of sound during propagation outdoors – Part 2 : General method of calculation"
LAeq (1 hour)	Equivalent noise levels, averaged over a 1 - hour time period
LAeq (12 hours)	Equivalent noise levels, averaged over a 12 - hour time period
LAeq (5 mins)	Equivalent noise levels, averaged over a 5 - mins time period
Mitigated Scenario/ Mitigated Case	This scenario/ case represents the latest optimised worksites at the time of writing this report. It includes the incorporation of feedbacks from various environmental disciplines on the design and the usual design evolvement over time, as appropriate.
Non-metric Multidimensional Scaling (NMDS) Ordination	A way of visualising the level of similarity of individual cases of a data set. In this report, NMDS is used to compare the forest quality of the Study Area to the forest quality of the Central Catchment Nature Reserve.
Non-volant Mammals	Non-flying mammals, i.e., all mammals in Singapore, excluding bats
Operational Phase	A period where all construction works are completed and the operation of the Project's facilities (i.e., station, rail and tunnel) has commenced.
Peak Particle Velocity (PPV)	A vibration metric of displacement of a particle in a medium, over time.
Pre-Construction Phase	A period before any construction works (i.e., prior to site clearance) are being carried out, where the designated work areas remain undisturbed in its original condition.
Project/Operational Footprint	Station aboveground footprint, ventilation shafts/facility building footprints which will remain as permanent above ground features during operational stage of CR2005
Reactive Management Plan	Plan based on the real time situation of air impacts in an area.
Rock Breaking and Excavation	Indicating activity where rocks are blasted and broken into rock pieces which then be excavated and removed from the construction site. It does not represent hydraulic rock breaking. Rock breaking and excavation is only required at a confined area within a designated worksite where rock removal by normal earth excavation means cannot be performed.
Root Mean Square (RMS)	The square root of the mean of the of a certain set of values squared
Sound Power Level, Lw	Sound power is the total sound energy radiated by the source in a specified frequency band over a certain time interval, divided by the interval. In simple terms, a sound source produces sound power and this generates a sound pressure fluctuation in the air.
Sound Pressure Level, Lp	Sound pressure is the difference between the pressure produced by a sound wave and the ambient pressure at the same point in space.
Species Abundance	The number of individuals per species in an area. Relative abundance refers to the evenness of distribution of individuals amongst species in the area.
Species Distribution	Refers to how a species is distributed throughout the area.

Acronym	Definition
Species Group	Plants that could not be identified to species with certainty
Species Richness	Number of distinct species recorded, per sampling point or area
Study Area (Air)	Construction: 50m (Ecological Impact) from construction worksite areas as per IAQM Guidance; Operation: 250m from Project Footprint.
Study Area (Biodiversity)	See definition of Biodiversity Study Area
Study Area (Airborne Noise)	Construction: 150m from the construction worksite areas; Operation: Boundary of Project Footprint
Study Area (Ground-Borne Vibration)	Construction: 100m from the construction worksite areas and centreline of entire alignment; Operation: 100m from the Project Footprint
Study Area (Soil and Groundwater)	Construction and Operation: 250 m from the rail alignment/ station or other construction sites footprint
LpA,S,max	Maximum A-weighted sound pressure level evaluated with a 'Slow' (1.0 second) time constant
Topography	The study of the shape and feature of land surfaces.
Trackout	The transport of dust and dirt from the construction/demolition site onto the public road network, where it may be deposited and then re-suspended by vehicles using the network. This arises when heavy duty vehicles (HDVs) leave the construction/demolition site with dusty materials, which may then spill onto the road, and/or when HDVs transfer dust and dirt onto the road having travelled over muddy ground on site.
Tree Mapping	Tree mapping is purely the mapping of trees using a Differential Global Positioning System (DGPS), without assessment by the arborists.
Trigger Value	The threshold value of a pollutant for which reactive management plan needs to be applied.
Vent Shaft	A shortened form of the term "Ventilation Shaft" used exchangeably to the complete term
Vibration Dose Values (VDV)	A vibration metric that considers the magnitude of vibration and the time it occurs, calculated by taking the fourth root of the integral of the fourth power of acceleration after being frequency-weighted.

1 Executive Summary

AECOM Singapore Pte Ltd was appointed by the Land Transport Authority, Singapore (LTA) to carry out the Contract 9175 – Advance Engineering Study (AES) for the Proposed Downtown Line 2 Extension and a New Station on Existing North-South Line. An Environmental Study (ES) is required as part of the contract to be undertaken to assess the potential environmental impacts arising from, and associated with, the construction and operation of the proposed Downtown Line 2 Extension (DTL2e) (hereinafter 'the Project') on the human and ecological receptors in the vicinity of the alignment.

This Environmental Study (ES) report provides an overview of the environmental baseline status in the vicinity of the Project before the commencement of any actual pre-construction works (including site clearance) and construction of this Project. It covers the construction impacts on the environment from above ground construction and underground tunnelling activities. It also covers the operational impacts on the environment from train operation and maintenance activities. The environmental parameters covered in this study include biodiversity, hydrology and water quality, air quality, airborne noise, ground-borne noise and vibration, soil and groundwater quality, waste management and vector control. Additionally, where the impacts are deemed to be "Significant" or "Moderate/Major", appropriate mitigation measures to be implemented during the construction and operational works are also recommended.

It should be noted that this report corresponds to the engineering design developed during preliminary design stage only. This ES only presents the impact assessment on the environmental parameters from the preliminary engineering design. Pursuant to this study there are some recommendations relating to the design; these will be discussed and then re-evaluated when the design incorporates, develops and/or changes at a later design stage.

This ES Report also includes the Biodiversity and Hydrology Study Report (as per Terms of Reference (TOR) Clause 10.31.2) in one (1) combined deliverable. This ES also has interfaced with multiple reports as part of the same AES contract as detailed in Table 1-1.

Table 1-1 Interface of ES Report with other related reports

Report	Details
Biodiversity and Hydrology Study Preliminary Report	The assessment on biodiversity and hydrology are all included within the ES; therefore, this ES Report is all inclusive.
Acoustics Preliminary Report	The Acoustics Preliminary Report focuses on the acoustic design and Public Address Voice Alarm (PAVA) design of the Project. As part of the report, boundary noise assessment from the vent shafts and station operation were assessed. The results from the Acoustics Preliminary Report were referenced, and assessment on ecological receptors has been conducted in this ES Report. Detailed calculation and modelling results can be found in a separate Acoustics Preliminary Report.
Noise and Vibration Study (NVS) Preliminary Report	The NVS Preliminary Report focuses on the airborne noise, ground-borne noise and vibration assessment from the underground train and potential future infrastructure operation on human receptors. The results from the NVS Preliminary Report were referenced, and assessment on ecological receptors has been conducted in this ES Report. Detailed calculation and modelling results can be found in a separate NVS Preliminary Report.
Traffic Noise Impact Assessment (NIA) Study Report	The Traffic NIA Report focuses on the noise impact assessment from the proposed vehicular bridge operation to the surrounding residential receptors. The results from the Traffic NIA Report were referenced, and assessment on ecological receptors has been conducted in this ES Report. Detailed calculation and modelling results can be found in a separate Traffic NIA Report.

Project Description

This DTL2e Project is planned to be a rail extension from Downtown Line DT1 Bukit Panjang Station to serve the north-western region including Yew Tee, Choa Chu Kang and the Sungei Kadut industrial area. DTL2e has a route length of approximately 5km and will interchange with a new station to be added to North-South Line (NSL) at Sungei Kadut (NS6). The project is estimated to be completed around 2035.

The NSL station, NS6 Sungei Kadut, will be an elevated station on the existing NSL, between NS5 Yew Tee and NS7 Kranji Stations. The DTL will be extended by 2 stations from the existing DT1 Bukit Panjang Station, through an intermediate station, to connect to the DT Sungei Kadut station. The Sungei Kadut station will thus be an important interchange station between the DTL and NSL.

The DTL2e and NS6 Sungei Kadut station would enhance public transport and rail connectivity for north-western area of Singapore. Key transport functions and benefits would include improving rail resiliency in which commuters will have alternative rail travel options, promoting decentralisation efforts where commuters have better accessibility to job opportunities in Sungei Kadut, travel time savings and increase in public transport mode share in Sungei Kadut area. The main Project elements of DTL2e consists of the following:

- One (1) DTL2e underground Intermediate Station;
- One (1) DTL2e underground Interchange Station with one (1) new NSL Sungei Kadut Elevated Station;
- One (1) temporary Docking Shaft worksite near Housing and Development Board (HDB) blocks at Senja Road to support the DTL2e construction;
- One (1) Reception Track of approximately 2 km with an at-grade connection to Gali Batu Train Depot, as well as one (1) temporary retrieval shaft worksite to support its construction;
- One (1) above-ground potential future infrastructure alignment of approximately 1.5 km to connect Interchange station and Gali Batu Train depot;
- One (1) Elevated Vehicular Bridge beside DTL2e underground intermediate station; and
- One (1) Pedestrian Linkbridge beside DTL2e underground intermediate station.

An above-ground potential future infrastructure to connect the Interchange Station and Gali Batu Train Depot was considered in this report. However, the viability of this potential future infrastructure is still under study and will be shared when ready.
The Project location is presented in Figure 3-1.

Impact Assessment Methodology

Sections 6, 7.2, 8.2, 9.2, 10.2, 11.2, 12.2 and 13.2 of the ES report discuss the methodologies used for impact identification, prediction and assessment on environmental parameters including biodiversity, hydrology and surface water quality, air quality, airborne noise, ground-borne noise and vibration, soil and groundwater and vector control during the construction and operational phases of the development.

Summary of Impact Assessment

Flora

The Study Area comprises six habitat types. The largest habitat is urban vegetation (33.74 ha; 36.65%), followed by scrubland (19.51 ha; 21.19%), mangrove forest (11.04 ha; 11.99%), and exotic-dominated secondary forest (6.38 ha; 6.93 %). Altogether, spontaneous vegetation takes up 40.12 % (36.93 ha) of the Study Area. The remaining non-vegetated habitats are waterbodies, such as Pang Sua Canal (9.55 ha; 10.37%), Sungei Pang Sua (7.02 ha; 7.63%), and a natural stream. Other infrastructure and amenities take up (4.82 ha; 5.24%) of the Study Area.

Of 206 species (including 2 species groups), 18 were considered species of conservation significance. All 16 species are associated with coastal and/or mangrove habitats, except for the Vulnerable *Bridelia stipularis* and *Digitaria longiflora.* The distribution of the species of conservation significance was recorded mostly within the mangrove forest. Some of these species are Critically Endangered *Sonneratia caseolaris, Finlaysonia obovata,* nationally Endangered *Ceriops zippeliana, Halophila beccarii, Lumnitzera littorea, Lumnitzera racemosa,* and

nationally Vulnerable *Nypa fruticans*. Specimens of *Sonneratia caseolaris* largely contributes to the total number of specimens of species of conservation significance that was recorded in the Study Area, of which, a higher number of seedlings and young saplings were recorded inland. The population was observed to be thriving and propagating. With only less than 20 specimens found outside of Sungei Pang Sua in Singapore, such as Woodlands Town Garden, Sungei Buloh Wetland Reserve and Pulau Ubin [P-50; W-77], it is highly likely that the mangrove forest in the Study Area is currently the stronghold for this species, with more than 200 specimens recorded in the Study Area. The highest density of *Sonneratia caseolaris* was observed inland of Sungei Pang Sua. Clusters of nationally Endangered *Halophila beccarii* were recorded near the mouth of Sungei Pang Sua. This species is also globally Vulnerable due to anthropogenic threats [W-78], such as the rapid increase of coastal developments and reclamation activities [W-79]. Only one specimen of *Ceriops zippeliana* was recorded at the bank of Sungei Pang Sua near the river mouth. It was officially declared as a new record of mangrove species in Singapore only in the recent years [P-39]. As for *Lumnitzera littorea* and *Lumnitzera racemosa,* only one specimen was recorded for the former and three specimens were recorded for the latter. The conservation status of these two species is most likely the product of the decrease in their population as they possess timber that is deemed highly valuable [W-73; W-74]. Lastly, *Nypa fruticans* is the second most abundant mangrove species that were recorded within the mangrove forest. Aside from the extensive loss of mangrove habitat over the years [P-46], the national population of this species could have also declined as this species is a widely utilised mangrove species for commercial purposes in the past [P-44].

A total of 226 large plant specimens are recorded in the Study Area, of which, 163 specimens are exotic, 61 are native and two are cryptogenic. With 47 individuals recorded, Senegal mahogany (*Khaya senegalensis*), forms the majority of large plant species, followed by raintree (*Samanea saman*) with 42 individuals recorded. The largest specimens recorded are two Malayan banyan (*Ficus microcarpa*) with a spread of 15 m and with a height of 25 m and 20 m respectively, while a noteworthy observation to highlight would be an *Avicennia alba,* with a girth size of 3.8 m. Eight specimens were identified as other specimens of value, of which six were bamboo clusters and two were albizia trees with raptor nest belonging to changeable hawk eagle (*Nisaetus cirrhatus)* and white-bellied sea eagle (*Haliaeetus leucogaster*) respectively. Finally, a total of 1,762 specimens belonging to 56 species and 1 species group (i.e., *Syzygium* cf *malaccense*) were tagged and recorded during tree mapping survey. More than half (52.1%; 918 specimens) of these trees are exotic, 47.4% (835 specimens) are native and the remaining 0.5% (9 specimens) are cryptogenic. Almost half of the total number of trees tagged were contributed by *Avicennia alba* (266 specimens), *Sonneratia caseolaris* (250 specimens), rain tree (*Samanea saman*; 159 specimens), and *Khaya senegalensis* (154 specimens). Of the 1,762 specimens, 313 of them specimens belonged to five species of conservation significance, of which, the majority of these specimens are *S. caseolaris* with girth sizes that ranges between 0.3 m – 2.0 m.

A total of 43 flora species receptors were identified for impact assessment. This includes (1) species of conservation significance, large specimens, other specimens of value, and/or trees found inside and within 30 m from the proposed worksite area, (2) keystone species, as defined in Section 7.3.3), (3) species associated with important fauna, and (4) species that make up ≤ 1% of the total number of specimens of conservation significance.

Four impacts were assessed for the flora species receptors during construction phase, namely i) injury/mortality, ii) impediment to seedling recruitment, iii) competition from exotic species and iv) decline in plant health. The impact significance ranged from Negligible to Minor. While impacts are considered Minor, mitigation measures were proposed to further minimise ecological impacts. This includes (but not limited to) proper installation of silt fences and earth control measures, engaging arborist for pruning of tree specimens, salvaging and harvesting of trees/saplings of conservation significance and monitoring of plant health. The residual impact significance remains **Negligible** to **Minor**.

Three impacts were assessed for the operational phase, namely i) mortality, ii) poaching and iii) competition from exotic species. Impact significance ranged from Negligible to Moderate. Four flora species receptors (i.e., *Cerbera odollam*, *Syzygium polyanthum*, *Terminalia catappa* and *Talipariti tilaceum)* were assessed with Moderate impact significance for the impact of competition from exotic species. Proposed mitigation measures include replanting unused cleared or bare areas with native planting palette, as well as in-fill or dense planting. With implementation of mitigation measures, impacts from competition from exotic species were reduced to

Minor. The residual impact significance for the remaining flora species receptors of all impact type remains as **Negligible to Minor**, as they have been reduced to a level that is as low as reasonably practicable.

Fauna

The faunistic field assessment recorded 293 faunal species within the Study Area, including 228 terrestrial species and 65 aquatic species. The terrestrial fauna community is dominated by birds (99 species) and butterflies (59 species), while the aquatic fauna community is dominated by molluscs (37 species). Terrestrial fauna observed are typical of secondary forest, woodland and scrubland habitats. Aquatic fauna observed is characterized by species from a continuum of habitat from slightly brackish to mostly marine, with tidal influence. This is because Sungei Pang Sua receives both freshwater inputs inland and tidal influence at the coast.

Twenty-one species of conservation significance were recorded. This comprised 18 bird, 1 non-volant mammal, 1 decapod and 1 horseshoe crab species. Species of conservation significance were distributed across the Study Area, although there appears to have higher records from the central to northern part of the Study Area.

Bird species of conservation significance recorded include waterbirds, such as the purple heron (*Ardea purpurea*) and yellow bitter (*Ixobrychus sinensis*); raptors such as the white-bellied sea eagle (*Haliaeetus leucogaster*) and changeable hawk-eagle (*Nisaetus cirrhatus*); passerine birds such as the oriental magpie-robin (*Copsychus saularis*) and the spotted wood owl (*Strix seloputo*). A nest of a pair of white-bellied sea eagle and a changeable hawk-eagle were observed within the Kranji woodland located just outside of the Study Area. Twenty-two migratory birds were recorded, including 16 common or abundant species such as the arctic warbler (*Phylloscopus borealis*); 5 uncommon species such as the black-capped kingfisher (*Halcyon pileata*); and 1 rare migrant, the yellow-browed warbler (*Phylloscopus inornatus*). These records show that the Study Area has value in supporting species of conservation significance and migratory birds.

A family of smooth-coated otter (*Lutrogale perspicillata*), with up to seven individuals, was seen within the Study Area. A spraint site of the otter was observed under the train track adjacent to Sungei Pang Sua. While not recorded in this study, the globally and nationally Critically Endangered Sunda pangolin (*Manis javanica*) was deemed likely to occur in the Study Area. The Study Area lies partially along the Rail Corridor can serve as a passageway for the dispersal of these wildlife.

Sungei Pang Sua is also home to mangrove- and mudflat-associated species. A dead mangrove horsecrab (*Carcinoscorpius rotundicauda*) was also observed, although local breeding population is unlikely present. Yet, it is home to nationally Endangered mud lobsters (*Thalassina* spp.). While not observed in this study due to its cryptic nature, the presence of active mounds suggests its presence. The highest density of mud lobster mounds was observed inland of Sungei Pang Sua. Although only striated heron (*Butorides striata*) was observed roosting within Sungei Pang Sua, it is a potential roosting habitat for other ardeids, such the black-crowned night heron (*Nycticorax nycticorax*), purple heron and grey heron, which were also observed in the Study Area. On the other hand, Pang Sua Canal is poor in aquatic life but may provide connectivity for some aquatic species such as the otters, and birds to move between waterways.

A total of 79 faunal receptors of Priority 1 were identified for impact assessment. These include species of conservation significance, of which, 22 were recorded during field assessment. The remaining 57 species were fauna deemed of probable occurrence.

Six impacts were assessed for the faunal species receptors during construction phase. The impact significance ranged from Negligible to Moderate. Moderate impacts were expected from accidental injury and mortality for 5 species that are either susceptible to roadkill or entrapment in construction site. Proposed mitigation measures for design and construction phase include integrating speed-calming measures. With the implementation of mitigation measures, impacts from accidental injury or mortality was reduced to **Minor**. Moderate impacts from loss/reduction of ecological connectivity for faunal movement was mitigated with a 30-m wide corridor that will be maintained on site for faunal movement, therefore, impact significance was reduced to **Minor**.

During operational phase, impact significance ranged from Negligible to Moderate. Moderate impact was expected from human-wildlife conflict for 2 species (long-tailed macaque and smooth-coated otter). Proposed mitigation measures include proper waste management. With implementation of mitigation measures, impacts were reduced to **Minor**.

Hydrology and Water Quality

While the hydrological baseline study aimed to identify watercourses present in the Study Area including their location, water flow conditions and bank characteristics, the water quality surveys determined the water quality of the surface watercourses.

The baseline hydrological conditions in the Study Area were analysed based on site observations. The Pang Sua Canal has perennial flow with water flow ranging from 0.2 to 0.6 m/s observed during dry weather and the water flow could be more than 2 m/s during heavy storm throughout the canal. The surface runoff generally originated from drainage networks collecting surface runoff from surrounding residential areas along the Canal before drains into the Kranji Reservoir eventually. Sungei Pang Sua is a tidal-influenced stream and has perennial flow with slow water flow (i.e., ranged from 0.04 to 0.3 m/s) and even could be in almost stagnant condition at some areas. A few surface runoff discharge outlets (i.e., E63 Drain, Drain 2, Drain 3, Drain 4, Drain 5, Drain 6, Drain 7 and Drain 8) which originated from urbanized area and forest area (i.e., Stream 1) were observed along the Sungei Pang Sua. All the streams and drains within the Study Area did not have any obvious smell based on site observation. The flow direction at marine area near to river mouth of Sungei Pang Sua normally was tidal influenced and varying and therefore, depended on the flood and ebb tides during spring and neap tidal periods.

In order to get comprehensive data that is representative of baseline conditions of water quality and to capture the possible changes in water quality parameters over time and different events, the identified watercourses were sampled during dry and wet weather conditions. Five (5) water quality stations were located at the upstream (i.e., WQ1, WQ2), midstream (i.e., WQ3, WQ4) and downstream (i.e., WQ5) of Pang Sua Canal. The location of stations WQ1 and WQ2 were selected to capture the water quality at the upstream of Pang Sua Canal which receives water from upstream drains and surrounding residential areas along the canal. Stations WQ3 and WQ4 were selected to capture the water quality of the midstream which receiving runoff from the residential area. Station WQ5 was selected to capture the water quality of downstream of Pang Sua Canal before flowing into Kranji Reservoir. Another ten (10) water quality stations (i.e., WQ6, WQ7, WQ8, WQ9A, WQ9, WQ10A, WQ10, WQ11A, WQ11 and WQ12) were sampled along Sungei Pang Sua as well as at the streams (i.e., Stream 1) and drains (i.e., E63 Drain, Drain 3 and Drain 6) which eventually discharge to Sungei Pang Sua. Three (3) water quality stations (i.e., WQ13, WQ14 and WQ15) were also sampled at the marine area near Sungei Pang Sua in order to capture the water quality from Sungei Pang Sua. The surface water samples were tested for the physical and chemical parameters relevant for sustenance of aquatic life including temperature, pH, salinity, conductivity, total dissolved solids (TDS), dissolved oxygen (DO), turbidity, total suspended solids (TSS), biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), total organic carbon (TOC), oil & grease (total), total phosphorous (TP), orthophosphate (PO_4-P), total nitrogen (TN), nitrate (NO_3-N), ammoniacal nitrogen (NH_4-N), *Enterococcus*, chlorophyll-a, cadmium, chromium, copper, zinc, lead, iron, mercury, nickel, arsenic, cyanide, barium, chloride, phenol and calcium. The data results of the water quality stations were compared with respective NEA discharge guideline of Singapore, international criteria for aquatic life and Singapore Marine Water Quality (SMWQ) guideline accordingly.

From the results of the hydrological and water quality baseline assessment, it could be inferred that the Pang Sua Canal was generally perennial (fed from stormwater), however, the water quality results indicate poor water quality for survival of aquatic life. This also aligns with biodiversity findings, which shows that only Pang Sua Canal supported poor aquatic life at the time of survey. For perennial Sungei Pang Sua, the water quality of the environment was mostly affected by the tidal influence and its surrounding urbanised areas (i.e., industrial area). Despite high nutrients, turbidity with some heavy metals contamination and lower DO found along the watercourse, the mangroves along Sungei Pang Sua still support certain flora and fauna species of conservation significance as described in biodiversity findings.

Based on the assessment of the hydrology and water quality related impacts on the various sensitive receptors, the activities of construction and operational phases were assessed qualitatively to cause Minor to Moderate

impacts on human receptors and the habitat and biocenosis of Sungei Pang Sua and Pang Sua Canal during construction and operational phases, even with implemented minimum controls. In terms of quantitative impact assessment, it was assessed that there will be no impacts on the hydrodynamic of Sungei Pang Sua and that the upstream riverbed level is expected to be brought back to the baseline condition within 2 years' time during the construction phase. As a mitigation measure, it was recommended that all the discharges from the construction worksites to Sungei Pang Sua should not contain Total Suspended Solids (TSS) in concentrations greater than the prescribed limits under Regulation 4(1) of the Sewerage and Drainage (Surface Water Drainage) Regulations. With such mitigation measure, the residual water quality impact on habitat and biocenosis of Sungei Pang Sua could be reduced to **Minor**.

For the cumulative impacts from concurrent developments identified in the vicinity of the Project during both construction and operational phases, it was assumed that all the concurrent developments would comply with the construction and operation standards and hence their impact on hydrology and surface water quality for the watercourses was not expected to be significant.

Air Quality

In order to assess the current baseline air quality within the Study Area, existing secondary baseline monitoring data was reviewed, and primary baseline data was collected.

Secondary weather data of the past 5 years shows an average of approximately 7.6 mm, 6.3 mm and 7.4 mm of daily rain was observed from Bukit Panjang, Admiralty and Tengah monitoring stations, respectively. With regards to mean temperature and mean wind speed, the temperature and wind speed within Study Area is expected to be relatively constant with average 27.7°C and 27.7°C mean temperature as observed from Admiralty and Tengah monitoring stations respectively, and 11.2 km/h and 10.2 km/h mean wind speed as observed from Admiralty and Tengah monitoring stations respectively.

Primary baseline air quality monitoring was also collected at five (5) representative monitoring locations for one (1) week each ranging from 28 February – 24 March 2022 across the Study Area. PM_{10} and $PM_{2.5}$ were monitored at all monitoring locations and additionally NO_2 was also monitored for areas that is potentially impacted during operational phase (i.e., A01, A02 and A05). Based on the monitored results, all pollutants' ambient air quality targets were met throughout the monitoring duration at all 5 monitoring locations. The pollutants recorded is generally affected by different sources depending on the monitoring location as detailed in Section 9.5.2.

Potential impacts to the neighbouring sensitive receptors during construction phase mainly include emissions from the heavy vehicular exhaust and dust emitted from the demolition, earthworks, construction and trackout activities. During the operational phase, emissions from vehicle exhaust due to increased traffic in the vicinity of the proposed development is identified as the predominant air emission source.

Air quality impact assessment for construction phase were undertaken in accordance with the UK IAQM Guidance on the Assessment of Dust from Demolition and Construction. Pursuant to which, 50 m and 350 m Study Area for ecological and human receptors respectively were considered for demolition, earthworks, construction and trackout activities. Dust generated during construction works can have adverse effects upon vegetation restricting photosynthesis, respiration and transpiration. Furthermore, it can lead to phytotoxic gaseous pollutants penetrating the plants. The overall effect can be a decline in plant productivity. For human receptors, the dust and gaseous emissions might cause respiratory problems and diseases in human health.

The results of the assessment show that unmitigated impacts are classified as Moderate to Major and have the potential to affect the receptors near the construction footprint unless mitigation measures are put in place (see Section 9.7 for assessment details). This is largely because of the large extent of the construction worksite located very close to the neighbouring sensitive receptors. This report pulls together mitigation measures that can be implemented by the contractor as administrative or management measures, sourcing from best practice measures internationally, which are detailed Section 9.8, which when applied successfully, the significance of impacts is anticipated to be reduced to **Minor** (see Section 9.9 for details). The key control and mitigation measures include but not limited to development and stringent implementation of air pollution control plan, dust

control measures on site, site hoarding, planning of dust causing activities-location and timing, reinstating land upon completion of works amongst several others.

For air quality impact assessment during operational phase, it is assumed that all new vehicles to meet their Euro emission standard. The buffer from some green areas which will not be disturbed as part of the Project, will also help in terms of providing cleaner air from the impact from the vehicles. At a much higher level, trains are meant to replace substantial vehicles from roads, therefore in that scheme, the Project may have a positive effect on road traffic. However, immediate localised road traffic to and from the stations may see minor increase. In this aspect with the information assessed at this stage, the air quality impact contributed from the proposed development is anticipated to be **Minor** during the operational phase. No mitigation measures are required during operational phase as no significant air quality impact is expected from Project operation.

Airborne Noise

In this study, noise impact assessment was carried out for both the construction and operational phases of the proposed developments within the Project site to assess for airborne noise impacts on the identified ecological and human noise sensitive receptors (NSRs).

Construction Phase

A quantitative means of assessment detailing noise levels predicted with noise models based on inputs of effective SWL of proposed PMEs was conducted for three (3) assessment scenarios defined for assessment in the construction phase – Scenario 1: Advanced Works; Scenario 2: Station, Docking Shaft, Pedestrian Linkbridge construction; and Scenario 3: Potential future infrastructure, reception track cut and cover areas, and vehicular bridge construction.

In predicting for the construction noise impacts associated with the three (3) assessment scenarios, the highest overall SWLs of the construction stages associated with each assessment scenario were selected to assess for the worst-case noisiest scenarios. The rationale behind deducing the worst-case scenarios is under the assumption that if the construction stage with the highest SWL can be mitigated for instance with permanent fixtures such as noise barriers or other means proposed in Section 10.8, noise impacts from other construction stages/ activities with lower SWLs will also be addressed.

Baseline airborne noise monitoring was conducted at eleven (11) locations within the 150 m Airborne Noise Study Area established accordance with noise legislations outlined in EPM, 2008 [R-22]. Secondary baseline airborne noise data from HDB CCK N1 were also referenced and adopted in this study in an agreement of information exchange between LTA and HDB. Construction noise impact assessment findings from the HDB CCK N1 EIS Project were also referenced.

For human receptors, recorded $L_{Aeq(12\ hours)}$, $L_{Aeq(1\ hour)}$, and $L_{Aeq(5\ mins)}$ noise levels were compared against the EPM, 2008 [R-22] guidelines to develop a Project-specific criterion for the construction phase. This criterion was then used as part of construction noise impact assessment for human NSRs (see Section 10.5.3.1.2). While for ecological NSRs, the average baseline noise monitoring results were adopted to assess for impact on fauna species identified within the Biodiversity Study Area, suitable in supporting the presence of fauna as a conservative means of assessment (see Section 10.5.3.1.1).

Noise sensitive ecological and human NSRs were identified within the 150 m Airborne Noise Study Area established in accordance with the noise legislations outlined in EPM, 2008 [R-22]. The identified NSRs were then assessed against the impact evaluation matrices in Section 6.4.2, with the noise contours reflecting the extent of noise propagation from source to receptors and the associated distribution of Impact Significance provided. Mitigation measures were also introduced following predicted noise exceedances for both ecological and human NSRs as detailed below.

Ecological Receptors

Based on the results predicted by the noise models, ecological NSRs are predicted to experience noise exceedances of up to 27.0 dB(A) for Scenario 1; 35.0 dB(A) for Scenario 2; and 36.0 dB(A) for Scenario 3. No noise exceedances were predicted for Scenario 3 during the night time for ecological NSRs. The resulting overall Impact Significance was evaluated to range from **Moderate** – **Major** for all three (3) assessment scenarios (see Table 10-32).

Mitigation measures were proposed to mitigate the noise impacts on the ecological NSRs to ALARP as discussed in Section 10.8. Vertical noise barriers of up to 3 m and 12 m in height were proposed, and an addition of 15 m noise enclosure for the docking shaft construction area of Scenario 2.

However, due to the proximity of the noise sources to the Biodiversity Study Area, with noise sources found within the Biodiversity Study Area during stages of construction involving the erection of columns, the proposed mitigation measures were found only to be effective in reducing noise minimally with a residual noise exceedance of up to 19.0 dB(A) for Scenario 1; 30.0 dB(A) for Scenario 2; and 30.0 dB(A) for Scenario 3. The overall residual Impact Significance was reduced from **Moderate** – **Major** to **Negligible** – **Major** (see Table 10-47).

Although the proposed mitigation measures in Section 10.8 were not able to eliminate the noise exceedances, a closer look into the comparison of the distribution of areas of Impact Significance reveals a considerable reduction of areas of Moderate – Major Impact Significance by 13.8 ha for Scenario 1; 30 ha for Scenario 2 day time; 33.1 ha for Scenario 2 night time; and 36 ha for Scenario 3 day time. This suggests that while Impact Significance remains unchanged, ecological NSRs will still benefit from the implementation of proposed mitigation measures with more land area to traverse, forage and seek shelter from a reduction of noise impacted areas. Also, majority of Moderate – Major impact is only expected during short period of time: approximately 2 years for Scenario 1; 6 months for Scenario 2 day time; 18 months for Scenario 2 night time; and 3-12 months for Scenario 3 day time. After this period, the noise impact is expected to reduce significantly until the end of construction period.

Human Receptors

Based on the results predicted by the noise models, human NSRs were predicted to experienced noise exceedances of up to 7.6 dB(A) for Scenario 1; 10.0 dB(A) for Scenario 2 day time; 22.7 dB(A) for Scenario 2 night time; 8.9 for Scenario 3 day time; and 8.1 dB(A) for Scenario 3 night time. The resulting overall Impact Significance was evaluated to range from **Negligible** – **Major**.

Mitigation measures were proposed to mitigate the noise impacts on the ecological NSRs to ALARP as discussed in Section 10.8. Vertical noise barriers of up to 3 m and 12 m in height were proposed for all three (3) assessment scenarios, and a 15 m noise enclosure for the docking shaft construction area of Scenario 2.

However, due to the proximity and height of the receptors and a limitation in height of noise barriers, the 3 m and 12 m vertical noise barriers were only found to be effective in reducing noise minimally with a residual noise exceedance of up to 8.9 dB(A) for Scenario 2 day time; 17.8 dB(A) for Scenario 2 night time; 3.0 dB(A) for Scenario 3 day time; and 3.1 dB(A) for Scenario 3 night time. No residual noise exceedances were predicted for Scenario 1 with the proposed mitigation measures predicted to effectively eliminate noise exceedances (see Table 10-49). The resulting overall residual Impact Significance was reduced from a range of **Negligible** – **Major** to **Negligible** – **Moderate**.

Although the proposed mitigation measures in Section 10.8 were not able to eliminate noise exceedances, a comparison of the distribution of Impact Significance by number of human NSRs reflects a reduction in number of buildings of **Moderate** – **Major** Impact Significance for all three (3) assessment scenarios. Considering this, communication efforts should be implemented to inform affected human NSRs during the period of works and complaints of noise nuisance that are anticipated should be addressed accordingly.

<u>Rock Breaking and Excavation</u>

As part of construction works, rock breaking, and excavation can be proposed as an effective and efficient method to break down and remove rocks when common excavation techniques are not able to. At the point of time in

writing this report, detailed information was not available. The rock breaking and excavation works could only be carried out by an appointed Contractor at a later stage.

Hence, the assessment approach detailed in BS5228-2:2009+A1:2014 was adopted as the assessment criterion. Due to the lack of information for rock breaking and excavation works specific to Singapore, the site constant was assumed based on AS 2187.2-2006.

Employing the assumptions on location, depth, and method of rock breaking and excavation, and known information of distance from location of rock breaking and excavation to the nearest NSRs, the assessment provided an estimate on the MIC that should be permitted in order to keep air overpressure within the stated criteria.

Ecological Receptors

Based on the approximate distance from Sungei Kadut Cut and Cover Station to the nearest boundary of the ecological NSRs and their respective MIC, airborne noise levels arising from rock breaking and excavation works and experienced by the ecological NSRs was predicted as 122 dB. The resulting overall Impact Significance were evaluated to as **Moderate**.

With an Impact Significance of **Moderate**, mitigation measures were proposed to mitigate these impacts to ALARP as part of ground-borne noise and vibration management.

Upon the application of the mitigation measures, the resulting residual Impact Significance from Sungei Kadut Cut and Cover Station to the ecological NSRs was reduced to **Minor**.

Human Receptors

Based on the approximate distance from Sungei Kadut Cut and Cover Station to the nearest boundary of the human NSRs and their respective MIC, airborne noise levels arising from rock breaking and excavation works and experienced by the human NSRs were predicted to range from 141 – 150 dB and (see Table 10-37). The resulting overall Impact Significance were evaluated as **Minor**.

No mitigation measures were proposed for the human NSRs subjected to airborne noise impacts from rock breaking and excavation.

Operational Phase

The assessment for operational noise impacts relating to ACMV systems and land traffic will be addressed in the separate standalone NVS Preliminary Report, Traffic NIA Study Report, and Acoustics Preliminary Report. The findings from the separate standalone report have been extracted and presented in this report.

A quantitative means of assessment detailing noise levels predicted with noise models was applied in the determination of impact predicted at the human NSRs due to operational noise emissions from ACMV systems and land traffic development associated with the Project, in accordance with noise legislations outlined in the ACMV Noise Guidelines, 2018, and TNIA Guidelines, 2016. For human NSRs, recorded $L_{Aeq(1\ hour)}$ noise levels were compared against the criterion outlined in the TNIA Guidelines, 2016, used as part of operational noise impact assessment for human NSRs in the NVS report. While for ecological NSRs, the average baseline noise monitoring results were adopted to assess for impact on fauna species identified within the Biodiversity Study Area, suitable in supporting the presence of fauna as a conservative means of assessment.

Baseline airborne noise monitoring was conducted at one (1) location as part of NVS, and two (2) locations for the Traffic NIA Study within the defined Airborne Noise Study Area established in accordance to the noise legislations outlined in TNIA Guidelines, 2016.

Information on operational noise impact assessment findings for human NSRs were extracted from the separate standalone reports and presented in this ES. While for ecological NSRs, the operational noise impacts were assessed as part of the ES, taking reference from results presented in these separate standalone reports. The identified ecological NSRs were then assessed against the ecology specific impact criteria and evaluation matrices, with the noise contours reflecting the extent of noise propagation from source to receptors and the associated distribution of Impact Significance provided. Mitigation measures were also introduced following predicted noise exceedances for both ecological and human NSRs where required as detailed below.

Ecological Receptors

Based on the results predicted by the noise models, ecological NSRs are predicted to experience noise exceedances of up to 13.0 dB(A) when subjected to operational noise from the operations of the potential future infrastructure. The resulting overall Impact Significance was valuated as **Negligible**.

No noise exceedances were predicted for ecological NSRs when subjected to operational noise from the operations of the elevated vehicular bridge (refer to Table 10-40), with an overall Impact Significance of **Negligible**.

No mitigation measures were proposed for ecological NSRs subjected to noise from the operational phase.

Human Receptors

Based on impact assessment of human NSRs extracted from the Traffic NIA Report, two (2) residential human NSRs were predicted to experience noise exceedances of the $L_{Aeq(1\ hour)}$ 67 dB land traffic noise criteria. While four (4) receptor buildings would experience noise levels that exceed the criteria of $L_{Aeq(1\ hour)}$, 71 dB in the NVS Report, as these buildings are not noise-sensitive or residential premises, mitigations measures were not required according to NEA's guidelines.

As such, mitigation measures have been proposed for the operational phase of the elevated vehicular bridge to mitigate the noise impacts to ALARP. It was observed that source noise control in the form of speed limit was effective in eliminating noise exceedances at the two (2) residential human NSRs.

Ground-borne Noise and Vibration

The Study assessed the vibration impacts due to construction and operational phases on human receptors and the Biodiversity Study Areas (i.e., Rail Corridor).

The Study reviewed several works of literature to gather information on vibration thresholds of fauna. Research shows that vibration thresholds for fauna are species-specific. There is a limited amount of information in this area for the indicator species for the Study. The Study uses the baseline results along the Rail Corridor to form conservative criteria for the impact assessment. Different standards and guidelines were also used to determine the criteria for human comfort.

Baseline vibration was also monitored in this Study. The 99th percentile of the ground-borne vibration levels measured across the 17 locations for baseline study ranged from PPV, 0.03 to 0.28 mm/s. Along the Rail Corridor, it ranged from PPV, 0.03 to 0.09 mm/s. Locations V1, V3, V10 and V11 stood out with PPV, 0.15 to PPV, 0.28 mm/s. This could be due to the locations being close to factories and roads or existing viaduct and could have been affected by the industrial operations and road traffic, leading to a higher recorded vibration level. The remaining locations, V2, V4 to V9 and VR1 to VR6, had results close to PPV, 0.03 to 0.10 mm/s.

The BS 5228-2:2009+A1:2014 guideline was used for vibration threshold for cosmetic damage, while the BS 6472-2:2008 guideline was used to assessed ground-borne vibration induced by rock breaking. The Study assessed ground-borne vibration impacts from construction and operational phases on the potential of burrow and mud lobster mounds damage/collapse (i.e. structural impact assessment) and the ecological behaviour of the sensitive receptors. The biodiversity habitats/fauna species classifies in Priorities 1, 2 and 3 as ecologically

sensitive receptors based on their ecological values and sensitivity towards vibration. The indicator species selected in this area were pangolin and mud lobster. The Study assessed the predicted vibration levels from the construction and operational phases of the Project and evaluated against the project specific criteria developed for this project. The Study also evaluated ground-borne noise and vibration on building receptors due to construction activities.

Construction Phase

Groundborne vibration - Ecological Receptors

For the ecological receptors, impacts from rock breaking and excavation at Sungei Kadut Station, rotary bore piling, vibratory piling, vibratory compactors and tunnel boring (hypothetical overall and spots) were assessed for ground-borne vibration. The impact significance caused by rotary bored piling and vibratory compactors (low and high) were predicted to be **Negligible - Minor**. Rock breaking and excavation at Sungei Kadut Station, vibratory piling, and tunnel boring at Spot 3 were predicted to cause **Negligible - Moderate** impact significance, while tunnel boring (hypothetical overall, Spot 1 and Spot 2) were predicted to cause **Negligible - Major** impact significance.

Mitigation measures were proposed for construction activities with **Moderate - Major** impact significance. The impact can be reduced to **Negligible** - **Minor** for rock breaking and excavation at Sungei Kadut Station by reducing the Maximum Instantaneous Charge (MIC) to 0.8 kg. By avoiding construction work at night, the impact significance of vibratory piling can be reduced to **Negligible - Minor**. As it is reasonable to assess the duration of impacts of TBM to be transient during the pass-by of the TBM in a day, mitigation measures are not required for TBM, thus the impact of the TBM remains as **Negligible – Major** impact significance. However, EMMP measures should be further enhanced, monitored and applied. The Contractor shall control construction vibration levels using the best available techniques (BAT). The Study recommends controlling vibration levels emitted to PPV, 8 mm/s where burrows and mud lobster mounds are sighted to prevent damage/collapse of the burrows and entombing the species.

Ground-borne vibration - Human Receptors

The Study assessed ground-borne vibration impacts from the construction phase on the human receptors. For the human receptors, impacts from rotary bore piling, rock breaking, vibratory piling, vibratory compactors and tunnel boring machine were assessed. The overall impacts for ground-borne vibration were predicted to be **Negligible - Minor** for most activities except for the tunnel boring machine, which was predicted to have **Negligible - Moderate** impact. With community engagement, the impacts can be managed through cooperation and communication with the affected community.

Ground-borne noise – Human Receptors

The Study also assessed ground-borne noise impacts from the construction phase on the human receptors resulting from rotary bore piling, vibratory pile driver, vibratory compactor, rock breaking and tunnel boring machine. The overall unmitigated impacts for ground-borne noise were predicted to be **Negligible - Minor** for vibratory compactions. While for rock breaking and excavation at Sungei Kadut Station, rotary bore piling and vibratory piling, they were predicted to have **Negligible - Moderate** impact. For tunnel boring, it was predicted to have Negligible – Major impact significance.

By reducing the MIC to 0.8 kg, the impact significance of rotary bore piling and rock breaking Sungei Kadut Station was predicted to be **Negligible - Minor** for ground-borne noise. The impacts caused by rotary bore piling and vibratory piling could be reduced by avoiding construction work at night. With community engagement, the impacts on ground-borne noise can be managed through cooperation and communication with the affected community and reduced to **Negligible – Moderate**. It should also be noted that since above-ground construction activities potentially generate a much higher noise, the ground-borne noise may be masked by the airborne noise.

Operational Phase

Operational vibration impact assessment results indicate that standard track forms do not cause exceedances in vibration levels or produce moderate or major impact significances towards ecological receptors. The residual impact significance on ecological behaviour is **Minor** along the Rail Corridor on ecologically sensitive receptors. Operational impacts on human receptors were covered in the Contract 9175 NVS Preliminary Report [R-90]; no receptor was predicted to experience any exceedances for ground-borne noise and vibration. Thus, no mitigation measures are required.

Concurrent construction activities at nearby works are unlikely to cause more impacts on the vibration Biodiversity Study Areas.

Soil, Groundwater and Waste Management

The main objective of soil, groundwater and waste baseline study as part of the EIS was to determine the potential environmental liabilities (i.e., soil and groundwater contamination) arising from past or existing facilities and/ or activities. The baseline study was conducted based on the findings from previously carried out HLUS [R-79].

The HLUS has found that there is a potential for existence of underground buried structures within study area (i.e., demolished buildings along Sungei Kadut Street 2 and remnants of the Singapore-Kranji railway tracks) while the presence of UXO is considered to be unlikely. Based on the non-intrusive investigation (carried out as a part of HLUS), potential sources of contamination within study area include:

- Discharge/ release of chemicals, oil products or other hazardous material due to accidental spills, leaks, and releases in storage, transport, and utility equipment areas;
- Land previously used for storing or handling chemicals, oil products, or other hazardous material;
- Manufacture of furniture and woodworks; and
- Repair of vehicles.

The potential CoC to be found in underlying soil were assessed based on the historical and current land uses and include: aromatic compounds, phenols, PAHs, metals, TPHs, VOCs, SVOCs, dioxins/ furans, chlorinated hydrocarbons, organotin and cyanides. Additional intrusive soil and groundwater investigation has been recommended to be conducted to confirm the findings of the HLUS and assess the severity of the contamination, if any.

Based on the information obtained during the intrusive soil investigation study, the soil profile encountered at the study area generally consisted of clay. Furthermore, layers of clayey sand, sandy clay and silty clay were also encountered within the study area.

Soil samples collected from the study area reported detections of metals (i.e. arsenic, barium, chromium, copper, nickel and zinc) and Total Petroleum Hydrocarbons (TPH). These detections were all below the DIVs.

Based on the groundwater data available at the time of writing this Report, groundwater level ranged from +1.73 mSHD to +9.80 mSHD with average groundwater levels ranging from +2.65 mSHD to +9.28 mSHD. Generally, higher groundwater elevations were observed at the southern portion of the site, slowly decreasing towards the north and generally following the topography of the area. Oscillations of groundwater levels were relatively low, with average difference between highest and lowest observed groundwater levels being 1.38 m.

Groundwater samples collected from the study area reported detections of metals (i.e. arsenic, barium, cadmium, chromium, cobalt, copper, lead, molybdenum and zinc), Polynuclear Aromatic Hydrocarbons (PAHs) and Total Petroleum Hydrocarbons (TPH). All of the detections were below their respective DIVs and ANZGFMWQ.

As the HLUS findings indicate possible historical contamination of soil within the study area, identified human sensitive receptors have been categorized as Priority 1 due to possible exposure to such soil. The sensitivity of ecological receptors has been determined based on their ecological significance and their dependency on

groundwater. Urban vegetation, scrubland, exotic-dominated secondary forest and Pang Sua Canal have been assessed as Priority 3, while Mangrove forest and Sungei Pang Sua as Priority 2 sensitive receptors.

The potential impacts on soil and groundwater resources associated with the construction phase of the Project include groundwater level decrease due to soil dewatering and decreased infiltration into the ground due to increase in impervious surfaces. Additionally, soil and groundwater quality could be affected due to seepage of contaminants from excavated contaminated soil (if encountered) and extracted groundwater, soil erosion as well as leakage of toxic chemical waste and chemicals used and stored on site.

During the operational phase of the Project, it is anticipated that the impact on soil and groundwater quality will be limited as the use of chemicals and generation of toxic chemical waste is expected to be of limited quantities. Although more impervious surfaces are expected to decrease infiltration into the ground, it is anticipated that the groundwater table in the long-term will equilibrate to its new level.

Based upon implementation of the minimum controls, the prediction and evaluation exercise of soil and groundwater impacts showed that there will be Negligible to Minor impact during both construction and operational phase of the Project. Therefore, no additional mitigation measures have been proposed to further minimize the adverse effect on the environment and receptors.

Vectors

Potential vectors sources identified during construction and operational phases are mainly vector-prone areas due to water accumulation and poor housekeeping on site and at station buildings, as well as improper management of construction site storage, waste areas and operational station facilities. Priority 1, 2, 3 sensitive receptors within the 400m study area have been identified and listed in Table 13-4 or Appendix DD, which are assumed to exist during both construction and operational phases of the Project. Any vector sensitive receptors identified beyond 400m may not be contributed by this Project, hence are not of an immediate concern and will be excluded from this vector impact assessment.

A baseline study for vectors was conducted via desktop assessment on 2 June 2022. The vector breeding grounds within the study area (i.e., 400m from the above ground construction worksites and the future operational footprint) were identified at the time of writing this report, as listed below:

- 3 areas with higher *Aedes aegypti* mosquito population at residential blocks near Choa Chu Kang Crescent
- 5 dengue clusters near Choa Chu Kang Crescent, Mandai Estate and Senja Road
- No active zika cluster (i.e., a potential mosquito hotspot).
- No hawker centres (i.e., mainly prone to rat infestation) were identified within the 400 m study area. The nearest future hawker centre will be the Senja Hawker Centre located approximately 450 m from the proposed docking shaft worksite.
- 15 restaurants/ eateries were identified within the 400 m study area.

Note that the above real-time baseline information will be constantly updating by NEA from time to time, hence subject to future changes when the actual construction takes place, therefore would not be taken into consideration as potential vector sources for this Project.

Being governed under the *Control of Vector and Pesticide Act (CVPA)* [R-51], minimum control measures and common best practices shall be implemented at construction worksites according to *LTA's* Safety, Health and Environmental (SHE) *Specifications* [R-19], NEA's guidelines for mosquito and rodent control, as well as the NEA's *Code of Practice for Environmental Control Officers (ECO)* [W-91] and the NEA's *Code of Practice for Vector Control Operator, Technician and Worker* [W-93].

With consideration of the minimum control measures or best practices (see Section 13.6), the likelihood of vector-breeding within the construction and operational footprints was assessed to be Less Likely, resulting in **Minor to**

Negligible impact significance levels for both construction and operational phases as detailed in Section 13.7.1 and Section 13.7.2 respectively.

As such, no further mitigation measures were required hence no residual impact assessments were undertaken. Nonetheless, vector control measures as part of the EMMP measures (see Section 14.12) for the implementation at construction worksites and operational station buildings or other associated facilities of this Project, shall be undertaken based on the relevant LTA and NEA guidelines governed under *Control of Vector and Pesticide Act (CVPA)* [R-57]

There are a few major concurrent development and other ongoing construction projects discussed in Section 3.5, and presented in Figure 3-31 and Figure 3-32 of this report, which were expected to have overlapping construction period with the construction phase of this Project. Since these areas are not governed under the same party/authority of this Project, it was presumed that minimum vector control measures will be implemented by the Project proponent on the concurrent and ongoing projects' worksites. Nonetheless, LTA should establish effective communication with the relevant Project proponent to ensure that vector control measures and other best practices advised by NEA (Refer to Section 13.6) as well as similar EMMP measures (Refer to Section 14.12) will be implemented so that cumulative impacts could be controlled and brought down to insignificant levels.

Conclusions and Recommendations

The summary of key specific mitigation measures recommended during each stage (i.e., Advance Works, Main Civil Works, and potential future infrastructure, Pedestrian Linkbridge, Vehicular Bridge, RT CCT) is presented in Table 1-2. The full list of mitigation measures can be found in the respective section of each environmental parameter.

Table 1-2 Summary of Specific Mitigation Measures during Each Stage of Construction Phase

Environmental Parameters	Recommended Key Specific Mitigation Measures
Advance Works	
Biodiversity	• Install hoarding to delineate worksite and ensure no works outside of agreed working space • Ensure pre-felling fauna inspection conducted • Wildlife Response Plan is established before works start • Biodiversity awareness training to be conducted for site personnel • Works to be conducted between 0800-1800h. No night works, unless for safety and critical emergency works • Provision of wildlife corridor of minimum 30 m along the Rail Corridor at all times
Airborne Noise	• Works to be conducted between 0800-1800h. No night works, unless for safety and critical emergency works • Setup noise reduction netting • Erect noise barriers of 3 m • Buildings behind to be demolished first while keeping first row of buildings facing Rail Corridor intact as much as feasible
Main Civil Works	
Biodiversity	• Wildlife Response Plan to be established before works start • Biodiversity awareness training to be conducted for site personnel • Works to be conducted between 0800-1800h. No night works, unless for safety and critical emergency works • Provision of wildlife corridor of minimum 30 m along the Rail Corridor at all times

Environmental Parameters	Recommended Key Specific Mitigation Measures
Airborne Noise	• Works to be conducted between 0800-1800h. No night works, unless for safety and critical emergency works • Erect noise barriers of 3m and 12m in height • Enclosure for docking shaft is currently being assessed
Ground-borne Noise and Ground-borne Vibration	• Avoid high vibration activities (rotary bore piling, rock breaking and excavation, and tunnel boring) near Rail Corridor during peak bird breeding season from March to July • Setup barriers using GI pipes and canvas sheet • Works to be conducted between 0800-1800h. No night works, unless for safety and critical emergency works • Schedule high vibration activities (rotary bore piling, rock breaking and excavation, and tunnel boring) during the daytime for safety critical works
Potential Future Infrastructure, Pedestrian Linkbridge, Vehicular Bridge, RT CCT	
Biodiversity	• Works to be conducted between 0800-1800h. No night works, unless for safety and critical emergency works • Provision of wildlife corridor of minimum 30 m along the Rail Corridor at all times • Ensure any associated slope stabilisation and grading works will not impact Sungei Pang Sua mangrove and waterbody. • Ensure minimum clearance between potential future infrastructure and Sungei Pang Sua mangrove to be achieved • Regular monitoring to identify possible collapse of the mud lobster mound at Sungei Pang Sua • Regular monitoring of Sungei Pang Sua to ensure no impacts to mangrove and Sonneratia caseolaris cluster
Hydrology and Surface Water Quality	Regular monitoring of water quality at Sungei Pang Sua
Airborne Noise	• Works to be conducted between 0800-1800h. No night works, unless for safety and critical emergency works • Erect noise barriers of 3 m and 12 m in height
Ground-borne Noise and Ground-borne Vibration	• Works to be conducted between 0800-1800h. No night works, unless for safety and critical emergency works • Schedule high vibration activities during the daytime for safety critical works • Conduct surveys of burrows when the monitored vibration levels approach a level of 80% of the ecological vibration criteria

In conclusion, the summary of unmitigated impact significance and potential residual impact significance of the assessed environmental aspects for both construction and operational phases are presented in Table 1-3 and Table 1-4.

A set of Environmental Monitoring and Management Plan (EMMP) has also been developed for each environmental parameter, which will be updated and implemented during construction and operational phases, to ensure the effectiveness of the proposed mitigation measures. The EMMP is described in Section 14 of this ES report.

Table 1-3 Summary of Potential Impact Significance during Construction Phase

Environmental Parameters	Impact Significance with minimum controls	Residual Impact Significance with mitigation measures (if required)
Biodiversity	Negligible to Moderate	Negligible to Minor
Hydrology and Surface Water Quality	Minor to Moderate	Minor
Air Quality	Moderate to Major	Minor
Airborne Noise	Negligible to Major	Negligible to Major
Ground-borne Noise and Ground-borne Vibration	Negligible to Major	Negligible to Moderate
Soil, Groundwater and Waste Management	Negligible to Minor	Negligible to Minor[1]
Vectors	Negligible to Minor	Negligible to Minor[1]
Note: [1] The initial impact assessment with minimum controls was considered insignificant (Negligible to Minor), no residual impact assessment was undertaken, hence the impact significance remained the same. Note that this does not indicate that impacts are completely eliminated.		

Table 1-4 Summary of Potential Impact Significance during Operational Phase

Environmental Parameters	Impact Significance with minimum controls	Residual Impact Significance with mitigation measures (if required)
Biodiversity	Negligible to Moderate	Negligible to Minor
Hydrology and Surface Water Quality	Minor	Minor[1]
Air Quality	Minor	Minor[1]
Airborne Noise	Negligible	Negligible[1]
Ground-borne Noise and Ground-borne Vibration	Minor	Minor[1]
Soil, Groundwater and Waste Management	Negligible to Minor	Negligible to Minor[1]
Vectors	Negligible to Minor	Negligible to Minor[1]
Note: [1] The initial impact assessment with minimum controls was considered insignificant (Negligible to Minor), no residual impact assessment was undertaken, hence the impact significance remained the same. Note that this does not indicate that impacts are completely eliminated.		

2 Introduction

AECOM Singapore Pte Ltd was appointed by the Land Transport Authority, Singapore (LTA) to carry out Contract 9175 – Advance Engineering Study (AES) for the Proposed Downtown Line 2 Extension and a New Station on Existing North-South Line. An Environmental Study (ES) is required as part of the contract to be undertaken to assess the potential environmental impacts arising from and associated with, the construction and operation of the proposed Downtown Line 2 Extension (DTL2e) (hereinafter 'the Project') on the human and ecological receptors in the vicinity of the alignment. The Project location is presented in Figure 3-1.

This ES report provides an overview of the environmental baseline status in the vicinity of the Project before the commencement of any actual pre-construction works (including site clearance) and construction of this Project. It covers the construction impacts on the environment from above ground construction and underground tunnelling activities. It also covers the operational impacts on the environment from train operation and maintenance activities. The environmental parameters covered in this study include biodiversity, hydrology and water quality, air quality, airborne noise, ground-borne noise and vibration, soil and groundwater quality, waste management and vector control. Additionally, where the impacts are deemed to be "Significant" or "Moderate/Major", appropriate mitigation measures to be implemented during the construction and operational works are also recommended.

It should be noted that this report corresponds to the engineering design developed during preliminary design stage only. This ES Prelim Report only presents the impact assessment on the environmental parameters from the preliminary engineering design. Pursuant to this study there are some recommendations relating to the design; these will be discussed and then re-evaluated when the design incorporates, develops and/or changes at a later design stage.

This ES also includes the Biodiversity and Hydrology Study Preliminary Report (as per Terms of Reference (TOR) Clause 10.31.2) in one (1) combined deliverable. This ES also has interfaces with multiple reports as part of the same AES contract as detailed in Table 2-1.

Table 2-1 Interface of ES with other related reports

Report	Details
Biodiversity and Hydrology Study Preliminary Report	The assessment on biodiversity and hydrology are all included within the ES; therefore, this ES is all inclusive.
Acoustics Preliminary Report	The Acoustics Preliminary Report focuses on the acoustic design and Public Address Voice Alarm (PAVA) design of the Project. As part of the report, boundary noise assessment from the vent shafts and station operation were assessed. The results from the Acoustics Preliminary Report were referenced, and assessment on ecological receptors has been conducted in this ES. Detailed calculation and modelling results can be found in a separate Acoustics Preliminary Report.
Noise and Vibration Study (NVS) Preliminary Report	The NVS Preliminary Report focuses on the airborne noise, ground-borne noise and vibration assessment from the underground train and potential future infrastructure operation on human receptors. The results from the NVS Preliminary Report were referenced, and assessment on ecological receptors has been conducted in this ES. Detailed calculation and modelling results can be found in a separate NVS Preliminary Report.
Traffic Noise Impact Assessment (NIA) Study Report	The Traffic NIA Report focuses on the noise impact assessment from the proposed vehicular bridge operation to the surrounding residential receptors. The results from the Traffic NIA Report were referenced, and assessment on ecological receptors has been conducted in this ES. Detailed calculation and modelling results can be found in a separate Traffic NIA Report.

This section will briefly introduce this Report in terms of the scope of works, report structure, study limitations, assumptions and constraints.

2.1 Scope of Work

Before this ES was commissioned, consultation was undertaken with LTA. Other relevant authorities (e.g., National Environment Agency (NEA), National Parks Board (NParks)), wherein the scoping of the ES was documented and submitted in the form of Inception Report Rev B [O-1], which was accepted by LTA on 7 July 2021. The scope of ES was summarised as below:

- Definition of Study Area around the Project construction footprint, considered for the assessment of environmental impacts;
- Identification of sensitive receptors for biodiversity, hydrology and surface water quality, air quality, air quality, airborne noise, ground-borne noise and vibration, soil and groundwater, waste management and vector control;
- Prediction and evaluation of impacts;
- Recommendation of mitigation measures;
- Assessment of residual impact; and
- Recommendation of Environmental Monitoring and Management Plan (EMMP), also in form of Environmental Impact Register (EIR).

This ES has assessed design elements, construction methodology, Project components, and operational activities within the preliminary design scope of Contract 9175 available at the time of writing. Understanding of the Project construction methods and operational activities has been clearly stated in Section 3.3 and 3.4 respectively, and detailed assumptions, if any, are described in individual assessment sections thereafter. Should the detailed design make alterations to these assumptions/approaches at later stage, a revised impact assessment shall be undertaken by LTA to address these changes.

2.2 Report Structure

The structure of the report is as follows:

- Section 3 – provides an overview of the background, location, activities and schedule/ plan that are known at this stage of the Project;
- Section 4 – provides a general description of the site setting, land use, heritage features, topography, geology, water catchment and climate of the Project;
- Section 5 – provides a list of Environmental Legislation, Policies, Standards, and Criteria applicable for the Project;
- Section 6 – provides the overview of the overall approach and methodology used for the assessment;

Sections 7-13 present the methodology, baseline study findings, sensitive receptors, potential sources of impacts, minimum controls and assessment of impacts from construction and operational activities, along with recommendations for mitigation measures for the various environmental disciplines within their respective study areas as mentioned below:

- Section 7 – Biodiversity;
- Section 8 – Hydrology and water quality;
- Section 9 – Air quality;
- Section 10 – Airborne noise;
- Section 11 – Ground-borne noise and vibration ;
- Section 12 – Soil and groundwater; and
- Section 13 – Vector control.

Section 14 described Environmental Monitoring and Management Plan (EMMP) developed for each environmental parameter, which will be updated and implemented during construction and operational phases,

to ensure the effectiveness of the proposed mitigation measures. Section 15 provides a conclusive summary of the ES outcomes.

2.3 Study Limitations, Assumptions and Constraints

The information contained in this document, originally produced by AECOM Singapore Pte. Ltd. ("AECOM"), was produced solely for the use of the Client and was prepared to assist in the Environmental Study for Contract 9175. This ES Prelim Report only focuses on the following environmental parameters: biodiversity, hydrology and water quality, air quality, airborne noise, ground-borne noise and vibration, soil and groundwater quality, waste management, and vectors for the construction and operational phases of the Project. At the time of writing of this report, soil and groundwater data from intrusive soil and groundwater investigations were unavailable. The intrusive testing will be carried out by LTA's Term contractor. Once available, AECOM may review the collected data and include it in the report depending on overall project's timeline.

AECOM devoted normal professional efforts compatible with the time and budget available in the bid process. AECOM's findings represent its reasonable judgments within the time and budget context of its commission and utilizing the information available to it at the time.

Neither AECOM nor its parent corporation or its affiliates, (a) makes any warranty, expressed or implied, with respect to the use of any information or methods disclosed in this document or (b) assumes any liability with respect to the use of any information or methods disclosed in this document. Any recipient of this document, by their acceptance or use of this document, releases AECOM, its parent corporation, and its and their affiliates from any liability for direct, indirect, consequential or special loss or damage whether arising in contract, warranty, express or implied, tort or otherwise, and irrespective of fault, negligence and strict liability.

AECOM undertakes no duty to, nor accepts any responsibility to, any other party who may rely upon such information unless otherwise agreed or consented to by AECOM in writing (including, without limitation, in the form of a reliance letter) herein or in a separate document. Any party who is entitled to rely on this document may do so only on the document in its entirety and not on any excerpt or summary. Entitlement to rely upon this document is conditional upon the entitled party accepting full responsibility and not holding AECOM liable in any way for any impacts on its work product for the Environmental Study for the Contract 9175 arising from changes in "external" factors such as changes in government policy, in the pricing of goods and materials or changes in the owner's policy affecting the operation of the Project.

This document may include "forward-looking statements". These statements relate to AECOM's expectations, beliefs, intentions or strategies regarding the future. These statements may be identified by the use of words like "anticipate," "believe," "estimate," "expect," "intend," "may," "plan," "project," "will," "should," "seek," and similar expressions. The forward-looking statements reflect AECOM's views and assumptions with respect to future events as of the date of this report and are subject to future economic conditions, and other risks and uncertainties. Actual and future results and trends could differ materially from those set forth in such statements due to various factors, including, without limitation, those discussed in this report. These factors are beyond AECOM's ability to control or predict.

No section or element of this document produced by AECOM may be removed from this document, reproduced, electronically stored or transmitted in any form by parties other than those for whom the document has been prepared without the written permission of AECOM.

3 Project Overview

The Project definition includes a description of the proposed Project and Project schedule supported by relevant maps and plans for the study area.

3.1 Project Location

The Project is planned to be located within or close to the Rail Corridor, Sungei Pang Sua and Pang Sua Canal. The Rail Corridor consists of a vegetated Sungei Pang Sua Woodland site, a portion of the existing Pang Sua Canal and the existing Rail Corridor alignment. Currently, it is still largely undisturbed and covered in vegetation that varies from low grass, denser vegetation, and scattered trees. The Rail Corridor (also known as Green Rail Corridor) also passes through this area. Sungei Pang Sua Woodland plays a vital role as a part of the Rail Corridor, providing a contiguous habitat patch that provides a “stepping stone” between other fragmented habitats, including Central Catchment Nature Reserve (CCNR) in the east, Western Water Catchment Area in the west, as well as Sungei Pang Sua, Mandai Mangroves and Mudflats in the north, which have become more isolated due to urban development.

The Project location is presented in Figure 3-1.

3.2 Project Description

DTL2e has a route length of approximately 5 km and will interchange with a new station to be added to North-South Line (NSL) at Sungei Kadut. The DTL2e alignment comprises two tracks commencing at the Bukit Panjang DT1 Station, proceeding north through two parallel tunnels with a typical diameter of 6.35 m along the Rail Corridor, turning slightly northwest near Sungei Pang Sua and ending at the proposed Sungei Kadut Station in Sungei Kadut industrial area. Besides the two main tracks, an underground reception track of 2 km connecting the proposed Sungei Kadut Station and Gali Batu Train Depot is also proposed; hence a temporary retrieval shaft worksite is planned near Gali Batu Train Depot to support this construction.

As part of the Project, an elevated vehicular bridge with a length of 200 m (clearance height above Rail Corridor track to be confirmed) is proposed and currently under planning to connect Choa Chu Kang North 7 on the west of Pang Sua Canal and Woodlands Road on the east of Pang Sua Canal. This elevated vehicular bridge will be constructed across Pang Sua Canal and Rail Corridor (clearance height to be confirmed) on top of Pang Sua Canal and Rail Corridor. A pedestrian linkbridge approximately 220m long, will also be constructed from the western tip of the Intermediate Station of this Project to the HDB estate of Choa Chu Kang Crescent.

The two underground stations, the elevated NSL station and the reception track to Gali Batu Depot, will be constructed using the cut and cover method. The twin tunnels and reception track will be constructed using tunnel boring machines (TBM). TBM will be launched and retrieved from Interchange Station and Intermediate Station construction worksites, with a docking shaft near the HDB Senja area. In contrast, the TBM for the reception track will be retrieved at the worksite near Gali Batu Train Depot.

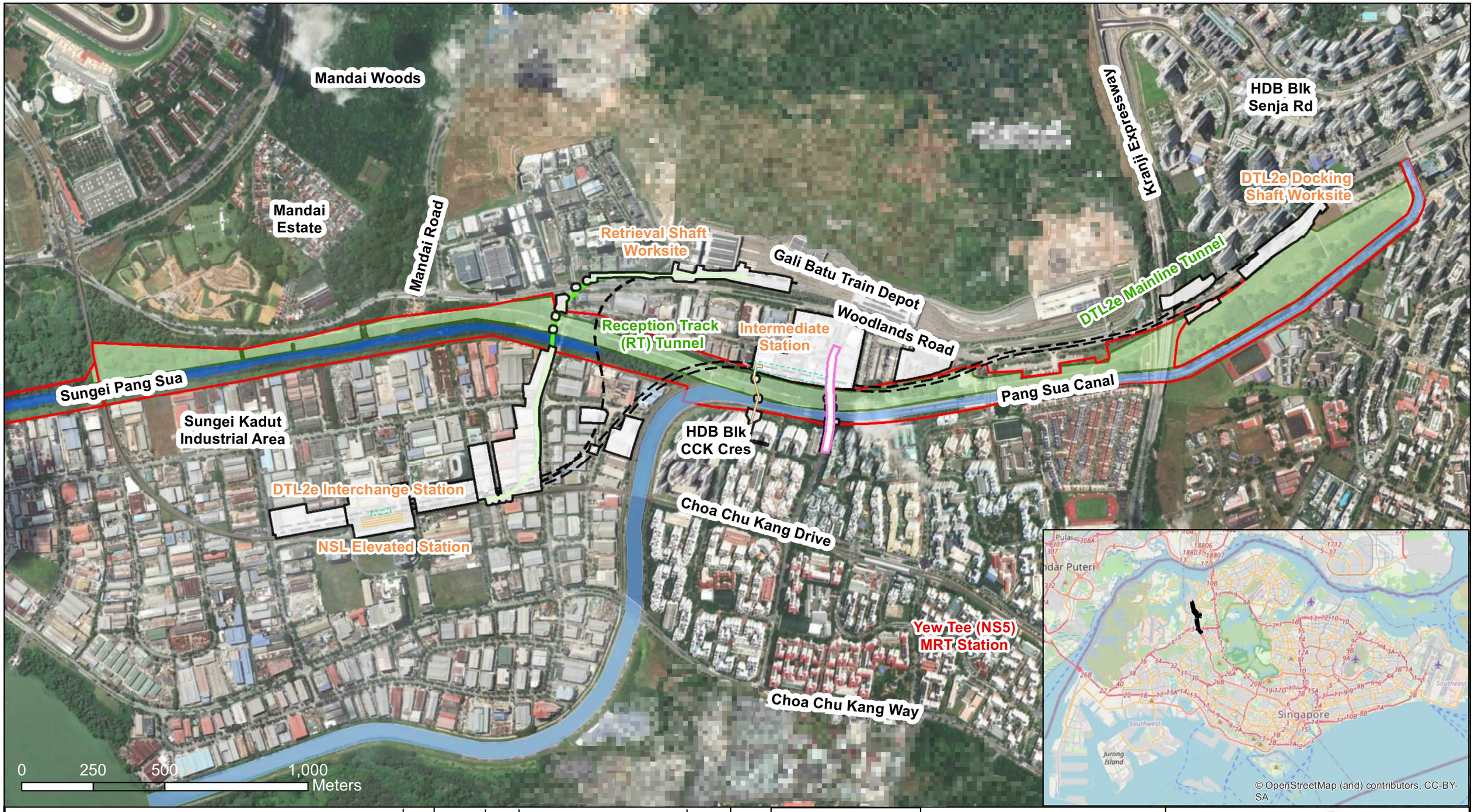
As part of the project components, there will also be an above ground potential future infrastructure that will connect the NSL to the Gali Batu Train Depot. The potential future infrastructure will be constructed using the pre-cast concrete cut and cover method. Based on the latest design, the potential future infrastructure will cross over Sungei Pang Sua and it will involve demolition or modification works when it passes too close to some buildings in Sungei Kadut industrial area. It will also come close to 23C Sungei Kadut St 1, classified as JTC Corporation (JTC) Adoptive Reuse (Heritage) Building. The viability of the potential future infrastructure is still under study and will be shared when ready.

3.2.1 Design Optimization

The project location and component described in Section 3.1 and 3.2 have taken the principle of avoidance of environmental impacts as one of its consideration. Some of the considerations are described below:

- The location of intermediate station is sited within JTC land providing direct access to JTC future development as part of JTC's redevelopment of Sungei Kadut. Additionally, the station box avoids Rail Corridor and this is expected to minimise impact on biodiversity, in terms of ecological connectivity, fauna mortality and human wildlife conflict. Additionally, it aims to reduce air quality, noise and vibration impacts on ecological receptors and Rail Corridor users.
- Yew Tee residents will have direct access to the station through the above ground pedestrian linkbridge and a vehicular bridge.
- With the above ground pedestrian linkbridge and vehicular bridge, the construction of subways through extensive cut and cover construction which affects the sensitive gas pipes, Pang Sua Canal and E63 drain, can be avoided as there is no requirement to divert the Pang Sua Canal and E63 drain. The above ground structures are expected to have less environmental impact compared to the construction of the underground subway.
- In terms of construction methodology, Tunnelling using TBM is chosen rather than cut and cover tunnel construction, as the former will minimize the environmental impact towards sensitive receptors along the tunnel alignment.
- The construction workspace for the potential future infrastructure (footings, storage and access routes) is located at least 5 m away from the banks of Sungei Pang Sua and does not affect the existing conditions (hydrology, water quality and slope stability) of Sungei Pang Sua and the mangroves along it. This is expected to reduce habitat degradation, accidental injury or mortality of fauna, and water quality impact on ecological receptors.

The unmitigated impact assessed in subsequent sections have already taken into account the abovementioned considerations.



Legend

- Proposed Pedestrian Overhead Bridge
- Potential Future Infrastructure
- Proposed Worksite Areas
- Proposed Vehicle Bridge
- Proposed DTL2e Tunnel Alignment
- Proposed DTL2e Stations (Underground)
- Proposed NSL Elevated Station
- Pang Sua Canal
- Sungei Pang Sua
- Biodiversity Study Area
- Existing Vegetated Area

N

Rev.	Date	By	Description	Chk'd	App'd
A	MAY 2023	TTR	Draft Final Report	HHL	JAG
-	AUG 2022	HHL	Draft Final Report	NHT	JAG

Qualified Person Endorsement : N/A

LTA Endorsement : N/A

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title :

CONTRACT 9175
ADVANCE ENGINEERING STUDY FOR THE PROPOSED DOWNTOWN LINE 2 EXTENSION AND A NEW STATION ON EXISTING NORTH-SOUTH LINE

Figure Title :

PROJECT LOCATION AND FOOTPRINT

Designed	Checked	Approved
HHL	HHL	JAG
	Drawn: TTR	Date: MAY 2023

Figure No. : 3-1 | Rev. : A | Sheet : 1 of 1

CAD File Name :N/A | A3

Note: Source of basemap - Google Earth Map and Open Street Map

3.3 Proposed Construction Activities

During the early stage of the construction phase, road and utility diversion may be required as part of the site preparation works. After the site clearance is completed, a temporary worksite will be formed with proper barricades at the designated area, where the major construction equipment can be placed. Each above-ground Project construction worksite area will typically include designated areas for construction, site office, equipment and material storage, worker's canteens and waste disposal area. The areas designated for the above-ground components will also support the construction of the underground components of the Project. Instruments such as piezometers and settlement markers will be installed at regular intervals within the designated construction worksite area.

After that, the main construction activities will take place, including ground improvement works, tunnel boring machine launch/retrieval works, station and superstructure construction, potential future infrastructure and underground rail tunnel construction and pedestrian linkbridge construction. During the last construction phase, general landscaping and finishing works will be undertaken to reinstate the designated work areas to their original or normal condition. It should be noted that most of the construction works will be performed outside the Rail Corridor and Sungei Pang Sua. The construction works planned within the Rail Corridor have been minimized as much as possible and are further discussed in subsequent sections.

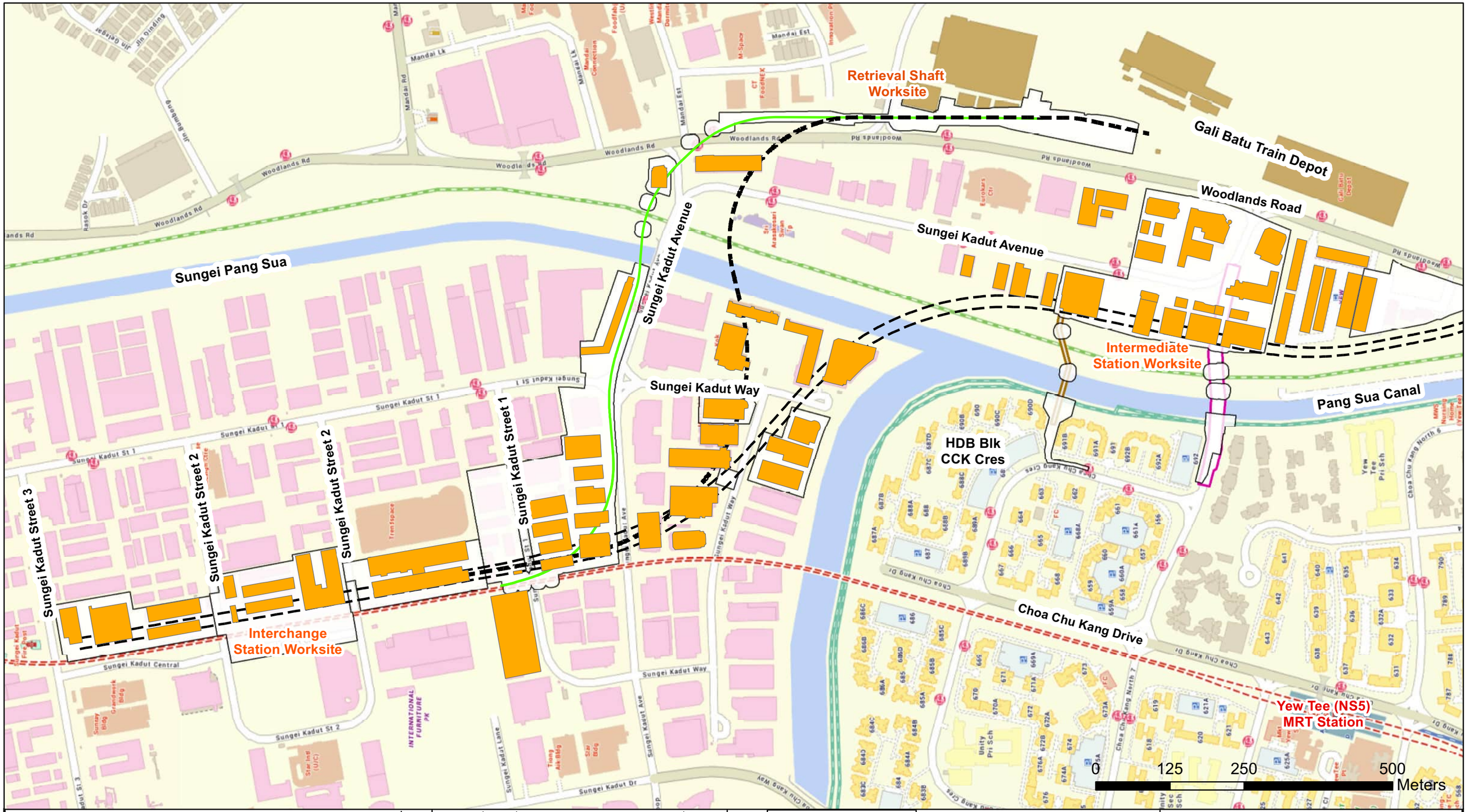
The Project construction indicative timeline is discussed in Section 3.5.1. All the construction activities associated with this Project are further discussed in the following sections.

Note that the scope of this Environmental Study excludes the impacts from Site Investigation (SI) works conducted in the pre-construction phase to inform the geotechnical design of the tunnel and station box.

3.3.1 Early Construction Phase (for Site Preparation)

3.3.1.1 Demolition Works

As part of site preparation works, demolition will be performed on existing buildings which footprint will be affected by the construction worksite areas. The demolition works are mainly conducted on industrial buildings along Woodlands Road, Sungei Kadut Avenue, Sungei Kadut Way, Sungei Kadut Street 1 and Sungei Kadut Street 2. The buildings to be demolished are divided into gangs where only 1-2 buildings will be demolished for each gang at the same time. Some of the buildings to be demolished have solid boundary walls while some only have metal fencing. Proposed buildings to be demolished and gangs are presented in Figure 3-2.



Legend

- Proposed Buildings to be Demolished
- Proposed DTL2e Tunnel Alignment
- Potential Future Infrastructure
- Proposed Worksite Areas
- Proposed Vehicle Bridge
- Proposed Pedestrian Overhead Bridge

N

Rev.	Date	By	Description	Chk'd	App'd
A	MAY 2023	HHL	Draft Final Report	ADP	JAG
-	AUG 2022	HHL	Draft Final Report	ADP	JAG

Qualified Person Endorsement :
NA

LTA Endorsement :
NA

Consultant : AECOM

Land Transport Authority
We Keep Your World Moving

Project Title :
CONTRACT 9175
ADVANCE ENGINEERING STUDY FOR THE PROPOSED DOWNTOWN LINE 2 EXTENSION AND A NEW STATION ON EXISTING NORTH-SOUTH LINE

Figure Title :
PROPOSED BUILDINGS TO BE DEMOLISHED

Designed	Checked	Approved
HHL	ADP	JAG
	Drawn: HHL	Date: MAY 2023

Figure No. : 3-2 | Rev. : - | Sheet : 1 of 1

CAD File Name : NA | A3

Note: Source of basemap - OneMap (www.onemap.sg)

3.3.1.2 Road and Utilities Diversion Works

A key initial preparation activity will be traffic and utility diversion. Sections of selected roads, which will be affected by the construction, will be either temporarily diverted or their access restricted to certain parts of the road. Works will include land clearing and tree feeling, road widening activities, and construction of temporary roads to divert traffic and set up barriers around impending cut-and-cover works or laydown areas. Drainage associated with temporary and permanent access roads will be constructed. Utilities which are shallow and likely to cause impedance to cut and cover works will be diverted first so that there is no disruption in the usage of utilities to nearby receptors. If required, some of the utilities will be reinstated after the underground station or tunnelling is completed. The utilities need to be restored at the same place. Depending on the utility to be diverted, it may involve tree felling, excavation, access road construction and concrete resurfacing works.

At each site, construction locations near HDB Senja Area (where docking shaft is planned), Sungei Kadut underground and above the ground station, utility diversion, and road traffic diversion to varying extents may be required. Currently, each area is covered with approximately 1%, 28%, and 5% of tree canopy as estimated from google earth images. All along the NSL viaduct may also involve traffic diversion along Sungei Kadut Avenue. Also, traffic diversion is expected at Gali Batu Close for the construction of retrieval shaft worksite. Hence, utilities and road traffic diversion are expected to occur.

Figure 3-3 Example of road diversion works at Sin Ming Avenue end of April 2016 [W-4]

3.3.1.3 Site Clearance

The site clearance stage will involve vegetation clearance, levelling of the site and creation of access roads. For this, the construction contractor's certified Qualified Erosion Control Professional (QECP) prepares Erosion Control Plan (ECP) and obtains approval from the Public Utilities Board (PUB). The contractor also helps to obtain tree felling approval from NParks.

At this stage, the ES report must be consulted by the Contractor for the following requirements and, therefore, plan of action:

- In an area rich in trees of conservation interest, the contractor should employ a certified arborist to map the trees carefully while applying for tree felling approval. This is to gauge the health, species, size and conservation significance of the tree;
- If there are trees that are required to be transplanted, this is done before commencing site clearance;
- If the area is rich in wildlife, the contractor consults a wildlife specialist, prepares a shepherding wildlife plan, and obtains NParks approval. In this case, the Wildlife Shepherding plan sets the direction of

clearance. The site clearance is led by wildlife specialist(s), who helps shepherd, save, and relocate wildlife as necessary;

- It is best to avoid site clearance in birds migratory season (September to February) or breeding season (March to July), as many nests and birds may be impacted. In such an event, the wildlife specialist not only assists in shepherding but also in spotting the birds' nests and recommends on-the-spot measures to be taken to avoid disruption; and
- The site hoarding process and extent should also be governed by the above factors and the plans approved by NParks (see example in Figure 3-4 below).

The SHE Personnel engaged by the Contractor during the construction phase shall incorporate the abovementioned requirements into the Environmental Management and Monitoring Plan (EMMP). Per current design, site clearance will happen mainly within the urban areas. Within the Rail Corridor, site clearance will only happen at small localized locations for column construction of vehicular bridge and POB. There will be no clearance for construction of the potential future infrastructure in the vicinity of Sungei Pang Sua. Site clearance to varying extents may be required at different construction worksites.

Figure 3-4 Example of site clearance, tree felling and internal access road [O-5]

Figure 3-5 Example of site hoarding erection [O-5]

In this process, the site is eventually levelled for construction to begin (see Figure 3-6 below). This may involve cutting and stabilising slopes in some areas (see Figure 3-7 below). In this Project, the construction worksite areas might require some level of ground levelling works at different degrees depending on the topography condition of each site. However, it should be noted that site levelling and slope cutting will only happen within urban areas, for example, at the docking shaft near HDB Senja.

Figure 3-6 Example of site levelling works [O-5]

Figure 3-7 Example of slope cutting works [O-5]

In this case, geotechnical engineers will develop Earth Retaining Stabilisation Structures (ERSS) schemes to stabilise the exposed slopes in their engineering design. In this Project, the locations which may require ERSS are mainly the Intermediate and Interchange Stations worksites, docking shaft worksite near HDB Senja and retrieval shaft worksite near Gali Batu MRT Depot.

ECO considers measures to prevent erosion of soil into the nearest drainage network. This may or may not accompany ground improvement works depending on the soil in the area. The construction site debris, felled trees and spoil will be temporarily stored on-site and then collected by licenced third parties for offsite disposal.

3.3.1.4 Establishment of Temporary Worksite

Following the site clearance, the temporary worksite structures are set up at each worksite. The site features will include areas for offices, toilets, worker accommodation and rest areas, raw material storage area, equipment storage and workshop area, tunnel segment storage area, staging areas, slurry treatment plant, waste management facilities and storage, hazardous materials storage, temporary internal roads for the movement of vehicles and vehicle parking lot (see Figure 3-8 below). A shaft hole will be constructed at the site of launch/retrieval shafts to launch/ retrieve the TBM for tunnel boring. Worksites for station boxes are much larger than the vent shaft worksite areas. The building worksite picture below shows a typical layout of a construction site with some basic features. It shows the site office, internal access roads, equipment laydown area, concrete batching plant, etc. There may be a concrete batching plant within Interchange and Intermediate Stations construction worksite for the project construction worksite areas. The road around the site boundary will also be constructed before site work's commencement.

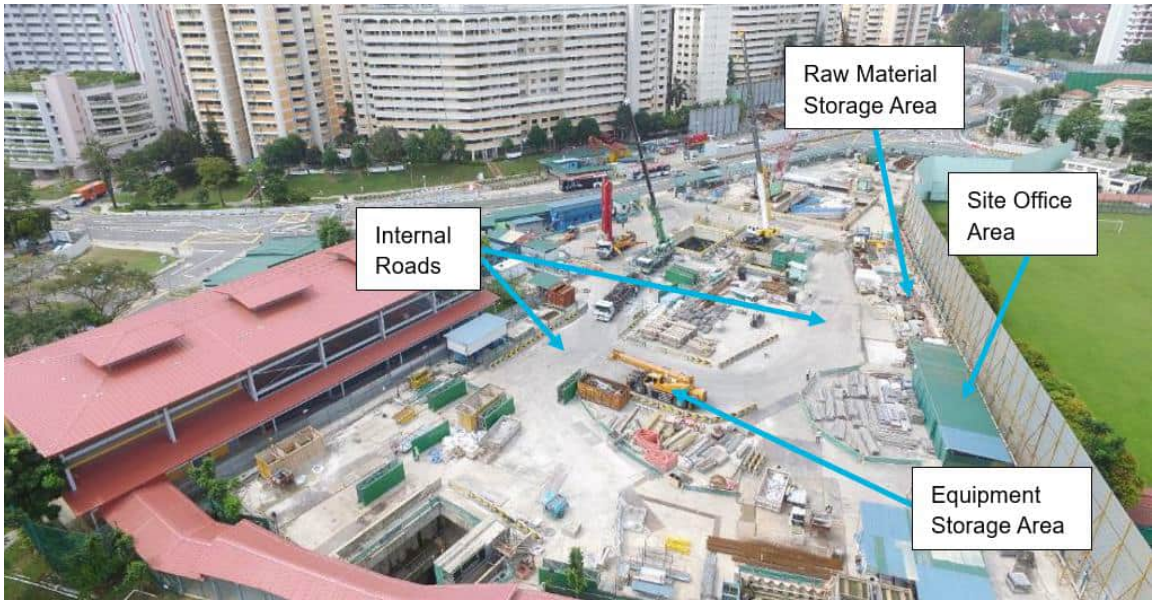


Figure 3-8 Example of temporary worksite area at Bright Hill MRT [W-16]

3.3.1.5 Installation of Monitoring Instrumentation

Instruments such as piezometers and settlement markers will be installed at regular intervals within the designated construction worksite area. A piezometer is usually spaced at 25 m and includes an arrangement of settlement markers installed in a 100 mm borehole.

- **Piezometer**: Surface monitoring groundwater pressure is a secondary source of pre-empting the onset of excessive groundwater ingress at the tunnel cutter head. It is recommended that the SI boreholes be used as future piezometer boreholes to avoid additional boreholes.

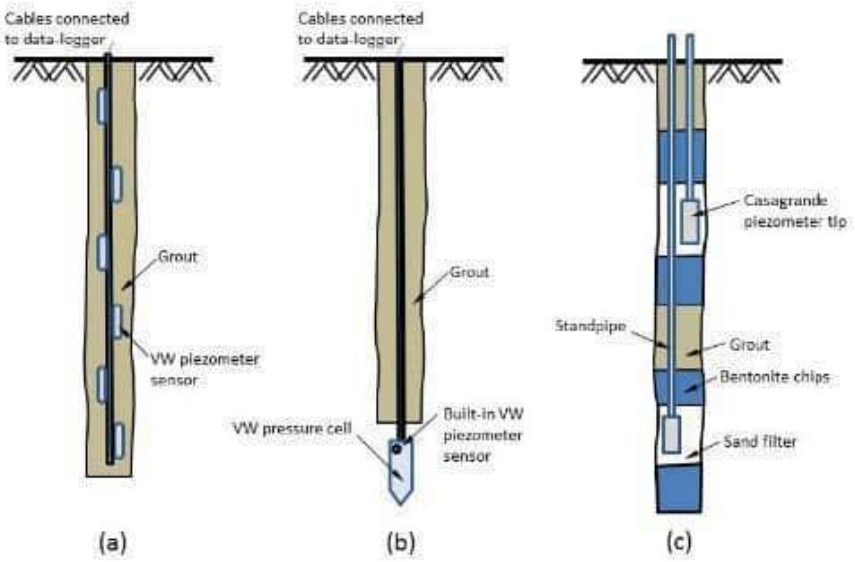


Figure 3-9 Schematic of a typical piezometer [P-8]

- **Settlement markers:** A settlement marker is a steel rod of approximately 20 mm diameter installed in the ground to record vertical settlement of the ground surface using an inclinometer or equivalent digital level equipment mounted on a tripod. In soft ground, the settlement marker can be a nail-shaped rod less than 20cm long, hammered directly into the ground. This is marked by visual markers such as reflective tape. The marker is a steel rod at least 1 m long where the ground is concrete, penetrating the concrete

layer to reach the soil. A concrete coring drill and handheld drill will be used to install each settlement marker.

Locations of this equipment were not available at the time of writing the ES report and have not been included as part of the assessment. The frequency of such measurements is typically not more than once a day. It is only necessary during the period the TBM approaches or passes under the piezometer/ marker. In the event of abnormal readings, the TBM operator increases the frequency of measurements at the piezometers/ markers and may alter the operational parameters of the TBM to mitigate to once every 4 hours.

Generally, the installation of the abovementioned monitoring instruments shall be constrained within the respective construction worksites to avoid additional site clearance. This is to minimise disruption to the biodiversity study areas nearby. Suppose installation of monitoring instruments has to be conducted outside of the worksites. In that case, it shall only be conducted on existing footpaths nearby where no additional land clearance is required, provided with approval from the Client and/ or relevant parties/ agencies (if necessary).

Figure 3-10 Example of settlement markers [W-6]

3.3.2 Main Construction Phase

Construction of the Project will involve the construction of ground improvement works, launch/ retrieval shafts, tunnelling works, tunnel cross passages, and superstructures such as Mass Rapid Transit (MRT) station, elevated viaduct, etc. and general landscaping/ finishing works.

3.3.2.1 Ground Improvement Works

Ground improvement may occur at the station worksite, where the soil condition requires ground improvement before excavation. In soil conditions ahead of the TBM where there is potential for mixed face conditions to be encountered (exact locations to be determined by Soil investigation), ground improvement works may be required ahead of the TBM cutter head.

As per the soil investigation works, ground improvement works are planned to be conducted at Interchange and Intermediate Station's worksites, retrieval shaft worksite near Gali Batu MRT Depot, docking shaft worksite near HDB Senja and also overrun tunnel towards Bukit Panjang.

For this Project, ground improvement works are planned to use the Jet Grout Column technique. Construction equipment required for ground improvement includes a jet grouting pile rig (JGP) high-pressure pump, air compressor, power generator, and vertical silo wet cement. Various steps of ground improvement are as below:

- Concrete breaking of the asphalt/ concrete covering the surface, where necessary;
- A 250 mm – 300 mm diameter casing is driven by a vibratory driving method, up to 3 m into the ground, to act as a guide for the JGP drill probe;
- The JGP drills down to tunnel depth and uses a jet system at the end of the drill probe to erode the surrounding soil column using high-pressure water and/ or air;

- The slurry formed from eroded soil and water is pushed up to the surface, where it is initially contained within a 1.5 m by 1.5 m metal box installed around the bore site and subsequently pumped out into a tote tank for collection and off-site disposal; and
- A grouting mix is pumped into the rill probe and injected into the soil column to form a concrete column within the soil strata.

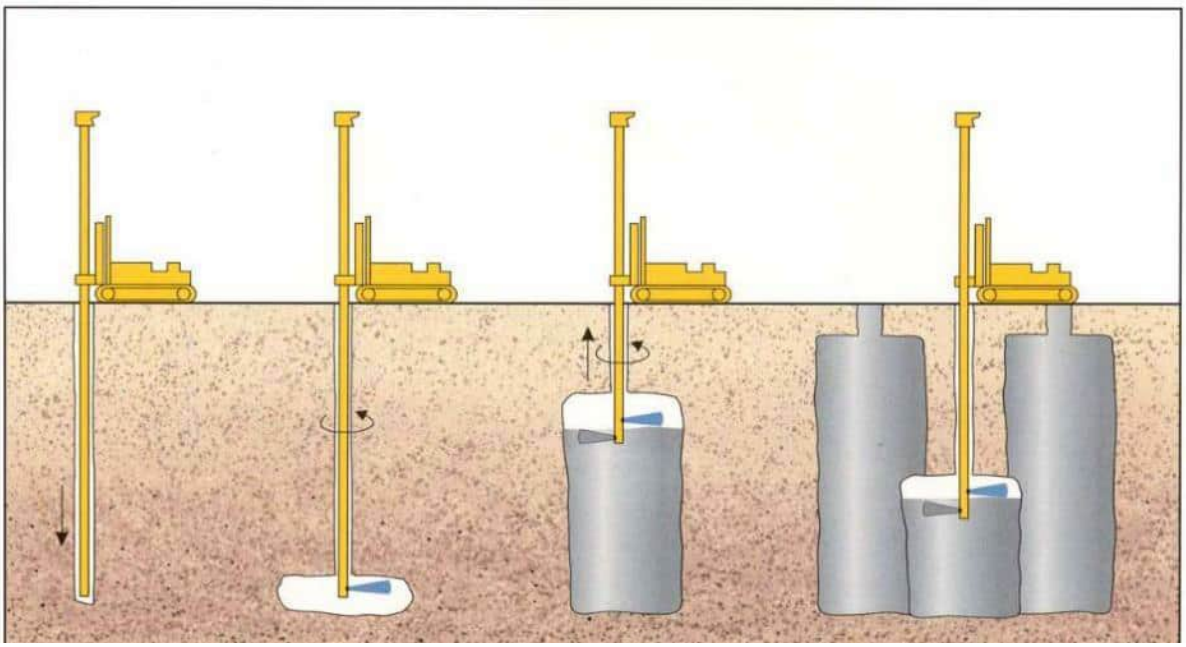


Figure 3-11 Schematic of jet grouting rig operational process [W-12]

3.3.2.2 Launch/ Retrieval Shaft Construction

Launch shaft construction typically involves excavation to allow TBM to be launched within or retrieved. Construction of the launch shaft begins with the installation of perimeter walls using sheet piling, or ERSS before the strutted excavation is carried out to form the opening of the launch shaft. This ERSS help to support the adjacent soil and prevents water ingress and caving in, thereby limiting ground movement to ensure the integrity of nearby buildings, structures and utilities. The ERSS will be designed to comply with the Building and Construction Authority (BCA)'s requirements and relevant standards and codes of practice, as stipulated in the LTA's Civil Design Criteria for Road and Rail Transit Systems, Sep 2019 Edition [R-60]. The ERSS will be waterproofed according to the underground structures standards, as detailed in LTA's Materials and Workmanship Specification for Civil and Structural Works, Jun 2010 Edition [R-61], to ensure minimal groundwater ingress into the shaft.

3.3.2.3 Tunnel Boring Works

TBM will be used for tunnelling the main alignment between Bukit Panjang DT1 Station, the Intermediate Station and the proposed Sungei Kadut Interchange Station in Sungei Kadut industrial area. Besides the two main tracks, the TBM will also be used for the tunnelling of an additional underground reception track connecting the proposed Sungei Kadut Station and Gali Batu Train Depot. The TBM launching shaft will be located at the Interchange and Intermediate Stations construction worksite. For the main tunnel, the TBM will be launched from Interchange Station towards Intermediate Station and Intermediate Station towards the docking shaft near HDB Senja area. The TBM parts will be dismantled and returned through the same bored tunnel. While for the reception track, the TBM will be launched from Interchange Station and retrieved at the worksite near Gali Batu Train Depot. Refer to Figure 3-16 for the TBM direction schematic diagram.

TBM is specially designed for excavating and constructing tunnels and is typically used to build a passage under an urban settlement, where access from above is difficult. With a large rotating steel cutter head at the front of the shield, TBMs can pass through different types of soil, rock or a mixture of both. The TBM can excavate and remove excavated materials and, at the same time, install the reinforced concrete or precast tunnel segments, forming a permanent lining of the tunnel as it progresses. Using a TBM requires relatively more minor work area than the cut-and-cover method, thus reducing the impact on public facilities and nearby traffic. A shaft is built to deliver the TBM components from ground level to the tunnel level for assembly. Tunnel segment linings are fabricated offsite and waterproofed according to relevant LTA standards. The TBM gantries will be provided in front of the secondary lining system to remove provisions left by the TBM after the tunnel boring works, such as working platforms, rails and pipes [W-21].

Figure 3-12 Example of slurry TBM [W-22] and twin-bored tunnel at a station site in Singapore [W-23]

A slurry TBM is used, a close shield TBM that pressurizes boring fluid, a suspension of bentonite, or a clay and water mix (slurry) inside the cutter head chamber, which then forms the filter cake for tunnel face support. Using the slurry shield technology, support pressure is directly controlled by regulating the suspension's inflow and outflow; mixed shield technology controls it by using compressed air. This slurry TBM is most suitable in unstable or soft grounds with high groundwater pressure or groundwater inflow. Before advancing TBM works, offsite prefabricated tunnel segments must be ready on standby in a nearby location to ensure the TBM is constantly fed with the segments. As the TBM pushes forward, the excavated materials will be transported from the cutter head to the back of the TBM for removal via the vertical shaft. The excavated materials are transported through the pipelines along the tunnels via the fluid conveying system into the slurry treatment plant above ground in the temporary worksite area. The slurry treatment plant above ground uses settling tanks to settle the solids, and the waste is sent for off-site disposal.

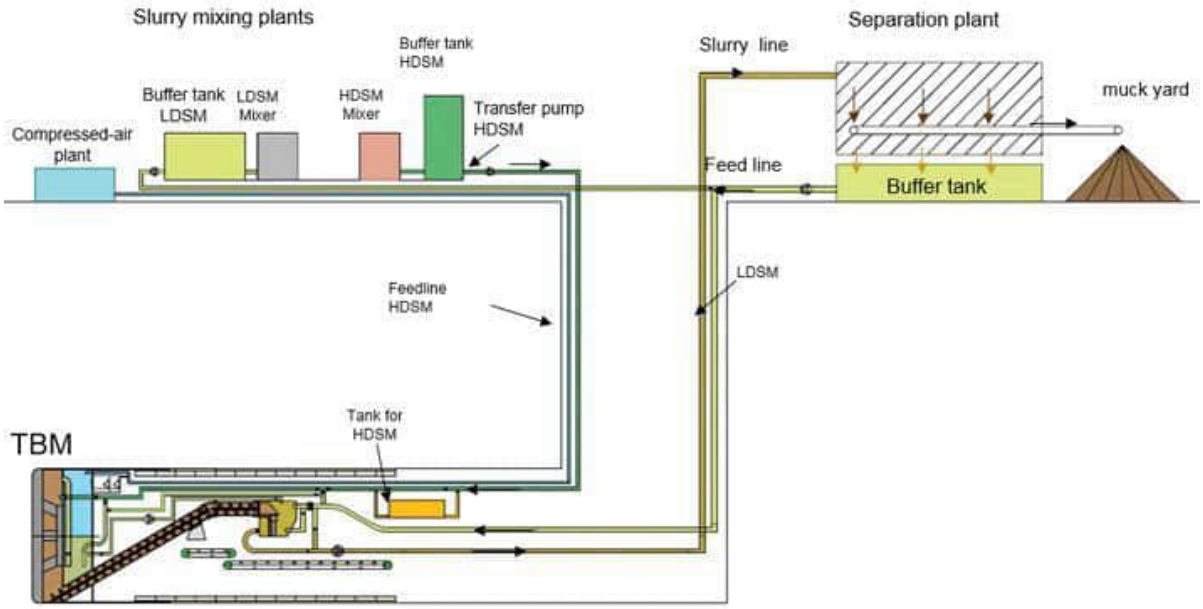


Figure 3-13 Schematic showing a variable density TBM operating below ground and treatment of extracted slurry at the above-ground plant [W-24]
(HDSM- High-density slurry material, LDSM- Low-density slurry material)

For this project, twin-bored TBM tunnelling works are planned to be conducted (see Figure 3-14). Once the TBM has advanced, and tunnel linings have been installed, escape provision between railway tunnels is provided per the Singapore Civil Defence Force (SCDF) requirements for emergency preparedness. As per the *Code of Practice for Fire Precautions in Rapid Transit Systems 2017* [W-69], escape or exit staircases of a minimum clear width of 1 m shall be provided throughout the underground or enclosed trainways spaced so that the distance between escape staircases is at most 760 m. The staircase shall be enclosed and lead directly to the outdoors or a safe refuge area. Where underground or enclosed trainways are divided by at least 2-hr fire-rated walls or twin-bored tunnels, cross passageways between the trainways shall be utilized instead of exit staircases to the

surface. The distance between a cross passageway, an escape staircase, or the platform public area shall be 500 m. Alternatively, cross-passageways shall be provided every 250 m throughout the underground rail tunnel.

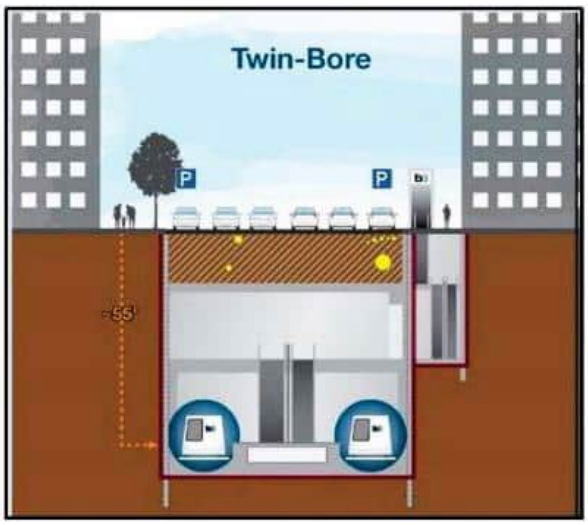


Figure 3-14 Example of single-bored and twin-bored tunnels [W-25]

Figure 3-15 Example of escape staircase and cross passage door [W-68]

Post construction of the tunnels, the trackwork engineers complete the trackwork, mechanical and electrical installations in the tunnels, and test run trains before the tunnels are declared complete.

Overall, the TBM has the advantage of not causing significant disturbance to surrounding soil and producing a smooth tunnel wall. However, a key disadvantage is its high cost. In addition, for safety considerations, all works associated with TBM are undertaken 24 hours a day until the work is completed, averaging up to 5- 7 m per TBM per day. The TBM is planned to be performed up to 20 months across different areas. Placing TBM equipment on standby is not considered economically viable. Also, the impacts from TBM operation are usually on ground-borne noise and vibration only. Therefore, unless this is a significant issue, this machine's operation is not stopped until it is complete. Associated above-ground non-critical works such as the delivery of long tunnel segments may be carried out at night to avoid traffic disruptions associated with the movement of these carriers.

Where required, sometimes ground improvement works precede the TBM movement to stabilize the ground ahead of the cutter head (see Section 3.3.2.1 for details about ground improvement works). These measures also minimize the risk of groundwater drawdown or loss of tunnel pressure to the surface to as low as reasonably practicable. As mentioned before, the groundwater ingress and ground settlement are constantly monitored ahead of TBM progress (see Section 3.3.1.5 for details about the installation of the monitoring instrument).

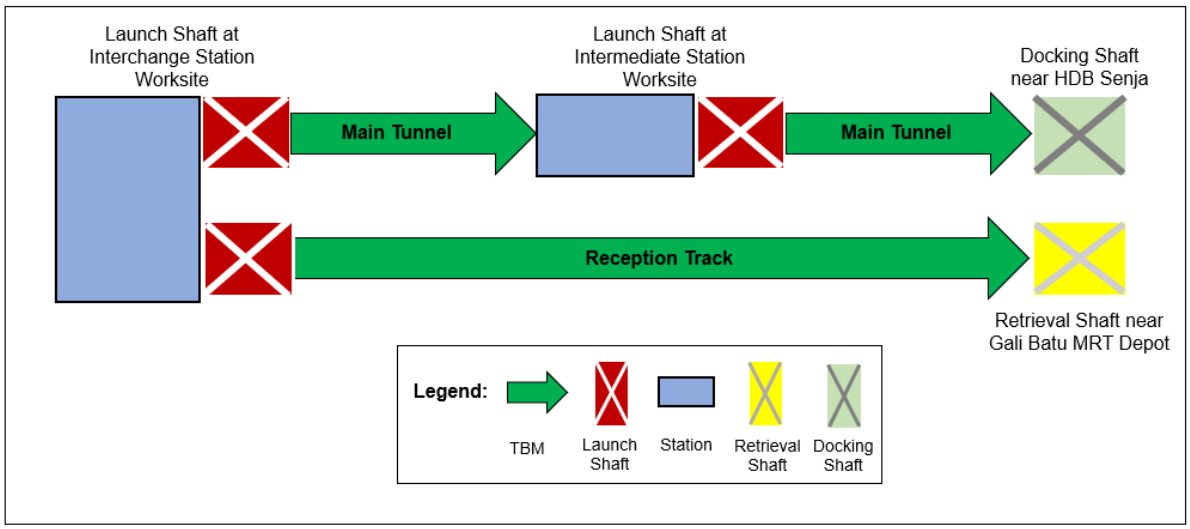


Figure 3-16 TBM direction schematic diagram

3.3.2.4 Construction of Station Boxes

The station box for the Intermediate and Interchange Stations (underground station) will be constructed using the cut and cover construction method. As per the AES Design Team's information, Intermediate and Interchange Stations are expected to be constructed using the top-down construction approach. In general, for cut and cover construction, the structure is built inside an excavation and covered over with backfill material when construction is complete. Excavation includes piling, earthworks, D-wall construction, ground improvement works, ERSS, roof slab formation, and many more.

In top-down construction, the tunnel walls are typically first constructed to support the excavation. Secondary finishing walls are provided upon completion of the construction, followed by the construction of the roof, which is tied into the support of excavation walls. The surface will then be reinstated before the completion of the construction. The remainder of the excavation will be completed under the protection of the top slab. Once the excavation is complete, the floor will be completed and tied into the walls.

Where the tunnels are wide, temporary or permanent piles or wall elements are sometimes installed along the centre of the proposed tunnel to reduce the span of the roof and floors of the tunnel. Diaphragm walls (also called D-walls) will be constructed to support excavation at the site. A D-wall is constructed using a narrow trench excavated in the ground and supported by an engineered fluid (typically a bentonite mud) until the permanent material replaces the mud. D-walls allow deep excavation without requiring a large site area to provide a stable slope and minimize groundwater flow. The diaphragm walls are anticipated to be approximately 1.5 m thick.

Following the establishment of the D-walls, excavation will commence for the construction of the cut and cover tunnel and TBM launching shaft. The cut and cover construction method is typically used for shallow structures such as station boxes, interfaces with existing MRT lines, turn-backs and supporting structures, such as underground pedestrian walkways (subways) and escape routes.

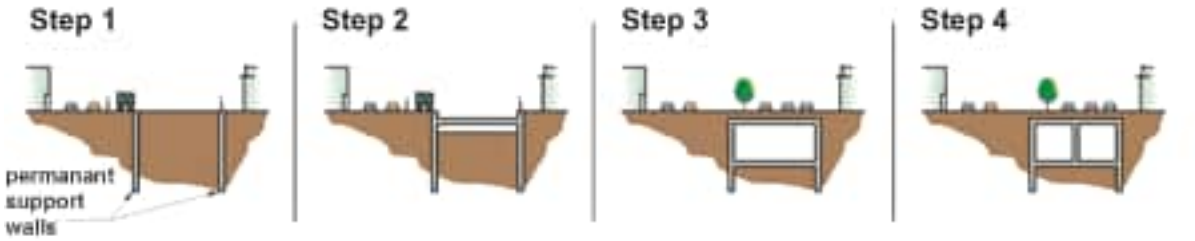


Figure 3-17 Typical top-down cut and cover construction [P-9]

Figure 3-18 Example of construction site employing top-down construction method [W-18]

3.3.2.5 Construction of MRT Superstructures

The construction of the MRT superstructure or the concourse level is similar to any other building superstructure construction. The station box for the Interchange Station (above the ground station) and entrances/ exits for Intermediate and Interchange Stations are constructed using either the top-down or bottom-up station box construction method (refer to Section 3.3.2.3). The construction method is well understood by contractors and simple in design and construction. It is also worth noting that ventilation shafts are always associated as part of the MRT superstructure or above-ground structure to support the tunnel ventilation.

After the completion of site clearance, the foundation works for the station can commence. Foundation for the stations will involve board piling with temporary and permanent casing using bentonite slurry. ERSS may also be used where necessary, as excavation will be required to expose the piles and area for the base slab and beam and to install the permanent walls for the station. Once the excavation is completed, concreting will be undertaken. Concreting involves the construction of a pile cap, and base slabs, beams and walls for the station will be poured in situ using reinforced concrete.

These construction works will include ticket vending machines or/ and offices, passenger service offices, office spaces such as station master room, technical rooms, stores and shops, and other station facilities, access routes (Entrance and exit passageways), and other station facilities such as electrical and mechanical installations, fire detection and alarm systems, and many more.

As per current planning, two (2) entrances/ exits associated with the DTL2e Intermediate Station will be potentially located within the proposed JTC future development. With 1 entrance/ exit connected with a POB towards an open area between HDB Blk 690D and 691B Choa Chu Kang Crescent, west of the Intermediate Station.

The construction method for the underpass to these entrances/ exits for DTL2e Intermediate Station is planned to be open cut and cover as part of the overall Intermediate Station worksite. The entrances/exists associated with the DTL2e Interchange Station at Sungei Kadut will be confirmed at later stage.

Figure 3-19 Concept façade entrance for proposed Intermediate Station towards the industrial area

3.3.2.6 Construction of the above ground potential future infrastructure

In this Project, an above-ground potential future infrastructure is proposed to connect NSL Elevated Station with Gali Batu Train Depot, spanning approximately 1.5 km. This infrastructure will be constructed above ground, and will consist of concrete foundations.

The construction of the potential future infrastructure will commence with the foundation works through bored piling. A steel sheet pile will be installed before the excavation and construction of the pile cap to ensure the stability of the adjacent road pavement and the safety of road users. Pre-cast concrete segments will be used, and gaps will be sealed with in situ concrete pours. Safety precautions such as a safety net shall be in place to prevent debris from falling onto the traffic passing underneath during construction.

Figure 3-20 Example of single track elevated viaduct [O-8] (typical above ground potential future infrastructure)

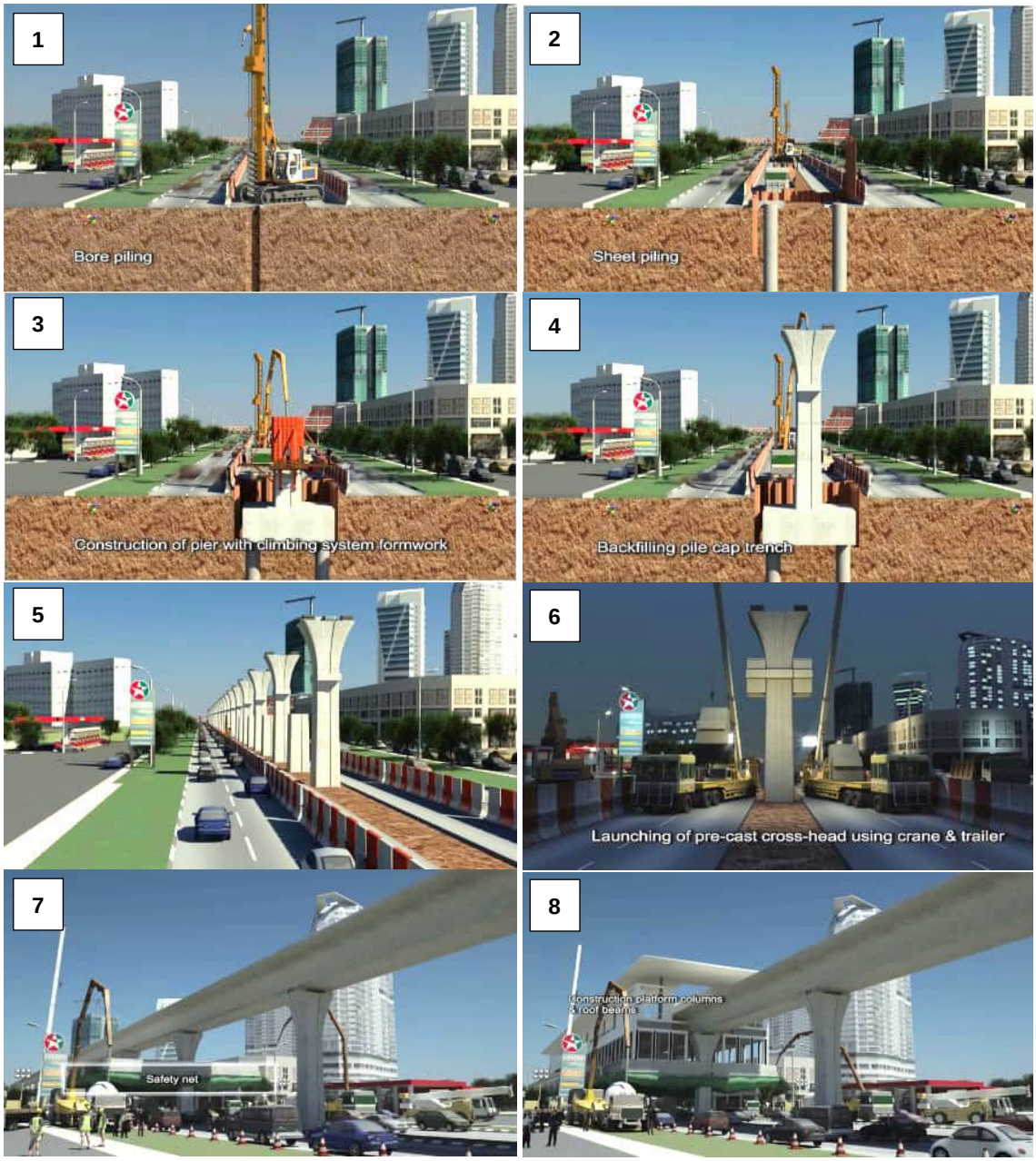


Figure 3-21 Example of elevated viaduct construction associated with station box [W-33]

3.3.2.7 Construction of Elevated Vehicular Bridge

An elevated vehicular bridge with a tentative length of 200 m (height of 4.5 m above Rail Corridor track) is proposed to connect Choa Chu Kang North 7 west of Pang Sua Canal and Woodlands Road on the east of Pang Sua Canal. This elevated vehicular bridge will be constructed across the Pang Sua Canal, Rail Corridor, and over the Woodlands Road to connect to the proposed JTC Future Development.

The vehicular bridge columns/piers will be cast-in-situ, while the pre-cast U-beams with RC slab will be used for the internal portions. The pre-cast U-beams with RC slab will be lifted by crane and attached to the constructed piers. Refer to Figure 3-22 and Figure 3-23 for a schematic diagram of the proposed vehicular bridge and an example of a similar bridge using the same construction method, respectively.

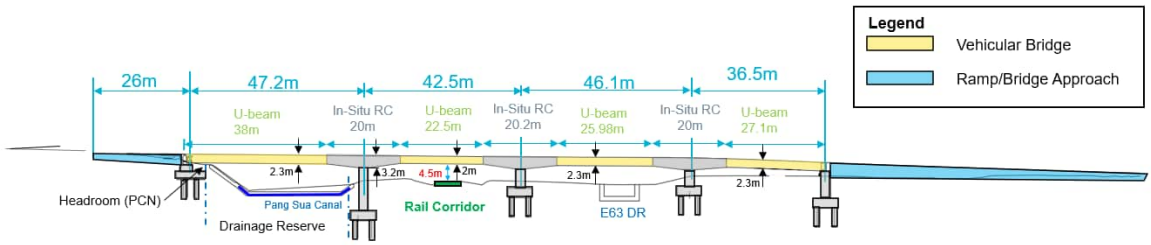


Figure 3-22 Proposed vehicular bridge schematic diagram

Figure 3-23 Example of pre-cast U-beam with cast-in-situ RC columns of Aljunied West Flyover

The pre-cast U-beam will be constructed with an RC slab on top. Due to limitations in transportation, the most extended precast beam is designed to be 38 m. The thickness of the overall precast structure is approximately 2-2.3 m, allowing for compliance with headroom criteria on top of the Rail Corridor track of 4.5 m. The precast beam method applies to irregular and long span lengths, congested project sites, rough and water terrain, rail crossings and environmentally sensitive areas [W-29]. This is similar to the current site condition of this Project, where the surrounding area is congested with existing and future development in the Yew Tee and Choa Chu Kang areas, as well as the environmentally sensitive Pang Sua Canal and Rail Corridor. Traffic diversion and management may be required before beginning the construction of this elevated vehicular bridge (refer to Section 3.3.1.1 on road diversion works).

Regarding the columns/piers, cast-in-situ construction is beneficial when large, considerably heavy segments are required to be constructed. Otherwise, for precast construction. For a cast-in-situ bridge, the construction will first commence at each pier with the construction of substructural elements, i.e., pile foundation, pile cap, and pier. The temporary truss will then be erected with the structure to support the built pile cap. The cast-in-situ RC crosshead will then be constructed, and temporarily supported on the truss.

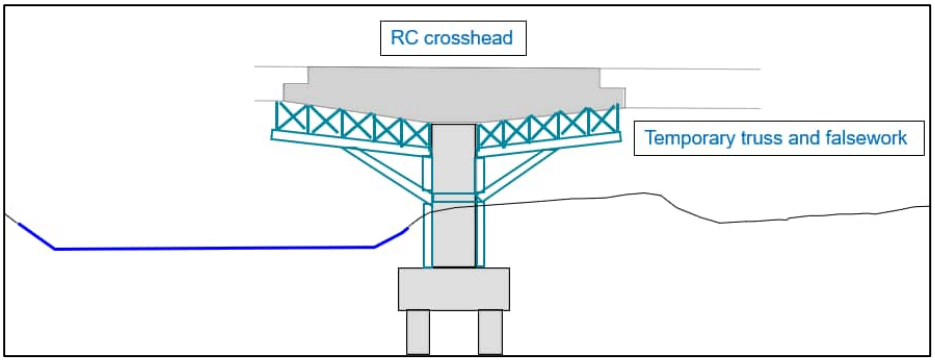


Figure 3-24 Columns/piers construction schematic

Upon delivery of pre-cast U-beams to the site, crane will be used to lift the pre-cast U-beam (2 lifting points) and attached to the cast-in-situ RC crosshead. The pre-cast U-beam will be temporary supported until the completion of in-situ stitching using pre-stressing bars and steel reinforcement to provide continuity. Refer to Figure 3-25 for the schematic diagram.

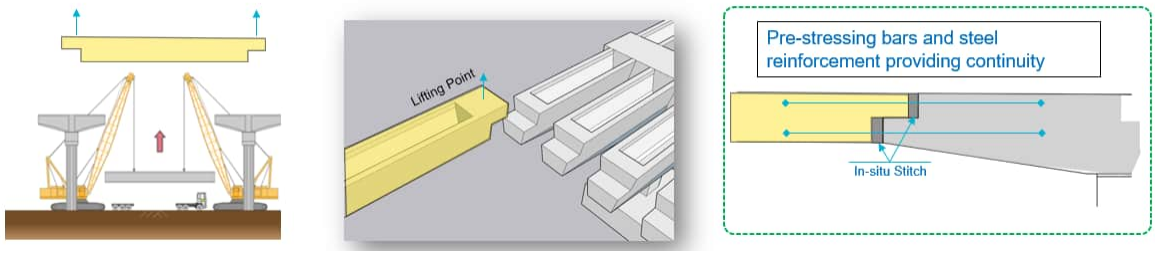


Figure 3-25 Lifting and connecting pre-cast U-beams to RC crosshead

Since this Project is still at the concept stage, no exact details of the construction method were available at the time of writing this report. Considering LTA's Engineering Group Civil Design Criteria for Road and Rail Transit Systems E/GD/09/106/A2 [W-32], the design of the bridge components shall consider noise and vibration propagation to adjacent properties (e.g., for selection of foundation type). It shall not cause undue noise or vibration impacts to the surrounding.

3.3.2.8 Construction of Pedestrian Linkbridge

Pedestrian linkbridges are usually constructed using the precast method. The pedestrian linkbridge is expected to span approximately 220 m with a height of 7 m above the Rail Corridor. The bridge components (e.g., main bridge, span, staircase) will first be built/ assembled and fabricated at the precast yard offsite, therefore not requiring major cast in-situ on site to avoid major disruption to the traffic. There are two typical forms of pedestrian linkbridge observed in Singapore: steel truss and concrete beam, as shown in Figure 3-26 below. The precast bridge columns (typically designed as pinned form) per span length and the associated access/ staircase at both sides will be erected on site before the bridge structure is delivered using a modular trailer. A Mobile crane will most likely be used to install the precast bridge [W-55].

Figure 3-26 Example of steel truss bridge at Clementi station [O-9]

As per the conceptual design at the time of writing this report, the pedestrian linkbridge from the northern tip of the intermediate station to the HDB estate of Choa Chu Kang Crescent is approximately 220 m long. It will straddle over the Pang Sua Canal and rest on four support columns stretching from the Intermediate Station of this Project to the HDB estate at Choa Chu Kang Crescent.

3.3.3 End Construction Phase (for Reinstatement)

3.3.3.1 General Landscaping and Finishing Works

MRT Station superstructures, elevated viaducts, vehicular flyovers, and Facility Buildings are provided with façade cosmetics with a theme for an MRT line. Landscaping around these buildings for the intermediate station in Rail Corridor will follow NParks Guidelines on Greenery Provision and Tree Conservation for Developments [R-64] as part of finishing works.

For the worksites where the existing topography has been altered during land grading works, the finishing works must include reinstatement and stabilization of the area.

Figure 3-27 Example of reinstatement and landscape works at TEL1 worksite [W-27]

3.4 Proposed Operational Activities

During the Commissioning phase, as mentioned in the section above, test trains are run, and extensive track testing is completed before the MRT line is opened to the public for safety reasons. During the operational phase of the MRT line, the stations will attract more public; hence, more vehicles for dropping off and taking on the public travelling via MRT. Therefore, the roads leading to the stations may be widened or enhanced. This shall be studied in the AES Design Team's Traffic Impact Assessment (TIA) Study.

Besides this, the stations operate extended hours, from 6 am to 11 pm, and therefore see an increase in human activities and light/ temperature changes in and around the station boxes. The operating hours will be finalised at a later stage. Rolling stock similar to the existing configuration will be used. Periodic maintenance works in the night-time (around 12 am to 4 am) will be undertaken within the tunnels and for equipment within station buildings. The station buildings will be built to comply with relevant NEA's mechanical buildings noise regulations at the boundary. The potential future infrastructure will also be in operation only during the maintenance engineering hours around 12 am to 4 am.

It should be noted that diesel operated wagon may be used for electrical maintenance work in the tunnels at night. The tunnels and train operation will require the trains to minimise the impact of ground-borne noise and vibration, which are studied in a separate Noise and Vibration Study (NVS) under the same contract. Since the trains operate on electrical systems, they do not emit air emissions directly impacting the environment.

As part of the Intermediate Station operation, an approximately 220 m long pedestrian linkbridge (height of 7 m above the Rail Corridor) will also be in operation to connect patrons from the HDB estate of Choa Chu Kang Crescent across the Pang Sua Canal to the northern tip of the Intermediate Station. During the operational phase, the pedestrian linkbridge is not expected to generate any environmental pollution.

An elevated vehicular bridge with a tentative length of 200 m (height of 4.5 m above Rail Corridor track) is also proposed as part of the Project to connect Choa Chu Kang North 7 west of Pang Sua Canal and Woodlands Road on the east of Pang Sua Canal. The vehicular bridge is expected to be a dual-2 road vehicular bridge with the projected peak number of vehicles of 1,400/hour for each direction with approximately 14% of heavy vehicles of the total number of vehicles during peak hours. Under the same contract, the elevated vehicular bridge's operational noise impact is studied in a separate Traffic Noise Impact Assessment (NIA).

Figure 3-28 Conceptual façade of proposed Intermediate Station with pedestrian linkbridge and Vehicular Bridge

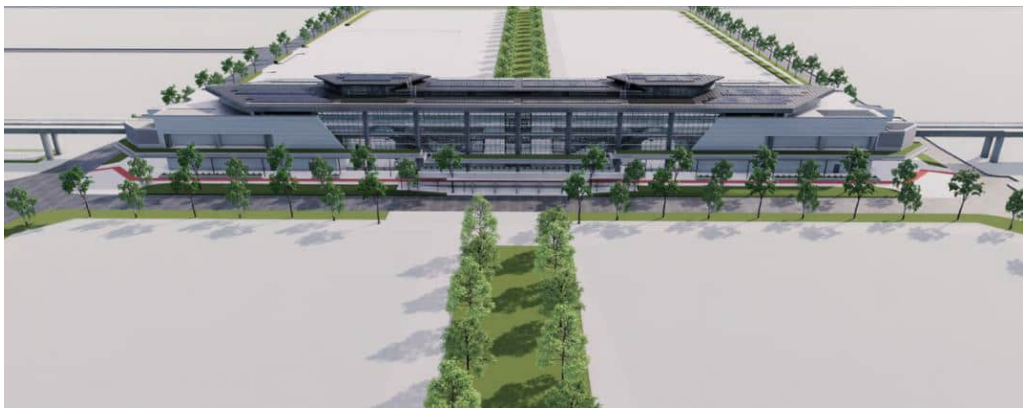


Figure 3-29 Conceptual façade of proposed Intermediate Station

Legend

- Proposed DTL2e Tunnel Alignment
- Potential Future Infrastructure
- Proposed Vehicle Bridge
- Proposed Pedestrian Overhead Bridge
- Proposed DTL2e Stations (Underground)
- Proposed NSL Elevated Station
- Bus Stop
- PUDO
- Pang Sua Canal
- Sungei Pang Sua
- Biodiversity Study Area
- Existing Vegetated Area

N

Rev.	Date	By	Description	Chk'd	App'd
A	MAY 2023	TTR	Draft Final Report	HHL	JAG
-	AUG 2022	HHL	Draft Final Report	NHT	JAG

Qualified Person Endorsement :
N/A

LTA Endorsement :
N/A

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title :
CONTRACT 9175
ADVANCE ENGINEERING STUDY FOR THE PROPOSED DOWNTOWN LINE 2 EXTENSION AND A NEW STATION ON EXISTING NORTH-SOUTH LINE

Figure Title :
PROPOSED PROJECT OPERATIONAL FOOTPRINT

Designed	Checked	Approved
HHL	HHL	JAG
	Drawn: TTR	Date: MAY 2023

Figure No. :	Rev.	Sheet
3-30	A	1 of 1

CAD File Name :N/A — A3

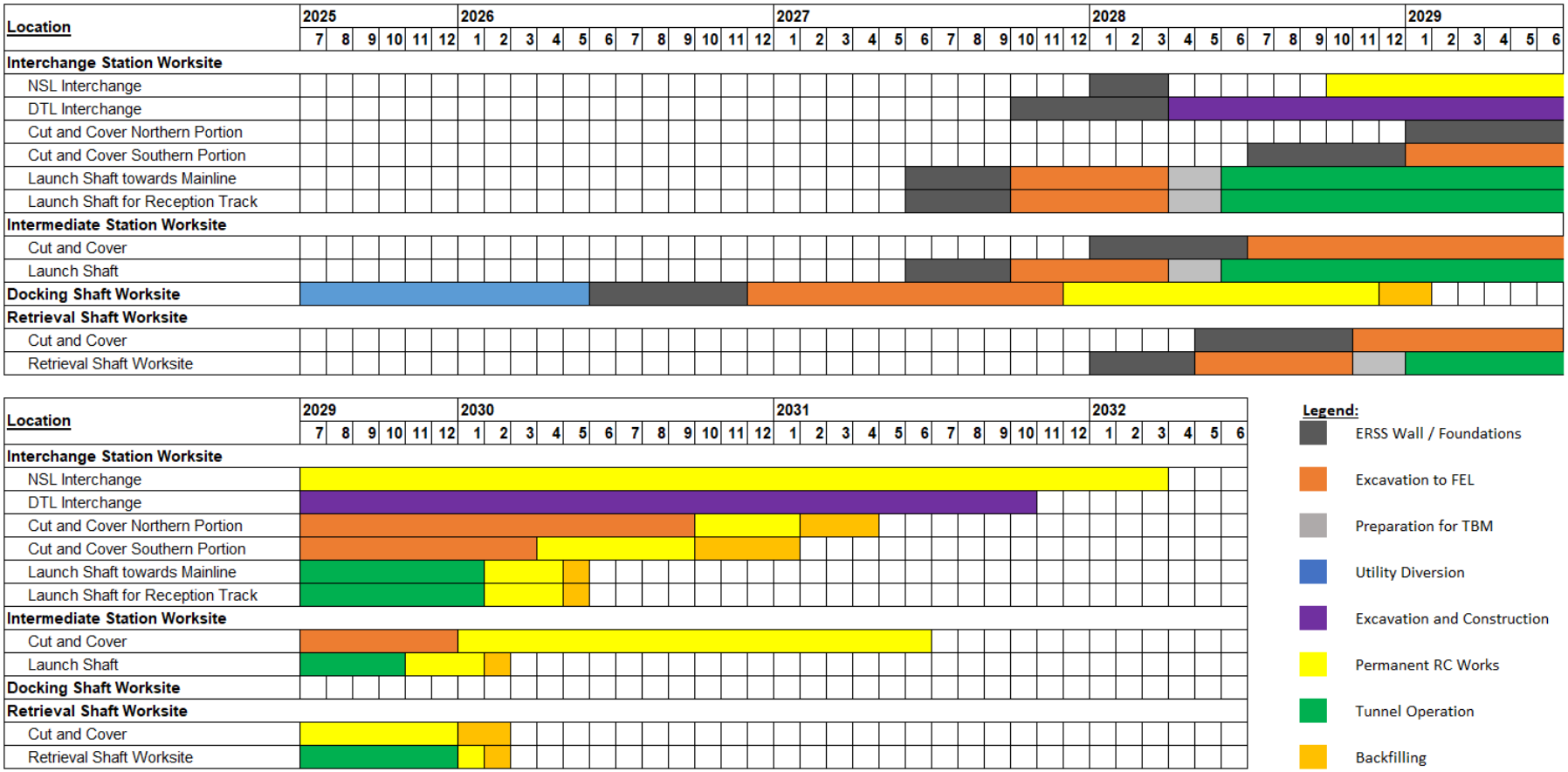
Note: Source of basemap - Google Earth Map

3.5 Project Schedule

3.5.1 Schedule of this Project

As per current planning, the construction of this Project is expected to commence in the Year 2025 and be completed in the Year 2032. Indicative detailed schedule is presented in Table 3-1 below. It is to be noted that the final schedule is still being discussed and may be adjusted at later stage.

Table 3-1 Project Construction Indicative Timeline



3.5.2 Major Concurrent Development

Concurrent projects in the vicinity of the Project must be reviewed in parallel with the Project's impact assessment to assess potential cumulative impacts. Some concurrent projects that were known at the time of writing include:

- HDB CCK N1 construction; and
- JTC Woodlands Road realignment

It should be noted that the list mentioned above may not be exhaustive. The major concurrent project locations are presented in Figure 3-31 for reference.

Cumulative impact assessment for each environmental parameters are discussed in Sections 7.11, 8.10, 9.10, 10.10, 11.11, 12.10 and 13.10 for biodiversity; hydrology and water quality; air quality; airborne noise; ground-borne noise and vibration; soil, groundwater quality and waste management; and vectors respectively.

3.5.2.1 HDB CCK N1 Construction

HDB CCK N1 will have an overlapping construction timeline with the construction of the Project's docking shaft near HDB Senja for approximately 1 – 2 years. The site clearance for HDB CCK N1 project was scheduled to begin in 2023 and building construction completed in 2028. At current stage, the Project's docking shaft ERSS works are planned to start only in second half of 2026. The overlap is considered minimal as by the time the Project commences work, HDB CCK N1 would already be at tail end of its construction period while the Project's docking shaft would have only started its commencement.

3.5.2.2 JTC Woodlands Road realignment

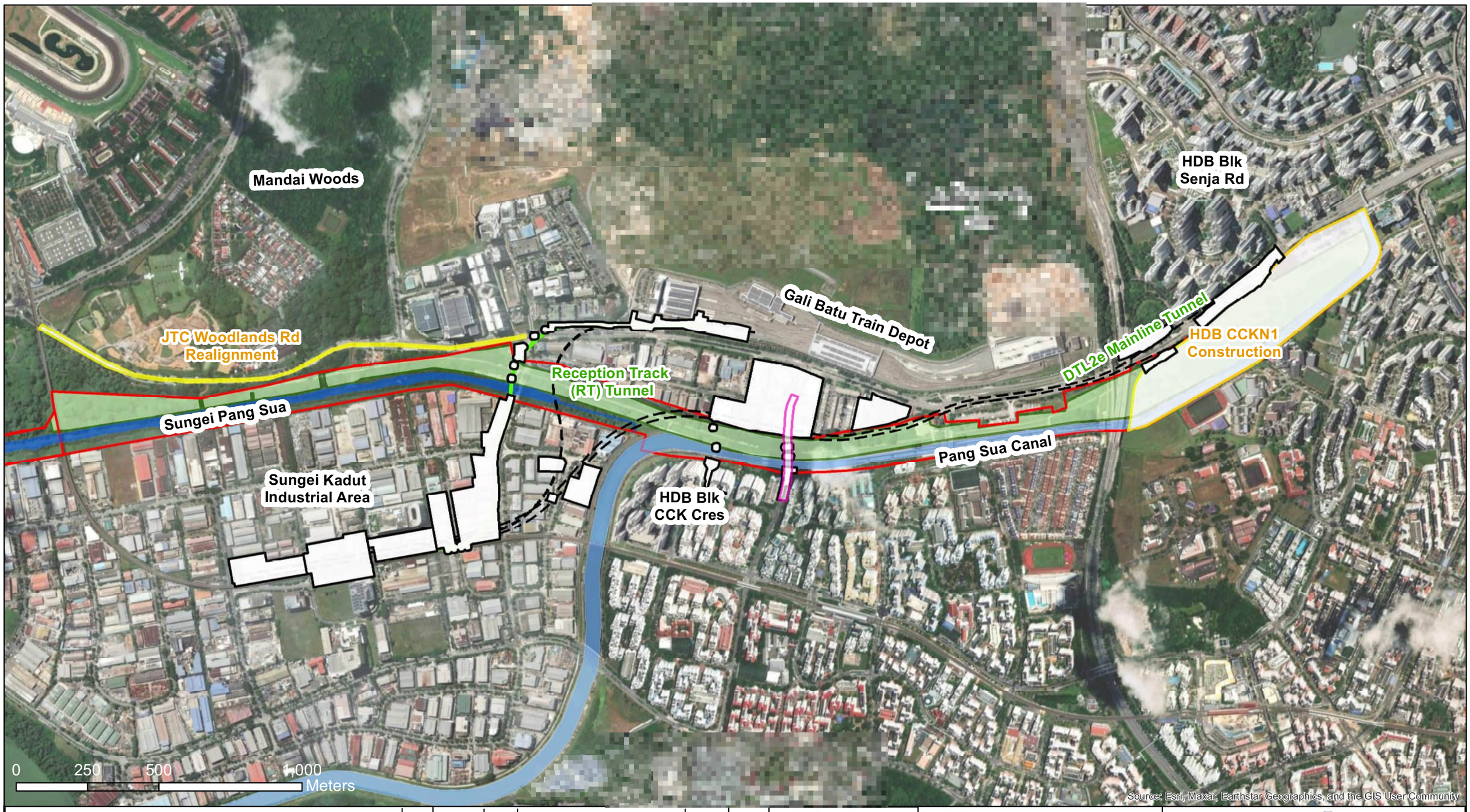
The timeline for JTC Woodlands Road realignment is not yet confirmed at the time of writing. However, the entirety of its construction may happen simultaneous and within the timeline of the Project.

3.5.3 Ongoing Construction Works

Understanding ongoing construction works in the vicinity of the Project is essential in determining baseline monitoring locations/ understanding baseline condition. This is to ensure that other ongoing construction works will not influence the results obtained during baseline in the vicinity of the Project or if no choice, but to locate baseline monitoring locations in the vicinity, then to be mindful of the situation while assessing the results or determining the criteria (if baseline dependent). Ongoing construction works near the Project include:

- PUB Mandai sewer pipeline works;
- LTA Gali Batu bus depot construction; and
- NParks park connector network enhancement.

It should be noted that the list mentioned above was gathered based on observations during the site survey conducted on 16 February 2021 and might not be exhaustive. Indicative ongoing construction project locations are presented in Figure 3-32 for reference.



Legend

- Major Concurrent Projects Location
- Proposed DTL2e Tunnel Alignment
- Potential Future Infrastructure
- Proposed Worksite Areas
- Proposed Vehicular Bridge
- Pang Sua Canal
- Sungei Pang Sua
- Biodiversity Study Area
- Existing Vegetated Area

N

Rev.	Date	By	Description	Chk'd	App'd
A	MAY 2023	TTR	Draft Final Report	HHL	JAG
-	AUG 2022	HHL	Draft Final Report	NHT	JAG

Qualified Person Endorsement :
N/A

LTA Endorsement :
N/A

Consultant : AECOM

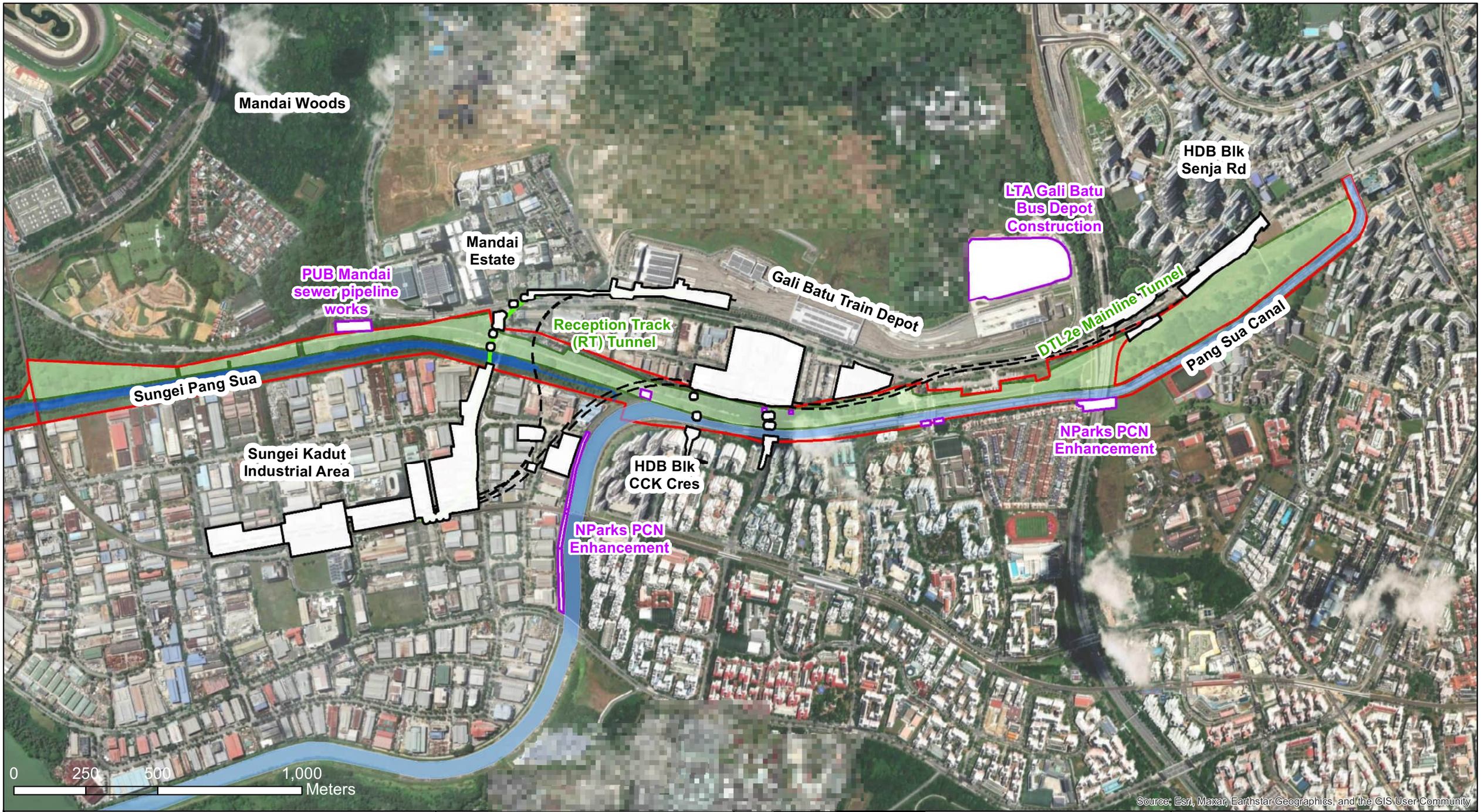
Land Transport Authority
We Keep Your World Moving

Project Title :
CONTRACT 9175
ADVANCE ENGINEERING STUDY FOR THE PROPOSED DOWNTOWN LINE 2 EXTENSION AND A NEW STATION ON EXISTING NORTH-SOUTH LINE

Figure Title :
MAJOR CONCURRENT PROJECTS LOCATION

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
HHL	HHL	JAG	3-31	A	1 of 1
	Drawn TTR	Date MAY 2023	CAD File Name :N/A		A3

Note: Source of basemap - Google Earth Map



Legend

- Indicative Ongoing Construction
- Proposed DTL2e Tunnel Alignment
- Potential Future Infrastructure
- Proposed Worksite Areas
- Pang Sua Canal
- Sungei Pang Sua
- Biodiversity Study Area
- Existing Vegetated Area

N

Rev.	Date	By	Description	Chk'd	App'd
A	MAY 2023	TTR	Draft Final Report	HHL	JAG
-	AUG 2022	HHL	Draft Final Report	NHT	JAG

Qualified Person Endorsement :
N/A

LTA Endorsement :
N/A

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title :
CONTRACT 9175
ADVANCE ENGINEERING STUDY FOR THE PROPOSED DOWNTOWN LINE 2 EXTENSION AND A NEW STATION ON EXISTING NORTH-SOUTH LINE

Figure Title :
ONGOING CONSTRUCTION WORKS IN THE VICINITY OF THE PROJECT

Designed	Checked	Approved
HHL	HHL	JAG
	Drawn: TTR	Date: MAY 2023

Figure No. : 3-32 | Rev. : A | Sheet : 1 of 1

CAD File Name :N/A | A3

Note: Source of basemap - Google Earth Map

4 Description of the Environment

This section provides an overview of the project's surrounding environment in terms of current and historical land uses, heritage features (if any), topography, geology, the existence of catchment areas (if any) and climate conditions.

4.1 Current Land Use and URA Land Zoning

According to the latest Urban Redevelopment Authority of Singapore (URA) Master Plan 2019, the alignment passes through various land use zones such as residential, educational, commercial among others. The current land uses or buildings situated in and/ or across different URA's planned land zoning [M-3] within the study area were identified through 2022 OneMap [M-2] and/or Google Map [M-1], as summarised in Table 4-1and presented in Figure 4-1.

Table 4-1 Current Land Uses and URA Land Zoning within the Study Area

URA Master Plan 2019		OneMap SG
Land Use	**Description**	**Current Buildings/ Spaces in the URA Land Use Plan**
Civic & Community Institution	These are areas used or intended to be used mainly for civic, community or cultural facilities or other similar purposes.	Sungei Kadut Fire Post, Westlite Mandai Dormitory
Educational Institution	These are areas used or intended to be used mainly for educational purposes, including tertiary education.	Yew Tee Primary School, Regent Secondary School, Jurong Pioneer Junior College, Teck Whye Primary School, Teck Whye Secondary School, West View Primary School, West Spring Secondary School
Place of Worship	These are areas used or intended to be used mainly for religious buildings.	Sri Arasakesari Sivan Temple, Senja Soka Centre
Open Space	These are areas used or intended to be used as open space.	Open spaces at Regent Secondary School, Yew Tee Primary School and West View Primary School
Park	These areas are used or intended to be used mainly for parks or gardens for the general public's enjoyment and include pedestrian linkages.	The Rail Corridor at Sungei Kadut Industrial Area, Pang Sua Park Connector, Villa Verde Park, Park at Senja Parc View, Senja Grand Playground
Residential	These are areas used or intended to be used mainly for residential development.	673B Choa Chu Kang Crescent Food Court, HDB Blocks at Choa Chu Kang Crescent/Choa Chu Kang North 6 & 7/Choa Chu Kang Drive/Choa Chu Kang Street 64, Yew Mei Green Condominium, The Windermere Condominium, The Quintet Condominium, Regent Grove Condominium, Villa Verde Estate, Senja Centre, HDB Blocks at Senja Road/Senja Gateway/Senja Green/Senja Grand/Senja Parc View/Teck Whye Crescent, Skool4Kidz Preschool @ Senja Parc View, Senja Gateway Housing Complex
Commercial	These are areas used or intended to be used mainly for commercial development.	Senja Hawker Centre at 2 Senja Close
Utility	These are areas used or intended to be used mainly for public utilities and telecommunication infrastructure, including water works, sewage disposal works and other public installations such as electrical substations.	Electrical Substation at Verde View, Shell at 695 Mandai Road, Bukit Panjang Telephone Exchange

URA Master Plan 2019		OneMap SG
Land Use	**Description**	**Current Buildings/ Spaces in the URA Land Use Plan**
Road	These are areas used or intended to be used for existing and proposed roads.	Kranji Expressway, Woodlands Road, Galisten Avenue, Jalan Teck Whye, Senja Road, Senja Way, Senja Close, Verde View, Verde Crescent, Verde Place, Verde Grove, Verde Avenue, Verde Crescent, Jalan Gali Batu,Choa Chu Kang North 6, Choa Chu Kang North 7, Choa Chu Kang Street 54, Yew Tee Flyover, Choa Chu Kang Link, Stagmoont Ring, Choa Chu Kang Crescent, Choa Chu Kang Drive, Sungei Kadut Avenue, Gali Batu Close, Mandai Estate, Mandai Link, Sungei Kadut Way, Sungei Kadut Avenue, Sungei Kadut Drive, Sungei Kadut Street 1, Sungei Kadut Street 2, Sungei Kadut Street 3, Sungei Kadut Street 4, Sungei Kadut Central
Mass Rapid Transit	These areas are used or intended for rapid mass transit (MRT).	Yew Tee MRT Station (NS5)
Transport Facilities	These are areas used or intended to be used mainly for parking of vehicles and transport facilities, including garages and at-grade structures of underground road tunnels and rapid transit system	Gali Batu Bus Terminal, Gali Batu Train Depot
Watercourses	These are areas used or intended for drainage purposes and water areas such as reservoirs, ponds, rivers and other water channels.	Sungei Pang Sua Canal
Reserve Site	These are areas the specific use of which has yet to be determined.	Sungei Kadut Industrial Estate, Yew Tee Industrial Estate, Stagmont Ring Heavy Vehicle Park, and other nearby industrial/commercial buildings (e.g., Matsushita House Singapore, Hua Kok Industrial Building, AOS Industrial Building, Durotec Industries, Tong Guan Plant, Yuan Ji Enterprises, etc.)
Business 2	There are areas used or intended to be used for clean, light, general, warehouse, public utilities, telecommunication, and other public installations.	Mandai Industrial Estate, JTC Trendspace (Furniture Hub), Sunray Building, BHL Factories (2A, 2B, 2C Mandai Estate), Innovation Place (31 Mandai Estate), Samwoh Corporation and other industrial/commercial buildings (e.g., Honda Mandai Service Centre, M-Space, Grandwork Building, Hup Huat Timber Co, Sheng Siong, Mandai Food Link, Foodfab@Mandai (U/C), etc.)
Business Park	These are areas used or intended to be used for business park operations.	Sungei Kadut Industrial Estate, Creative Polymer Industries, and other industrial/commercial buildings (e.g., LUXX Newhouse Design Centre, Maclloyd Industrial, Whye Wah Development & Construction, etc.)
Health & Medical Care	These are areas used or intended to be used mainly for medical services.	MWS Nursing Home (Yew Tee), Pacific Healthcare Nursing Home II @ Bukit Panjang
Special Use	These are areas used or intended to be used for particular purposes.	Stagmont Camp

Reception Track (RT) Tunnel

DTL2e Mainline Tunnel

Sungei Pang Sua

Pang Sua Canal

0 250 500 1,000 Meters

Legend

- Proposed DTL2e Tunnel Alignment
- Potential Future Infrastructure
- Proposed Worksite Areas
- Proposed Vehicular Bridge
- Biodiversity Study Area

	Residential		Civic & Community Institution
E	Educational Institution	H	Health & Medical Care
U	Utility	W	Place of Worship
	Waterbody		Residential with Commercial at 1st Storey
	Commercial & Residential		Sports & Recreation
	Commercial		Park
	Hotel		Special Use
	Business 1		Open Space
	Business 2		Cemetery
C	Conservation Area		Reserve Site
	Road		Mass Rapid Transit
NR	Nature Reserve	2.8	Maximum Permissible Plot Ratio

Rev.	Date	By	Description	Chk'd	App'd
A	MAY 2023	TTR	Draft Final Report	HHL	JAG
-	AUG 2022	HHL	Draft Final Report	NHT	JAG

Qualified Person Endorsement :
N/A

LTA Endorsement :
N/A

Consultant : AECOM

Land Transport Authority
We Keep Your World Moving

Project Title :
CONTRACT 9175
ADVANCE ENGINEERING STUDY FOR THE PROPOSED DOWNTOWN LINE 2 EXTENSION AND A NEW STATION ON EXISTING NORTH-SOUTH LINE

Figure Title :
CURRENT LAND USE WITHIN THE STUDY AREA

Designed	Checked	Approved
HHL	HHL	JAG
	Drawn TTR	Date MAY 2023

Figure No. : 4-1 | Rev. A | Sheet 1 of 1

CAD File Name :N/A | A3

Note: Source of basemap - URA Master Plan 2019

4.2 Historical Land Use

As far as possible, a chronological account of the changes in land use of the Project Site is provided below and distinguished based on the following segregated areas:

- Sungei Kadut Industrial Area (see Section 4.2.1);
- Near Sungei Pang Sua (see Section 4.2.2); and
- South of Kranji Expressway (see Section 4.2.3).

Inferences were drawn from historical resources (maps and aerial photographs) from the Map Resource Centre of the Department of Geography of the National University of Singapore (NUS) dating from 1945 – 1953; satellite imagery from Google Earth Maps from 2009 – 2015; and Onemap Historical Maps (Old Street Maps) dating from 1972 – 1988 unless otherwise mentioned.

4.2.1 Sungei Kadut Industrial Area

Sungei Kadut Industrial Area is bounded by lines joining Leigh Mardon Pacific Packaging Pte Ltd, Wee Tee Tong Chemicals Pte Ltd, Beng Cheng Metal Pte Ltd, Luxx Newhouse Design Center, Ker & Ker Co Pte Ltd, and Innovation Place.

Table 4-2 Historical Land Use Changes in Sungei Kadut Industrial Area

Year	Historical Land Use Changes in Sungei Kadut Industrial Area
1903	Completion of the Singapore-Kranji Railway (refer to Section 4.2.2.2 for more details)
1945	Rubber and Sundry tree Plantations, Existing Sungei Pang Sua
1953	Sungei Kadut
1970s	Establishment of furniture companies and sawmills, Existing Mandai Estate
1983	Development of Sungei Kadut Industrial Estate
1996	Opening of Woodlands Extension of North-South Line
2000	Development of Choa Chu Kang HDB Blocks
2005	Widening of waterbodies near Rail Corridor to form Pang Sua Canal
2009	Demolition of some buildings (refer to Section 4.2.1.2 for more details on demolished buildings)
2012	Removal of railway tracks and conversion to Rail Corridor

Additional information from the research and elaboration of a few developments from the table above are presented in Section 4.2.1.1 to Section 4.2.1.4

4.2.1.1 Key Industrial Facilities in Sungei Kadut Industrial Area

This area mainly lies within the Sungei Kadut Industrial Estate and Mandai Estate, where many different types of industries exist. In the 1970s and 1980s, furniture companies and milling factories started cropping up across Sungei Kadut. These factories house combustible substances, which have caused previous severe fires, with fires raging for a few hours. As a result, the Sungei Kadut Fire Post was set up in the region [W-56]. Some key industries within the Sungei Kadut Industrial Area include timber, furniture, construction and some chemicals companies. These industries can potentially release hazardous chemicals into soil and groundwater, as well as associated chemicals and heavy metals to the vicinity. A comprehensive list of industries within the Project Corridor and their primary functions are shown in Appendix N.

4.2.1.2 Demolished buildings near Sungei Kadut Street 2

Satellite imagery [M-11, M-12, M-14] from Google Earth indicates land lots MK11-03733M, MK11-00542N, MK11-03732C, MK11-00541K, MK11-03639L, MK11-03638X and MK11-03585C (according to URA Master Plan 2019) were cleared in around 2009 to 2015 and are currently abandoned. This poses the risk of underground buried structures at these land lots. Figure 4-2 shows the satellite imagery of the buildings before and after clearance,

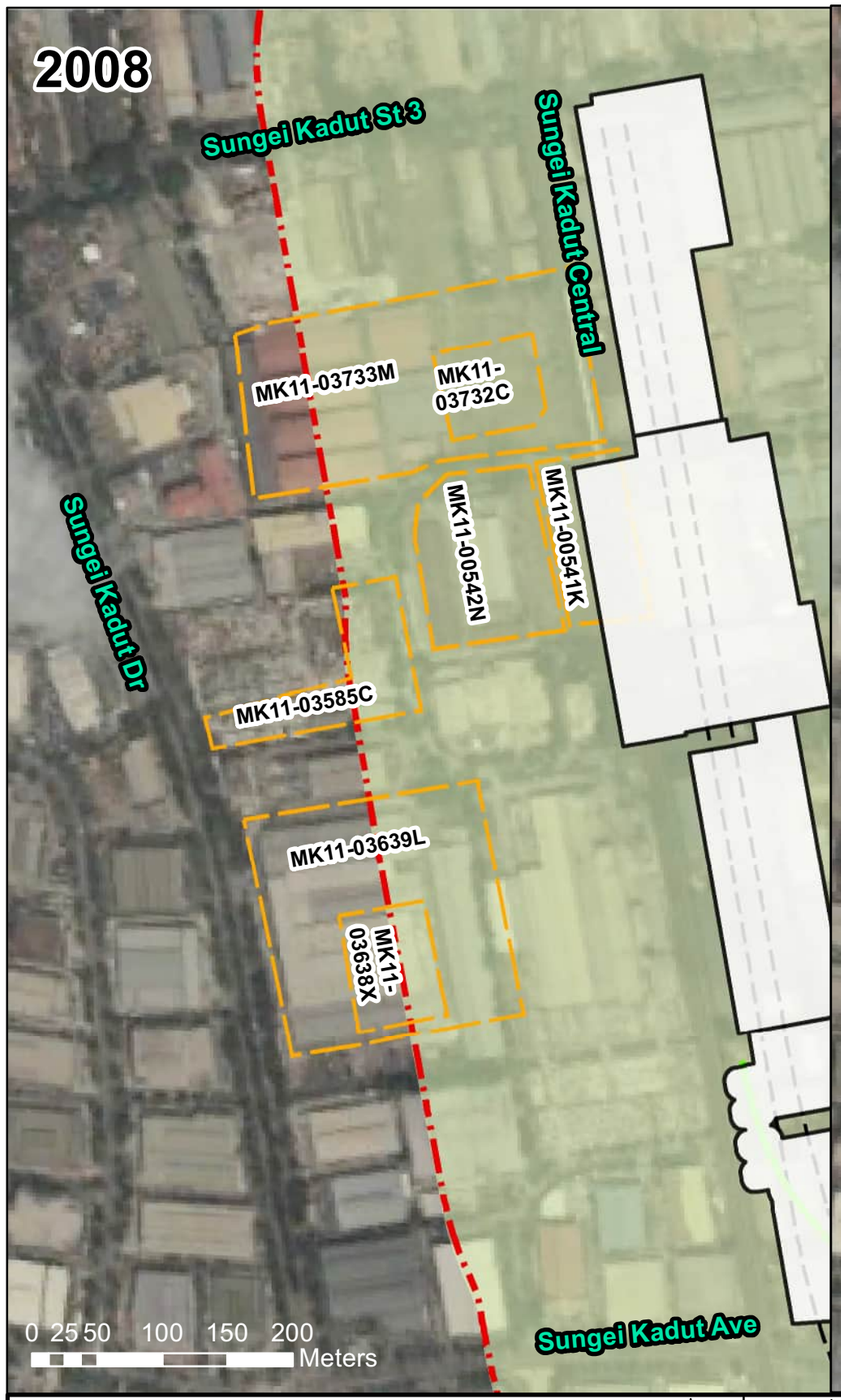
together with the corresponding land lot number. For future demolition to be part of the project, piles of demolished buildings will need to be assessed and excavated.

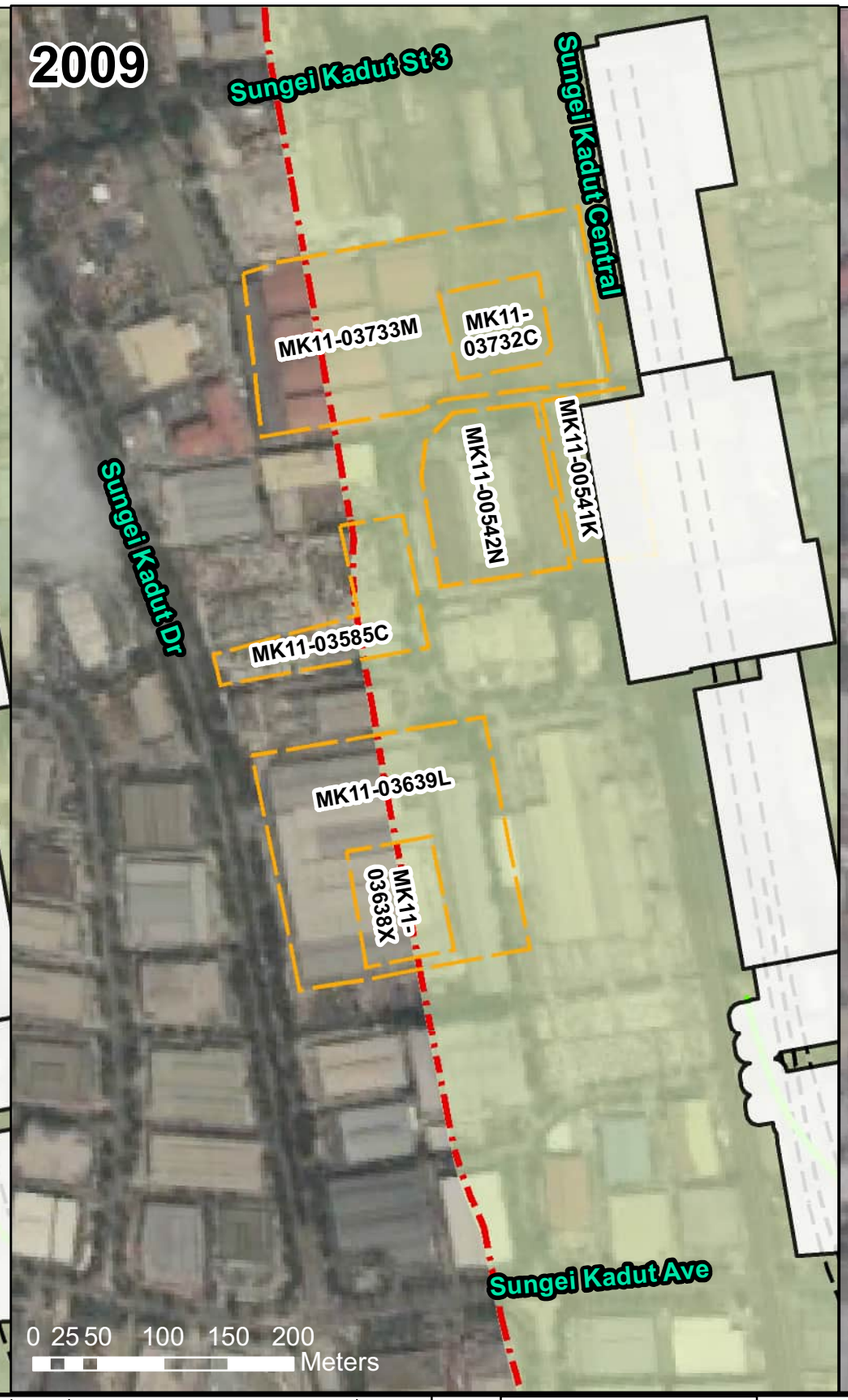
4.2.1.3 Sungei Pang Sua and Pang Sua Canal

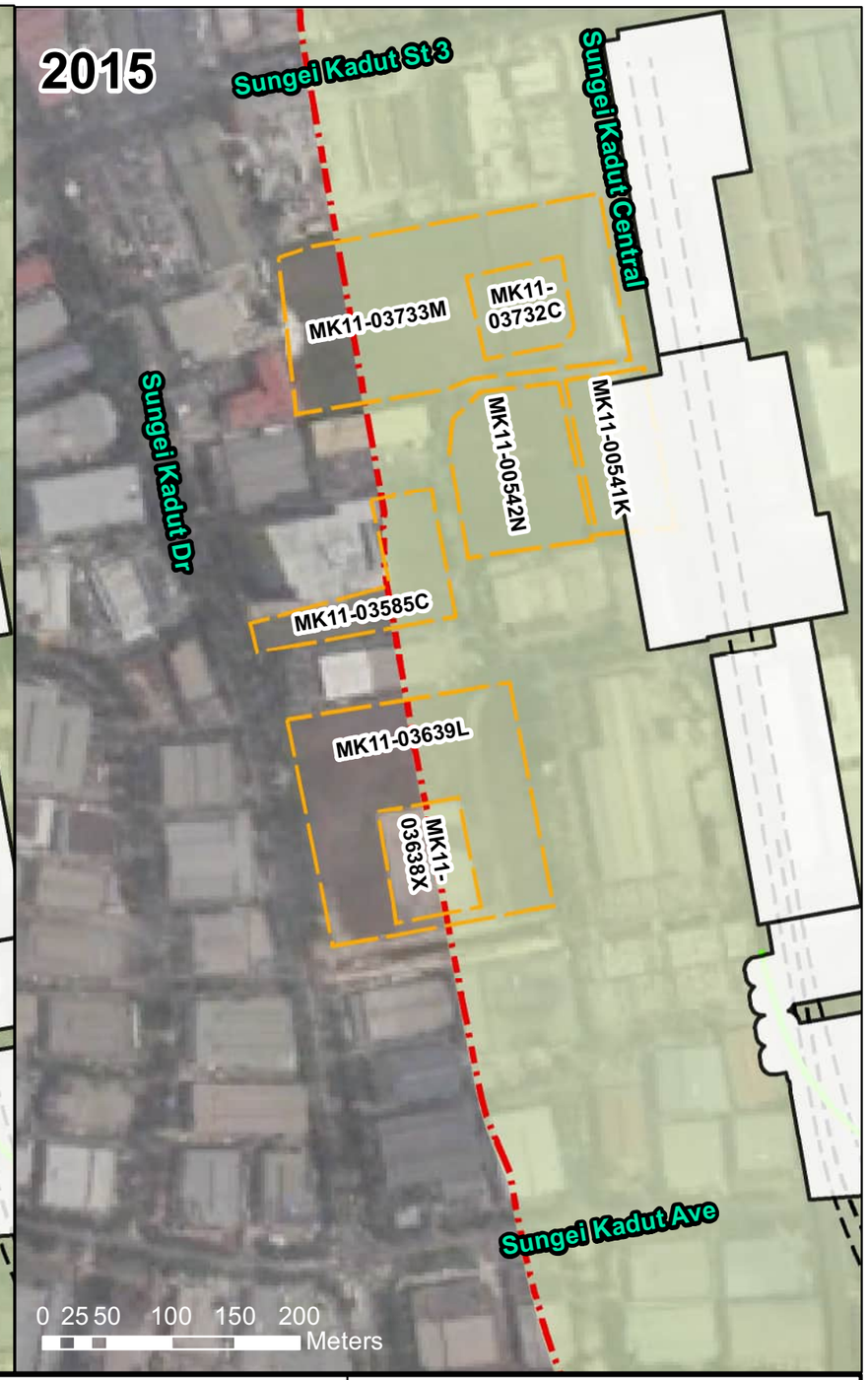
Sungei Pang Sua is first observed in the 1945 Topography Map [M-4]. It is seen to run along Woodlands Road and then the existing Singapore Kranji Railway track. Another river called Sungei Kadut is seen in the 1953 Topography Map [M-5]. This river has a similar alignment to the existing constructed Pang Sua Canal. In the early 2000s, the waterbodies that were initially cutting through the Rail Corridor were widened to form Pang Sua Canal to make it more interconnected with other waterbodies throughout Singapore, as part of PUB's effort to connect reservoirs and waterbodies in Singapore.

4.2.1.4 North South Line

The Woodlands Extension of the North-South MRT Line was officially opened in 1996, which connects Yishun station and Choa Chu Kang station. This extension includes Kranji station and Yew Tee station, where the Project Corridor lies between these MRT stations.







Legend

- Proposed Worksite Areas
- Potential Future Infrastructure
- Proposed DTL2e Tunnel Alignment
- Demolished Buildings
- Project Corridor
- Sungei Kadut Industrial Area

N

Rev.	Date	By	Description	Chk'd	App'd
A	MAY 2023	HHL	Draft Final Report	ADP	JAG
-	AUG 2022	HHL	Draft Final Report	ADP	JAG

Qualified Person Endorsement :

LTA Endorsement :

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title :

CONTRACT 9175
ADVANCE ENGINEERING STUDY FOR THE PROPOSED DOWNTOWN LINE 2 EXTENSION AND A NEW STATION ON EXISTING NORTH-SOUTH LINE

Figure Title :

DEMOLISHED BUILDINGS IN SUNGEI KADUT INDUSTRIAL AREA

Designed	Checked	Approved
HHL	ADP	JAG
	Drawn: HHL	Date: MAY 2023

Figure No. : 4-2 | Rev. : A | Sheet : 1 of 1

CAD File Name :N/A | A3

Note: Source of basemap - Google Earth Maps

4.2.2 Near Pang Sua Canal

Near Pang Sua Canal area is bounded by lines joining Gali Batu MRT Depot, Regent Secondary School, and Regent Grove Condominium.

Table 4-3 Historical Land Use Changes Near Pang Sua Canal

Year	Historical Land Use Changes Near Pang Sua Canal
1903	Completion of the Singapore-Kranji Railway (refer to Section 4.2.2.2 for more details)
1942	Yew Tee Village – Storage of Oil (refer to Section 4.2.2.4 for more details)
1945	Existing Yew Tee Village
1972	Singapore Granite Quarries Mill, Existing Jalan Gali Batu
1988	Existing Yew Tee Industrial Estate
1995	Development of Choa Chu Kang HDB estates
2000	Development of Choa Chu Kang HDB estates, Condominiums, Terraced houses and educational institutions
2005	Widening of waterbodies near Rail Corridor to form Pang Sua Canal
2009	Land cleared for construction of Gali Batu MRT Depot
2012	Removal of railway tracks and conversion to Rail Corridor, Construction of Gali Batu MRT Depot
2015	Construction of Gali Batu Bus Terminal and expansion of Gali Batu MRT Depot
2020	Land cleared for Gali Batu Bus Depot (U/C)

4.2.2.1 Gali Batu MRT Depot, Bus Terminal, and Bus Depot

Satellite Imagery from Google Earth shows that the construction for Gali Batu MRT Depot began in late 2011 – early 2012 [M-13]. Images also show that the land was cleared in late 2009 [M-11]. The Gali Batu MRT Depot stabling area was expanded in 2015, and the Gali Batu Bus Terminal was constructed as part of the expansion project. The satellite imagery also shows that the land was cleared in late 2010 to construct the Gali Batu Bus Terminal [M-12]. The Gali Batu Bus Depot, a multi-storey depot built east of the current bus terminal, is currently under construction and plans to commence operations by 2024.

4.2.2.2 Singapore-Kranji Railway

The Singapore-Kranji Railway was completed in 1903 and was limited to Singapore before the Johor-Singapore Causeway was built to facilitate trade between Singapore and Malaysia. The Railway was only opened to goods and passenger trains in 1923 to transport passengers and goods between Singapore and Malaysia. The goods transported on the railway were mainly tin and rubber.

The railway line initially stretched from Tank Road to Bukit Timah but was extended twice in 1903 and 1907 to Woodlands and then to Pasir Panjang (Figure 4-3). The Tank Road Station served as the only terminus for passenger trains in Singapore until the Tanjong Pagar Railway Station was completed in 1932 [W-63]. In 2011, the last train went from Tanjong Pagar station to Woodlands. Most of the rail tracks had been dismantled in 2012, and the remaining make up the current Rail Corridor [W-57]. The presence of railway tracks may pose a potential risk of underground buried structures in the area.

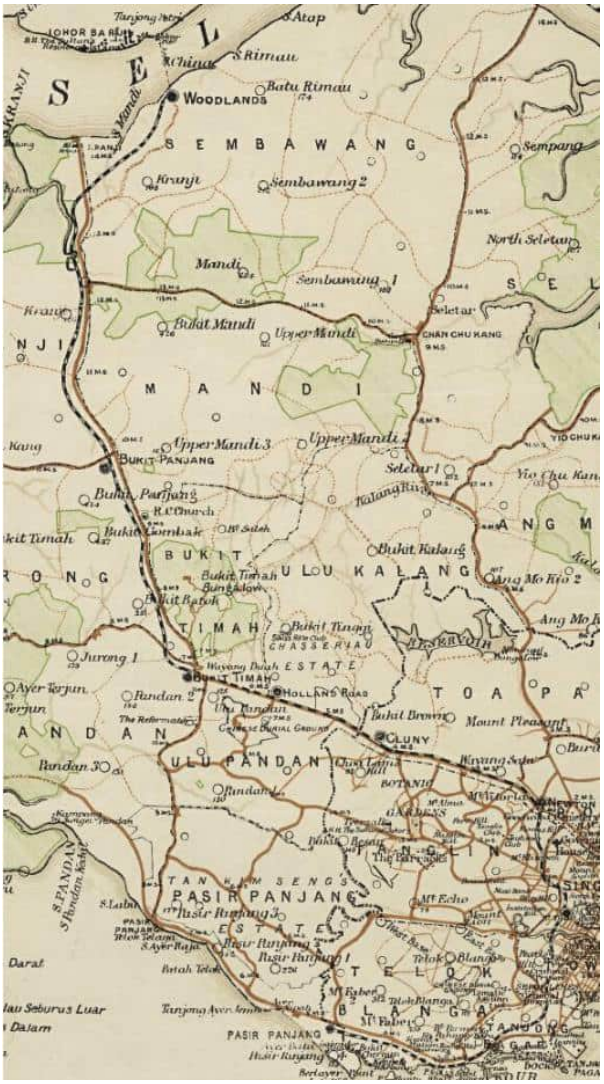


Figure 4-3 Singapore-Kranji Railway Tracks [W-57]

4.2.2.3 Singapore Granite Quarries Mill

According to the topographic maps by the NUS Department of Geography, Singapore Granite Quarry Mills are shown on the maps of 1953, 1966 and 1975 along Woodlands Road, where the current Gali Batu MRT Depot is present (Figure 4-4). The Singapore Granite Quarries Mill was also shown in the OneMap Historical Maps from 1972 to 1988 [M-6 to M-10] and was located at the intersection of the existing Jalan Gali Batu and Woodlands Road. There are no photos of the mill found online.

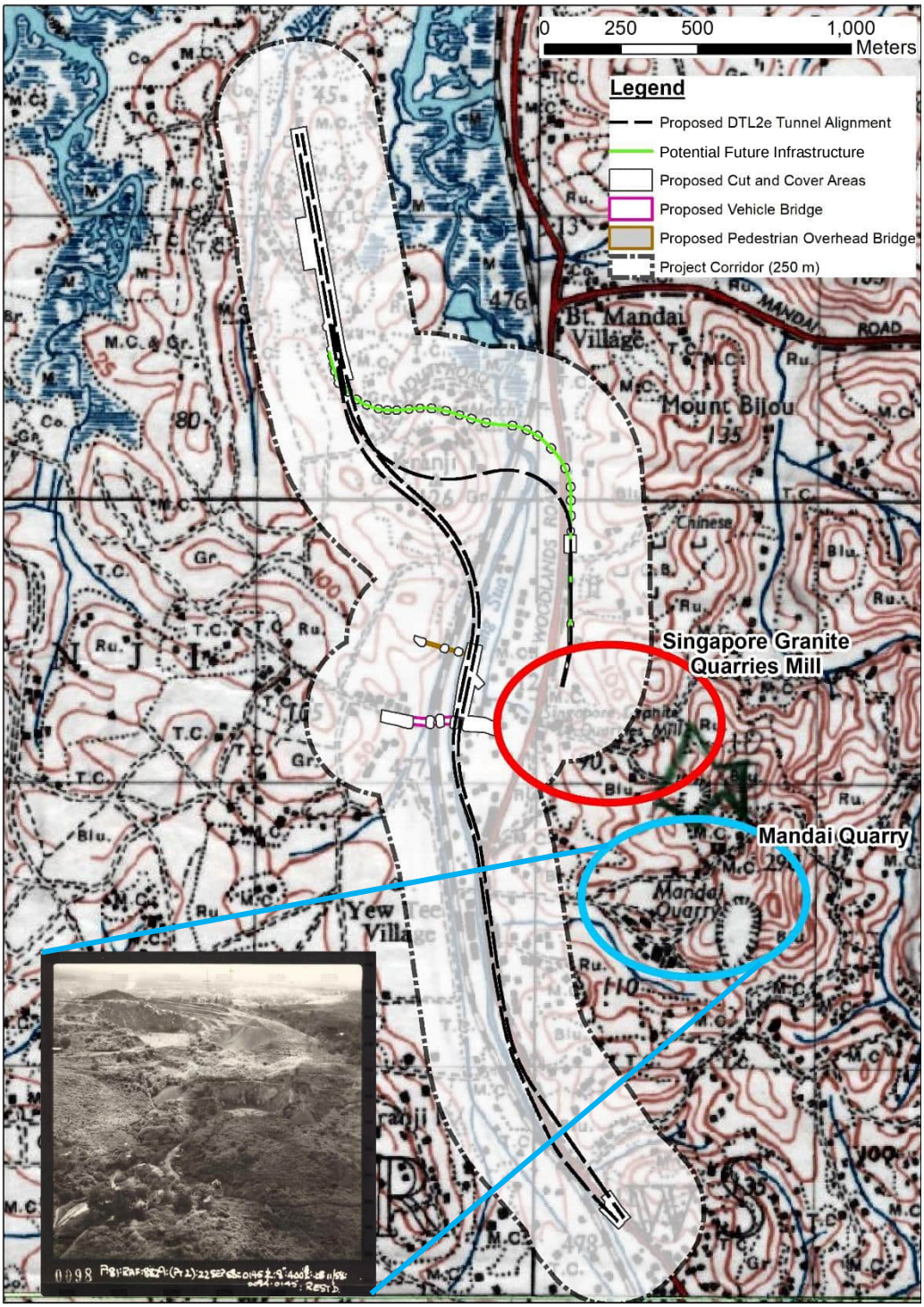


Figure 4-4 1953 Topographical Map – Singapore Granite Quarries Mill [M-5]

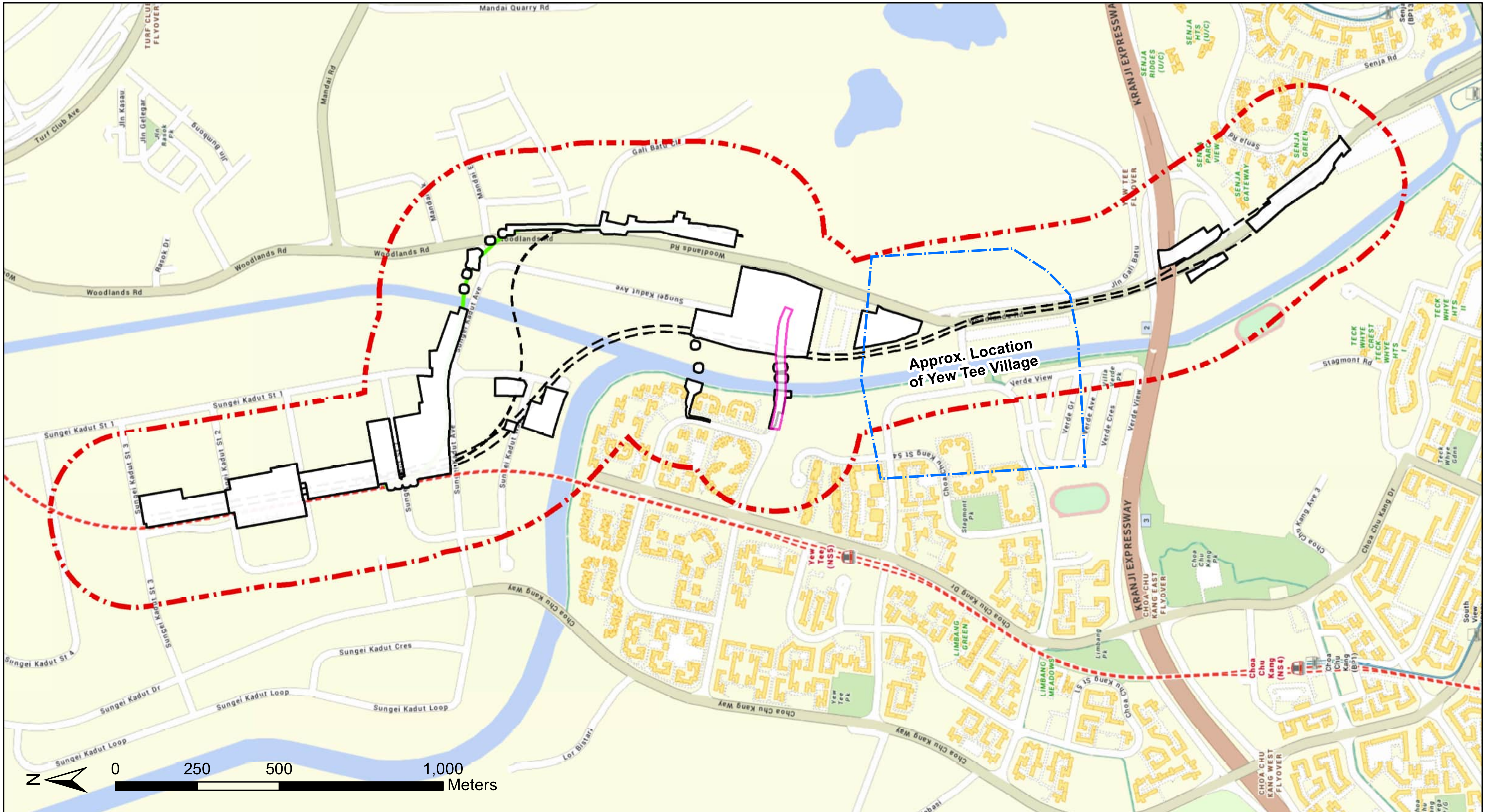
4.2.2.4 Yew Tee Village

Yew Tee Village is located off Woodlands Road, near Stagmont Ring. Figure 4-5 shows the approximate location of the old Yew Tee Village with the Project Corridor. The approximate location of the old Yew Tee Village was based on the NUS Topographical Maps and OneMap Historical Maps [M-5, M-6]. It was used to store oil during the Japanese occupation of Singapore. It was once a busy village numbering 300 families, and the residents worked mainly as small-time vegetable and poultry farmers. When the land in Yew Tee was developed, and new estates like Choa Chu Kang started coming up, many residents moved out. By 1991, the village had less than 20 houses [W-58]. Currently, Yew Tee is a subzone within the Choa Chu Kang estate.

According to an article by Singaporean Chinese writer Mo He in the Singapore Memory Project portal, the British army used to store many gasoline tanks in warehouses near Stagmont Ring Road during the British colonisation. The purpose was to supply gasoline to the nearby British army based in Southeast Asia for military purposes. However, the Japanese military bombed the gasoline tanks warehouse during World War II, which caused fires to burn for days and destroyed the rubber plantations [W-59]. The burning of the gasoline tanks during World War II may have caused soil contamination in the area.

4.2.2.5 Key Industrial Facilities Near Pang Sua Canal

The industries near Pang Sua Canal lie within the Yew Tee Industrial Estate. Some of the key industries in this zone include vehicle repairing and maintenance, steel manufacturers, glass manufacturers and woodwork/furniture manufacturers. These industries store bulk chemicals for their use and potentially release hazardous chemicals into soil and groundwater, as well as associated chemicals and heavy metals to the vicinity. A comprehensive list of industries within the Project Corridor and their primary functions are shown in Appendix N.



Legend

- Approximate Location of Yew Tee Village
- Proposed Vehicular Bridge
- Proposed Worksite Areas
- Potential Future Infrastructure
- Proposed DTL2e Tunnel Alignment
- Project Corridor

Rev.	Date	By	Description	Chk'd	App'd
A	MAY 2023	HHL	Draft Final Report	ADP	JAG
-	AUG 2022	HHL	Draft Final Report	ADP	JAG

Qualified Person Endorsement : NA

LTA Endorsement : NA

Consultant : AECOM

Land Transport Authority
We Keep Your World Moving

Project Title :
CONTRACT 9175
ADVANCE ENGINEERING STUDY FOR THE PROPOSED DOWNTOWN LINE 2 EXTENSION AND A NEW STATION ON EXISTING NORTH-SOUTH LINE

Figure Title :
APPROXIMATE LOCATION OF YEW TEE VILLAGE AND PROJECT CORRIDOR

Designed	Checked	Approved	Drawn	Date
HHL	ADP	JAG	HHL	MAY 2023

Figure No. : 4-5
Rev. A
Sheet 1 of 1
CAD File Name :N/A
A3

Note: Source of basemap - OneMap (www.onemap.sg)

4.2.3 South of Kranji Expressway

The South Kranji Expressway area is bounded by lines joining Kranji Expressway, West View Primary School, and Jurong Pioneer Junior College.

Table 4-4 Historical Land Use Changes in South of Kranji Expressway

Year	Historical Land Use Changes in South of Kranji Expressway
1903	Completion of the Singapore-Kranji Railway
1945	Bukit Panjang Estate
1972	Kampong Bukit Panjang
1995	Construction of Kranji Expressway
2000	Existing Jurong Pioneer Junior College
2009	Construction of HDB Senja Green
2012	Construction of HDB Senja Parc View, HDB Senja Gateway, Removal of railway tracks and conversion to Rail Corridor

Additional information from the research and elaboration of a few developments from the table above are presented in Section 4.2.3.1 to Section 4.2.3.2.

4.2.3.1 Kranji Expressway (KJE)

The KJE was built between 1994 and 1995. Construction of the expressway began in 1990 and was completed in six stages. It links the Bukit Timah Expressway (BKE) and the Pan-Island Expressway (PIE) [W-62].

4.2.3.2 Rail Corridor

In the 1900s, this region was covered by rubber plantations but later cleared for the Singapore-Kranji Railway track. In 1993, a canal was built to connect Sungei Pang Sua with other water bodies throughout Singapore. In 2012, the railway tracks were removed and converted to the existing Rail Corridor.

In the early 1900s, the original vegetation within the Rail Corridor was likely to be mangrove swamp forest. However, it was later cleared for rubber plantations. The Keretapi Tanah Melayu (KTM) railway track that runs towards Malaysia was later constructed across this area. A village settlement was developed with increased public housing. From 1958 to 1969, there seems to be an accelerated rate of development and continuous disturbance and vegetation clearing. Several minor fair-weather roads were also constructed around this area and linked to the railway. Within the Rail Corridor area, although the vegetation coverage was reduced, a large portion was still used for sundry cultivation.

By 1974, the surrounding area had become significantly more inter-connected, with numerous motor roads passing through and linking with the railway and surrounding area. Settlements and buildings were systematically organised, likely due to the government's roadmap and urban planning. In the early 2000s, the watercourses that were initially cutting through the Rail Corridor were widened to form Pang Sua Canal, enhancing connectivity with other watercourses throughout Singapore, as part of PUB’s effort to connect reservoirs and watercourses across Singapore.

Towards the early 2000s, remnants of buildings were removed, except the KTM railway track. The area continued to regenerate into spontaneous vegetation in less than ten years. In 2011, the KTM railway track was dismantled and converted into an existing Rail Corridor.

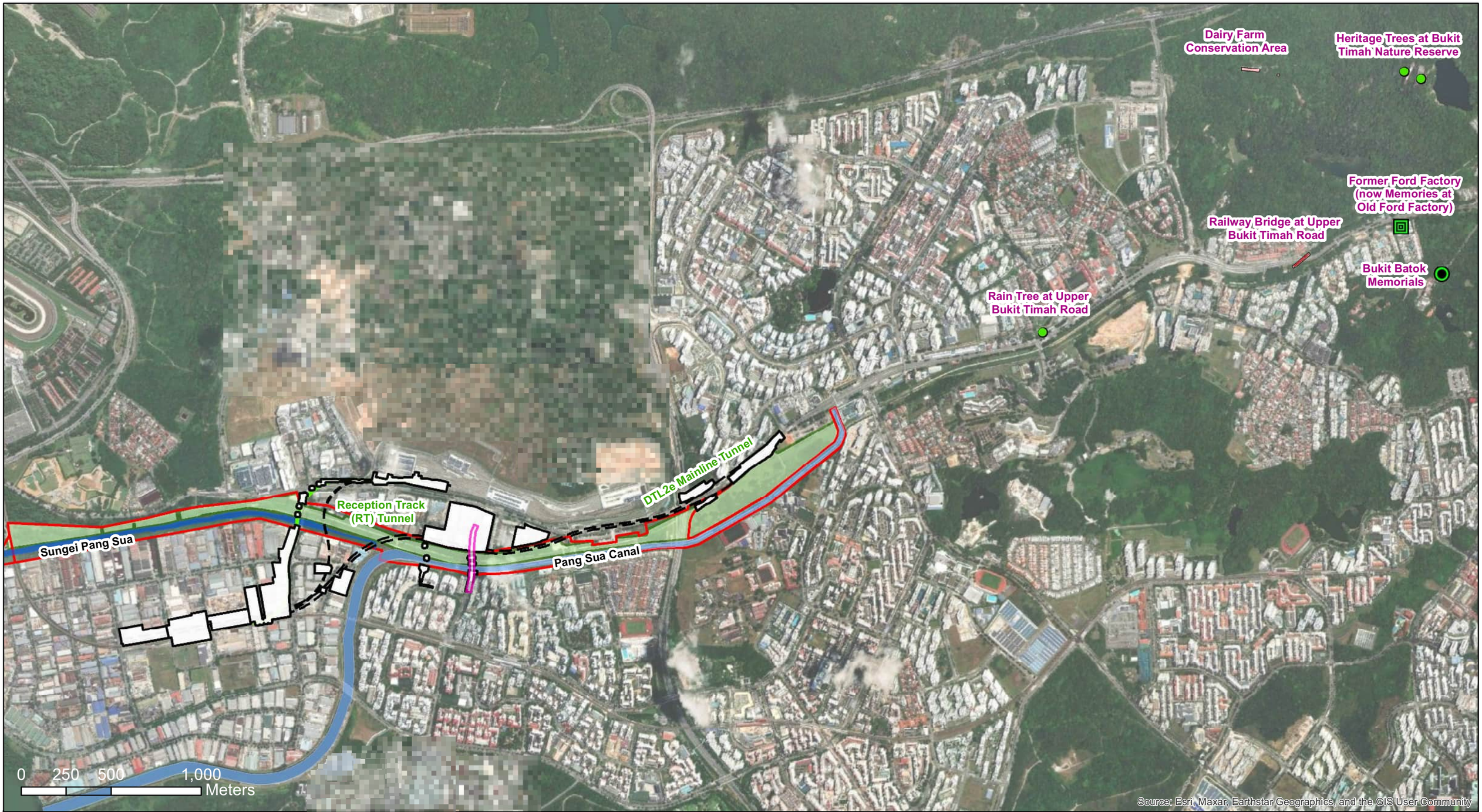
4.3 Heritage Features

According to Singapore's Planning Act (Chapter 232) Section 9, "*any area of special architectural, historic, traditional or aesthetic interest*" can be designated as a conservation area, which may comprise an area, a single building or a group of buildings. Individuals must not conduct any work within the conservation area without obtaining conservation permission. As governed by the Planning Act, "*competent authority may, from time to time, issue guidelines for the conservation of buildings or land within a conservation area and for the protection of their setting*". [R-74] The two main competent authorities responsible for conservation buildings and areas in Singapore are National Heritage Board (NHB) and URA, where the former is governed under Ministry of Culture, Community and Youth (MCCY) and the latter is under Ministry of National Development (MND).

Besides, according to NParks, "*mature trees are the natural heritage of Singapore and serve as important green landmarks of our City in Nature*", hence a Heritage Tree Scheme was announced on 17 August 2001, which advocates the conservation of Singapore's mature trees [W-53].

Based on the desktop review of heritage features via OneMap SG [M-2] with NHB/NParks-contributed sources (i.e., monuments, historic sites, heritage trees) and URA Space Map [M-3] (i.e., conservation area, a site with conserved building/structure), there were no heritage features found to be blocked or encroached by the construction worksite area and Project Footprint, which were considered relatively far away, as shown in Figure 4-6 and listed below:

- **Monument (NHB):** The nearest is the Former Ford Factory (now Memories at Old Ford Factory) at 351 Upper Bukit Timah Road, approximately 3.7km from the Project alignment.
- **Historic Site (NHB):** The nearest is the Bukit Batok Memorials at Bukit Batok Nature Park, approximately 3.9km from the Project alignment.
- **Conserved Building/Structure and Conservation Area (URA):** The nearest is the Railway Bridge at Upper Bukit Timah Road, approximately 3.1km from the Project alignment.
- **Heritage Tree (NParks):** The nearest is a Rain Tree (*Samanea saman*) with a 7.18m girth size (measured at 1.3m height) and 21.4m tree height at Upper Bukit Timah Road [W-54], approximately 1.7km away from the Project alignment.



Legend

- Proposed DTL2e Tunnel Alignment
- Potential Future Infrastructure
- Proposed Worksite Areas
- Proposed Vehicular Bridge
- Pang Sua Canal
- Sungei Pang Sua
- Biodiversity Study Area
- Existing Vegetated Area

Heritage Features

- Monuments [by NHB]
- Historic Sites [by NHB]
- Heritage Trees [by NParks]

Conservation Areas [by URA]

- Conserved Building/ Structure
- Conservation Site

Sources: *National Heritage Board (NHB) and Urban Redevelopment Authority (URA) as of 22nd March 2022*

N

Rev.	Date	By	Description	Chk'd	App'd
A	MAY 2023	TTR	Draft Final Report	HHL	JAG
-	AUG 2022	HHL	Draft Final Report	NHT	JAG

Qualified Person Endorsement :
N/A

LTA Endorsement :
N/A

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title :
CONTRACT 9175
ADVANCE ENGINEERING STUDY FOR THE PROPOSED DOWNTOWN LINE 2 EXTENSION AND A NEW STATION ON EXISTING NORTH-SOUTH LINE

Figure Title :
THE NEAREST HERITAGE FEATURES OUTSIDE OF PROJECT'S STUDY AREA

Designed	Checked	Approved
HHL	HHL	JAG
	Drawn: TTR	Date: MAY 2023

Figure No. : 4-6 | Rev. : A | Sheet : 1 of 1

CAD File Name :N/A | A3

Note: Source of basemap - Google Earth Map

4.4 Topography of Project Site

The Client provided the topographic survey data (i.e., from 2014, 2019, 2020 and 2022) within the study area. Based on the review of this topographic survey data and observations from the site visit, it is noted that the existing topography of the study area is generally flat along the alignment, ranging from -10 mSHD to 32 mSHD based on available topographic data as shown in Figure 4-7. The topographic characteristics of each worksite are described as follows.

The interchange station will be within Sungei Kadut Industrial Area with flat terrain. It has an elevation ranging from 4 mSHD to 7 mSHD, generally rising from north to south.

The retrieval shaft worksite is flat terrain within the Gali Batu Depot. The worksite spans across an area with the same elevation of 6 mSHD as an average.

The immediate station and proposed vehicular bridge worksites are located within Yew Tee Industrial Estate. They span across the Pang Sua Canal towards the HDB blocks at Choa Chu Kang Crescent. The terrain in these regions is generally flat with ranging elevations of 5 mSHD to 15 mSHD, generally rising from east to west of the worksites.

The docking shaft worksite is located near the HDB blocks at Senja Road with generally flat terrain. It has an elevation ranging from 9 mSHD to 15 mSHD, generally rising from east to west.

Legend

- Proposed DTL2e Tunnel Alignment
- Potential Future Infrastructure
- Proposed Worksite Areas
- Proposed Vehicular Bridge
- Biodiversity Study Area

Elevation (mSHD)

- < 5
- 5 - 10
- 10 - 15
- 15 - 20
- 20 - 25
- > 25

N

Rev.	Date	By	Description	Chk'd	App'd
A	MAY 2023	TTR	Draft Final Report	HHL	JAG
-	AUG 2022	HHL	Draft Final Report	NHT	JAG

Qualified Person Endorsement :
N/A

LTA Endorsement :
N/A

Consultant : AECOM

Land Transport Authority
We Keep Your World Moving

Project Title :
CONTRACT 9175
ADVANCE ENGINEERING STUDY FOR THE PROPOSED DOWNTOWN LINE 2 EXTENSION AND A NEW STATION ON EXISTING NORTH-SOUTH LINE

Figure Title :
TOPOGRAPHY OF THE STUDY AREA

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
HHL	HHL	JAG	4-7	A	1 of 1
	Drawn TTR	Date MAY 2023	CAD File Name :N/A		A3

Note: Source of basemap - Google Earth Map

4.5 Ecological Significance and Connectivity

The Study Area is part of the Rail Corridor and serves as a passageway for the dispersal of wildlife along the Rail Corridor [P-13]. Species using the surrounding green spaces (e.g., Kranji woodland, Bukit Mandai forest to the northeast and Bukit Gombak forest to the south) may use the Rail Corridor as an ecological corridor to move to other green spaces (Figure 4-8).

0 5 10 km

Legend

- Study Area
- Rail Corridor
- Kranji Reservoir
- Green Space

N

Rev.	Date	By	Description	Chk'd	App'd
-	AUG 2022	JT	Draft Final Report	NHT	JAG

Qualified Person Endorsement :
N/A

LTA Endorsement :
N/A

Consultant : AECOM

Land Transport Authority
We Keep Your World Moving

Project Title :
CONTRACT 9175
ADVANCE ENGINEERING STUDY FOR THE PROPOSED DOWNTOWN LINE 2 EXTENSION AND A NEW STATION ON EXISTING NORTH-SOUTH LINE

Figure Title :
CONNECTIVITY OF STUDY AREA TO SURROUNDING GREEN SPACES

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
HHL	NHT	JAG	4-8	-	1 of 1
	Drawn JT	Date AUG 2022	CAD File Name :N/A		A3

Note: Source of basemap - OneMap and Open Street Map

4.6 Geology

Information relating to geology is provided in the geological publication published by the Defence Science and Technology Agency (DSTA) of Singapore entitled “Geology of Singapore” (2009) [F.1], “A Field Guide to the Geology of Singapore” (2017) published by Lee Kong Chian National History Museum, National University of Singapore [F.2] and “Singapore Geology (2021): Memoir of the bedrock, superficial and engineering geology” (2021) published by Building and Construction Authority Singapore [F.4].

4.6.1 Regional

The geology of Singapore primarily consists of three (3) formations: (i) igneous rocks of granitic composition (i.e., Bukit Timah Granite) in the central and northwest of Singapore, (ii) deposits of Tertiary to early mid-Pleistocene age (i.e., Old Alluvium) which masks older rock units located beneath the eastern part of Singapore, and (iii) sedimentary rocks (i.e., Jurong Group) in the west.

In general, igneous rocks from Permian to the early part of the Late Triassic (about 227 to 299 million years ago) are found beneath Singapore's central and northern regions. The surface geology of the area is covered by igneous rock deposits of granite from the Bukit Timah Centre. The Bukit Timah Granite is covered by weathered residual soil and recent deposits of the Kallang Group. The rocks from Bukit Timah Centre vary from igneous rock granite through adamellite to granodiorite, and several hybrid rocks are included.

Boulders of granodiorite have been discovered in an excavation near the coast of Kranji between Kranji Reservoir and Woodlands. Granodiorite from Kranji contains quartz and plagioclase of oligoclase to andesine composition. The crystals are often crudely anhedral, and the feldspar has been slightly sericitized. Orthoclase is present in subordinate amounts and appears interstitially. Green hornblende dominates over partially chloritized brown biotite. In the hand specimen, the granodiorite along Kanji appears darker than specimens from other areas. The rocks are seen in thin sections to contain more ferromagnesian minerals. Undifferentiated Marine member sediments are also found in Kranji Reservoir.

The Choa Chu Kang Granodiorite-tonalite Pluton consists almost entirely of light to medium grey granodiorite and tonalite. It was pervasively deformed in the period after it crystallised and before the Gombak pluton. There are large solid pieces of glassy metasandstone up to several metres across. These are usually rare but abundant locally and have quick contact with host granitic rock.

Bukit Timah Granite (BTG) is generally moderately strong to extremely strong, white and grey, coarse-grained, dacite porphyry, and found in highly fractured and brecciated places. The granite can be classified into grades I to VI (GI to GVI), where GI is the strongest and GVI is the weakest.

Parts of the surface geology in the Sungei Kadut region were underlain with the Kallang Group's recent alluvium during the Holocene and late Pleistocene age (in the last 15,000 years). The Kallang Group can be found in the southern and eastern parts of Singapore near the Singapore River and other river valleys and commonly overlies the eroded upper surface of the Old Alluvium, Bukit Timah Granite and Jurong Group. The coastal deposits are inferred to be comprised of littoral deposits, marine clays and estuarine materials. At the same time, inland valleys consist of alluvial and transitional estuarine materials deposited in fluvial environments (e.g., former river channels which erode underlying rocks).

Fill is also present in topsoil, a highly variable material with a relatively low density. Fill in an artificial deposit of predominantly natural earth materials. The soil is usually white to light grey, dark brown to blackish brown, fine to coarse-grained, locally or with firm, soft clay sand with organic matter, decomposed wood and gravel.

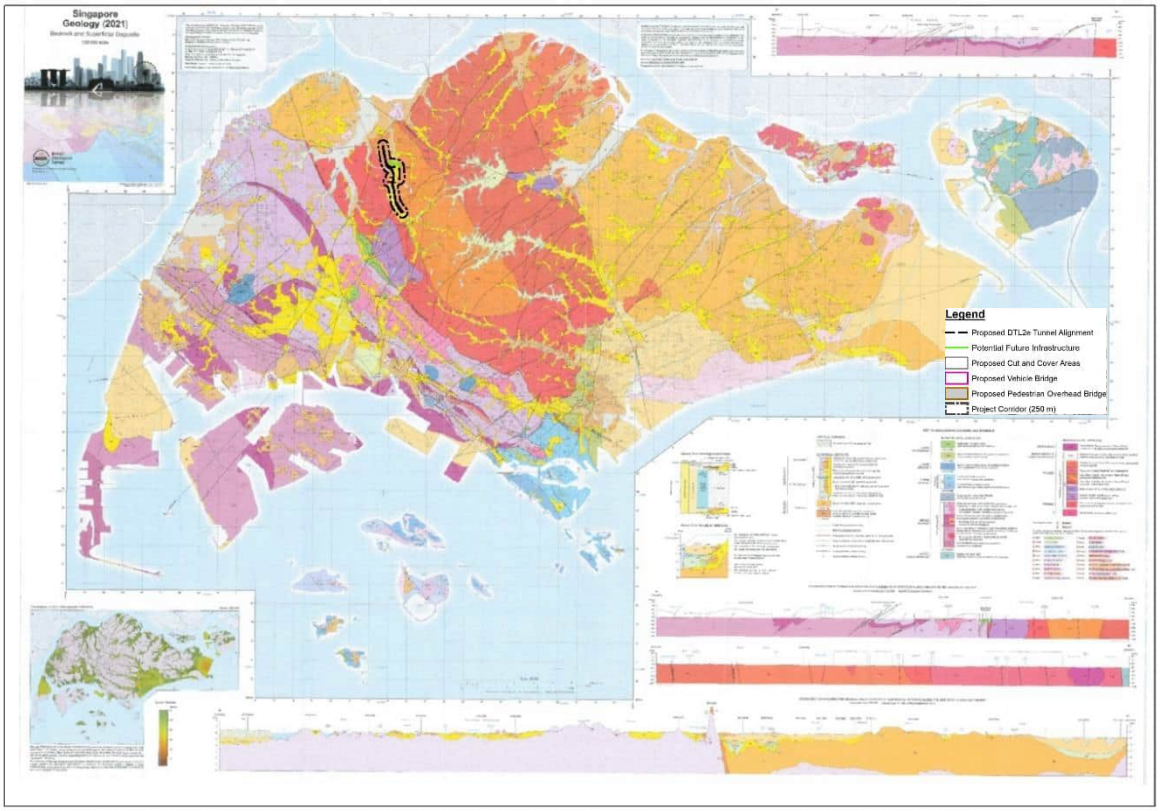


Figure 4-9 Geological maps of Singapore with Location of Project Corridor [F.4]

4.6.2 Project Corridor

The prevailing geological formation underlying the site for the Project Corridor is the Bukit Timah Granite, with the Kallang Group found above it in localised areas. Fill may also be present.

Figure 4-10 and the tables below detailed geological information beneath the project corridor.

Table 4-5 Geological Information beneath the Proposed Alignment, Potential Worksites and Potential future infrastructure [F.4]

Lithostratigraphic / Lithodemic Unit		Type/Description
Fill		Generally, heterogenous soils may be mixed with gravels, rock fragments, concrete/brick pieces, organic matters and other foreign materials. These materials usually exist as a layer just below the ground surface. The Fill thickness varies from 1m to 8m along the Project Corridor.
Kallang Group (Superficial deposit)	Jalan Besar Formation (Kjbf)	Silt to coarse sand with occasional traces of organic matter and pebbles ranges in colour from brown and red to light-grey. The unit can be around 25 m thick but is average, 4 m thick.
	Kranji Formation (Kkf)	Deposited in river mouths and tidal (typically mangrove) swamps. Comprises of peat-rich clay and silt containing decomposed wood and fragments of vegetation. It is on average 3m thick but can be up to 24m thick in some river valleys.
Bukit Timah Centre (Bedrock)	Dairy Farm Granite-microgranite Pluton (BTdpm)	Monzogranite composition and dominantly inequigranular (porphyritic) in the western part. They are made up of phenocrysts of plagioclase, alkali feldspar, biotite and quartz, in a quenched

Lithostratigraphic / Lithodemic Unit		Type/Description
		groundmass of very fine, equigranular quartz and feldspar. Quartz phenocrysts are generally strongly corroded and embayed.
	Choa Chu Kang Granodiorite-tonalite Pluton (BTcp)	It consists almost entirely of light- to medium-grey granodiorite and tonalite. Faults and younger intrusions have dissected the original pluton.

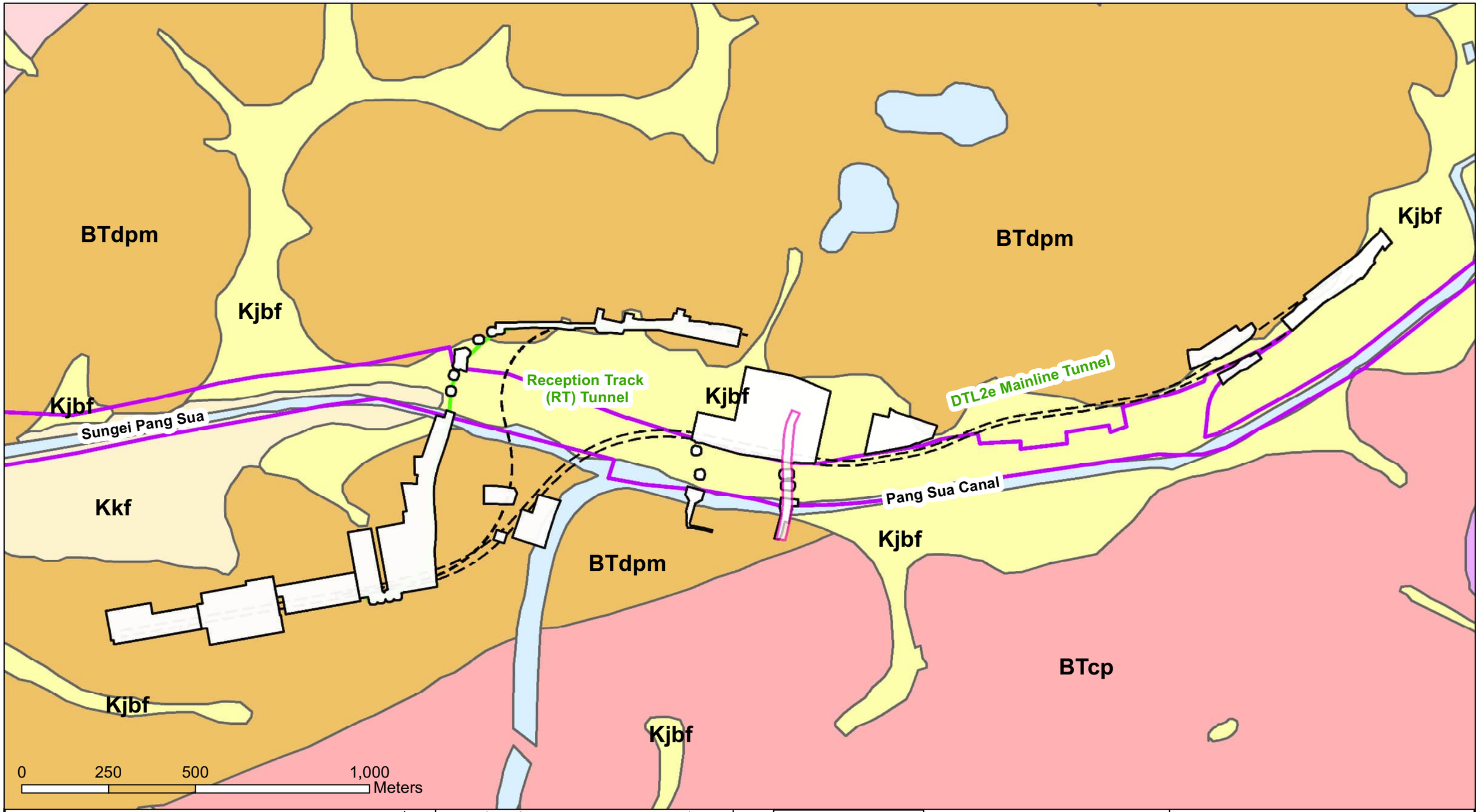
Table 4-6 Description of Soil Series beneath the Proposed Alignment, Potential Worksites and Potential future infrastructure

Soil series	Type/ description	Drainage/ permeability	Locations
Sungei Kadut series	• They are characterised by dense, greenish, or dark-coloured gabbro or norite. • It was formed from the slow cooling of magnesium-rich and iron-rich magma into a holocrystalline mass deep beneath the Earth's surface. • It undergoes massive, uniform intrusion via in-situ crystallisation of pyroxene and plagioclase or as part of a layered intrusion as a cumulate formed by settling of pyroxene and plagioclase.	More permeable	Sungei Kadut Industrial Estate
Jurong series	Very deep brown granular clay loams to sandy loams. Usually overlie black peaty loams or organic clays which in turn occur over dark grey massive sandy loams ranging to clay loam. Usually very wet and have a sulphurous odour and high organic matter content.	Less permeable	Kranji War memorial
Kranji series	They are characterised as recent alluvium. They are typically encountered at the coast or in areas subjected to flooding by brackish water or under mangrove vegetation. Soils are sticky, grey to dark grey or organic clay of varying thickness with no discernible profile development.	Less permeable	Sungei Kadut Industrial Estate, Yew Tee
Rengam series	They are characterised by granitic coarse-grained structure igneous soil. This mineral composition usually gives granite reddish brown coarse-grain clay. Granite is found in a range of soils and textures.	More permeable	Gali Batu

Table 4-7 Description of Longitudinal Soil Profile Findings for the Proposed Alignment

Soil series	Type/ description	Drainage/ permeability	Underground Alignment
Bukit Timah Granite	It consisted of new granite or granodiorite to moderately weathered soil. It is characterised by gravel with intact discoloured rock fragments.	More permeable	DTL2e Main Line Tunnel (see Figure 3-1)
	It consisted of highly weathered residual soil. It was characterised by very soft to stiff, slightly gravelly sandy silt, which can readily disaggregate.	Less permeable	

Soil series	Type/ description	Drainage/ permeability	Underground Alignment
Kallang Formation	Fluvial sand: Characterized by unconsolidated sandy soils with occasional muddy sand.	More permeable	Reception Track (RT) Tunnel (see Figure 3-1)
	Fluvial clay: Characterized by blue-grey clay to clayey mud.	Less permeable	



Legend

- Potential Future Infrastructure
- Proposed Vehicular Bridge
- Biodiversity Study Area

Geology

- Kjbf — Jalan Besar Formation
- Kkf — Kranji Formation
- BTcp — Choa Chu Kang Granodiorite-tonalite Pluton
- BTdpm — Dairy Farm Granite-microgranite Pluton
- BTdpg — Dairy Farm Granite-microgranite Pluton
- BTgp — Gombak Gabbro-granite Pluton
- Watercourses

N

Rev.	Date	By	Description	Chk'd	App'd
A	MAY 2023	TTR	Draft Final Report	HHL	JAG
-	AUG 2022	HHL	Draft Final Report	NHT	JAG

Qualified Person Endorsement :
N/A

LTA Endorsement :
N/A

Consultant : AECOM

Land Transport Authority
We Keep Your World Moving

Project Title :
CONTRACT 9175
ADVANCE ENGINEERING STUDY FOR THE PROPOSED DOWNTOWN LINE 2 EXTENSION AND A NEW STATION ON EXISTING NORTH-SOUTH LINE

Figure Title :
GEOLOGICAL CONDITION OF THE PROJECT

Designed	Checked	Approved
HHL	HHL	JAG
	Drawn: TTR	Date: MAY 2023

Figure No. : 4-9 | Rev. : A | Sheet : 1 of 1

CAD File Name :N/A | A3

Note: Source of basemap - National Archives Singapore

4.7 Catchment Area

Singapore does not have extensive natural aquifers or lakes. It has limited land to collected stormwater, so it aims to maximise stormwater harvesting. Stormwater is collected through a network of rivers, canals and drains and channelled to seventeen (17) reservoirs according to Singapore's local water catchment map by PUB [W-1], after which it is treated, filtered and disinfected at the water treatment plants. Stormwater is one of Singapore's main sources of drinking water and industrial water. Figure 4-11 shows an eastern segment of the proposed underground portion of the DTL2e Tunnel Alignment (which is near Pang Sua Canal), and a portion of the reception track/ potential future infrastructure within Gali Batu depot will be located within the catchment area of Kranji Reservoir. This indicates that the stormwater runoff within that area will be collected for drinking water purposes in the reservoir. In the western half of the alignment, i.e., proposed new station in NSE, the underground station of DTL, and above-ground potential future infrastructure, the stormwater will drain to the northern marine area. The detailed hydrology baseline information will be further discussed in Section 8.

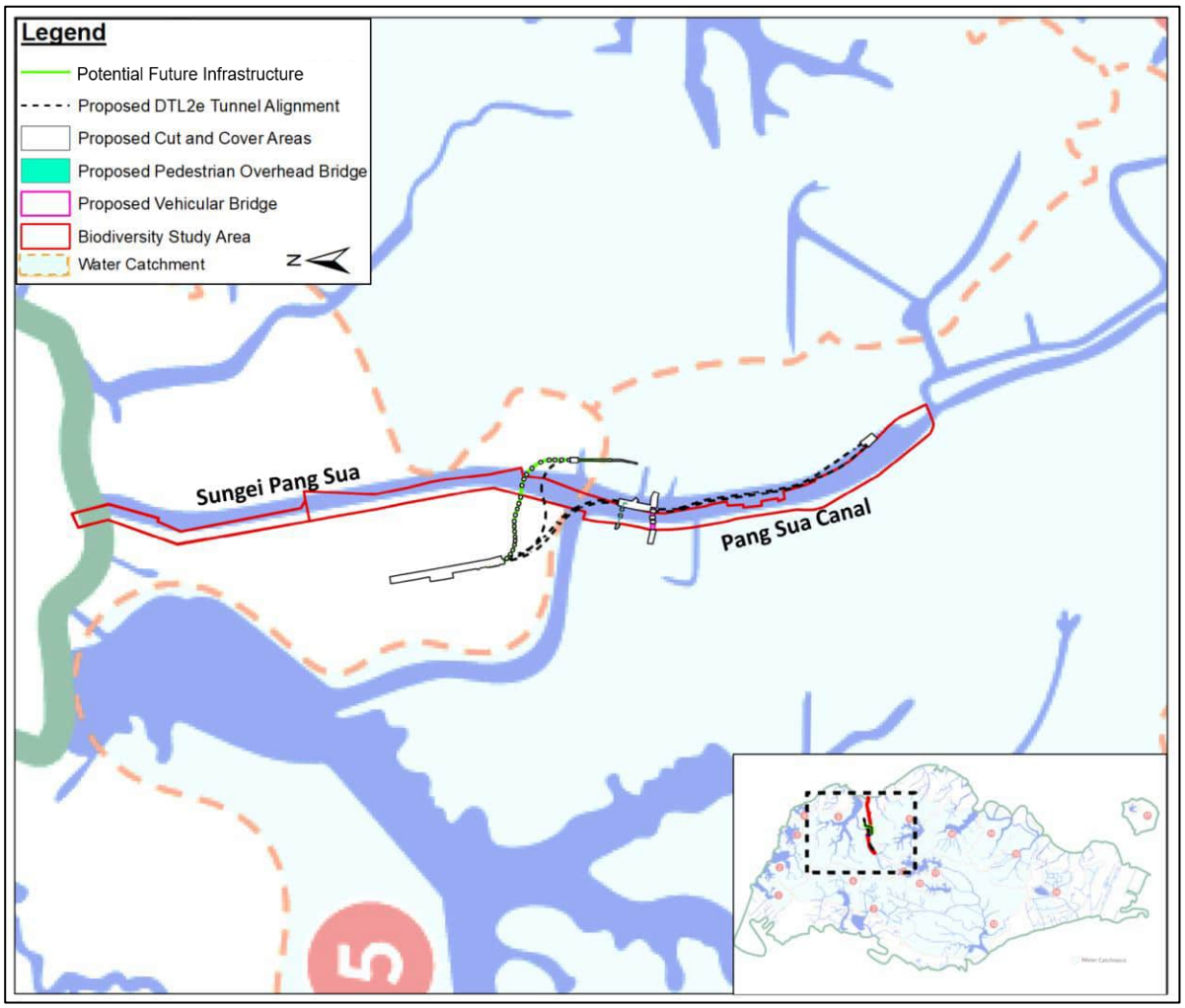


Figure 4-11 Catchment area of the project

4.8 Climate

4.8.1 Rainfall

Singapore is situated near the equator and has a typically tropical climate. Singapore's year-to-year rainfall is highly variable. However, on a longer-term basis, the annual rainfall total has increased at an average rate of 67 millimetres (mm) per decade since 1980 (see Figure 4-12) [W-71]. Rainfall is plentiful in Singapore; it rains an average of 167 days of the year [W-65]. The long-term mean annual rainfall total is 2534.4 mm when averaged across island-wide stations with long-term records [W-71].

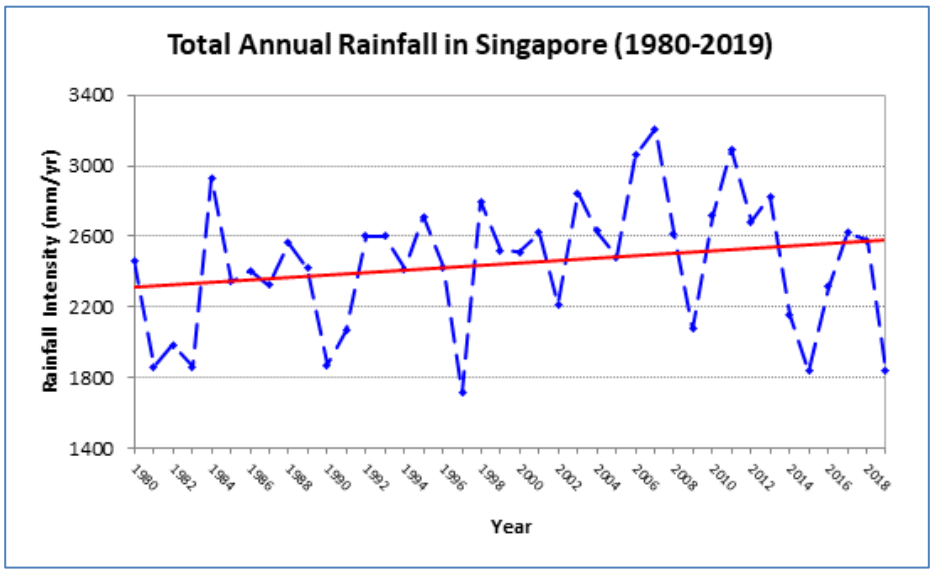


Figure 4-12 Annual rainfall total in Singapore from 1980 to 2019 (sourced from MSS [W-71])

Regarding spatial distribution, rainfall is higher over the northern and western parts of Singapore. It decreases towards the eastern part of the island (see Figure 4-13) [W-65]. The figure also shows that the Bukit Panjang area possibly receives the maximum rainfall in Singapore. The annual rainfall in the Bukit Panjang area is anticipated to be approximately 2,800 to 3,000 mm.

Figure 4-13 Annual average rainfall spatial distribution from 1981 to 2010 (sourced from MSS [W-65])

Singapore has two monsoon seasons separated by inter-monsoonal periods. The Northeast Monsoon occurs from December to early March, and the Southwest Monsoon from June to September. It also has abundant rainfall all year round, with relatively higher mean rain days (more than 13 days) and means rainfall amount (more than 230 mm) from November to January every year (refer to Figure 4-14). The average rainfall in Singapore is

approximately 230 mm and 180 mm during Northeast and Southwest Monsoon, respectively. Most months in 2021 had rainfall that was above average (refer to Figure 4-14).

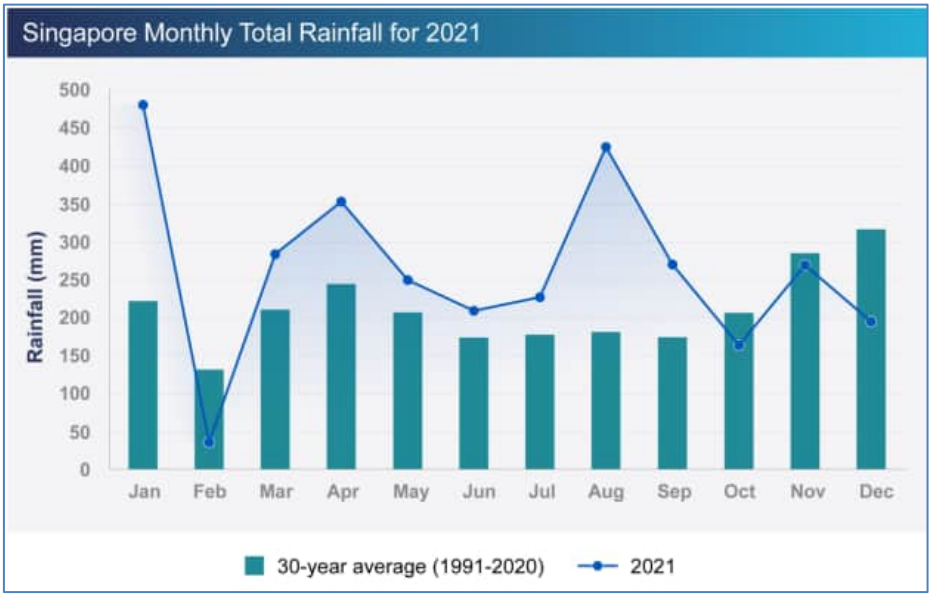


Figure 4-14 Monthly total rainfall in Singapore for a 30-year average over island-wide stations with long-term records (bars, 1991 – 2020) compared to 2021 (solid line) (sourced from MSS [W-71])

4.8.2 Temperature

Singapore's continuous temperature records since 1948 show that the island has warmed by an average of 0.25°C per decade, with a visible and sudden rapid increase after the mid-1970s (see Figure 4-15). This may have been due to the rapid economic development and urbanization that took place after Singapore's political reformation and the influence of anthropogenic global warming effects. Eight (8) out of the ten (10) warmest years recorded in Singapore have occurred in the 21st century, and all ten (10) occurred after 1997. This increasing trend has led to an increase in warm days and nights and a decrease in cool days and nights.

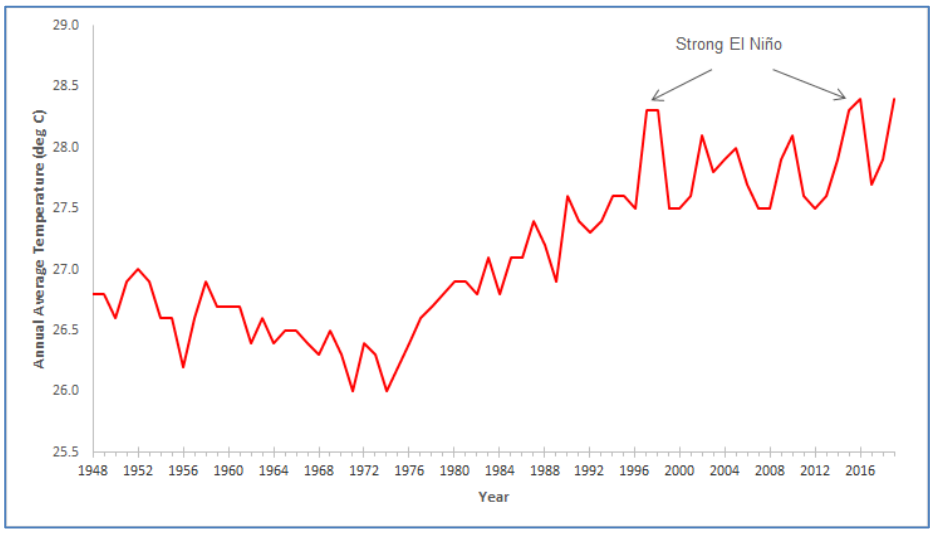


Figure 4-15 Annual mean temperature in Singapore from 1948 to 2019 (sourced from MSS [W-71])

Generally, the temperature variation throughout the year is relatively small compared to the mid-latitude regions. Singapore has high and uniform mean temperatures ranging from 24°C to 32.3°C throughout the year (refer to Figure 4-16). The mean temperature from 2012 to 2021 was 27.97°C, which is 0.02°C higher than the previous

record of 27.95°C for the decade from 2010 to 2019 [W-71]. Extreme minimum and maximum temperatures range from 20°C to 36°C.

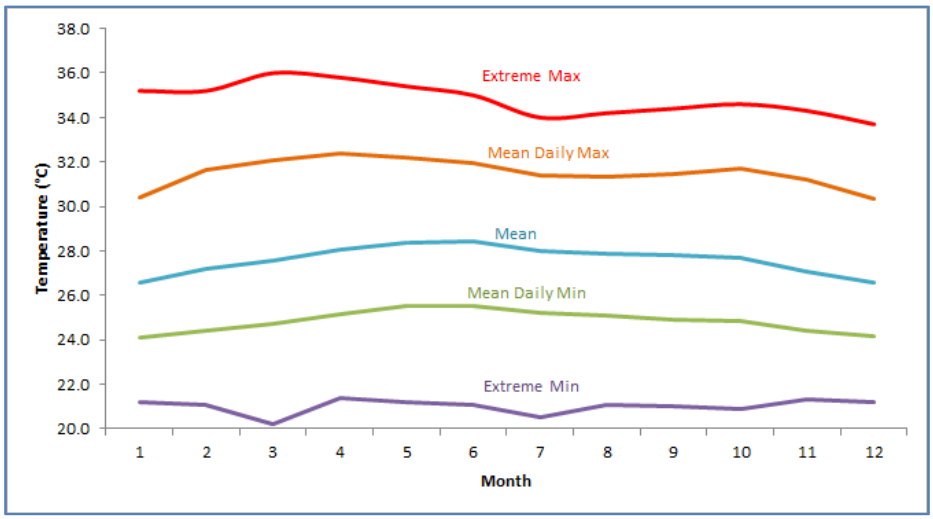


Figure 4-16 Mean monthly temperature variation from 1981 to 2010 (sourced from MSS [W-65])

Although there is no distinct borderline between “urban” and “rural” areas in Singapore, a maximum temperature difference of 4.01°C was observed between well-planted areas, such as the Lim Chu Kang area and the Central Business District (CBD) area [P-52]. This shows an Urban Heat Island (UHI) effect in Singapore. Green areas in cities have been considered a potential measure to mitigate the UHI effect. This finding is also supported by a study by Jusuf et al. (2007), which shows the different daytime temperatures in different land-use areas in Singapore. In Figure 4-17, the daytime temperature in park areas is considerably lower compared to other land use areas [P-51].

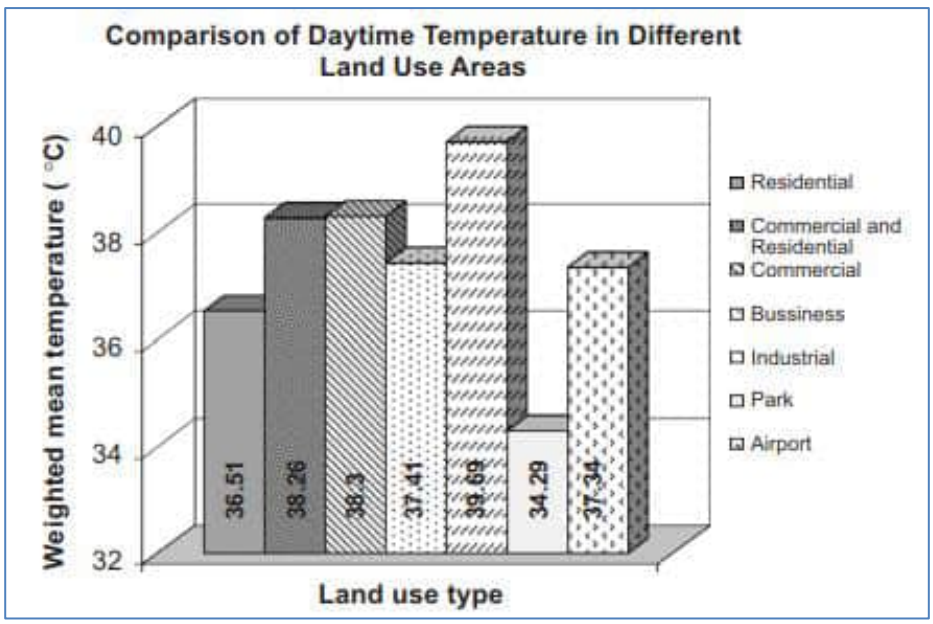


Figure 4-17 Comparison of daytime and night time temperature in different land use areas [P-51]

4.8.3 Relative Humidity

Relative humidity shows a uniform pattern throughout the year. It does not vary much monthly (refer to Figure 4-18). Its daily variation is more marked, from more than 90% before sunrise to around 60% in the mid-afternoon

on days without rain. While the mean annual relative humidity is 83.9%, the relative humidity frequency reaches 100% during prolongated periods of rain.

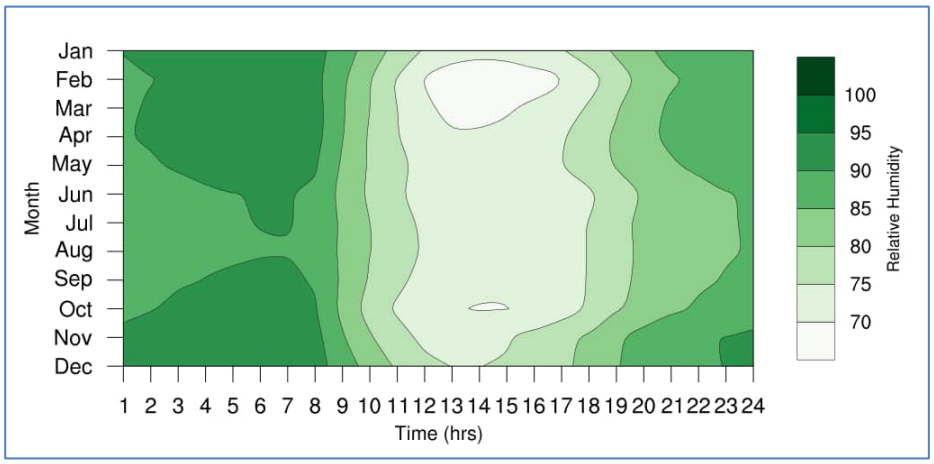


Figure 4-18 Hourly variations of relative humidity for each month from 1981 to 2010 (sourced from MSS [W-65])

4.8.4 Surface Wind

Singapore's wind is generally light, with the mean surface wind speed normally less than 2.5 m/s. An exception to this is during the presence of a Northeast Monsoon surge, where mean speeds of 10 m/s or more have been observed. Strong winds also occur during thunderstorms. Surface wind gusts are produced from thunderstorm downdrafts and Sumatra Squall Lines' passage. As shown in Figure 4-19, the most prominent winds in Singapore are from the northeast and the south, occurring during the Northeast and Southwest Monsoon, respectively. The mean monthly wind speeds range from 1.5 m/s to 3 m/s [W-65].

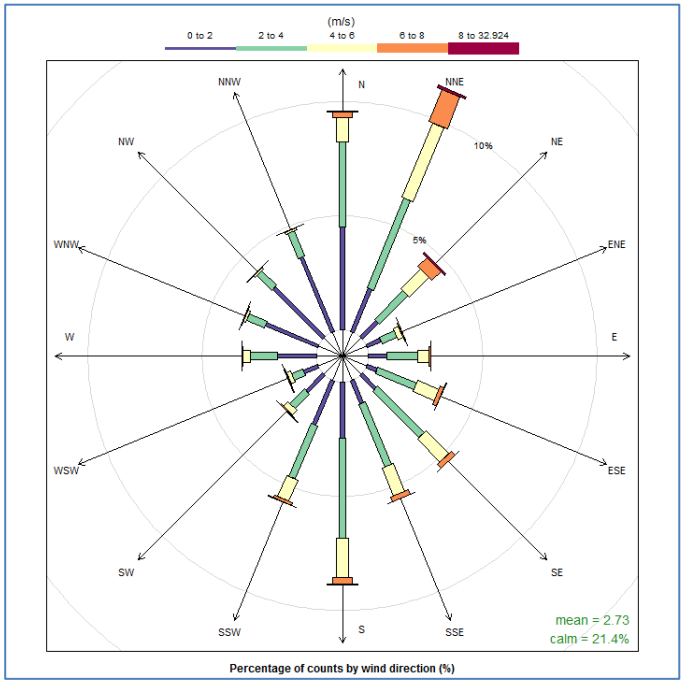


Figure 4-19 Annual wind rose of Singapore (sourced from MSS [W-65])

5 Relevant Regulatory Framework, International Standards and Guidelines

Proposed parameters/ applicable legislation for compliance with Environmental regulations at the construction and operational stage of the Project are listed in the table below.

Table 5-1 Applicable Legislation for Environmental Compliance

Environmental Parameter	Applicable Legislation/Standard/Guideline	Key Points
Biodiversity	National Parks Board Biodiversity Impact Assessment (BIA) Guidelines 2020 [R-63]	The guideline provides suggested methods for baseline surveys and critical components to a robust impact assessment related to biodiversity. The guideline also includes best practices of BIA conducted worldwide and offers guidance on assessment matrix and mitigation measures. The guideline also provides information on developing the biodiversity component of EMMP.
	National Biodiversity Strategy and Action Plan (NBSAP), 2009 [R-37]	This document provides a framework to guide biodiversity conservation efforts in Singapore. It intends to establish policy frameworks and specific measures to ensure better planning and coordination in the sustainable use, management and conservation of biodiversity. A holistic approach has been adopted where the input of various public sector agencies and nature groups has been considered in the document's preparation.
	Wildlife Act, Chapter 351 [R-38]	Any person who kills, takes or keeps any wild animal or bird other than those specified in the Act without a license shall be guilty of an offence and shall be liable on conviction to a fine not exceeding $1,000 and to the forfeiture of the wild animal or bird. No person should take, destroy or possess the eggs of any wild bird during the specified time of the year or during the bird's breeding season.
	Parks and Trees Act, 2006 [R-39]	An Act to provide for the planting, maintenance and conservation of trees and plants within national parks, nature reserves, three conservation areas, heritage road green buffers and other specified areas, and for matters in addition to that. No tree with a girth exceeding one meter (when measured 1-m from the ground) should be cut or damaged without the prior approval of the relevant authorities; and No tree or plant will be cut or damaged if located within the heritage road green buffer.
	Parks and Trees Act (Parks and Trees Regulations), 2006 [R-40]	Prohibitions and regulations on trees and animals within the national park, nature reserve or public park.

Environmental Parameter	Applicable Legislation/Standard/Guideline	Key Points
	Parks and Trees (Heritage Road Green Buffers) Order, 2006 [R-41]	Lists the areas designated as heritage road green buffers.
	Parks and Trees (Preservation of Trees) Order, 1998 [R-42]	Lists the designated tree conservation areas No cutting or damaging of a tree having a girth of more than one metre.
	Guidelines on Greenery Provision and Tree Conservation for Developments [R-64]	This handbook provides a guide on the statutory and technical requirements for conserving trees, safeguarding green spaces and implementing lush landscaping as part of development projects. The handbook also informs QPs on the procedures for submitting development plans to NParks for clearance.
	The Singapore Red Data Book (SRDB) [P-8]	Lists the endangered plants and animals in Singapore, Published by Singapore's Nature Society Provides the scientific name, common name, status, description, habitat, distribution, threats, scientific interest and potential value, as well as conservation measures for each plant and animal listed.
	The International Union for Conservation of Nature and Natural Resources (IUCN) Red List of Threatened Species [R-43]	Provides taxonomic, conservation status and distribution information on plants, fungi and animals that have been globally evaluated.
Surface Water Quality and Hydrology	LTA General Specification (For Rail Project) - Appendix A, Safety, Health and Environment, April 2015 [R-19]	Cover the requirements for eliminating and mitigating incidents, injuries and environmental harm in LTA construction sites.
	SS 593: 2013 – Code of Practice for Pollution Control (COPPC) [R-1]	Provides guidelines for appropriately discharging any effluent into public sewer or watercourse. Provides guidelines for the appropriate storage and accidental release of oils & chemicals.
	Environmental Protection and Management (Trade Effluent) Regulations, 2008 [R-3]	Regulates the discharge of trade effluent. Any discharge into a watercourse has to comply with the regulatory standards established in these regulations.
	Sewerage and Drainage Act, 2001 [R-4]	An Act to provide for and regulate the construction, maintenance, improvement, operation and use of sewerage and land drainage systems and to regulate the discharge of sewage and trade effluent. Regulates the protection, maintenance and provision of the stormwater drainage systems.
	Sewerage and Drainage (Trade Effluent) Regulations, 2007 [R-6]	Regulates trade effluent discharge into public sewerage system.

Environmental Parameter	Applicable Legislation/Standard/Guideline	Key Points
	Sewerage and Drainage (Surface Water Drainage) Regulations, 2007 [R-5]	Regulates measures to be implemented to protect the stormwater drainage system.
	PUB Code of Practice on Surface Water Drainage, 2013 [R-7]	Provides guidelines for measures to be implemented to protect the stormwater drainage system and manage surface water drainage (e.g., development and implementation of an Earth Control Measures (ECM) plan).
	Allowable Limits for Trade Effluent Discharge to Watercourse or Controlled Watercourse (NEA), 2008 [R-18]	Provides allowable limits for trade effluent discharge to watercourse or controlled watercourse in Singapore.
	PUB Circular on Preventing Muddy Water from the Construction Site, October 2015 [R-8]	All new construction sites with site area of 0.2ha and above, sites with problematic ECM, and sites within sensitive areas are required to implement CCTV including a Silty Imagery Detection System (SIDS) at the public drain to monitor the surface run-off discharges from the sites.
	Sewerage and Drainage (Exemption – Approval for Discharge of Trade Effluent) Notification 2013 [R-65]	Exemptions from sections 16(1) and 16A(1) of Sewerage and Drainage Act
	Public Utilities (Water Supply) Regulations, 2004 [R-66]	This regulation regulates water fittings, water service installations, metered water consumption, water conservation, metered water consumption, water conservation, and water efficiency management.
	Public Utilities (Reservoirs, Catchment Areas and Waterway) Regulations 2006 [R-67]	This regulation regulates activities in catchment area park, central water catchment area and waterway, vessel activities in reservoirs, and navigation rules.
	PUB Guidebook on Erosion and Sediment Control at Construction Sites 2018 [R-68]	This handbook provides practical site implementation guideline for erosion and sediment control at construction sites.
	Standard Statistical Classification of Surface Freshwater Quality for the Maintenance of Aquatic Life, New York and Geneva UNECE (1994) [R-9]	Provides standards for water quality assessment relating to aquatic life for surface watercourses.
	Water Quality Requirements WHO (n.d.) [R-10]	Provides standards for water quality assessment relating to aquatic life for surface watercourses.
	Water Quality Standards Handbook USEPA (2017) [R-11]	Provides standards for water quality assessment relating to aquatic life for surface watercourses.

Environmental Parameter	Applicable Legislation/Standard/Guideline	Key Points
	Australian & New Zealand Guidelines for Freshwater and Marine Water Quality (2000) [R-12]	Provides standards for water quality assessment relating to aquatic life for surface watercourses.
	Canadian Water Quality Guidelines for the Protection of Aquatic Life (2007) [R-13]	Provides standards for water quality assessment relating to aquatic life for surface watercourses.
	Mitigating Impact from Aquaculture in the Philippines (PHILMINAQ) [R-14]	Provides standards for water quality assessment relating to aquatic life for surface watercourses.
	ASEAN Marine Water Quality Management Guidelines and Monitoring Manual (2008) [R-17]	Provides marine water quality criteria for the protection of the coastal and marine environment and human health within ASEAN.
	ASEAN Strategic Plan of Action on Water Resources Management (2005) [R-72]	Provides freshwater water quality criteria for the protection of the river environment within ASEAN.
	National Water Quality Standards for Malaysia (DOE) [R-16]	Provides standards for water quality assessment relating to aquatic life for surface watercourses.
Air Quality	Environmental Protection and Management Act, 2018 [R-2]	Provides standards and regulations on air impurities
	Environmental Protection and Management (Air Impurities) Regulations 2015 [R-33]	Regulates air emissions and impurities in Singapore.
	Singapore Ambient Air Quality Targets (Long Term Targets) [W-2]	Stipulates the recommended limit values for ambient concentrations of NO_2, SO_2, PM_{10}, $PM_{2.5}$, CO and O_3 to be applied from the year 2020. Target values are based on World Health Organisation (WHO) Limit Values (mixture of Interim and Final values).
	Environmental Protection and Management (Off-Road Diesel Engine Emissions) Regulations 2012 [R-34]	Stipulates that all off-road diesel engines (including construction equipment with diesel engines) imported for use in Singapore from July 2012 must comply with the EU Stage II, US Tier II or Japan Tier I off-road diesel engine emission standards.
	Environmental Protection and Management (Vehicular Emissions) Regulations 2008 [R-36]	The document provides guidance for enforcement against smoky vehicles and idling engines while the vehicle is stationary.
	UK Institute of Air Quality Management (IAQM) Guidance on the Assessment of Dust from Demolition and Construction [R-35]	The document provides guidance for developers, their consultants and environmental health practitioners on how to undertake a construction impact assessment (including demolition and earthworks).
Airborne Noise	General	

Environmental Parameter	Applicable Legislation/Standard/Guideline	Key Points
	SS593:2013 Code of Practice for Pollution Control (COPPC), 2013 [R-1]	Specifies recommended pollution control requirements and good practices for prevention of impacts to noise.
	Biodiversity 2020 (UK) [R-23]	"Theme 3: reduce environmental pressures -integrate consideration of biodiversity within the sectors which have the greatest potential for direct influence and reduce direct pressures." The guide does not provide airborne noise criteria for biodiversity impact assessment but only serves as a reference that sets out biodiversity policies and strategies to conserve biodiversity for AECOM to consider and implement in the ES.
	Construction Stage	
	SS602:2014 Code of Practice for Noise Control on Construction and Demolition Sites, 2014 [R-21]	Specifies recommendations and good practices for prevention of noise impacts from construction and demolition activities.
	Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008 [R-22]	Stipulates a set of maximum allowable noise limits for construction sites for different time periods of the day and for different types of premises affected by construction noise. Stipulates the correction factor that needs to be applied to the applicable noise criteria based on background noise levels.
	Operational Stage	
	Technical Guideline for Land Transport Noise Impact Assessment from National Environment Agency (NEA) [R-25]	Airborne noise limit (from MRT trains) of LpAeq1hr of 67 dB when measured at 1m from the façade of existing residential buildings/noise sensitive premises are set by the National Environment Agency (NEA). This criteria will be used for human receptors only. No worse off will be proposed for ecological receptors.
	Guideline on Boundary Noise Limit for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Buildings by National Environment Agency (NEA) [R-26]; Code of Practice on Pollution Control by National Environment Agency [R-1]	Legislative requirements for boundary noise due to noise emissions from mechanical ventilation systems for non-industrial buildings.

Environmental Parameter	Applicable Legislation/Standard/Guideline	Key Points
Airborne Noise (Ecology)	Although some publications mentioned noise impacts on birds, there is inadequate literature to justify how the noise studies are to be carried out reliably for reference. Furthermore, sensitivity thresholds depend on a wide variety of factors, such that should sensitivity parameters be available for one species; they may not be relevant for a different species (even if the species are superficially similar). Also, seasonal and behavioural variations and propensity for habituation to noise and vibration will determine responses of particular species. Once the potential receptor species have been identified in undertaking ES, we will review available publications to try to determine suitable thresholds for the identified species based on the available data. However, where this is not possible, for example, there is no data, or where we consider the data that are available to be unreliable, we will generally rely on a qualitative assessment of the various disturbance sources that particular receptors are likely to encounter and focus on the factors that are likely to cause the most disturbance (which may be noise or noise in combination with other things, such as habitat loss, human presence and visual disturbance.	
Ground-borne Noise and Ground-borne Vibration (Human)	BS 7385-2:1993 Evaluation and measurement for vibration in buildings. Guide to damage levels from ground-borne vibration [R-28]	This standard establishes the basic principles for evaluating vibration effects on buildings. It presents guide values for transient and continuous vibration, above which there is a likelihood of cosmetic damage.
	BS 5228-2 2009+A1:2014: Code of practice for noise and vibration control on construction and open sites – vibration [R-24]	BS 5228-2 provides a ‘best practice’ guide for control of construction vibration and guidance on the human response to vibration in terms of peak particle velocity (PPV). It also provides case history vibration data and calculation methods for vibration from construction activities, including piling and tunnel boring.
	BS 6472-2:2008 Guide to Evaluation of Human Exposure to Vibration in Buildings Part 2: Blast Induced Vibration [R-27]	This part of BS 6472 gives guidance on human exposure to blast induced vibration in buildings. It is used for assessing other forms of vibration that are caused by blasting, including when explosives are utilized in civil engineering works and in demolition activity.
	ISO14837:2005 Mechanical vibration - Ground-borne noise and vibration arising from rail systems. International Organization for Standardization. [R-29]	Advice on the prediction of ground-borne noise and vibration from rail systems.
	American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) curves for sensitive equipment [R-30]	In the absence of specific vibration criteria supplied by Priority 1 Receptors, generic criteria for the types of equipment will be used.

Environmental Parameter	Applicable Legislation/Standard/Guideline	Key Points
	Federal Transit Administration (FTA) Transit Noise and Vibration Impact Assessment Manual (September 2018) [R-31]	Provides guidelines to assess noise and vibration impacts due to construction and operation for transit projects. It states that it is rare for vibration to impact elevated alignment except when the viaduct is located within approximately 15 m of buildings.
Ground-borne Vibration (Ecology)	Ground-borne noise impact is only relevant for a [human] receptor inside a building; thus, AECOM has scoped out ground-borne noise impact assessment for ecology out of this report. Existing legislation governing ground-borne vibration is only applicable to the [human] receptor. In undertaking ES, the prediction of vibration levels will be done quantitatively. However, due to the absence of an established international criteria for ecology, the assessment analysis part towards ecological receptors will be qualitative of the various disturbance sources that particular receptors are likely to encounter and focus on the factors that are likely to cause the most disturbance. Based on the faunal surveys by biodiversity team at later stages, this shall be researched further and relevant references, guidelines will be included in the ES report. Vibrational signalling, vibration reception and behaviour (prey catching, courtship, territorial behaviour) guided by substrate vibrations1 (best studied in vertebrates and arthropods).	
Chemical Substances (Surface water and soil and groundwater sections)	Environmental Protection and Management (Hazardous Substances) Regulations, 2008 [R-45]	Regulates the transport, use and storage of hazardous substances.
Fire Safety (Surface water and soil and groundwater sections)	Fire Safety Act, 2013 [R-46]	Makes provisions for fire safety and for matters connected therewith.
	Fire Safety (Petroleum and Flammable Materials) Regulations, 2008 [R-47]	Regulates the transport, use and storage of flammable material to prevent occurrence of accidents.
	Code of Practice for the Storage of Flammable Liquids (SS 532:2007) [R-48]	Provides guidelines for the transport, use and storage of flammable material to prevent occurrence of accidents.
Waste (Surface water and soil and groundwater sections)	Environmental Public Health Act, 2002 [R-49]	Regulates the storage, handling and disposal of wastes.
	Environmental Public Health (Toxic Industrial Waste) Regulations, 2000 [R-50]	Regulates the storage, collection and disposal of toxic industrial waste.
	Environmental Public Health (General Waste Collection) Regulations, 2000 [R-51]	Regulates general waste (incinerable and non-incinerable waste) disposal.

[1] In an ecology context, the ground-borne vibration is typically known as “substrate vibration”.

Environmental Parameter	Applicable Legislation/Standard/Guideline	Key Points
	Hazardous Waste (Control of Export, Import & Transit) Regulations 1998 [R-52]	Provides the application and granting of import, export, transit, Basel or special permits for hazardous wastes.
	Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal [R-53]	Singapore signed the Basel Convention in 1995. Its requirements were transposed into Singaporean law through the Hazardous Waste Act. The Convention obligates parties to provide for the environmentally sound management of hazardous and other wastes, e.g., restrictions on the import, export and trans-boundary movement of hazardous wastes. Appropriate measures must be taken to ensure that the generation of such wastes, as well as the consequences of waste pollution on human health and the environmental is minimal. Adequate disposal facilities must be available.
	SS603: 2014 Code of Practice for hazardous waste management [R-54]	This code provides guidance on best practice measures for managing hazardous waste on site
	Code of Practice for Licenced Waste Collector [R-1]	This code provides list of wastes allowed to be collected by various licenced collector types.
	NEA circulars on import and export of waste [W-3]	Several circulars have been rolled out prohibiting certain import / export of waste One of the circulars prohibits import/ export of metal/plastic scrap containing toxic or heavy metals (PCD/BASEL/05-0021)
Soil and Groundwater	Environmental Protection and Management Act, 2018 [R-2]	Regulates the discharge of trade effluent, oil chemical, sewage or other pollution onto land.
	SS 593:2013 Code of Practice for Pollution Control (COPPC) [R-1]	Provides guidelines for the control of land pollution and remediation of contaminated sites. Provides guidelines for the appropriate storage and accidental release of oils & chemicals.
	Environmental Protection and Management (Trade Effluent) Regulations, 2008 [R-3]	Regulates the discharge of trade effluent into any watercourse or onto land.
	Sewerage and Drainage Act, 2001 [R-4]	Regulates the construction, maintenance, improvement, operation and use of sewerage and land drainage systems.
	Sewerage and Drainage (Surface Water Drainage) Regulations, 2007 [R-5]	Regulates measures to be implemented to protect the storm water drainage system and avoid flooding. Regulates the provision and maintenance of ECM in accordance with the Code of Practice on Surface Water Drainage.

Environmental Parameter	Applicable Legislation/Standard/Guideline	Key Points
	JTC Guideline on Environmental Baseline Study, 2015 [R-56]	Provide the responsible parties necessary guidance for conducting EBS for assessing contamination of a site
	Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer. Target Values, Soil Remediation Intervention Values and Indicative Levels for Serious Contamination, 2020 [R-55]	The soil remediation intervention values indicate when the functional properties of the soil for humans, plant and animal life, is seriously impaired or threatened. They are representative of the level of contamination above which there is a serious case of soil contamination.
	Section 7 of SS 593:2013 Code of Practice for Pollution Control (COPPC) [R-1]	Provides the necessary guidance for conducting Environmental Baseline Study (EBS) for assessing contamination of a site and the respective standards to be followed.
Vectors	Control of Vectors and Pesticides Act (CVPA) 1998, 2020 Revised Edition [R-57]	Prohibits the creation of conditions favourable to vectors

6 ES Approach and Methodology

This section outlines the approach and methodology followed for this ES.

6.1 Overview of Approach

The overall ES workflow is shown in Figure 6-1, and the general approach to the ES is listed as follows:

- Scoping of Project (Section 6.2);
- Data Collection and Analysis (Section 6.3.1);
- Prediction of Impacts (Section 6.4.1);
- Evaluation of Impacts (Section 6.4.2);
- Recommendations of Mitigation Measures (Section 6.5); and
- Environmental Monitoring and Management Plan (Section 6.5).

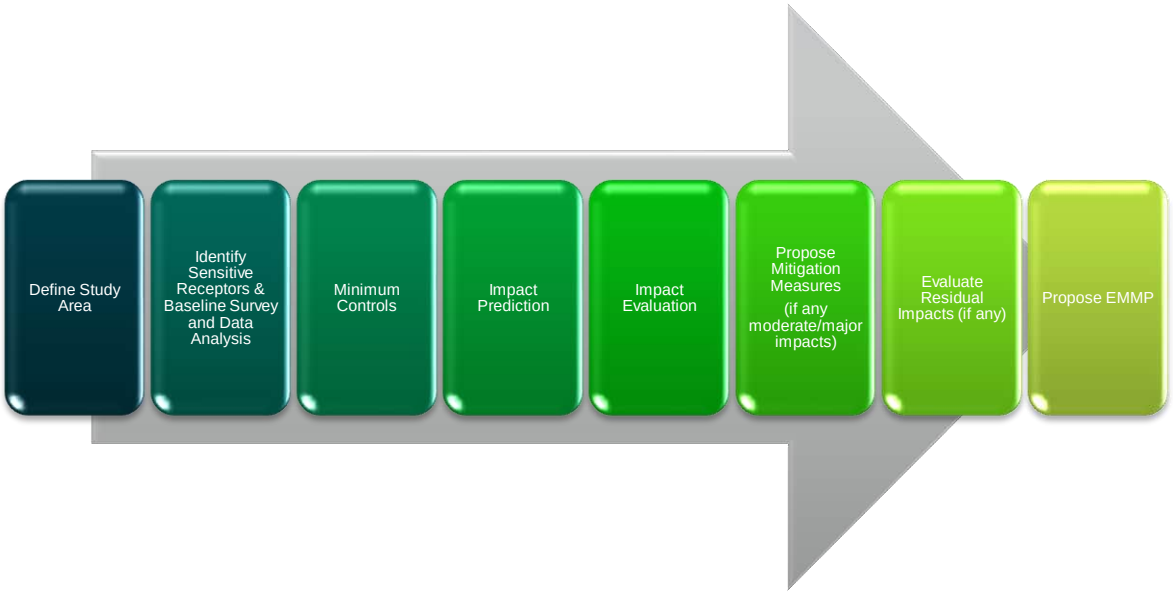


Figure 6-1 Overall ES workflow

6.2 Scoping of Project

6.2.1 Definition of Study Area

The study area is the area on either side of the construction/ operational footprint of the defined Project that is used for the assessment of environmental impacts. A varying study area size is required for each environmental parameter based on legislation or international guidelines. The study area for each environmental parameter is provided below and is defined by the following Project areas:

- Entire alignment: refers to both the DTL2e underground rail alignment and potential future infrastructure, unless it is specified otherwise;
- Above ground Project Footprint: refers to the above ground footprint of the station, potential future infrastructure, vehicular bridge and pedestrian linkbridge which will remain as permanent above ground features during the operational stage of Contract 9175; and
- Above ground construction worksite area: areas where surface impacts may occur due to construction footprint above ground level, e.g., all areas excluding the underground tunnels.

The study area was defined for each environmental parameter in the Inception Report Rev B submitted to LTA [O-1] and presented in Table 6-1 below.

Table 6-1 Study Area

Environmental Parameter	Study Area	Justification
Biodiversity	• Sungei Pang Sua • Pang Sua Canal • Rail Corridor	Sungei Pang Sua, Pang Sua Canal and the Rail corridor are ecologically sensitive areas near/along the entire alignment. All freshwater streams within Study Area are also considered sensitive areas.
Hydrology and Surface Water Quality	Any watercourse with direct impact from the proposed development	During the construction phase, the construction footprint above ground has potential to impact surface water quality. Underground tunnelling works much below surface water especially at proposed DTL2e alignment crossings at Sungei Pang Sua is likely to cause hydrodynamic and morphological impact due to initial river bed settlement during construction process. During operation phase, increased urbanized area and human activities may lead to reduction in baseflow and increased improper littering.
Air Quality	• 50 m and 350 m around the construction worksite area for construction phase for ecological and human receptors respectively • 250 m around the above ground Project Footprint for operational phase	In accordance with UK IAQM Guidance adopted for this study for Construction phase. Based on experience from other projects for operational phase.

Environmental Parameter	Study Area	Justification
Airborne Noise	Construction Stage • 150 m - around above ground construction worksite areas only Operational Stage • Boundary of above ground Project Footprint for boundary noise assessment • 70 m from the train at-grade and on viaduct for traffic noise assessment	Construction Stage • In accordance with Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008. Airborne noise impacts will occur from above ground construction sites only; and • Although the assessment will apply to the immediate study area, noise contours will be provided to the extent that topography is available. Operational Stage • In accordance with NEA Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Buildings, 2018; and • In accordance with NEA Technical Guideline for Land Traffic Noise Impact Assessment, 2016 for noise sensitive and residential building receptors.
Ground-borne Noise and Ground-borne Vibration	100 m around above ground construction worksite areas and from the centreline of DTLe alignment as a starting point.	There is very little guidance available on identifying vibration screening distances. This project proposes 100 m for construction, operational vibration, and ground-borne noise impact based on extensive technical experience on rail projects. Within the 100 m study area, there are no sensitive receptors (laboratory/manufacturing facilities or sound recording/broadcast studios) where low ground-borne noise and vibration are critical to operations. As vibration attenuates over the distance, it is anticipated that effects from ground-borne noise and vibration will not occur at distances greater than 100 m from the source. Therefore ground-borne noise and ground-borne vibration impacts on humans are assessed within the 100 m radius of the source. Suppose there are vibration impacts on the ecologically sensitive areas - Sungei Pang Sua, Pang Sua Canal and the Rail Corridor; ground-borne vibration impacts on sensitive ecological receptors are assessed. Ground-borne noise is excluded as the impacts occur in a built environment only.
Soil, Groundwater and Waste Management	250 m on both sides of DTLe alignment and potential future infrastructure	This follows the typical study area of Historical Land Use Survey (HLUS) for potential contamination of soil and groundwater from historical activities.
Vectors	400 m – around the above ground construction and operational footprint	According to WHO [W-14], the maximum distance that a matured female Aedes mosquito can fly is 400 m.

6.2.2 Identification and Categorization of Sensitive Receptors

Sensitive receptors are those receptors within the study area which may potentially be impacted by the Project's construction and operational activities. Environmentally sensitive and/or receptors are sub-categorised into three categories: Priority 1, Priority 2 and Priority 3 (from the most sensitive to the least) as shown in Table 6-2 below.

Sensitive receptors are identified with reference to the location of the Project, specifically:

- Identification of Air Sensitive Receptors (ASR) within the study area (i.e., up to 350 m and 250 m from both sides of construction worksite areas and Project footprint for construction and operational phase respectively – See previous Table 6-1 for details);
- Identification of Noise Sensitive Receptors (NSR) within the study area (i.e., 150 m from both sides of construction worksite areas and Project footprint);
- Identification of Vibration Sensitive Receptors (VSR) within the study area (i.e., 100 m from both sides of construction worksite areas and Project footprint;
- Identification of Hydrology and Water Quality Sensitive Receptors within/surrounding the study area (i.e., any watercourse with direct impact from the proposed development);
- Identification of Soil, Groundwater and Waste Receptors within the study area (i.e., 250 m from both sides of construction worksite areas and Project footprint); and
- Identification of Biodiversity Receptors within the study area (i.e., ESS sites overlapping works sites).

Table 6-2 Receptor Sensitivity Classification

Environmental Parameter	Receptor Sensitivity		
	Priority 1	**Priority 2**	**Priority 3**
Biodiversity	Flora, fauna species and habitats of high ecological value (i.e., presence of conservation significant flora, fauna species and habitats; trees of conservation significance and NParks-designated heritage trees)	Flora, fauna species and habitats of moderate ecological value (i.e., mainly native species of flora, fauna and habitats)	Flora, fauna species and habitats of low ecological value (i.e., mainly exotic or cryptogenic flora, fauna and habitats; managed vegetation which can provide crucial habitat for significant species)
Hydrology	<u>For human receptors:</u> Residential developments or high-value industrial or agricultural developments in the vicinity of watercourses without any flood mitigation measures Any other development where human activity would be changed long-term, severely altered or completely prevented due to changes in existing hydrology	<u>For human receptors:</u> Residential developments or high-value industrial or agricultural developments in the vicinity of watercourses with implemented flood mitigation measures Any other development where human activities would be changed short-term and/or moderately altered due to changes in existing hydrology	<u>For human receptors:</u> Non high-value industrial or agricultural developments in the vicinity of the watercourses Any other development in the vicinity of the watercourse where human activity will not be affected by changes in hydrology
	<u>For ecological receptors:</u> Habitats and/or biocenosis of high ecological value that require certain quantities of	<u>For ecological receptors:</u> Habitats and/or biocenosis of high ecological value that could be flooded due to changes in existing	<u>For ecological receptors:</u> Habitats and/or biocenosis that are not of high ecological value and that will not be flooded or

Environmental Parameter	Receptor Sensitivity		
	Priority 1	**Priority 2**	**Priority 3**
	water for normal functioning	hydrology which would cause moderate and/or short-term disturbances in their functioning	disturbed due to changes in existing hydrology
Surface Water Quality	For human receptors: • Humans or entities (e.g., companies, facilities) that use water for beneficial purposes (i.e., drinking purposes or irrigation) • Industrial or agricultural developments that require water of high-quality or water with particular physico-chemical characteristics for their processes and activities • Humans that may come in contact with contaminated water (i.e., water with one or more parameters that exceed adopted screening criteria[s] with respect to human health)	For human receptors: • Entities (e.g., companies, facilities) that use water for industrial purposes and do not have special requirements regarding the water quality • Humans that may come in contact with water that is not contaminated (i.e., water with all the parameters below adopted screening criteria[s] with respect to human health)	For human receptors: • Humans or entities (e.g., companies, facilities) within or in the vicinity of the Study Area that do not use water for any beneficial purpose (i.e., drinking or industrial purposes, irrigation) • Humans within or in the vicinity of the Study Area that will not come in contact with water
	For ecological receptors: Habitats and/or biocenosis of high ecological value with low tolerance[2] to changes in water quality	For ecological receptors: Habitats and/or biocenosis of high ecological value with medium to high tolerance[2] to changes in water quality	For ecological receptors: Habitats and/or biocenosis within or in the vicinity of the Study Area that are not of high ecological value
Air Quality	Ecological Receptors: Flora, Fauna Species and Habitats of High Ecological Value within 20 m of construction worksite area	Ecological Receptors: • Flora, Fauna Species and Habitats of High Ecological Value within 20 m to 50 m of construction worksite area. • Ecological sites having known sensitive communities within 20 m of construction worksite area.	Ecological Receptors: • Ecological sites having known sensitive communities within 20 m to 50 m of construction worksite area • Any other ecological sites within the study area of 50 m.

[2] Tolerance to changes in surface water quality for identified ecological receptors will be determined with biodiversity specialists

Environmental Parameter	Receptor Sensitivity		
	Priority 1	**Priority 2**	**Priority 3**
	Human Receptors: • Sensitive receptors[3] (more than 100 receptors) within 50 m of the construction area. • Sensitive receptors (1-100 receptors) within 20 m of the construction area.	Human Receptors: • Sensitive receptors (more than 100 receptors) between 50 m to 100 m of the construction area. • Sensitive receptors (1-100 receptor) between 20 m to 50 m of the construction area. • Office, industrial facilities, or shops (more than 10 receptors) within 20 m of the construction area.	Human Receptors: • Public footpath, playing fields and parks within 20 m from the construction area. • All other buildings within the 350 m study boundary.
Airborne Noise	Ecological Receptors: Areas inhabited by CS/ non-CS fauna species that use sound for communication, foraging, and breeding, and are known to have their behaviours disrupted by the increase in airborne noise levels (e.g., due to immobility from impacted area such as raptor nests)	Ecological Receptors: Areas inhabited by CS fauna species that are less affected by airborne noise/ CS species which have the ability to move away temporarily to neighbouring areas which are not impacted by construction noise	Ecological Receptors: Areas inhabited by fauna species that are less affected by airborne noise and are non-CS species
	Human Receptors: Schools and Education Buildings, Hospitals, Religious Buildings and Medical Centres, Nursing Homes.	Human Receptors: Residential buildings	Human Receptors: Other Buildings (Industrial, Commercial, Infrastructure, Sport & Recreation Areas, etc.).
Ground-borne Noise and Ground-borne Vibration	Human Receptors: Hospitals using sensitive equipment, industries/laboratories using sensitive equipment.	Human Receptors: Residential buildings, community centres, religious buildings, schools and education buildings, hospitals or medical centres, nursing homes, heritage buildings and national monuments.	Human Receptors: Commercial buildings, industrial buildings, infrastructure, industrial food centres, sports and recreation centres (e.g., golf courses, stadiums, club houses).
Ground-borne Vibration	Ecological Receptors:	Ecological Receptors:	Ecological Receptors:

[3] Sensitive receptors for air impact assessment include residential blocks, hospitals, medical centre, schools and education and residential care home. This is according to classification made in the IAQM's guidance. Hawker centres shall also be checked.

Environmental Parameter	Receptor Sensitivity		
	Priority 1	**Priority 2**	**Priority 3**
	Vibration-sensitive species with conservation status and low mobility and habitats of high sensitivity to ground-borne vibration in consultation with Biodiversity specialist after surveys[4]	Vibration-sensitive species without conservation status and low mobility and habitats of moderate sensitivity to ground-borne vibration in consultation with Biodiversity specialist after surveys	Vibration-sensitive species with high mobility; species not sensitive to vibration, and habitats of low sensitivity to ground-borne vibration in consultation with Biodiversity specialists after surveys
Soil, Groundwater and Waste Management	Ecological Receptors: Habitats and biocenosis of high ecological value that are dependent of groundwater.	Ecological Receptors: Habitats and biocenosis of high ecological value that are partly dependent of groundwater.	Ecological Receptors: Habitats and biocenosis of high ecological value that are not dependent of groundwater. Habitats and biocenosis that are not of high ecological value.
	Human Receptors: • Humans or entities (e.g., companies, facilities) that use groundwater for drinking purposes or irrigation. • Humans (e.g., workers, visitors) that may come in direct contact with contaminated soil and/ or groundwater.	Human Receptors: • Entities (e.g., companies, facilities) that use groundwater for industrial purposes. • Humans that may come in contact with soil and/ or groundwater that are not contaminated.	Human Receptors: • Humans or entities (e.g., companies, facilities) that do not use groundwater for any beneficial purpose (i.e., drinking or industrial purposes, irrigation). • Humans that will not come in contact with soil and/ or groundwater.
Vectors (for human sensitive receptors only)	Human habitats with natural ventilation[5] less than 50 m away from construction worksites.	• Human habitats with natural ventilation between 50 m and 150 m from construction worksites.[6] • Buildings with mechanical ventilation [7]	• Human habitats with natural ventilation between 150 m and 400 m away from construction worksites[8] • Buildings with mechanical ventilation between 150 m and

[4] The receptor sensitivity of ground-borne noise and vibration will be determined based on the biodiversity baseline survey results.
[5] Human habitats with natural ventilation represent buildings with opened window where human resides, with long-term exposure to vector impact, e.g. residential household, etc.
[6] According to Ministry of Health (MOH) Singapore, a dengue cluster is defined as two or more cases epidemiologically linked by place (within 150m) and time (within 14 days).
[7] Buildings with mechanical ventilation represent buildings or venues where human activity is conducted with mostly enclosed condition and installed with air-conditioning, which of short-term exposure to vector impact, e.g. shops, worships places, industrial, schools, hospital, etc.
[8] According to WHO Fact Sheet, the maximum distance that a matured female Aedes mosquito can fly is 400m.

Environmental Parameter	Receptor Sensitivity		
	Priority 1	**Priority 2**	**Priority 3**
		within 150 m from construction worksites. • Public footpath, playing fields, parks and public areas for utility and transport within 150 m from construction worksites.	400 m away from construction worksites. • Public footpath, playing fields, parks and public areas for utility and transport between 150 m and 400 m away from construction worksites.

6.3 Baseline Approach and Methodology

The baseline study aims to establish the extent and conditions of the existing environment that may be potentially affected by the execution of the proposed Project. The baseline study provides the basis for the prediction of potential impacts of the Project across each the environmental parameter.

The collection of pre-construction environmental baseline data within the Project Site was conducted both from primary and secondary sources.

6.3.1 Primary Baseline Data Collection (On-Site Field Surveys and/or Monitoring)

The sample collection and survey locations were selected for baseline data collection based on their proximity to the Projects and the nearby human and ecologically sensitive receptors within the defined study area. The representative locations were confirmed during site reconnaissance surveys. Site visits and sampling dates are tabulated in the following Table 6-3.

Table 6-3 Site Visits for Data Collection

Environmental Parameter	Site Visits
Biodiversity	Site reconnaissance survey: • 12, 15 and 22 October 2021 Sampling dates: • 22 November 2021 – 15 March 2022 Camera trapping dates: • 6 December 2021 – 16 March 2022
Hydrology and Surface Water Quality	Site reconnaissance survey: • 18 February 2021 • 8 November 2021 Sampling dates: • 8 November 2021 • 9 November 2021 • 2 March 2022 • 3 March 2022 • 7 March 2022 • 18 March 2022 • 21 March 2022 • 31 March 2022
Air Quality	Site reconnaissance survey: • 16 February 2021 • 24 February 2022 Sampling dates: • 28 February – 7 March 2022 • 8 – 15 March 2022 • 17 – 24 March 2022

Environmental Parameter	Site Visits
Airborne Noise	Site reconnaissance survey: • 18 February 2021 • 24 September 2021 Sampling dates: • 14 July 2021 – 20 July 2021 • 8 November 2021 – 14 November 2021 • 3 December 2021 – 16 December 2021
Ground-borne Noise and Ground-borne Vibration	Site reconnaissance survey: • 24 September 2021 Sampling dates: • 2 – 8 December 2021 • 10 – 16 December 2021 • 21 – 27 December 2021 • 24 – 31 January 2022 • 3 – 10 February 2022 • 11 – 14 February 2022 • 14 – 17 February 2022 • 18– 20 February 2022
Soil, Groundwater and Waste Management	Site reconnaissance survey: Conducted by AECOM, for the purposes of HLUS: 16 February 2021 Sampling dates: Conducted by LTA term Contractors on: • 16 September 2022 • 24 September 2022 • 25 - 26 October 2022 • 7 November 2022
Vectors	Nil. Only secondary data collection via desktop study.

Further information on sample collection and survey locations and parameters is provided in Section 7 (Biodiversity), Section 8 (Hydrology and Surface Water Quality), Section 9 (Air Quality), Section 10 (Airborne Noise), Section 11 (Ground-borne Vibration), Section 12 (Soil and Groundwater) and Section 13 (Vectors).

6.3.2 Secondary Baseline Data Collection (Desktop Study and Information Analysis)

Additional secondary data was collected from sources including, but not limited to, the following:

- Review of publicly available data, existing literature, and books;
- Singapore ambient air quality is available online;
- Historical, current and planned land uses, including commercial and recreational activities;
- Online databases;
- Aerial photographs;
- Drainage maps of the catchment area;
- Weather data (rainfall, wind, evaporation);
- Landscape maps;
- Commercial and recreational activities; and
- Vector data from online sources.

Further information on secondary data collection is provided in Section 7 (Biodiversity), Section 8 (Hydrology and Surface Water Quality), Section 9 (Air Quality), Section 10 (Airborne Noise), Section 11 (Ground-borne Vibration), Section 12 (Soil and Groundwater) and Section 13 (Vectors).

6.4 Assessment Criteria

6.4.1 Prediction of Impacts

Key potential environmental impacts arising from the Project's pre-construction, construction and operational activities were assessed within the Project scope. The methodology for predicting impacts in line with the Inception Report Rev B submitted to LTA [O-1] is presented in the following tables.

Table 6-4 Methodology for Prediction of Construction Impacts

Environmental Parameters	Predictive Methods	Assessment Criteria
Biodiversity	Qualitative assessment to evaluate the impacts of construction activities on terrestrial/aquatic ecology, including conservation significant species, significant vegetation types, ecologically sensitive habitats and important ecological processes.	Review the location of identified flora, fauna and habitats against the construction worksite area and predict impacts from construction activities.
Hydrology and Surface Water Quality	Qualitative and analytical methods were applied to assess direct impact on hydrological and water quality and indirect impact on human beings and ecology from the construction footprint. Quantitative methods were applied to assess hydrodynamic and morphological of development construction phases nearby Sungei Pang Sua.	• Environmental Protection and Management (Trade Effluent) regulations • Allowable Limits for Trade Effluent Discharge to Watercourse or Controlled Watercourse (NEA) • Water Quality Criteria for Aquatic Life from other countries including United Nations Economic Commission for Europe (UNECE, 1994), ASEAN Strategic Plan of Action on Water Resources Management (2005), ASEAN Marine Water Quality Management Guidelines and Monitoring Manual (2008), United States Environmental Protection Agency (USEPA, 2017) and Mitigating Impact from Aquaculture in the Philippines (PHILMINAQ, n.d.), Canadian Water Quality Guidelines for the Protection of Aquatic Life (2007) and Australian & New Zealand Guidelines for Freshwater and Marine Water Quality (2007)
Air Quality	Qualitative assessment following dust risk assessment methodology focusing on fugitive particulate emissions (dust) from the construction site.	Assessment broadly follows "Guidance on the Assessment of Dust from Demolition and Construction" which was published by the UK Institute of Air Quality Management (IAQM) in 2014.
Airborne Noise	Quantitative assessment: Cumulative noise in Decibels (dB) generated from construction activities and the Baseline shown in 3D predicted	Assess all noise sensitive receptors when compared to Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008

Environmental Parameters	Predictive Methods	Assessment Criteria
	at sensitive receptors based on the Singapore standard SS602:2014 "Code of Practice (CP49) for Noise Control on the Construction and Demolition Sites; and British Standard BS5228-1:2009 using SoundPLAN ver 8.2 or equivalent. Qualitative assessment of the cumulative construction impacts from nearby activities surrounding the proposed Project.	Biodiversity 2020 (UK) "Theme 3: reduce environmental pressures - integrate consideration of biodiversity within the sectors which have the greatest potential for direct influence and reduce direct pressures."
Ground-borne Noise and Ground-borne Vibration	Empirical relationships defined in British Standard BS 5228-2:2009+A1:2014 [R-25] If required, these relationships will be supplemented by case history data in BS 5228-2:2009+A1:2014 [R-25] plus the AECOM source and propagation data database.	Empirical relationships are provided for piling activities (construction works that will produce the highest vibration levels throughout the construction period) and a range of exceedance probabilities for categorised ground types. Alternative data were used for construction activities not included in the BS 5228-2:2009+A1:2014 empirical relationships. Reference data comprises either case history data from BS 5228-2:2009+A1:2014 or AECOM's database. As universal criteria assessment for ecological receptors is unavailable, AECOM reviews the baseline vibration data collected from the study area and proposes project-specific criteria. Section 11.6.
Soil, Groundwater and Waste Management	Qualitative assessment of impacts on soil and groundwater due to proposed construction activities (e.g., general and toxic solid/ liquid waste generation, spoil handling, storage of hazardous materials on site) which may impact identified human and ecological receptors.	The soil and groundwater will be assessed by referring to HLUS report [R-79]. Laboratory analytical results from the soil and groundwater samples will be compared to international standards such as the Soil Remediation Circular (Dutch Standards) and Australian and New Zealand Guidelines for Fresh and Marine Water to determine potential impacts to downstream waterbodies (if any).
Vectors	Qualitative assessment to evaluate the impacts of construction activities (e.g., waste generated during the construction phase, site practices) that potentially promotes vector-breeding within the project's study area.	Review desktop findings and discuss the potential vector-promoting activities from the construction footprint of the Project.

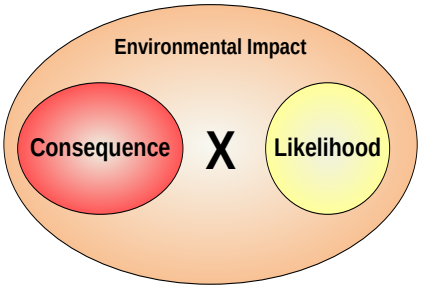
Table 6-5 Methodology for Prediction of Operational Impacts

Environmental Parameters	Predictive Methods	Assessment Criteria
Biodiversity	Qualitative assessment to evaluate the impacts of operational activities on terrestrial/aquatic ecology, including conservation significant species, significant vegetation types, ecologically sensitive habitats and important ecological processes.	Review the location of identified flora, fauna and habitats against the operational footprint and predict impacts from operational activities.
Hydrology and Surface Water Quality	Qualitative and analytical methods were applied to assess direct impact on hydrological and water quality and indirect impact on human beings and ecology from the operational footprint. Additional Quantitative methods to be applied to assess hydrodynamic and morphological of development nearby Sungei Pang Sua only if there is significant change on Sungei Pang Sua predicted for construction phase.	• Environmental Protection and Management (Trade Effluent) regulations • Allowable Limits for Trade Effluent Discharge to Watercourse or Controlled Watercourse (NEA) • Water Quality Criteria for Aquatic Life from other countries including ASEAN Strategic Plan of Action on Water Resources Management (2005), ASEAN Marine Water Quality Management Guidelines and Monitoring Manual (2008), United Nations Economic Commission for Europe (UNECE, 1994), United States Environmental Protection Agency (USEPA, 2017) and Mitigating Impact from Aquaculture in the Philippines (PHILMINAQ, n.d.), Canadian Water Quality Guidelines for the Protection of Aquatic Life (2007) and Australian & New Zealand Guidelines for Freshwater and Marine Water Quality (2007)
Air Quality	Qualitative assessment was conducted to assess air quality impacts of the development operational phases due to increased traffic in the vicinity of the stations.	Compare the change in predicted increase in traffic volume and access routes in the vicinity of the stations and vehicular bridge
Airborne Noise	For operational airborne noise, the ES will take reference to the results of separate Noise and Vibration Study and Acoustics Study for assessment on biodiversity purpose. Assessment on human receptors from operational airborne noise will be undertaken as part of the Noise and Vibration Study and Acoustics Study.	Technical Guideline for Land Transport Noise Impact Assessment from National Environment Agency (NEA) [R-25] Guideline on Boundary Noise Limit for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Buildings by National Environment Agency (NEA) [R-26]; Code of Practice on Pollution Control by National Environment Agency [R-1]

Environmental Parameters	Predictive Methods	Assessment Criteria
Ground-borne Vibration	ISO 14837:2005 Mechanical vibration - Ground-borne noise and vibration arising from rail systems. International Organization for Standardization [R-82]	MOTIV is used to predict the vibration from moving trains for the assessment. As universal criteria assessment for ecological receptors is unavailable, AECOM reviews the baseline vibration data collected from the study area and proposes project-specific criteria. Refer to Section 11.6. Human impacts are excluded from this study as they are reported separately in the NVS Prelim Report.
Soil, Groundwater and Waste Management	Qualitative assessment of impacts on soil and groundwater due to proposed operational activities (e.g., maintenance of infrastructure and facilities, storage of chemicals) which may impact identified human and ecological receptors.	The soil and groundwater will be assessed by referring to HLUS report [R-79]. Laboratory analytical results from the soil and groundwater samples will be compared to international standards such as the Soil Remediation Circular (Dutch Standards) and Australian and New Zealand Guidelines for Fresh and Marine Water to determine potential impacts to downstream waterbodies (if any).
Vectors	Qualitative assessment to evaluate the impacts of operational activities (e.g., above-ground station facilities' operation) that potentially promote vector-breeding within the project's study area.	Review desktop findings and discuss the potential vector-promoting activities from the operational footprint of the Project.

6.4.2 Evaluation of Impacts

Impacts were evaluated based on their significance, a measure of the weight that should be given to each impact in decision making and if it warrants impact management. It was assessed using the following two factors in the Impact Significance Assessment Matrix (refer to Table 6-9) as detailed below and in the following sections:



• **Impact Consequence:** The consequence of an impact is a function of a range of considerations, including impact spread, impact duration, impact intensity and nature, legal and guideline compliance;

• **Likelihood of Occurrence:** The likelihood of the impact occurring in the life of the Project.

6.4.2.1 Impact Consequence

In evaluating the consequence of environmental impacts, the following aspects were taken into consideration:

- Receptor Sensitivity: Categorises receptors according to their susceptibility to adverse impacts from the Project's construction and operational phases (refer to Table 6-2);
- Impact Intensity: Defines the magnitude of the impact and the status of the impact in relation to environmental parameters of interest, based on regulations (e.g., discharge limits), standards (e.g.,

environmental quality criteria) and guidelines. The criteria presented in Table 6-6 were used to categorise the impact intensity.

Table 6-6 Evaluation of Impact Intensity for Construction and Operational Phases (Human Response)

Environmental Parameters	Impact Intensity			
	Negligible	**Low**	**Medium**	**High**
Biodiversity	No detectable change to flora, fauna and habitats.	Potential impacts last a short duration, are reversible and/or of a small magnitude for an area with low ecological value.	Potential impacts last for a moderate duration, are reversible with significant input and compensatory measures, and/or of a moderate magnitude for an area with moderate ecological value.	Potential impacts last for a long time, are non-reversible, and/or of a significant magnitude for an area with high ecological value.
Hydrology	Very minor change to existing hydrology and flow.	Small scale localised changes to existing hydrology or flow.	Medium scale changes to existing hydrology or peak flow.	Major changes to existing hydrology or peak flow.
Water Quality	No contamination; or likely to be well within regulatory limits.	Small scale localised contamination within regulatory limits.	Medium scale contamination or just exceed regulatory limits.	Large scale contamination exceeds regulatory limits by hazardous levels for the habitat/ conservation species.
Air Quality (Construction Phase)[9]	-	For Demolition: 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	For Demolition: Total building 20,000 – 50,000 m^3 Potentially dusty construction material Demolition activities 10-20 m above ground level	For Demolition: Total building >50,000 m^3 Potentially dusty construction material (e.g., concrete) On-site crushing and screening Demolition activities >20 m above ground level

[9] This impact intensity criterion is equivalent to the Emission Magnitude as defined in IAQM's Guidance [R-9].

Environmental Parameters	Impact Intensity			
	Negligible	Low	Medium	High
	-	For Earthworks: 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 <20,000t Earthworks during wetter months	For Earthworks: Total site area 2,500 m^3 – 10,000 m^3 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 20,000-100,000t	For 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 >100,000t
	-	For Construction: Total building volume <25,000 m^3 Construction material with low potential for dust release (e.g., metal cladding or timber)	For Construction: Total building volume 25,000-100,000 m^3 Potentially dusty construction material (e.g., concrete) On-site concrete batching	For Construction: Total building volume >100,000 m^3 On-site concrete batching sandblasting
	-	For Trackout: <10 HDV[10] (>3.5t) outward movements in any one day Surface material with low potential for dust release Unpaved road length <50 m	For Trackout: 10-50 HDV[10] (>3.5t) outward movements in any one day Moderately dusty surface material (e.g., high clay content) Unpaved road length 50-100 m	For Trackout: >50 HDV[10] (>3.5t) outward movements in any one day Potentially dusty surface material (e.g., high clay content) Unpaved road length >100 m
Air Quality (Operational Phase)	Insignificant increase in air quality levels in the vicinity of the Project operation	Small scale increase in air quality levels in the vicinity of the Project operation	Medium scale increase in air quality levels in the vicinity of the Project operation	Large scale increase in air quality levels in the vicinity of the Project operation

[10] Heavy duty vehicles (HDV) defined as vehicles with a gross weight greater than 3.5 tonnes.

Environmental Parameters	**Impact Intensity**			
	Negligible	**Low**	**Medium**	**High**
Airborne Noise (Human Response)	The predicted noise levels are within the regulatory noise limits.	The exceedance of values compared to regulatory noise limits is within 0-3 dB (A).	The exceedance of values compared to regulatory noise limits is within 3-6 dB (A).	The exceedance of values compared to regulatory noise limits is greater than and equal to 6 dB (A).
Airborne Noise (Ecological Response)	No detectable change to flora, fauna and habitats.	The exceedance of values compared to baseline noise results is within 0-3 dB (A)	The exceedance of values compared to baseline noise results is 3-6 dB (A).	The exceedance of values compared to baseline noise results is greater than 6 dB (A).
Ground-borne Noise (see note 1) (Human Response)	**No Priority 1 sensitive receptors have been found for the assessment.**			
	Human only (Priority 2)			
	≤ L_{ASmax} 35 dB	L_{ASmax} 36 - 39 dB	L_{ASmax} 40 - 44 dB	≥ L_{ASmax} 45 dB
	Human only (Priority 3)			
	≤ L_{ASmax} 45 dB	L_{ASmax} 46-49 dB	L_{ASmax} 50-54 dB	≥ L_{ASmax} 55 dB
Ground-borne Vibration due to rock breaking and excavation (see note 3) (Human Response)	**No Priority 1 sensitive receptors have been found for the assessment.**			
	Human only (Priority 2)			
	< PPV, 6.0 mm/s	PPV, 6.0 – 10.0 mm/s	PPV, > 10.0 - < 15.0 mm/s(see note 4)	
	Human only (Priority 3)			
	< PPV, 14.0 mm/s	PPV, 14.0 - < 15.0 mm/s(see note 4)		
Ground-borne Vibration due to other construction activities (see note 2) (Human Response)	**No Priority 1 sensitive receptors have been found for the assessment.**			
	Human only (Priority 2)			
	< PPV, 0.30 mm/s	PPV, 0.30 – < 1.0 mm/s	PPV, 1.0 – < 10.0 mm/s	≥ PPV, 10.0 - <15.0 mm/s(see note 4)
	Human only (Priority 3)			
	< PPV, 1.0 mm/s	PPV, 1.0 – < 10.0 mm/s	≥ PPV, 10.0 - < 15.0 mm/s(see note 4)	
Ground-borne Vibration due to blasting(see note 3) and other construction activities (Ecological Response)	Lower bound of baseline(see note 5) along Rail Corridor (0.03 mm/s) – < Upper bound of baseline(see note 5) along Rail Corridor (0.09 mm/s)	Upper bound of baseline(see note 5) along Rail Corridor (0.09 mm/s) - < PPV, 1.2 mm/s	PPV, 1.2 mm/s, - < PPV, 5.0 mm/s	≥ PPV, 5.0 mm/s

Environmental Parameters	Impact Intensity			
	Negligible	Low	Medium	High
Soil, Groundwater and Waste Management	No contamination of soil and groundwater. No reduction in groundwater levels.	Small scale, localised soil or groundwater contamination which is not likely to extend beyond the study area and is possible to remediate. Small scale, localised groundwater level decrease which is not likely going to extend beyond the study area.	Medium scale soil or groundwater contamination which is likely to extend beyond the study area but is possible to remediate within the construction period time frame. Medium scale groundwater level decrease that is possibly going to extend beyond the study area.	Large scale soil or groundwater contamination which is likely to extend beyond the study area and may require large scale remediation. Large scale groundwater level decrease that is likely going to extend far beyond the study area.
Vectors	Construction or operational activities generate negligible amounts of food waste and/or stagnant water.	Construction or operational activities generate low accumulation of stagnant water and/or waste.	Construction or operational activities generate moderate accumulation of stagnant water and/or waste.	Construction or operational activities generate high accumulation of stagnant water and/or waste.

Notes:

1. Operational ground-borne noise impact assessment for human response is excluded from this report. Ground-borne noise impact assessment is not applicable for ecological receptors.
2. The impact intensity criteria for ecology are explained in Section 11.7.1. Operational ground-borne noise impact assessment on humans is excluded from this report.
3. Blast occurs in the day only, and this impact assessment assesses up to three blast events per day.
4. > PPV, 15.0 mm/s is unacceptable as this will lead to cosmetic damage to the building
5. Refer to Section 11.5 for the baseline findings.

A consequence category is then derived based on receptor sensitivity and impact intensity, as shown in Table 6-7. The air quality impact assessment uses matrices specific to the Institute of Air Quality Management (IAQM) Guidance on assessing dust from demolition and construction, which are provided in Section 9.2.2.3.

Table 6-7 Impact Consequence Matrix for Construction and Operational Phases

Sensitivity / Impact Intensity	Priority 3	Priority 2	Priority 1
Negligible	Imperceptible	Imperceptible	Very Low
Low	Very Low	Very Low	Low
Medium	Very Low	Low	Medium
High	Low	Medium	High

6.4.2.2 Likelihood

Likelihood is estimated on the basis of experience and/ or evidence that such an outcome has previously occurred. Impacts resulting from routine/ planned events (normal operations) are classified under Likely/ Certain Likelihood.

Table 6-8 Likelihood Criteria

Likelihood Criteria	Definition for All Environmental Parameters	Definition for Quantitative Evaluation (Construction & Operational)
Unlikely/ Remote*	Would be unlikely or remotely expected to occur during construction and operational phases.	When the frequency of exposure to noise/vibration impacts for fauna is < 5% during the construction or operation phase.
Less Likely/ Rare*	Would less likely or rarely occur during construction and operational phases.	When the frequency of exposure to noise/vibration impacts for fauna is 5 – 15% during the construction or operation phase.
Possible/ Occasional*	Would possibly or occasionally occur during construction and operational phases.	When the frequency of exposure to noise/vibration impacts for fauna is 16 – 25% during the construction or operation phase.
Likely/ Regular*	Would likely to occur or would occur on a regular basis during construction and operational phases.	When the frequency of exposure to noise/vibration impacts for fauna is 26 – 50% during the construction or operation phase.
Certain/ Continuous*	Would be certain to occur or would occur continuously during construction and operational phases.	When the frequency of exposure to noise/vibration impacts for fauna is > 50% during the construction or operation phase.

Note:
* The second term (i.e., remote, rare, occasional, regular, continuous) is not applicable to noise/ground-borne vibration.

References:
1. Ecological Impact Assessment (EcIA). EIANZ Guidelines for use in New Zealand: terrestrial and freshwater ecosystems. 2nd Edition. May 2018. [R-58]
2. CIEEM (2018). Guidelines for ecological impact assessment in the UK and Ireland: Terrestrial, Freshwater and Coastal. September 2018. [R-59]

6.4.2.3 Impact Significance

The significance of each impact will be determined by assessing the impact consequence against the likelihood of the impact occurring using the Impact Significance Assessment Matrix. A simple risk-based matrix will be used for the summation of consequence and likelihood, a sample of which is shown below.

Table 6-9 Impact Significance Matrix

Consequence / Likelihood	Imperceptible	Very Low	Low	Medium	High
Unlikely/ Remote	Negligible	Negligible	Negligible	Negligible	Negligible
Less Likely/ Rare	Negligible	Negligible	Minor	Minor	Minor
Possible/ Occasional	Negligible	Minor	Minor	Moderate	Moderate
Likely/ Regular	Negligible	Minor	Moderate	Moderate	Major
Certain/ Continuous	Negligible	Minor	Moderate	Major	Major

Positive impacts are classified under a single category. Impacts assessed as negligible or minor will require no additional management or mitigation measures (on the basis that the magnitude of the impact is sufficiently small, or that the receptor was of low sensitivity and/or that adequate controls were already included in the Project design). Negligible and minor impacts are therefore deemed to be "Insignificant". Impacts evaluated as moderate or major require the adoption of management or mitigation measures. Major impacts are therefore deemed to be "Significant" and moderate impact as "Relatively Significant". Major impacts always require further management or mitigation measures to minimize or reduce the impact to an acceptable level.

An "acceptable level" is the reduction of a major impact to a moderate one after mitigation. In seeking to mitigate moderate impacts, the emphasis is on demonstrating that the impact has been reduced to a level that is as low as reasonably practicable. It will not always be practical to reduce moderate impacts to minor ones in consideration of the cost-ineffectiveness of such an approach (due to the diminishing return of a reduction of impact versus cost). Residual impact assessment will be conducted for those parameters where impact from the activity is identified to be significant and additional mitigation measures are recommended. Positive impacts were not assessed for significance. Assessment of residual impact will follow similar risk approach as outlined above.

The table provides the brief understanding for the final impact significance level.

Table 6-10 Definition of Final Impact Significance Level

Impact Significance Levels	Definitions
Negligible	Impacts are indistinguishable from the existing baseline environmental conditions, or non-noticeable by the receptor/ habitat as a change. A negligible impact is unlikely to pose concern to the government, communities and organisations.
Minor	Impacts of low magnitude, shorter term, reversible. Minor impacts are usually within accepted limits/standards provided with minimum controls or best practices, and is unlikely to pose concern to the government, communities and organisations.
Moderate	Impacts of medium magnitude, longer term, but reversible. Moderate impacts are manageable within accepted limits/standards after consideration of suitable mitigation measures or can be reduced to a level that is as low as reasonably practicable.
Major	Impacts of high magnitude, exceeds limits/standards, permanent and non-reversible.

Impact Significance Levels	Definitions
	Major impacts should seek alternatives in design/ location etc. and/ or mitigation measures to avoid/compensate and/or reduce major impacts to as low as reasonably practicable.

6.5 Mitigation of Impacts and Environmental Monitoring and Management Plan (EMMP)

Where the implementation of minimum controls is insufficient to alleviate any significant environmental construction and operational impacts (moderate to major impacts), Project-specific final mitigation measures, in consultation with the LTA and relevant Authorities, will be proposed. Where applicable and practical, engineering control measures will be accompanied by specifications (product brochures), estimated cost and source of supply. In addition, mitigation measures at receptors' end will also be recommended on a case-by-case basis.

For example, if the unmitigated construction noise levels are found exceeding the relevant criteria, practical direct mitigation measures such as the use of noise barriers, enclosures, quieter powered mechanical equipment (PME) and construction methods, etc. will be recommended. Effective dust control measures will be recommended to minimize dust emission from the site, where necessary. Mitigation measures will be proposed in accordance with the following hierarchy in line with Biodiversity Impact Assessment (BIA) Guidelines published by NParks in year 2020 [R-63]:

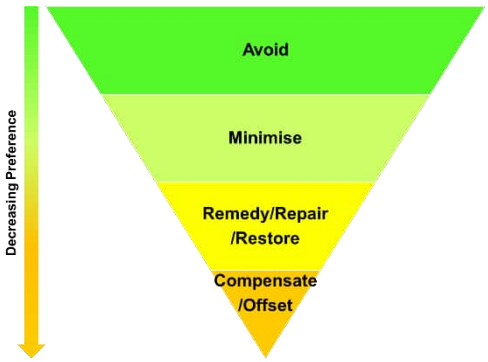


Figure 6-2 Mitigation Hierarchy

- **Avoid** – Where changes to the Project design and construction/ operational methodology can be made to eliminate or avoid an identified impact (e.g., optimisation or reduction of construction footprint, shift or elimination of construction site in critical areas, etc.). If a full elimination is not possible, the next level of mitigation is to minimize the identified impact;
- **Minimize** – Where changes to the Project design and construction/ operational methodology cannot affect impact elimination or avoidance, use of alternative construction methodology or any enhancement measures can be adopted to minimize for identified impacts. For e.g., a wildlife shepherding plan is put in place to allow any animals trapped on the site to escape into the surrounding vegetation;
- **Remedy/ Repair/ Restore** – Where changes to the Project design and construction/ operation cannot affect impact avoidance and impact minimization, restoration methodology can be applied after construction is completed to remedy/ repair/ restore the ecological habitat as much as possible. For e.g., after construction, appropriate trees and shrubs are replanted in appropriate locations on the impacted site to restore part of the habitat;
- **Compensation/ Offset –** Where measures taken to compensate or offset the residual impacts after implementing the first three steps of the mitigation hierarchy, wherever technically and financially feasible, e.g., transplanting of rare shrubs or trees to elsewhere in consultation with government authorities, etc.

Subsequently, a Construction phase EMMP and Operational phase EMMP will be formulated specifying mitigation measures, monitoring scope, methodology and location, and triggers to report and escalate the irregularities in the baseline conditions at construction/ operational phase. The basis of EMMP is provided in Section 14 which also summarises information about identified sensitive receptors, potential impacts evaluated, residual impacts (if any) and frequency of monitoring (if required), as well as close up actions.

It is worth noting that the potential cumulative impacts from a few concurrent developments nearby the Project are discussed qualitatively during the impact evaluation process of this ES, as provided in the individual sections

of each environmental discipline. When there is significant escalation of environmental impacts due to the concurrent development, relevant mitigation measures are proposed holistically for this Project, and where appropriate, recommendations are provided to the Client and/or the corresponding developers to minimise or manage the potential cumulative impacts.

7 Biodiversity

7.1 Introduction

The Biodiversity Impact Assessment aims to establish baseline biodiversity information of the Study Area and evaluate the impacts of the proposed construction works on existing flora and fauna. Baseline information will be first gathered through reviews of past and present biodiversity records, published literature. Actual field surveys were carried out to verify and supplement the data, in consultation with taxonomic experts. Through desktop and field assessments, important habitats, species of flora and fauna of conservation significance were identified.

This information will be used to evaluate the extent of the impact of activities at both construction and operational phase. Mitigation measures will be recommended to reduce and/or minimize the impacts. This report only presents the baseline findings.

7.2 Methodology

7.2.1 Desktop Assessment (Secondary Data Collection)

7.2.1.1 Land Use History

Historical and present-day land use of the Study Area were reviewed. Information on land use history was primarily be gathered from old maps in the online collection of the National Archives of Singapore (NAS) as well as historical maps on the OneMap and the National University of Singapore (NUS) Libraries portals. A list of faunal species of conservation significance that are likely to occur at the site (termed thereafter as “species of probable occurrence”) was also be generated using information on past faunal records and existing habitat types and past fauna records up to 2 km from the Study Area.

7.2.1.2 Taxonomy and Nomenclature

Past and present floristic as well as faunistic species composition were examined using relevant key references that include books, scientific publications, unpublished literature, and online databases. Sources of databases include Singapore Red List by the National Parks Board [W-75], The Biodiversity of Singapore by the Lee Kong Chian Natural History Museum [W-80], Flora and Fauna Web by the National Parks Board [W-82] and iNaturalist [W-84]. Other key references include the Singapore Red Data Book [P-8], Singapore Biodiversity Records [W-81], encyclopedia on Singapore’s biodiversity [P-33] and the database of flora and fauna records compiled by AECOM.

Key local and/or regional references for the various taxonomic groups are listed in the table below.

Table 7-1 Summary of Identified Sensitive Receptors

Taxon	Key References
Plants	Chong et al., 2009 [P-6]; NParks Flora and Fauna Web [W-82]; Lindsay et al., 2022 [P-25]; NParks Singapore Red List [W-75]
Freshwater molluscs	World Register of Marine Species [W-34]
Odonates	NParks Singapore Red List [W-75]
Butterflies	NParks Singapore Red List [W-75]
Freshwater decapod crustaceans	Ng, 1997 [P-32]; Cai et al., 2007 [P-3]

Taxon	Key References
Freshwater fish	Kottelat, 2013 [P-22]; Suzuki et al., 2015 [P-41]; Ho et al., 2016 [P-15]
Herpetofauna	Figueroa et al. [P-9]
Birds	NParks Singapore Red List [W-75]
Mammals	NParks Singapore Red List [W-75]

7.2.1.3 Species 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 Singapore Red List [W-75] as nationally Vulnerable, Endangered, Critically Endangered, or Presumed Extinct (which indicates a rediscovery)—will be 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 will be 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. If the origin of a threatened species population is disputable or difficult to determine, we will corroborate findings from field surveys of fauna and/or adopt the more conservative approach by considering them of conservation significance. In carrying out such assessments, we are then able to prioritize conservation needs and focus resources 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 reference the Singapore Red List [W-75]. The global conservation status references the Red List of Threatened Species by the International Union for Conservation of Nature Nature (IUCN, 2012 [P-18]).

7.2.2 Field Assessment (Primary Data Collection)

7.2.2.1 Site Reconnaissance

Site reconnaissance surveys were conducted from 12 – 22 October 2021 to obtain an initial understanding of the existing habitats and biodiversity. Field observations were used for planning and execution of the actual surveys. The objectives of the reconnaissance survey are as follows:

- Determine site accessibility and terrain
- Conduct a preliminary assessment to determine the dominant vegetation types
- Identify locations of existing natural permanent waterbodies, such as streams, ponds, and swampy areas (if any)
- Mark out survey sampling routes and potential locations for camera traps

7.2.2.2 Floristic Field Assessment

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

7.2.2.2.1 Habitat and Vegetation Mapping

A preliminary vegetation map was first prepared based on visual interpretations of satellite images from Google Earth Pro 7.3.3.7786 (Google Inc. 2021 [O-4]). Preliminary classification of the vegetation types—for example, scrubland, forest and mangroves vegetation—was determined using visual features, such as textures and colors, observed in the satellite images. Adjustments were then made to the preliminary maps according to actual observations during ground truthing. Ground truthing was conducted throughout the Study 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 Pro 7.3.3.7786. The classification of vegetation types reference NParks [R-63].

7.2.2.2.2 General Walking 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 and national conservation status follow that of Chong et al. (2009) [P-6], and/or other published papers with information on the updated assessment of the species nomenclature and/or conservation status. The latter is usually for one or a few individual species. Other information on the plant species were also be crosschecked with online databases, namely, the National Parks Board Flora and Fauna Web and Singapore Biodiversity Online.

For plants that could not be immediately identified with certainty in the field, photographs and/or voucher specimens were also 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 will be collected from the forest floor and used to aid in species identification.

Species of Conservation Significance
The geographic coordinates of plants of conservation significance 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 are clusters of plants of conservation significance—i.e., more than one individual occurring within 5 m or less of another individual—the geographic coordinates of the approximate centre of the area were marked using the GPS receiver.

Large Plant Specimens
Similarly, the GPS receiver was used to record locations of all trees of ≥ 3 m girth, as well as bamboo clusters, palm clusters, and strangling *Ficus* species of ≥ 3 m spread. Individuals were identified to species and whenever possible, measure girth (for trees)/estimate spread (for bamboo clusters, palm clusters, and strangling Ficus species), estimate height and tag them with unique serial numbers.

Other Plant Specimens of Value
Locations of other plants that are of value but do not meet the minimum size requirement, as detailed in the above sub- section, were also be recorded using the GPS receiver. Examples of such include bamboo clusters of <3 m spread that may be important refugia for rare bamboo bats, amongst others. These specimens can fall under the categories mentioned above (i.e., species of conservation and large specimens) and trees and/or strangling species of ≥ 1.0 m girth which was recorded during tree mapping survey. Geographic locations of all keystone species were recorded using the GPS receiver (Garmin GPSMap® 64s or/and Differential GPS receivers).

7.2.2.2.3 Tree Mapping

Mapped specimens were tagged with a unique serial number on site; this includes all trees, single-stemmed palms, and strangling Ficus species of ≥ 1.0 m girth or spread, mangrove trees of ≥ 0.3 m girth, as well as those of species of conservation significance of ≥ 0.3 m girth or spread. Single-stemmed palms are defined in this study as having one obvious and erect stem. Geographic locations, girth/spread and height were also recorded. A Differential Global Positioning System (DGPS) receiver which records locations with accuracy of ± 1 m and less

was used to record geographic locations of the specimens. The model of DGPS used during the tree mapping survey are:

- CHC® Navigation HCE320 Global Navigation Satellite System [GNSS] data controller, CHC® Navigation i90 Pro GNSS receiver and Leica DISTO™ D510 rangefinder) (Figure 7-1A);
- Hi-Target Qmini A5 High Precision Handheld data controller, Hi-Target V-90 GNSS receiver and Leica DISTO™ D510 rangefinder) (Figure 7-2), and
- Ulefone Armor 7 X-Pad GO GNSS data controller, Geomax Zenith06 Smart Antenna, and DISTO™ D510 rangefinder).

Geographic location of specimens was captured 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 [W-36]). Where there are clusters of specimens of the same species occurring within 1–2 m of each other, only one specimen will be tagged, and its location marked using the DGPS.

Figure 7-1 (A) CHC® Navigation HCE320 GNSS data controller (Source: Geo-Matching.Com); (B) How it is used in the field

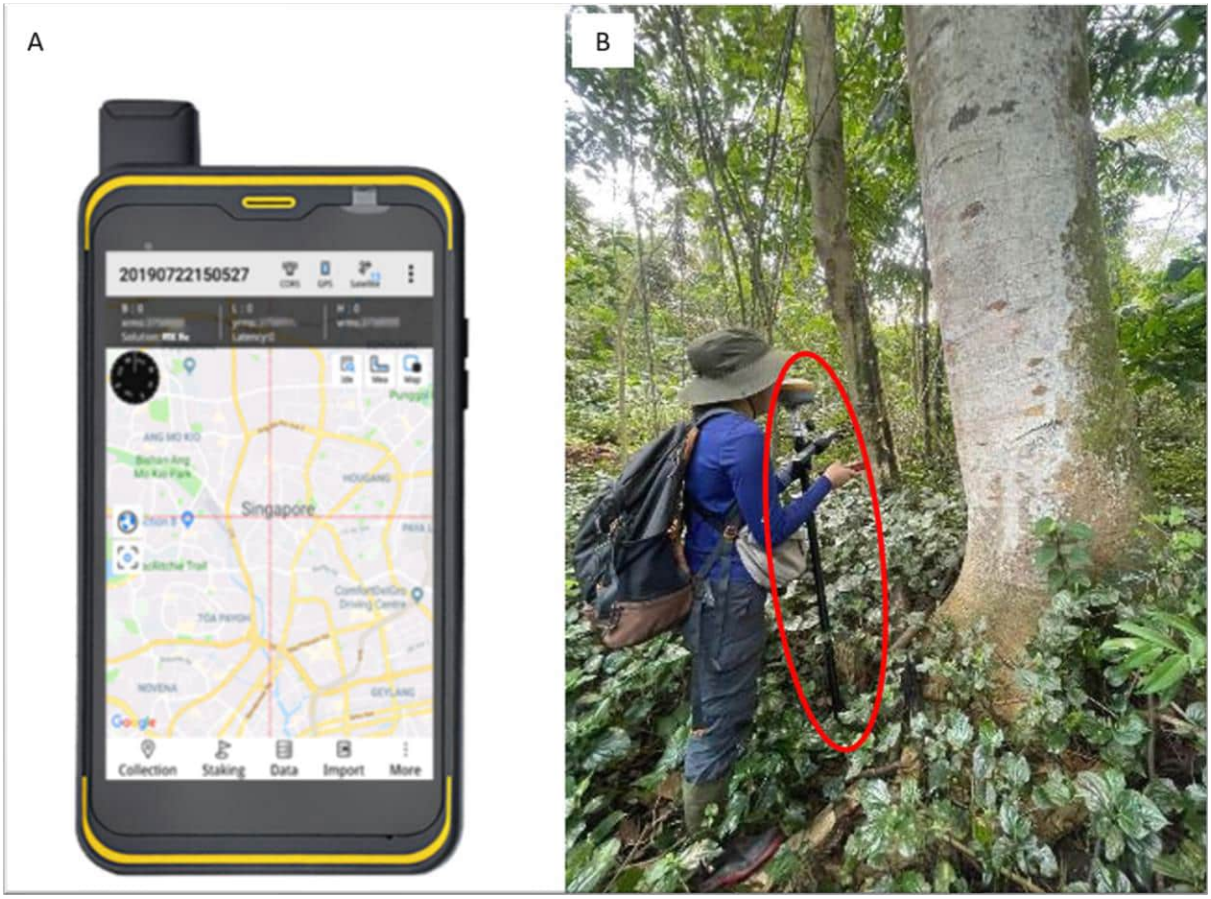


Figure 7-2 (A) Hi-Target Qmini A5 High Precision Handheld data controller (Source: Geo-Matching.com); (B) How it is being used in the field

Figure 7-3 (A) Ulefone Armor 7 X-Pad GO GNSS data controller; (B) How the DGPS is used in the field

7.2.2.3 Faunistic Field Assessment

Faunal field surveys were carried out for the following taxa: (1) butterflies, (2) odonates (damselflies and dragonflies), (3) herpetofauna (amphibians and reptiles), (4) birds, (5) mammals (including bats), and (6) aquatic fauna (fish, decapod crustaceans and limulids and molluscs). All observations of notable species from the aforementioned taxa were also recorded if seen outside the stated survey times. Mapping of mud lobster mounds

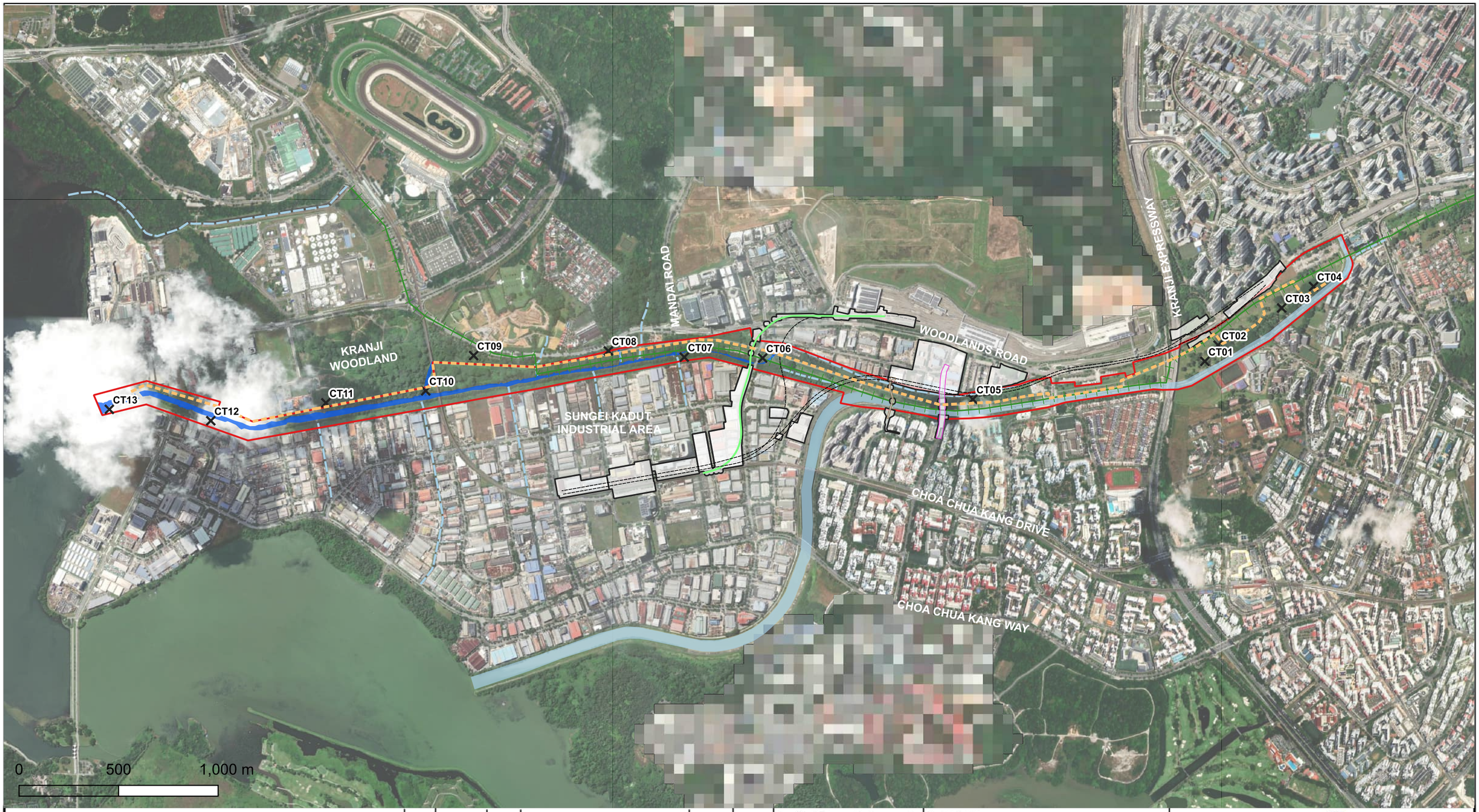
were also conducted along Sungei Pang Sua. The finalised locations of fauna sampling units are shown in Figure 7-4 to Figure 7-6.

Table 7-2 summarises all the surveys that were carried out for fauna. Each survey was performed by at least two surveyors. All fauna encountered were identified to species, or to the next lowest taxonomic level possible, and the location of each individual were recorded using a handheld GPS (Garmin GPSMAP 64s). The number of individuals observed were documented.

Table 7-2 Summary of survey methods for fauna

Survey Type	Taxon	Timing (h)	Duration	Sampling Unit	Technique
Diurnal transect surveys	Butterflies	0900–1500	20–30 minutes per transect	200-m continuous transects along a sampling route	Visual only; up to 25 m left, right, and front of surveyor
	Odonates (damselflies and dragonflies)	0900–1500	20–30 minutes per transect	200-m continuous transects along a sampling route	Visual only; up to 25 m left, right, and front of surveyor
Diurnal and nocturnal transect surveys	Herpetofauna (amphibians and reptiles)	0700–1000; 2000–2300	20–30 minutes per transect	200-m continuous transects along a sampling route	Visual and auditory; up to 50 m left, right, and front of surveyor
	Birds	0700–1000; 2000–2300	20–30 minutes per transect	200-m continuous transects along a sampling route	Visual and auditory; up to 50 m left, right, and front of surveyor
	Mammals (non-volant)	0700–1000; 2000–2300	20–30 minutes per transect	200-m continuous transects along a sampling route	Visual and auditory; up to 50 m left, right, and front of surveyor
Diurnal point counts	Odonates (damselflies and dragonflies)	0900–1500h	5 minutes per point	Sampling points at waterbodies	Visual only; up to 25 m from sampling point or the extent of waterbodies, whichever is smaller
Diurnal and/or nocturnal mangrove point counts	Aquatic fauna (fish, decapod crustaceans and molluscs)	0700–1000	5 minutes per point	Sampling points at waterbodies	Visual only; up to 25 m from sampling point or the extent of waterbodies, whichever is smaller
	Herpetofauna (amphibians and reptiles)	0700–1000; 2000–2300	5 minutes per point	Sampling points at waterbodies	Visual only; up to 25 m from sampling point or the extent of waterbodies, whichever is smaller
	Birds	0700–1000; 2000–2300	5 minutes per point	Sampling points at waterbodies	Visual only; up to 25 m from

Survey Type	Taxon	Timing (h)	Duration	Sampling Unit	Technique
					sampling point or the extent of waterbodies, whichever is smaller
	Mammals (non-volant)	0700–1000; 2000–2300	5 minutes per point	Sampling points at waterbodies	Visual only; up to 25 m from sampling point or the extent of waterbodies, whichever is smaller
Bioacoustics surveys	Mammals (bats)	2000–2300	20–30 minutes per transect	200-m continuous transects along a sampling route	Auditory only
Roost emergence surveys	Mammals (bamboo bats only)	1830–2100	-	Bamboo clusters	Visual and auditory
Camera trapping	Mammals (non-volant)	24 hours a day	60 days	Traps spaced at approximately 250 m apart	Infrared motion sensing
Quadrat sampling	Aquatic fauna (fish, decapod crustaceans and molluscs)	0900–1500; 2000–2300	5 minutes per point	Sampling points at Sungei Pang Sua	Visual only; up to 25 m from sampling point or the extent of waterbodies, whichever is smaller
Push and scoop netting*	Aquatic fauna (fish, decapod crustaceans and mollusc)	Daytime	-	Two sampling points at Sungei Pang Sua (M01, M02) and stream (A01)	-
Minnow trapping*	Aquatic fauna (fish and decapod crustaceans)	Overnight	One day one night	Traps at waterbodies	Baited
Mud lobster mound mapping	Mud lobster	Day	-	-	Visual



Legend

- Biodiversity Study Area
- Proposed DTL2e Tunnel Alignment
- Potential Future Infrastructure
- Proposed Cut and Cover Area
- Proposed Vehicular Bridge
- Pedestrian Overhead Bridge
- Existing Vegetated Area
- Sungei Pang Sua
- Pang Sua Canal
- Stream
- Drain
- Terrestrial sampling route
- Camera trap

Rev.	Date	By	Description	Chk'd	App'd
-	Aug 2024	JT	Environmental Study Report	NHT	JAG

Qualified Person Endorsement :
N/A

LTA Endorsement :
N/A

Consultant : AECOM

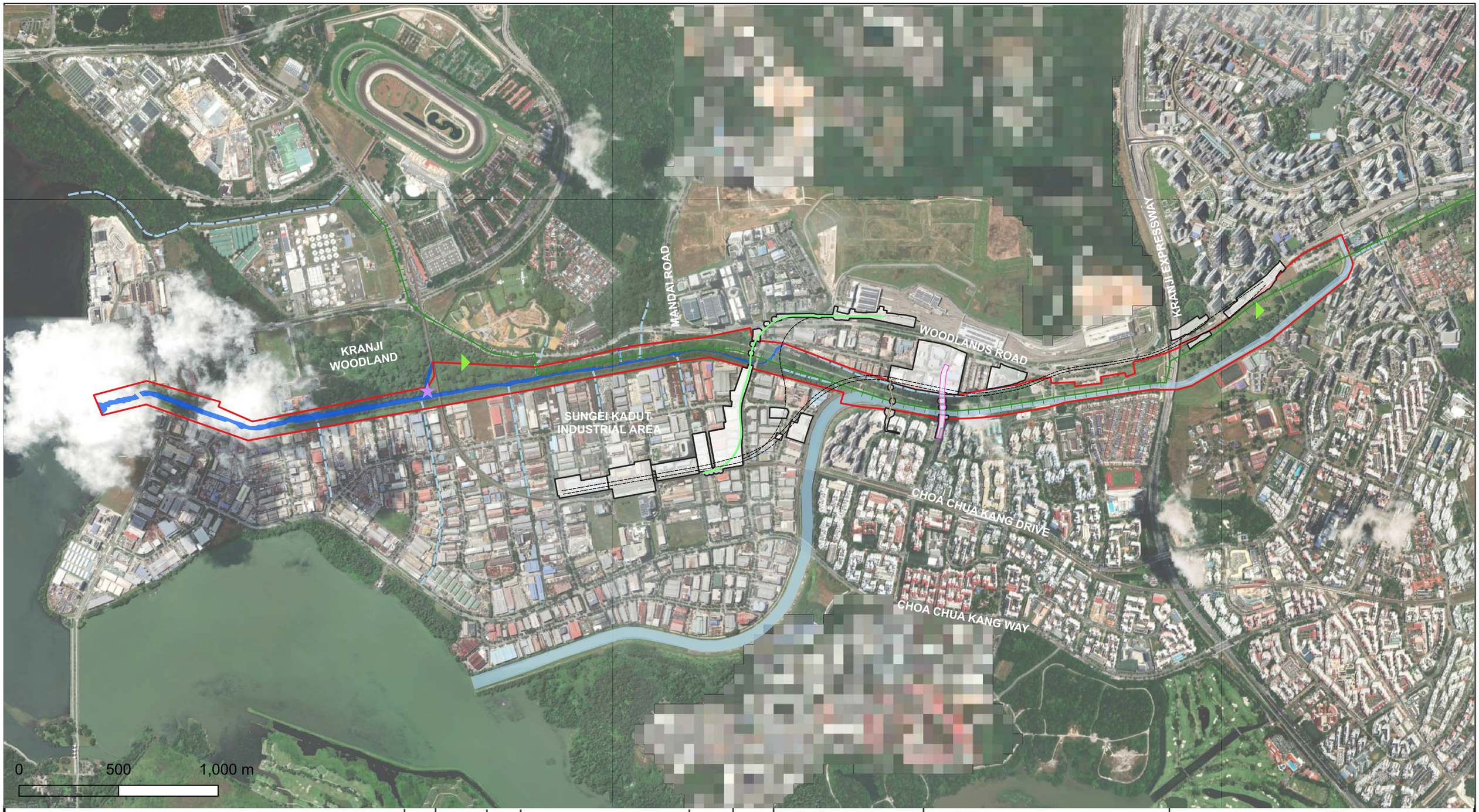
Land Transport Authority
We Keep Your World Moving

Project Title :
CONTRACT 9175
ADVANCE ENGINEERING STUDY FOR THE PROPOSED DOWNTOWN LINE 2 EXTENSION AND A NEW STATION ON EXISTING NORTH-SOUTH LINE

Figure Title :
LOCATION OF TERRESTRIAL SAMPLING ROUTES AND CAMERA TRAPS

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
HHL	NHT	JAG	7-4	-	1 of 1
	Drawn JT	Date Aug 2024	CAD File Name :N/A		A3

Note: Source of basemap - OneMap and Open Street Map



Legend

- Biodiversity Study Area
- Proposed DTL2e Tunnel Alignment
- Potential Future Infrastructure
- Proposed Cut and Cover Area
- Proposed Vehicular Bridge
- Pedestrian Overhead Bridge
- Existing Vegetated Area
- Sungei Pang Sua
- Pang Sua Canal
- Stream
- Drain
- Harp trap
- Bamboo (for roost emergence survey)

Rev.	Date	By	Description	Chk'd	App'd
-	Aug 2024	JT	Environmental Study Report	NHT	JAG

Qualified Person Endorsement :
N/A

LTA Endorsement :
N/A

Consultant : AECOM

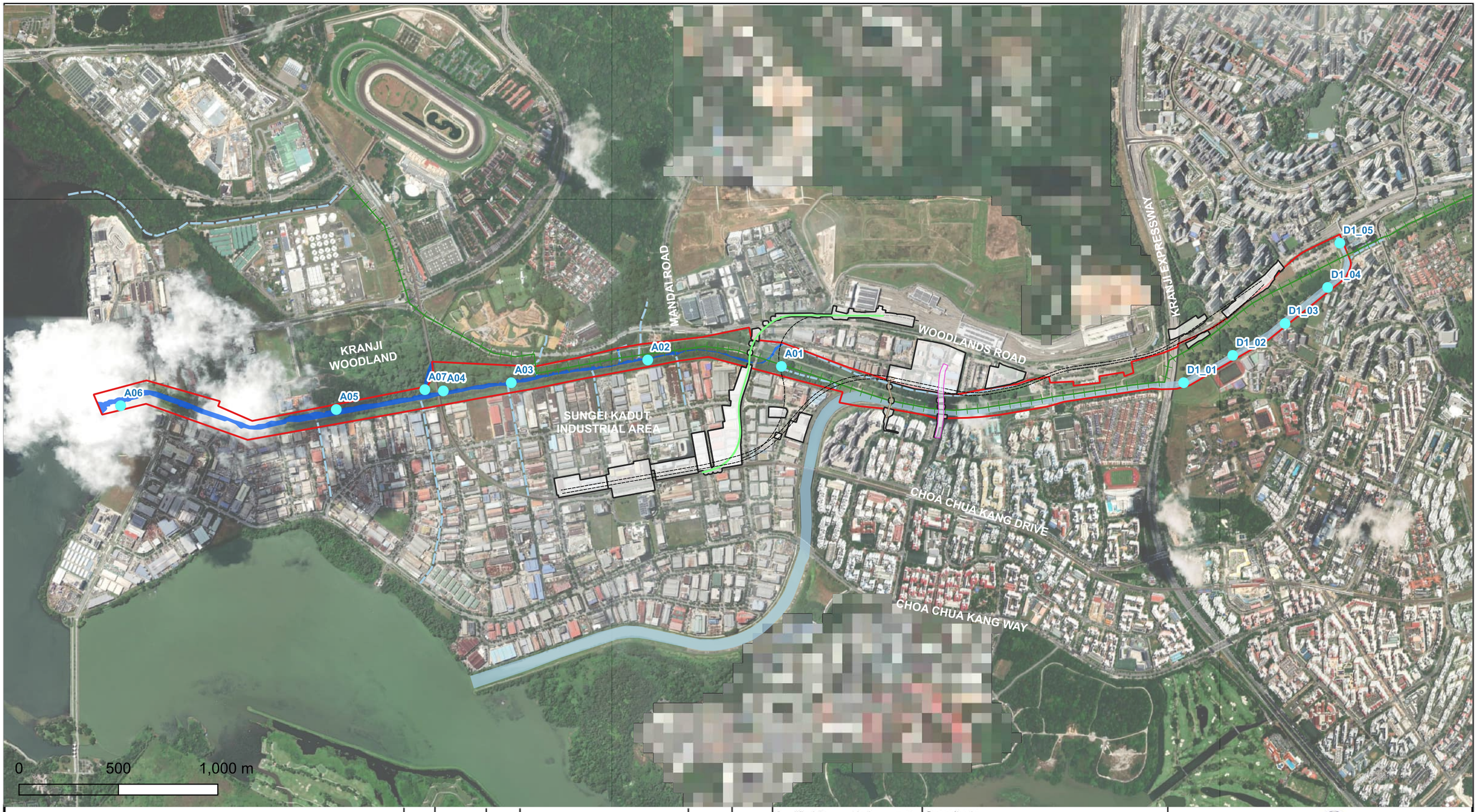
Land Transport Authority — We Keep Your World Moving

Project Title :
CONTRACT 9175 ADVANCE ENGINEERING STUDY FOR THE PROPOSED DOWNTOWN LINE 2 EXTENSION AND A NEW STATION ON EXISTING NORTH-SOUTH LINE

Figure Title :
LOCATION OF HARP TRAP AND ROOST EMERGENCE SURVEYS

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
HHL	NHT	JAG	7-5	-	1 of 1
	Drawn JT	Date Aug 2024	CAD File Name :N/A		A3

Note: Source of basemap - OneMap and Open Street Map



Legend

- Biodiversity Study Area
- Proposed DTL2e Tunnel Alignment
- Potential Future Infrastructure
- Proposed Cut and Cover Area
- Proposed Vehicular Bridge
- Pedestrian Overhead Bridge
- Existing Vegetated Area
- Sungei Pang Sua
- Pang Sua Canal
- Stream
- Drain
- Aquatic sampling point

Rev.	Date	By	Description	Chk'd	App'd
-	Aug 2024	JT	Environmental Study Report	NHT	JAG

Qualified Person Endorsement :
N/A

LTA Endorsement :
N/A

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title :
CONTRACT 9175
ADVANCE ENGINEERING STUDY FOR THE PROPOSED DOWNTOWN LINE 2 EXTENSION AND A NEW STATION ON EXISTING NORTH-SOUTH LINE

Figure Title :
LOCATION OF AQUATIC SAMPLING POINTS

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
HHL	NHT	JAG	7-6	-	1 of 1
	Drawn JT	Date Aug 2024	CAD File Name :N/A		A3

Note: Source of basemap - OneMap and Open Street Map

7.2.2.3.1 Butterflies

Diurnal transect surveys were carried out for adult butterflies along 200-m continuous transects on a sampling route between 0900h and 1200h. Butterfly caterpillars, pupae, eggs, and host plants were also be 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.

7.2.2.3.2 Odonates (Dragonflies and Damselflies)

Diurnal transect surveys were carried out for adult damselflies and dragonflies along 200-m continuous transects on a sampling route, as well as 5-minutes point counts at aquatic sampling points, between 0900h and 1200h. Owing to difficulties in sampling and identification, aquatic larvae and exuviae were not surveyed. Adult odonates were identified visually (with binoculars where necessary), photographed or caught using insect nets, if required. Captured individuals were released immediately after identification.

7.2.2.3.3 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, as well as 5-minutes point counts at aquatic sampling points within Sungei Pang Sua. 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 were also located or identified by call recognition, whenever possible. For species that are capable of quick retreats and escapes, the individuals were captured by hand, or using hooks, tongs, or dip nets for identification. Captured individuals were released immediately after identification.

7.2.2.3.4 Birds

Diurnal (0700h–1000h) and nocturnal (2000h–2300h) surveys were carried out for birds along 200-m continuous transects on a sampling route, as well as 5-minutes point counts at aquatic sampling points within Sungei Pang Sua. 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. Diurnal point counts were also conducted at aquatic sampling points along Sungei Pang Sua to identify presence of shorebirds.

7.2.2.3.5 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, as well as 5-minutes point counts at aquatic sampling points within Sungei Pang Sua. Both the diurnal and nocturnal surveys also involved searches in burrows and tree holes. Tracks, scats and holts were also be recorded. Mammals will be identified visually (with binoculars where necessary) and photographed. Torches and/or headlamps were also used to elicit eyeshine during nocturnal surveys. Vocalising mammals, such as the squirrels, were located or identified by call recognition, whenever possible.

A total of 13 camera traps were deployed across the Study Area (Figure 7-4). The camera traps were spaced at least 250 m apart within the Study Area. Each camera trap was set up at approximately 20–30 cm above ground (Figure 7-7). They operate 24 hours a day and was programmed to record 10-second footage per motion trigger with a 10-second quiet period following each trigger. Each camera trap was deployed for 60 days. The two camera trap models used are (1) Browning Dark Ops HD Pro X BTC-6HDPX and (2) Browning Strike Force Explorer BTC-EXP.

Figure 7-7 Example of a camera trap setup

7.2.2.3.6 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.

Roost emergence surveys were also be carried out between 1830h and 2100h for bamboo bats, specifically, at bamboo clusters (if any). If present, bamboo bats were identified visually and photographed, and calls recorded using the Echo Meter Touch 2 Pro detector. Bamboo slits that are at least 1 cm wide and long and are actively used for entry and exit, as well as the number of bats residing within each internode were recorded.

Harp trapping was conducted at two locations within the Study Area (Figure 7-5).

7.2.2.3.7 Aquatic Fauna (Fish, Decapod Crustaceans and Molluscs)

There are 12 aquatic sampling points within the Study Area, including 6 along Sungei Pang Sua, 1 in the natural stream at Kranji woodland and 5 along Pang Sua Canal (Figure 7-6).

At the aquatic sampling points along Sungei Pang Sua, mangrove aquatic fauna were surveyed through quadrat sampling on the mudflats during low tide levels between 0.0–0.7 m. Quadrat sampling involves setting 50 x 50cm quadrats at three random locations along the 15-m transect at aquatic sampling points along Sungei Pang Sua (Figure 7-8A). Three random locations were generated using a random generator online (https://www.random.org/; numbers generated were from 1-15); the first three numbers were taken and are not regenerated even if numbers are close to each other. Quadrants are place down in an alternating fashion starting from the right of the transect (Figure 7-8B). In the event the area does not allow a 15m transect to be laid down, haphazard sampling of 3 quadrants were carried out. Within each quadrat, the species visible on the surface were first be recorded together with their abundance. After which, a hand shovel was used to dig about 5 cm into the mud before the mud was sieved for benthic invertebrates (Figure 7-8C). The abundance of each species was also recorded. After surveying the three quadrats, a visual survey of the vicinity was conducted using the 15-m

transect as a rough diameter, forming a circle (Figure 7-8B). This is to survey for more mobile species such as decapods or other species that were not captured during the benthic survey.

Push and scoop netting were only conducted at A01 and A02 in the day. It was not conducted at the rest of the points as water were either too shallow or inaccessibility due to high water levels. Visual diurnal and/or nocturnal surveys were conducted along Sungei Pang Sua and Pang Sua Canal. Minnow trapping was also conducted at the aquatic sampling points along Sungei Pang Sua. Minnow traps were baited with halal meat (e.g., sausage or liver) (Figure 7-9). However, due to the nature of the wide and deep channel of Sungei Pang Sua, tray netting could only be carried out only at selected points where the channel was narrower and safe for accessibility (i.e., A01 and A02; Figure 7-6). Traps were left in place for a maximum of 2 nights, or two tidal cycles and collected at the same time of the day the traps were deployed. No nocturnal sampling was conducted due to safety reasons (risk of encountering crocodiles near water at night).

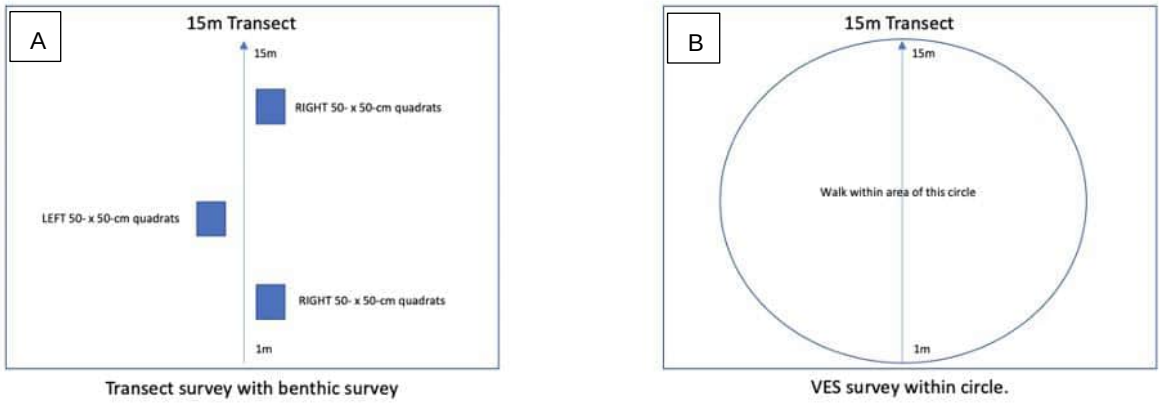


Figure 7-8 (A) Quadrat sampling along a 15-m transect, (B) Visual survey of the vicinity within the 15-m diameter circle, and (C) Quadrat sampling in the mudflat

Figure 7-9 Minnow traps deployed within Sungei Pang Sua.

7.2.2.3.8 Mud Lobster

Since mud lobsters are elusive and difficult to encounter, the presence of mud lobster mounds was used to provide an indication of the presence of mud lobsters along Sungei Pang Sua. Mounds of mud lobsters were mapped to examine the relative abundance of mounds, and corresponding, mud lobsters, along Sungei Pang Sua.

Two to three surveyors walked along both banks of Sungei Pang Sua, at the high tide line during mid tide or lower (<2.0 m tide), to identify and mark the presence of mud lobster mounds. The height of the mound was also recorded. A mound is used as a proxy as the presence of one mud lobster individual [P-28]. An example of the mud lobster mound is shown in Figure 7-10. The data is then used for the calculation of the estimated density of mud lobsters, and for obtaining the distribution of the mud lobster mounds along Sungei Pang Sua.

Figure 7-10 An example of mud lobster mound

7.2.3 Data Analyses

7.2.3.1 Species Distribution Maps

Locations of species of conservation significance were presented on maps to show their distribution within the Study Area. All maps were prepared and generated using the mapping software QGIS 3.4.12.

7.2.3.2 Camera Trapping

Camera trap location, species identity, and the number of individuals were recorded for each video with a positive capture of fauna. An independent detection constitutes video of one or a group of individuals of the same faunal species occurring within 60 minutes at each camera trap. The number of independent detections was used to calculate detection rate of each mammal species.

7.2.3.3 Bat Sound File Analysis

All bat sound files were processed using Kaleidoscope v.4.5.4 (Wildlife Acoustics, Inc.) to separate extraneous noise from files with bat echolocation calls. The signal parameters for recognising a potential bat echolocation call were configured as follows: frequency range of 20–200 kilohertz (kHz), duration of 2–500 milliseconds (ms), maximum inter-syllable gap of 500 ms, and a minimum of 2 pulses. These files were visually processed to identify bat species based on call structures, peak frequency, minimum frequency, and call duration [P-37]. They were identified with reference to those in Pottie et al. (2005) [P-37], which provides echolocation signatures for bats in Singapore, and other relevant references [P-7; P-16].

7.2.3.4 Taxon Sampling Curves

Taxon sampling curves were plotted for selected taxa with sufficient occurrences as large sample sizes are required for the estimation of sample coverage to be robust [P-4]. The observed sample of incidence data was used to estimate sample coverage and species richness. Species richness was plotted against sample coverage, as opposed to survey effort, to estimate sample completeness/ survey adequacy, i.e., how extensively we have sampled the species in the community. Sample coverage refers to "the proportion of the total number of species in a community that belongs to the species represented in the sample" [P-4]. The curve was extrapolated to provide an estimation of species richness and sample coverage if sample size was doubled. The associated standard error and 95% confidence interval were also computed. Standard error represents the range of uncertainty of the estimate, while 95% confidence interval is the interval in which there is a 0.95 probability of containing the estimated true species richness. As some species will always remain undetected, total species richness had to be estimated via extrapolation. This was done using the Chao estimator. All statistical analyses were carried out in the statistical programming environment R version 3.4.3 using the "iNEXT" package 2.0.20 [R-77].

7.3 Biodiversity Baseline Findings

The baseline findings presented below are based on data collected from the floristic and faunistic surveys conducted between 22 November 2021 to 16 March 2022. Data from HDB CCK N1 EBS report was also extracted and compiled under the baseline findings [R-78]. Surveys for the HDB CCK N1 EBS study was conducted between 1 March 2021 to 29 April 2021, as well as migratory bird surveys in October and November 2021. All baseline data were assessed and presented in the sections below.

7.3.1 Floristic Baseline Results

7.3.1.1 Habitat Description

The Study Area comprises six habitat types (Figure 7-11). The habitat type that occupies the largest area is the urban vegetation, which takes up 33.74 ha (36.65%) of the Study Area. This is followed by scrubland (19.51 ha; 21.19%), mangrove forest (11.04 ha; 11.99%), and exotic-dominated secondary forest (6.38 ha; 6.93 %). Altogether, spontaneous vegetation (i.e., a mix of species that grows and reproduces without human care or intent [P-45]) takes up 40.12 % (36.93 ha) of the Study Area. The remaining non-vegetated habitats are waterbodies, such as Pang Sua Canal (9.55 ha; 10.37%), Sungei Pang Sua (7.02 ha; 7.63%), and a natural stream. Other infrastructure and amenities take up (4.82 ha; 5.24%) of the Study Area. The Rail Corridor also runs along the boundary of the Study Area, as seen in Figure 7-11.

Table 7-3 Absolute (ha) and relative (%) sizes, number of vegetation plots, and species richness of each habitat type

Habitat Type	Area (ha)	Percentage (%) of Study Area
Urban vegetation	33.74	36.65
Scrubland	19.51	21.19
Mangrove Forest	11.04	11.99
Exotic-Dominated Secondary Forest	6.38	6.93
Sungei Pang Sua	7.02	7.63
Pang Sua Canal	9.55	10.37

Habitat Type	Area (ha)	Percentage (%) of Study Area
Natural Stream	-	-
Others (Infrastructure and Amenities)	4.82	5.24
Total Spontaneous Vegetation	36.93	40.12
Total Area	**92.06**	**100.00**

KRANJI WOODLAND

SUNGEI KADUT INDUSTRIAL AREA

MANDAI ROAD

WOODLANDS ROAD

KRANJI EXPRESSWAY

CHOA CHUA KANG DRIVE

CHOA CHUA KANG WAY

0 500 1,000 m

Legend

- Biodiversity Study Area
- Proposed DTL2e Tunnel Alignment
- Potential Future Infrastructure
- Proposed Cut and Cover Area
- Proposed Vehicular Bridge
- Pedestrian Overhead Bridge
- Existing Vegetated Area
- Sungei Pang Sua
- Pang Sua Canal
- Stream
- Drain

Habitat Types

- Mangrove
- Exotic-dominated Secondary Forest
- Scrubland
- Urban Vegetation
- Others
- Inaccessible Area

Rev.	Date	By	Description	Chk'd	App'd
-	Aug 2024	JT	Environmental Study Report	NHT	JAG

Qualified Person Endorsement :
N/A

LTA Endorsement :
N/A

Consultant : AECOM

Land Transport Authority
We Keep Your World Moving

Project Title :
CONTRACT 9175
ADVANCE ENGINEERING STUDY FOR THE PROPOSED DOWNTOWN LINE 2 EXTENSION AND A NEW STATION ON EXISTING NORTH-SOUTH LINE

Figure Title :
HABITAT TYPES WITHIN THE STUDY AREA

Designed	Checked	Approved
HHL	NHT	JAG
	Drawn: JT	Date: Aug 2024

Figure No. : 7-11 | Rev. : - | Sheet : 1 of 1

CAD File Name :N/A | A3

Note: Source of basemap - OneMap and Open Street Map

7.3.1.1.1 Urban Vegetation

The majority of the urban vegetation is located in the south of the Study Area. This includes the extension of Villa Verde Park beside Pang Sua Canal which was currently under construction [W-87], Villa Verde Bridge, which is connected to a park connector (Figure 7-12B), and an area known as Pang Sua woodland [P-11; P-13] (Figure 7-12A). This habitat type comprises mostly exotic trees, such as rain tree (*Samanea saman)*, Senegal mahogany (*Khaya senegalensis*) and trumpet tree (*Tabebuia rosea*), and native species, such as sea almond (*Terminalia catappa)*, wild cinnamon (*Cinnamomum iners)* and yellow-flame tree (*Peltophorum pterocarpum*). These trees are distributed across this habitat type, although the majority are located within Pang Sua Woodland. Sapling of native trees, such as *Pteleocarpa lamponga*, *Sterculia parviflora,* and *Syzygium zeylanicum* were also seen planted within Villa Verde Park.

Within this habitat type, there are also areas with little to no trees, comprising of cow grass (*Axonopus compressus*), as well as tall grasses such as elephant grass (*Cenchrus purpureus*) and lalang (*Imperata cylindrica*) that are mostly located along the Rail Corridor. Ground covers, such as creeping tick trefoil (*Desmodium trifolium*), sensitive plant (*Mimosa pudica*), and *Nelsonia canescens* were also observed within this habitat type. Pruning and mulching activities were observed during the survey, suggesting that the trees undergo frequent maintenance. To add on, the height of the grasses was observed to be kept short, which indicates that it is frequently trimmed, especially in areas along the Rail Corridor.

This habitat type is regularly maintained in the Study Area. Pruning and mulching activities observed during the survey suggest that the trees undergo frequent maintenance. Grasses were also observed to be short, which indicates that it is frequently trimmed, especially in areas along the Rail Corridor.

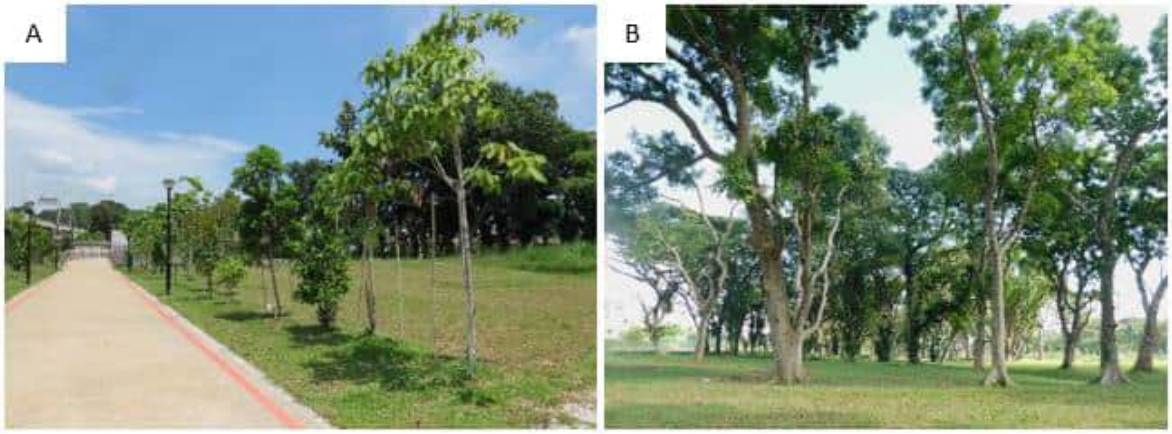


Figure 7-12 Managed vegetation in the Study Area. (A) Pang Sua woodland; (B) A portion of Villa Verde Park

7.3.1.1.2 Scrubland

This habitat type is typically made up of shrubs, climbing/creeping plants, and grasses as a result of any tree fall or recent land clearance which encourages the colonization of sun-loving herbaceous plants, leading to the formation of a scrubland P-47]. Majority of the scrubland within the Study Area occurs along the Rail Corridor (Figure 7-13A), adjacent to the exotic-dominated secondary forest dominated by albizia (*F. falcata*), and behind the mangrove forest (Figure 7-13B). This habitat type comprises exotic grasses and tall grasses, such as elephant grass (*C. purpureum*), lalang (*I. cylindrica*), as well as other herbaceous plant species such as *Bidens pilosa*, *Nephrolepis biserrata, Ottochloa nodosa, Asystasia gangetica* ssp. *micrantha*, as well as climbing/creeping plants, such as *Paederia foetida* and *Passiflora suberosa*.

Figure 7-13 (A) Scrubland that forms along the Rail Corridor, dominated by tall grasses; (B) Scrubland behind the mangrove forest

7.3.1.1.3 Mangrove Forest

Mangrove forest comprises plants and trees that can be found in the intertidal zones which are exposed to highly variable environmental factors, such as sedimentation, temperature, and the fluctuation of the tide level [P-30].

Within the Study Area, the mangrove forest borders the banks of Sungei Pang Sua and stretches towards the north of the Study Area where the waterbody meets with the open sea (Figure 7-14A). Over time, sediment deposition along the banks have also created mudflat habitats for benthic organisms to colonise. Being in proximity to the nearby mangrove and mudflat habitats, namely the Sungei Buloh Wetland Reserve to its east and Mandai Mangrove and Mudflats to its west, some of the fauna and flora communities present here are shaped by the proximity of the Study Area to these coastal habitats. Out of the 36 true mangrove species that can be found in Singapore, almost half (i.e., 17 species) were recorded within this mangrove forest [P-46]. This includes species of conservation significance, such as the nationally Endangered *Ceriops zippeliana* and both species of *Lumnitzera* sp.— *L. littorea* and *L. racemosa.* The water that flows through the mangrove forest is mainly of brackish condition (i.e., water with salinity levels between seawater and freshwater [W-72]. Hence, this encourages the colonisation of mangrove species that thrives in such conditions (Figure 7-14B) [P-31; W-75]. Towards the river mouth where the salinity level increases, the number of specimens of the aforementioned species reduced significantly (low salinity observed in WQ6, water sampling results are detailed in Section 8.4.2). Common mangrove species, *Avicennia alba*, and clusters of nationally Vulnerable Nipah palm (*Nypa fruticans*) are abundant throughout the mangrove forest.

Towards the back mangrove areas where it is often drier, common coastal associated species, such as sea hibiscus (*Hibiscus tiliaceus;* (Figure 7-14C), *Derris trifoliata* (Figure 7-14D) and *Volkameria inermis* grow abundantly. To add on, the nationally Critically Endangered climber *Finlaysonia obovata* was also recorded in multiple clusters within the back mangrove.

The Sungei Pang Sua has mangrove forest lining both the eastern and western banks. Sungei Pang Sua was often observed with high levels of rubbish and pollutions, seemingly contributed by industries in the immediate surroundings.

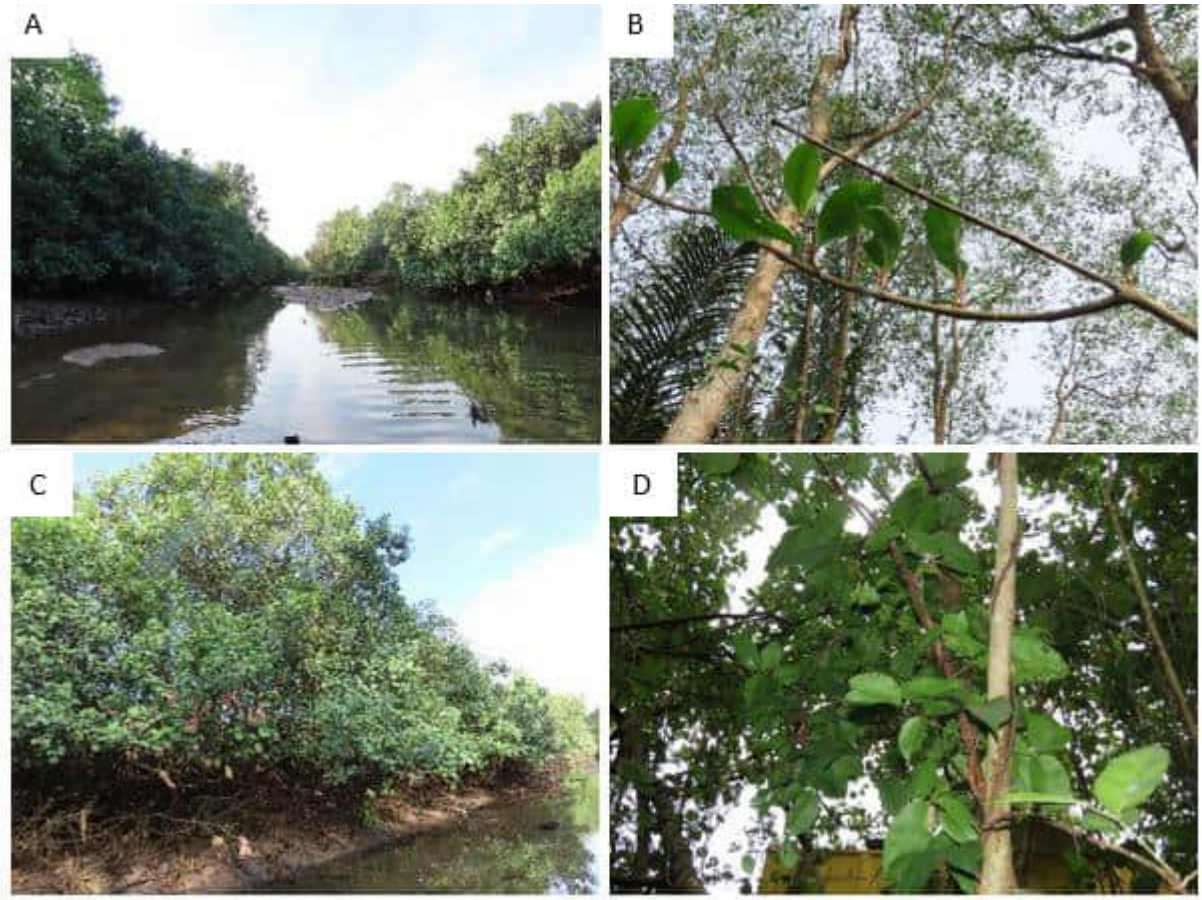


Figure 7-14 Mangrove forest in the Study Area. (A) Strips of mangroves that border the banks of Sungei Pang Sua; (B) Specimens of *Sonneratia caseolaris* had densely colonised the mangrove. Back mangrove species that grow abundantly: (C) *Taliparitiliaceum* and (D) *Derris trifoliata*

7.3.1.1.4 Exotic-Dominated Secondary Forest

This habitat type usually comprises exotic-dominated species that had established themselves on areas that were recently cleared. This vegetation type usually starts as a scrubland that is dominated by sun-loving herbs and shrubs and in time, transforms into an exotic-dominated forest [P-47]. The majority of this habitat type are located mainly in the east of the Study Area, of which, some patches lie along the Rail Corridor (Figure 7-15A). and some abutting the stretch of mangrove. A fragmented patch of this habitat type is also observed beside the mouth of Sungei Pang Sua in the east (Figure 7-11).

Within this habitat type, exotic species, such as albizia (*Falcataria falcata*) mostly dominated the canopy stratum (Figure 7-15B). In some areas where the understorey stratum has formed, African tulip (*Spathodea campanulata*) and *Claoxylon indicum* are observed, along with their saplings on the forest floor. Other exotic species that are occasionally encountered and are typical to this habitat type are *Acacia auriculiformis* and *Leucaena leucocephala*. It is observed that in most areas, the understorey stratum of the forest structure is absent. As such, this allows adequate amount of sunlight to penetrate through the forest floor, encouraging the growth of sun-loving herbs and climbers, such as *A. gangetica* ssp. *micrantha*, *Calopogonium mucunoides* and *Mikania micrantha*. Given that some patches of this habitat type are also located beside scrubland vegetation, grasses such as elephant grass (*C. purpureus*), are a common sight along the edges of the forest (Figure 7-15C).

Based on Google satellite imagery and desktop analysis, the inaccessible area along the mouth of Sungei Pang Sua had been cleared numerous times in the past, leaving only a few stands of trees intact over the years [O-4]. As such, majority of the area that was cleared was eventually dominated by *L. leucocephala* (Figure 7-15D) and

a few specimens of albizia (*F. falcata*). It is also observed that some trees that had persisted within the area were small clusters of trumpet trees (*T. rosea*) which could have been planted in the past.

Figure 7-15 (A) Exotic-dominated secondary forest located beside the Rail Corridor; (B) Exotic-dominated secondary forest dominated by albizia (*Falcataria falcataria*); (C) Edge of the habitat dominated by elephant grass (*Cenchrus purpureus*); (D) Inaccessible area that was dominated by Leucaena leucocephala, indicated by the red arrow

7.3.1.1.5 Waterbodies

Waterbodies that were identified within the Study Areas are the Sungei Pang Sua, Pang Sua Canal, and a natural stream (Figure 7-16). Sungei Pang Sua makes up 7.02 ha within the Study Area. From the south of Sungei Kadut Avenue, it stretches for approximately 3.7 km, before it drains into the open sea located north of the Study Area (Figure 7-16B). The water level is influenced by the tide of the sea and flows through the mangrove forest, forming a continuum of marine and brackish conditions (Section 8.4.2). The Pang Sua Canal is located west of the urban vegetation, which channels water into Kranji Reservoir (Figure 7-16A). Lastly, the 150 m natural stream drains from the adjacent Kranji woodland into the Sungei Pang Sua (Figure 7-16C).

Figure 7-16 Waterbodies in the Study Area. (A) Pang Sua Canal; (B) Sungei Pang Sua and (C) natural stream

7.3.1.1.6 Others (Amenities and Infrastructure)

Infrastructure that is located within the Study Area includes roads, drains (Figure 7-17A), two heavy vehicle carparks (Figure 7-17B) that are located south of the Study Area, and overhead structures, such as the Kranji MRT viaduct that runs above Sungei Pang Sua at the centre of the Study Area (Figure 7-17C), and Kranji Expressway which is located beside Villa Verde Bridge (Figure 7-17D). Four roads were constructed above Sungei Pang Sua. These roads are Sungei Kadut Avenue which is located in proximity to the potential future infrastructure, Stagmont Ring Road, Choa Chu Kang Link, and Kranji Loop which is located north of the Study Area. Amenities, such as shops, Club July Cafe, and Sri Arasakesari Sivan Temple are also located within the Study Area.

Figure 7-17 Infrastructure in Study Area. (A) Drain; (B) Heavy vehicle carpark; (C) Kranji MRT viaduct and (D) Kranji Expressway that runs on top of Villa Verde Park

7.3.1.2 Overall Floristic Findings

A total of 206 species including 2 species groups (i.e., plants that could not be identified to its species with certainty), belonging to 69 families were recorded from the floristic surveys (Appendix B). The species group recorded consists of the following: (1) *Acanthus* sp., and (2) *Syzygium* cf *malaccense.* Of all species recorded, 108 (52.4%) are exotic, 91 (44.2%) are native and 7 (3.4%) are cryptogenic, i.e., of unknown/uncertain origins (Table 7-4). One native species, *Dimocarpus lichi*, is considered as 'data deficient' according to the latest revision of Singapore plant statuses that was published in the Singapore Red List [W-75] (Table 7-4).

For *Acanthus* sp., all three local species, *A. ebracteatus*, *A. ilicifolius* and *A. volubilis*, are of conservation significance. Based on the growth habit and vegetative specimens, this species is either *A. ebracteatus*, which is nationally Vulnerable, or *A. ilicifolius*, which is nationally Endangered [P-38; W-75]. Since the specimens did not bear any inflorescence or fruits during the point of encounter, it is difficult to ascertain the exact species. Thus, the status for this native species is reflected as 'undetermined' in Table 7-4. As a conservative approach, this species was also be regarded as a species of conservation significance in Section 7.3.1.2.1.

The identification *Syzygium* cf. *malaccense* could not be ascertained as vegetative specimen could not be collected during the time of survey due to the tall height of the specimen.

The number of threatened native species makes up 13.1% (27 species) of the total flora species count. For overall findings, a distinction is not made as to whether these 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 therefore not be of conservation significance even though they have been accorded a threatened conservation status. This is discussed in greater detail in Section 7.2.1.3 and Section 7.3.1.2.3.

Table 7-4 Number and percentage (%) of species belonging to each status category in the Study Area.

Origin	Status	Number of Species	Percentage (%)
Exotic		**108**	**52.4**
	Casual	24	11.7
	Cultivated Only	35	17.0
	Naturalised	49	23.8
Native		**91**	**44.2**
	Common	60	29.1
	Data Deficient	1	0.5
	Vulnerable	8	3.9
	Endangered	7	3.4
	Critically Endangered	12	5.8
	Nationally Extinct (Cultivated)	2	1.0
	Undetermined (*Acanthus* sp.)	1	0.5
Cryptogenic		**7**	**3.4**
Total		**206**	**100.0**

7.3.1.2.1 Species of Conservation Significance

Of the 28 threatened native species, 16 species were considered species of conservation significance (Section 7.2.1.3; Table 7-5; Appendix C). All of the 16 species are associated with coastal and/or mangrove habitats, except for *Digitaria longiflora,* The location of this grass species was not recorded during the execution of floristic

survey since its status has been revised in the Singapore Red List from common native to nationally Vulnerable after the baseline survey was completed [P-25]. The same case also applies to *Acanthus ilicifolius.* As such, these species are excluded in Table 7-6 and Figure 7-18.

Since the status of *Acanthus* sp. is undetermined, this species group has also been excluded in Table 7-6.

Four species are considered as species of conservation significance even though they have been seen cultivated in recent years across Singapore as part of reforestation efforts. These species are 1) *Barringtonia racemosa*, 2) *Calophyllum inophyllum*, 3) *Dolichandrone spathacea*, and 4) *Nypa fruticans*. They are regarded as species of conservation significance as they occur within their natural habitats, which are mangrove and/or coastal habitats. As such, a conservative approach was taken during the assessment to consider them as species of conservation significance.

The distribution of the species of conservation significance was recorded mostly within the mangrove forest, as reflected in Table 7-5 and Table 7-6.

Table 7-5 Breakdown of threatened plant species and those regarded as species of conservation significance

National Status*	VU	EN	CR	Total
Non-cultivated Threatened Species	5	6	4	15*
Cultivated Threatened Species	3	1	8	12

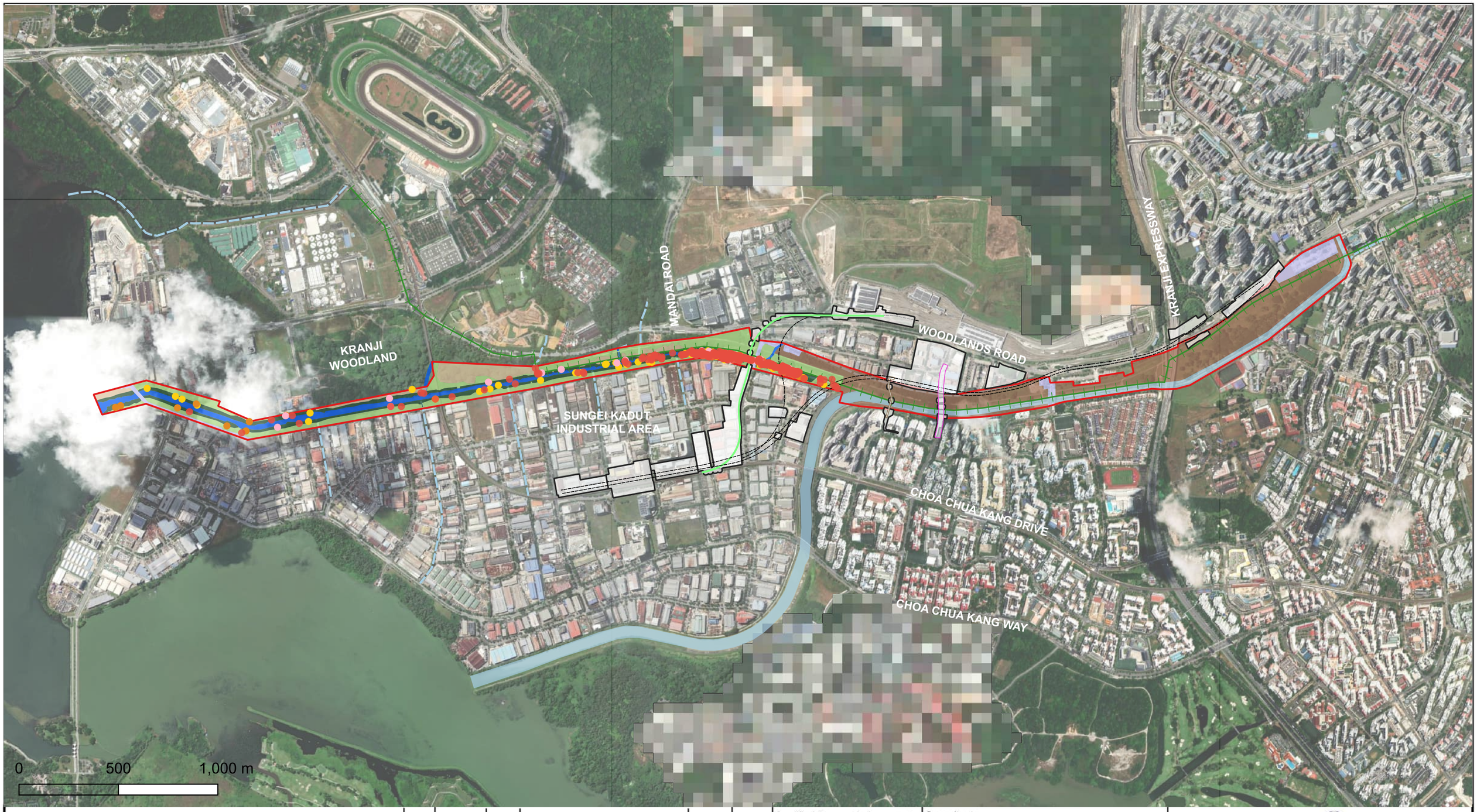
Note: VU – Vulnerable; EN – Endangered; CR – Critically Endangered

* Excluded *Acanthus* sp. as it is not possible to confirm its national status

Table 7-6 Number of plant specimens and species of conservation significance in each vegetation type

Vegetation Type	Number of Individuals and Clusters					Number of Species				
	VU	EN	CR	Un-determined	Total	VU	EN	CR	Un-determined	Total
Urban vegetation	0	0	1	0	1	0	0	1	0	1
Scrubland	12	1	24	2	39	1	1	3	1	6
Mangrove Forest	77	10	233	24	362	4	5	4	1	14
Exotic-Dominated Secondary Forest	1	0	0	0	1	1	0	0	0	1

*Total species richness is not the sum of species richness per vegetation type as some species occur in more than one vegetation type.



Legend

- Biodiversity Study Area
- Proposed DTL2e Tunnel Alignment
- Potential Future Infrastructure
- Proposed Cut and Cover Area
- Proposed Vehicular Bridge
- Pedestrian Overhead Bridge
- Existing Vegetated Area
- Sungei Pang Sua
- Pang Sua Canal
- Stream
- Drain

Habitat Types
- Mangrove
- Exotic-dominated Secondary Forest
- Scrubland
- Urban Vegetation
- Others

Species of Conservation Significance
- Critically Endangered
- Endangered
- Vulnerable
- Undetermined

Rev.	Date	By	Description	Chk'd	App'd
-	Aug 2024	JT	Environmental Study Report	NHT	JAG

Qualified Person Endorsement :
N/A

LTA Endorsement :
N/A

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title :
CONTRACT 9175
ADVANCE ENGINEERING STUDY FOR THE PROPOSED DOWNTOWN LINE 2 EXTENSION AND A NEW STATION ON EXISTING NORTH-SOUTH LINE

Figure Title :
LOCATION OF ALL PLANT SPECIES OF CONSERVATION SIGNIFICANCE WITHIN THE STUDY AREA

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
HHL	NHT	JAG	7-18	-	1 of 1
	Drawn JT	Date Aug 2024	CAD File Name :N/A		A3

Note: Source of basemap - OneMap and Open Street Map

Seven species of conservation significance are highlighted of interest here due to three factors: abundance and/or distribution within the Study Area as well as their declining local population. These species are:

1. *Sonneratia caseolaris* – nationally Critically Endangered;
2. *Finlaysonia obovata* – nationally Critically Endangered;
3. *Halophila beccarii* – nationally Endangered
4. *Ceriops zippeliana* – nationally Endangered;
5. *Lumnitzera littorea* – nationally Endangered;
6. *Lumnitzera racemosa* – nationally Endangered; and
7. *Nypa fruticans* – nationally Vulnerable.

Critically Endangered

Specimens of *Sonneratia caseolaris* largely contributes to the total number of specimens of species of conservation significance that were recorded in the Study Area. This species can be distinguished by its short petiole that has a reddish-pink base (Figure 7-20A) and leaves that are relatively more oblong, as compared to other *Sonneratia* species. However, the most distinguishable characteristic would be its large red flowers with prominent red and white stamens (Figure 7-20B) and the rounded and flat fruits (Figure 7-20C) [P-50]. Within the Study Area, a higher density of the specimens was recorded inland and eventually tapers off as it approaches nearer to the mouth of Sungei Pang Sua (Figure 7-26). Similarly, there were also a higher number of seedlings and young saplings inland (Figure 7-20D; Figure 7-26), of which, the population is observed to be healthy and propagating (Figure 7-20D; Figure 7-26).

In Singapore, this species was only found in woodlands Town Garden, Sungei Buloh Wetland Reserve, Pulau Ubin, and the upper reaches of Sungei Seletar [P-12; W-75]. Presently, there are only less than 20 specimens found in those locations [P-12; W-75]. Hence, it is highly likely that the mangrove forest in the Study Area is currently the stronghold for *S. caseolaris,* with more than 200 specimens recorded in the Study Area.

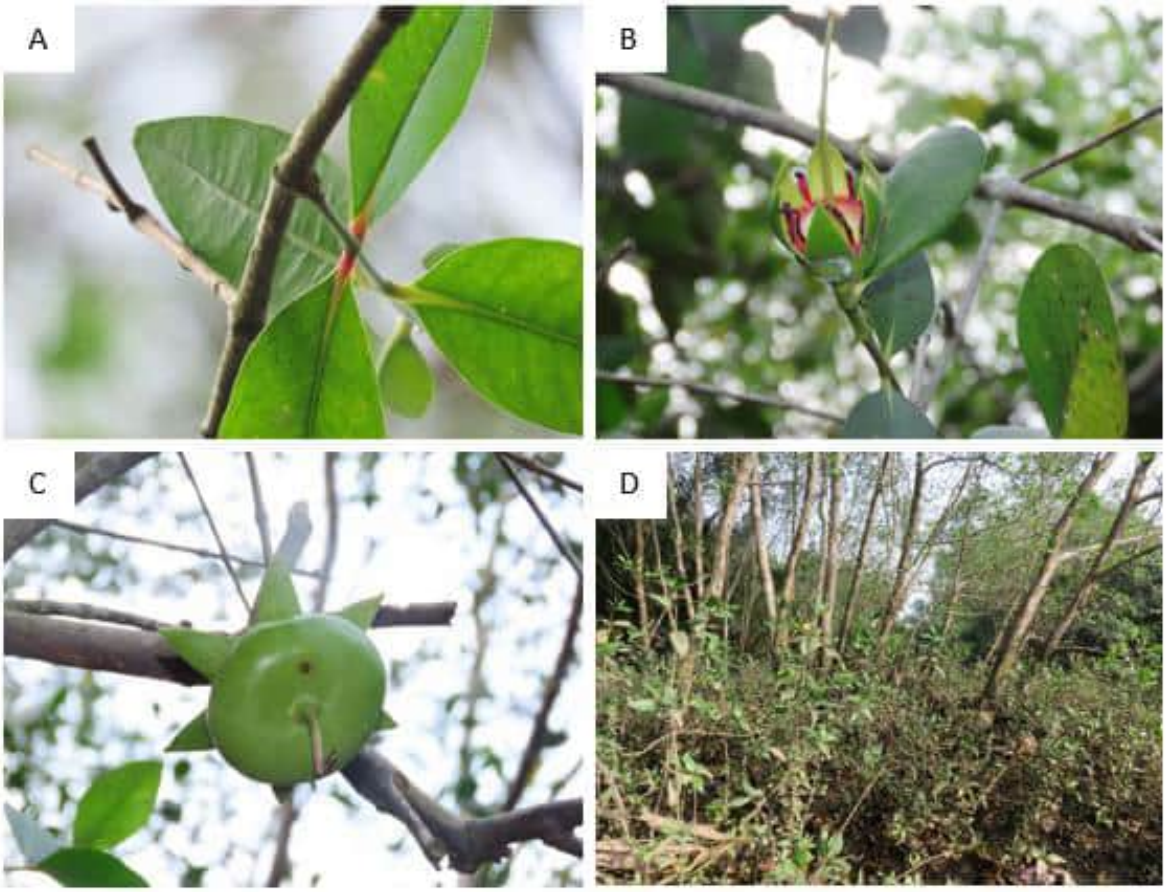


Figure 7-19 (A) Leaves of *Sonneratia caseolaris* with short petioles and reddish-pink base; (B) Inflorescence that is prominently red; (C) Rounded and flat fruit (D) Higher number of seedlings and young saplings observed at the upper stream

Multiple clusters of the mangrove-associate climber, *Finlaysonia obovata,* were recorded in multiple locations throughout the mangrove forest (Figure 7-26). This climber is recognisable by its ovate to broadly oblong leaves that are arranged in an opposite manner (Figure 7-20). This climber also produces a milky white sap when it is cut (Figure 7-20).

Figure 7-20 *Finlaysonia obovata* which is recognisable by its opposite leaf arrangement and milky white sap, indicated by the red arrow

This species was initially listed as nationally Vulnerable in the first edition of the Singapore Red Data Book (SBDR) but has since been uplisted to Critically Endangered in the latest edition [P-8; P-34]. In Singapore, it is estimated that there are fewer than 50 mature individuals left in the wild, with some evidence of decline or fragmentation of their natural habitat [P-39]. Back mangrove habitat has since then declined rapidly due to the urban development in Singapore since 1960s [P-12]. Hence, there is a high probability for wild populations of this climber to be extirpated if no appropriate measures are taken to conserve them [P-1].

Endangered

Halophila beccarii, also known as the Beccari's seagrass, is the smallest in size as compared to the other 12 seagrass species that can be found in Singapore (Figure 7-21). They are usually found in muddy to sandy substrates, similar to that observed at the mouth of the Sungei Pang Sua where clusters of this seagrass were recorded (Figure 7-26). Besides being nationally Critically Endangered, *H. beccarii* is also globally Vulnerable due to anthropogenic threats [W-78], such as the rapid increase of coastal developments and reclamation activities which alter the environment of its habitat, causing it to be undesirable for its growth [W-79].

Currently, in Singapore, this species can be found in the mangroves of Mandai, Sungei Buloh Wetland Reserve (SBWR), Kranji Nature Trail, and Chek Jawa at Pulau Ubin [W-79]. Given the proximity of Mandai mangroves and SBWR to the Study Area, there is a high possibility that the seed source of the seagrass that was recorded in the Study Area derived from the aforementioned locations.

Figure 7-21 (A) Clusters of the nationally Endangered seagrass, *Halophila beccarii.*

Only one specimen of *Ceriops zippeliana* was recorded at the bank of Sungei Pang Sua which is in proximity to the river mouth (Figure 7-26). The specimen is distinguishable by its 'flat' stipule (Figure 7-22A) and its reproductive characteristics where its fruit has netted surface decoration and ascending persistent calyx lobes [P-39] (Figure 7-22B). It was only in 2010 whereby a publication by Sheue et. al. (2010) was released to confirm *C. zippeliana* as a new record of mangrove species in Singapore [P-39]. In the past, specimens that were collected in multiple mangrove areas and deposited to SING herbarium were misidentified as another *Ceriops* species, *C. tagal*, which is now believed to be rarer than *C. zippeliana* [P-39; P-46].

One specimen of *Lumnitzera littorea* was recorded a kilometre away from the river mouth, closer to the back mangrove area where inundation is lower (Figure 7-22C; Figure 7-26). During the time of the survey, only a few inflorescences were observed. Its congener, *L. racemosa*, was recorded in three locations within the mangrove forest (Figure 7-26). Unlike *L. littorea*, this species has a higher tolerance to saline conditions [W-73]. These two species can be differentiated by the colour of their inflorescence, of which, *L. littorea* produces red flowers, while *L. racemosa* produces white flowers (Figure 7-22D). The conservation status of these two species is most likely the product of the decrease in their population as they possess timber that is deemed highly valuable [W-73; W-74]. The timber is known to be hardy and durable and is used to construct structures, such as bridges, wharves, flooring, and sleepers [W-74].

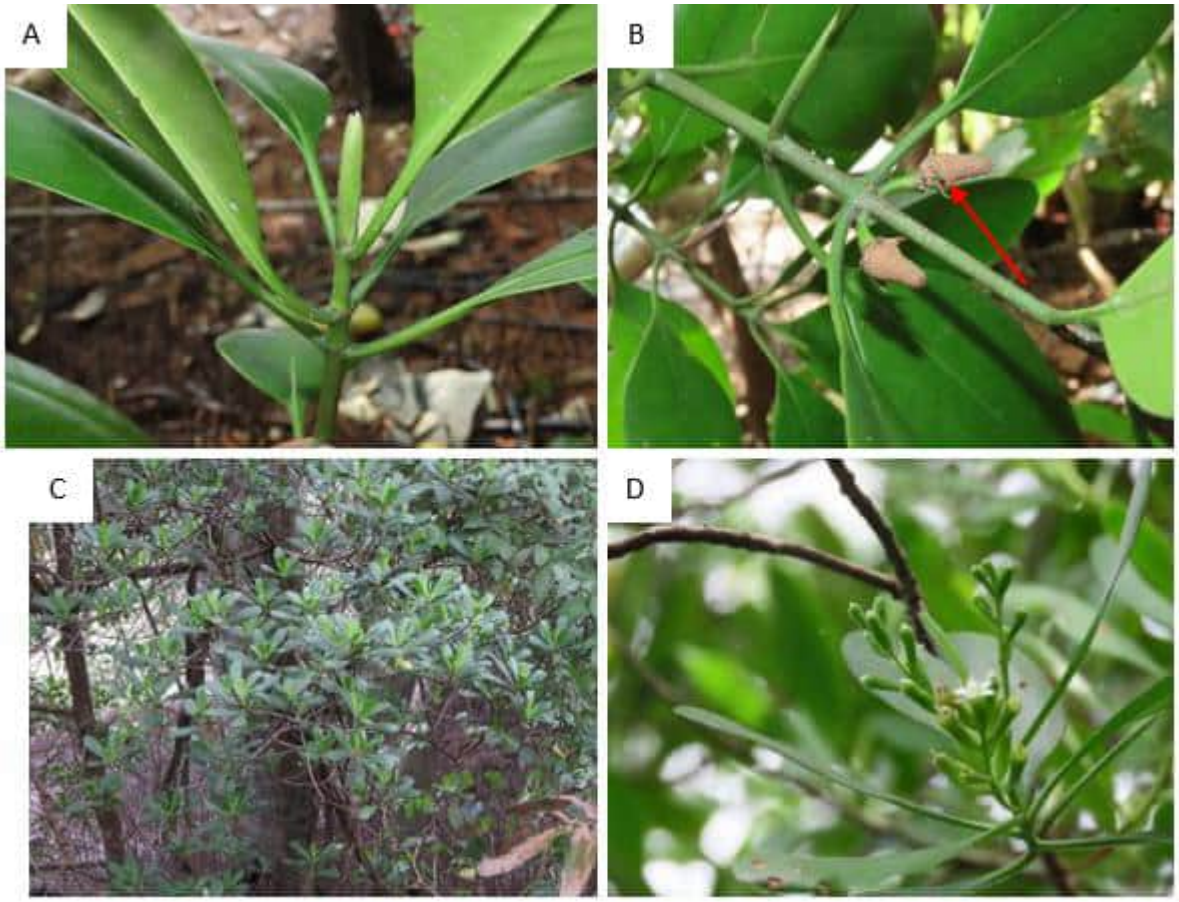


Figure 7-22 (A-B) Characteristics of *Ceriops zippeliana*. (A) 'Flat' stipule; and (B) Ascending persistent calyx lobes, indicated by the red arrow; (C) *Lumitzera littorea* growing at a less inundated area; and (D) White inflorescence of *L. racemosa*

Vulnerable

Nipah palm (*Nypa fruticans*) is the second most abundant mangrove species that were recorded within the mangrove forest. Similar to the distribution of *S. caseolaris*, the majority of the clusters were recorded inland (Figure 7-23A; Figure 7-26), and eventually reduces as it approaches the mouth of Sungei Pang Sua. This is probably since the species often prefer areas that are more brackish and/or inland areas, away from direct exposure to pure seawater [P-44]. Most specimens were also observed to be flowering and/or fruiting during the period of survey (Figure 7-23B).

N. fruticans is one of the most widely utilised mangrove species [P-44]. As such, the conservation status of this species is most probably due to the commercial usage of this palm for various purposes. Known for their durability, the fronds were commonly used as roofs for 'attap' huts and daily items, such as hats and bags in the past [P-44]. Today, fruit of this species is still being used in various delicacies.

There has not been a comprehensive record of the distribution of the nipah palm in Singapore. The majority of the population is currently found in the northern region of Singapore, such as Lim Chu Kang, Sungei Buloh Wetland Reserve, Kranji Reservoir, woodlands Town Garden, and Khatib Bongsu. Populations of this species have extirpated in areas such as Kallang, where it was recorded in the past. As such, the population of this species is exposed to the risk of rapid decline due to the accelerating rate of urban development [P-44].

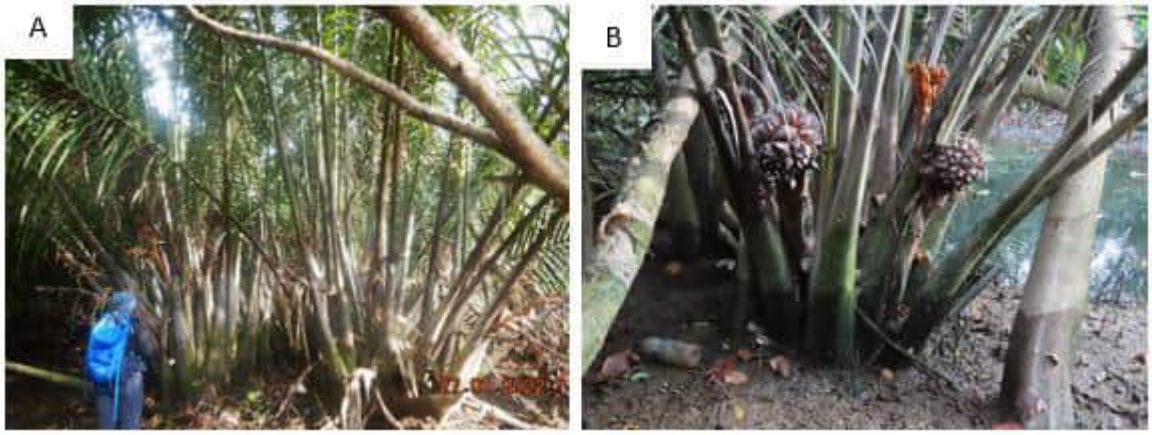
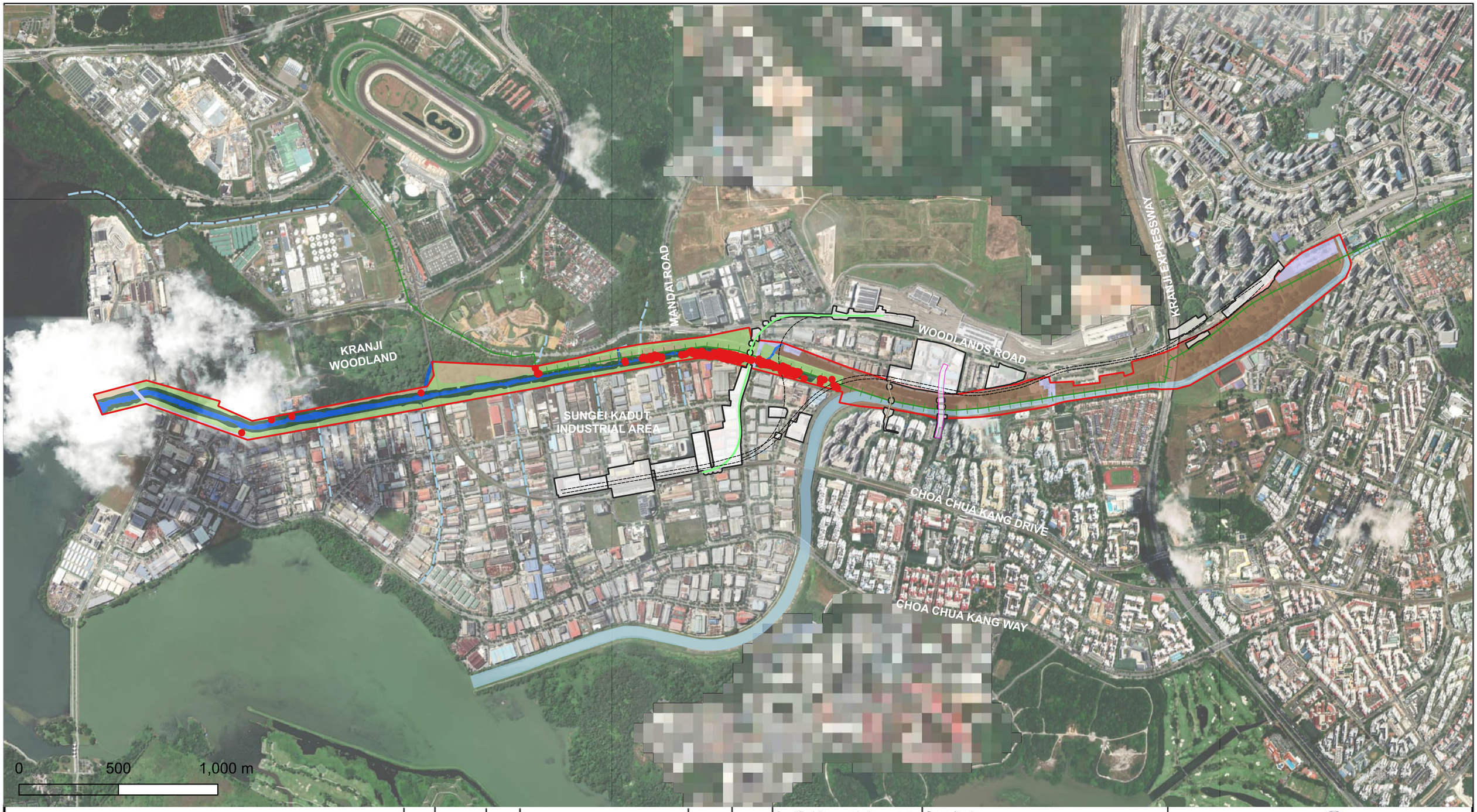


Figure 7-23 (A) Cluster of *Nypa fruticans* located upstream; (B) Inflorescence and fruit of the species



Legend

- Biodiversity Study Area
- Proposed DTL2e Tunnel Alignment
- Potential Future Infrastructure
- Proposed Cut and Cover Area
- Proposed Vehicular Bridge
- Pedestrian Overhead Bridge
- Existing Vegetated Area
- Sungei Pang Sua
- Pang Sua Canal
- Stream
- Drain

Habitat Types
- Mangrove
- Exotic-dominated Secondary Forest
- Scrubland
- Urban Vegetation
- Others

Species of Conservation Significance
- Sonneratia caseolaris

Rev.	Date	By	Description	Chk'd	App'd
-	Aug 2024	JT	Environmental Study Report	NHT	JAG

Qualified Person Endorsement : N/A

LTA Endorsement : N/A

Consultant : AECOM

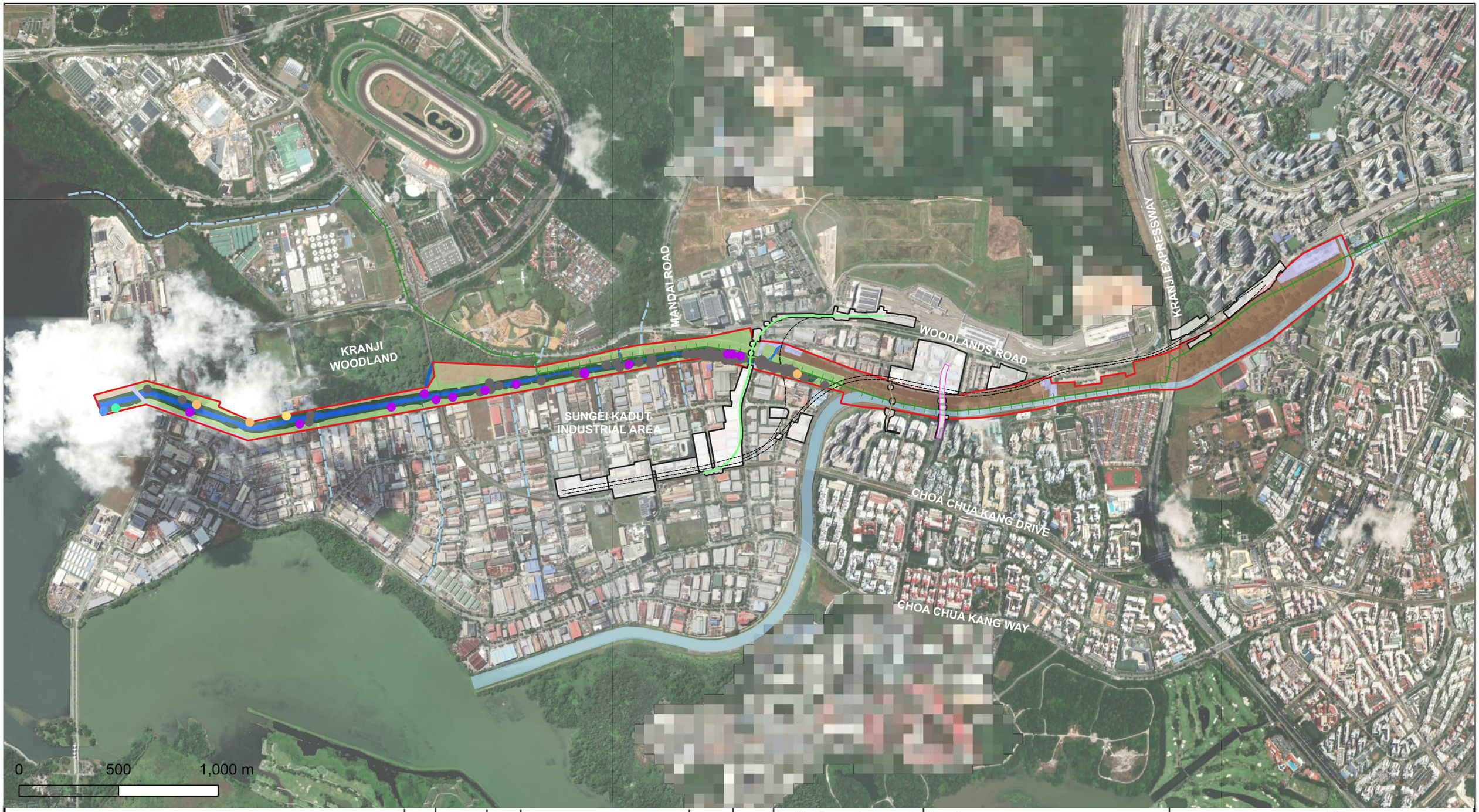
Land Transport Authority — We Keep Your World Moving

Project Title :
CONTRACT 9175 ADVANCE ENGINEERING STUDY FOR THE PROPOSED DOWNTOWN LINE 2 EXTENSION AND A NEW STATION ON EXISTING NORTH-SOUTH LINE

Figure Title :
DISTRIBUTION OF PLANT SPECIES OF CONSERVATION SIGNIFICANCE THAT ARE OF INTEREST (SONNERATIA CASEOLARIS)

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
HHL	NHT	JAG	7-24	-	1 of 1
	Drawn JT	Date Aug 2024	CAD File Name :N/A		A3

Note: Source of basemap - OneMap and Open Street Map



Legend

- Biodiversity Study Area
- Proposed DTL2e Tunnel Alignment
- Potential Future Infrastructure
- Proposed Cut and Cover Area
- Proposed Vehicular Bridge
- Pedestrian Overhead Bridge
- Existing Vegetated Area
- Sungei Pang Sua
- Pang Sua Canal
- Stream
- Drain

Habitat Types

- Mangrove
- Exotic-dominated Secondary Forest
- Scrubland
- Urban Vegetation
- Others

Species of Conservation Significance

- Ceriops zippeliana
- Finlaysonia obovata
- Halophila beccari
- Lumnitzera littorea
- Lumnitzera racemosa
- Nypa fruticans

Rev.	Date	By	Description	Chk'd	App'd
-	Aug 2024	JT	Environmental Study Report	NHT	JAG

Qualified Person Endorsement : N/A

LTA Endorsement : N/A

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title :

CONTRACT 9175 ADVANCE ENGINEERING STUDY FOR THE PROPOSED DOWNTOWN LINE 2 EXTENSION AND A NEW STATION ON EXISTING NORTH-SOUTH LINE

Figure Title :

DISTRIBUTION OF PLANT SPECIES OF CONSERVATION SIGNIFICANCE THAT ARE OF INTEREST (SELECTED)

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
HHL	NHT	JAG	7-25	-	1 of 1
	Drawn JT	Date Aug 2024	CAD File Name :N/A		A3

Note: Source of basemap - OneMap and Open Street Map

7.3.1.2.2 Large Plant Specimens

A total of 226 large plant specimens are recorded in the Study Area, of which, 163 specimens are exotic, 61 are native and two are cryptogenic (Appendix D). The majority of the large plant specimens are distributed mostly around the centre and the southern portion of the Study Area within the exotic-dominated secondary forest, mangrove, and managed vegetation habitat types. The distribution of these specimens is reflected in Figure 7-27.

Of the 226 large plant specimens, 184 are trees, 31 are palm which is contributed by only one species—Nipah (*Nypa fruticans*), and the remaining 11 are stranglers (Table 7-7). With 47 individuals recorded, Senegal mahogany (*Khaya senegalensis*), forms the majority of large plant species. The second most abundant large plant species is raintree (*Samanea saman*) with 42 individuals recorded. The majority of the specimens of these two species are located within the Pang Sua woodland. The largest specimens recorded are two Malayan banyan (*Ficus microcarpa*) with a spread of 15 m and with a height of 25 m and 20 m respectively (Figure 7-26A).

A noteworthy observation would be an *Avicennia alba,* with a girth size of 3.8 m (Figure 7-26B). It is uncommon to encounter large mangrove specimens due to different abiotic conditions that they have to overcome, such as changes in hydrology (i.e., tidal activity) that influences the salinity levels and the nutrient supply for the mangrove. These abiotic factors mentioned above are considered essential factors to promote an optimal growth condition for mangroves, amongst other factors, such as light availability and competition among other mangrove specimens [P-36].

Table 7-7 Type and species of large specimens recorded, accompanied by their origin, status, and count of individuals of each species

Habit	Tree Species	Origin	Status	No. of Specimens
Tree	*Artocarpus altilis*	Exotic	Casual	4
	Avicennia alba	Native	Common	1
	Dimocarpus lichi	Native	Data Deficient	1
	Excoecaria agallocha	Native	Common	3
	Falcataria falcata	Exotic	Naturalised	38
	Ficus religiosa	Exotic	Naturalised	2
	Khaya senegalensis	Exotic	Cultivated only	47
	Macaranga gigantea	Native	Common	1
	Pterocarpus indicus	Exotic	Casual	3
	Samanea saman	Exotic	Casual	42
	Spathodea campanulata	Exotic	Naturalised	20
	Tabebuia rosea	Exotic	Casual	7
	Hibiscus tilaceus	Native	Common	8
	Terminalia catappa	Native	Common	5
Strangler	*Ficus microcarpa*	Native	Common	11
	Ficus benjamina	Cryptogenic	-	2
Palm	*Nypa fruticans*	Native	Vulnerable	31

Habit	Tree Species	Origin	Status	No. of Specimens
Total	**17**	**-**	**-**	**226**

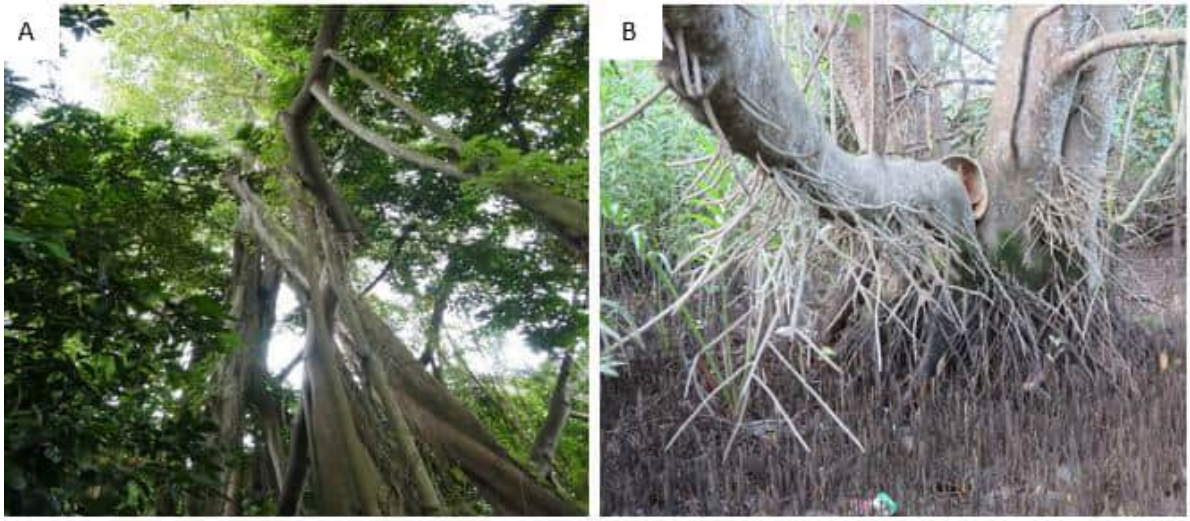
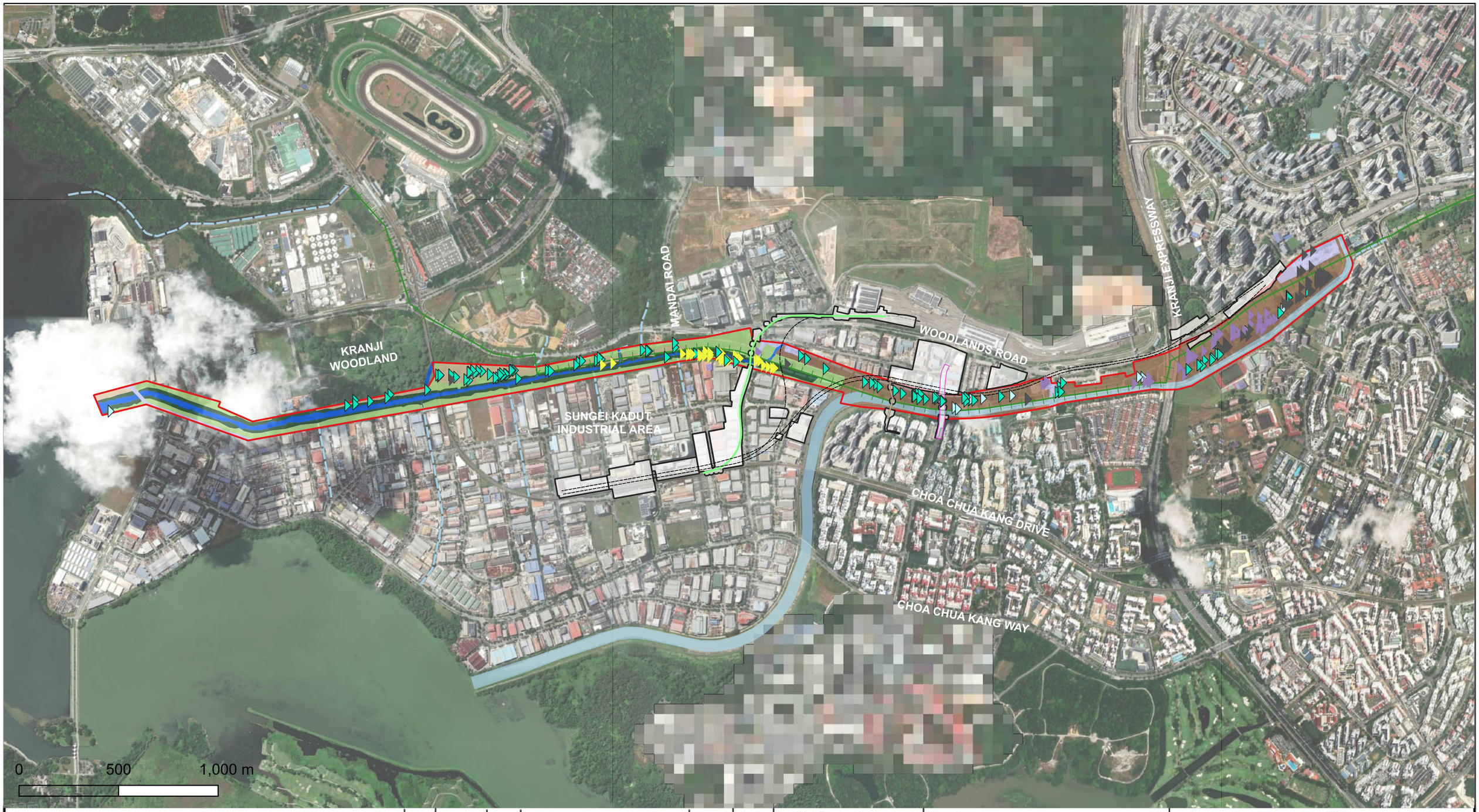


Figure 7-26 (A) One of the largest plant specimen, *Ficus microcarpa* with a spread of 15 m; (B) *Avicennia alba* with a girth of 3.8 m



Legend

- Biodiversity Study Area
- Proposed DTL2e Tunnel Alignment
- Potential Future Infrastructure
- Proposed Cut and Cover Area
- Proposed Vehicular Bridge
- Pedestrian Overhead Bridge
- Existing Vegetated Area
- Sungei Pang Sua
- Pang Sua Canal
- Stream
- Drain

Habitat Types
- Mangrove
- Exotic-dominated Secondary Forest
- Scrubland
- Urban Vegetation
- Others

Large Plant Specimens
- Palm
- Strangler
- Tree
- Tree (Khaya)
- Tree (Raintree)

Rev.	Date	By	Description	Chk'd	App'd
-	Aug 2024	JT	Environmental Study Report	NHT	JAG

Qualified Person Endorsement :
N/A

LTA Endorsement :
N/A

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title :
CONTRACT 9175
ADVANCE ENGINEERING STUDY FOR THE PROPOSED DOWNTOWN LINE 2 EXTENSION AND A NEW STATION ON EXISTING NORTH-SOUTH LINE

Figure Title :
DISTRIBUTION OF LARGE PLANT SPECIMENS IN THE STUDY AREA

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
HHL	NHT	JAG	7-27	-	1 of 1
	Drawn JT	Date Aug 2024	CAD File Name :N/A		A3

Note: Source of basemap - OneMap and Open Street Map

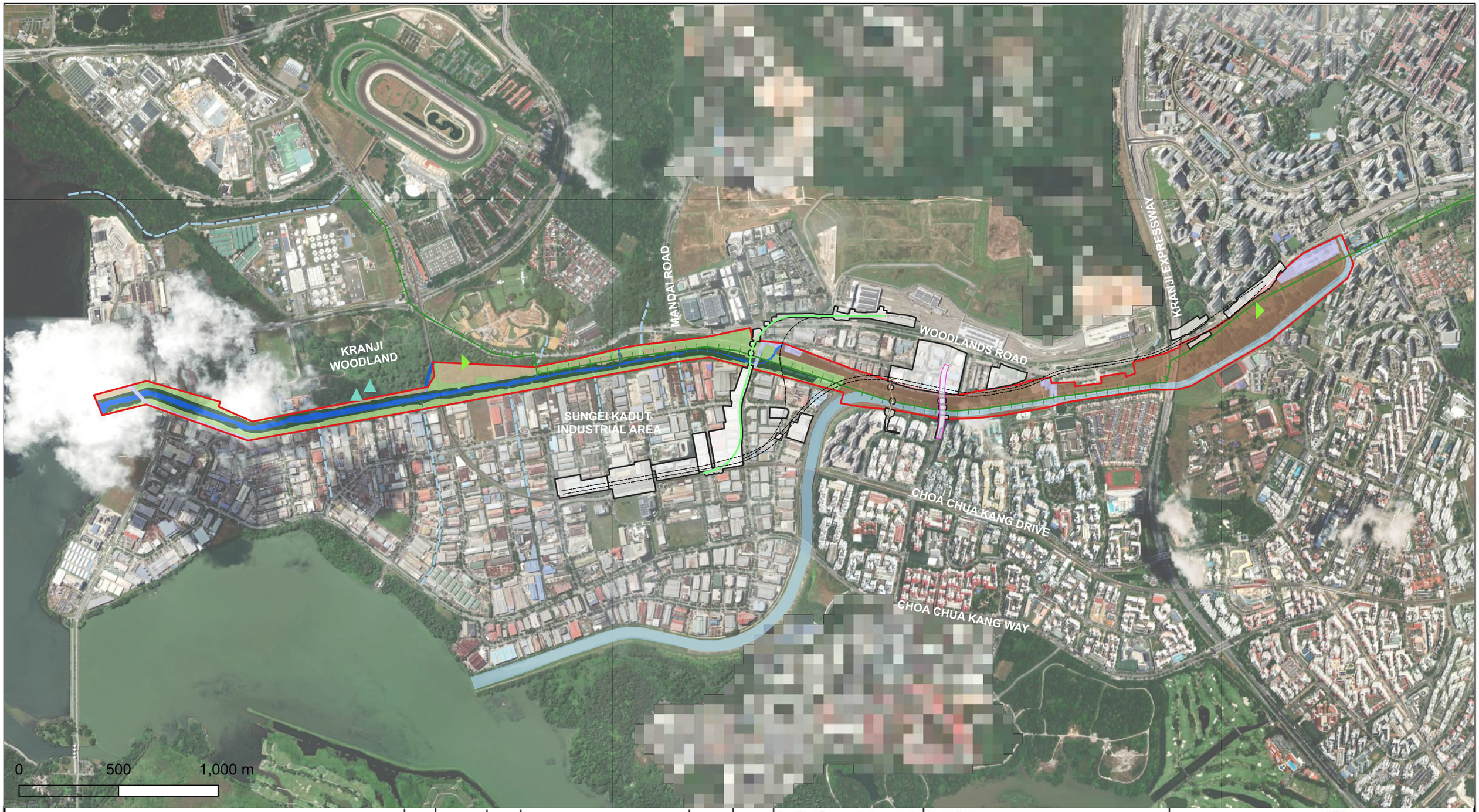
7.3.1.2.3 Other Specimens of Value

Eight specimens were identified as other specimens of value (Appendix E). The location of all specimens is reflected in Figure 7-29.

In total, six bamboo clusters are considered as other specimens of value. Five clusters of *Bambusa heterostachya* are located in proximity to each other in the central part of the Study Area (Figure 7-28A) and hence, are represented using the same location (Figure 7-29). A specimen of *Bambusa* cf *heterostachya* of spread 2.5 m was recorded within the Pang Sua woodland, south of the Study Area (Figure 7-28B). Although no bamboo bats were recorded during the roost emergence survey (Section 7.3.2.3.7), these bamboo clusters are potential habitats for the nationally Vulnerable bamboo bats (*Tylonycteris spp.*).

Two raptor nests were located on two specimens of albizia (*Falcataria falcata*) respectively. These nests are identified to be the nest of a changeable hawk eagle (*Nisaetus cirrhatus;* Figure 7-28C) and a white-bellied sea eagle (*Haliaeetus leucogaster;* Figure 7-28D). The location of these nests is located in the forest patch adjacent to the Study Area. This is discussed further in Section 7.3.2.3.5.

Figure 7-28 (A) Clusters of *Bambusa heterostachya*; (B) A specimen of *B.* cf *heterostachya* at Pang Sua Woodland, located south of the Study Area; (C) Nest of changeable hawk eagle (*Nisaetus cirrhatus*); (D) Nest of white-bellied sea eagle (*Haliaeetus leucogaster*)



Legend

- Biodiversity Study Area
- Proposed DTL2e Tunnel Alignment
- Potential Future Infrastructure
- Proposed Cut and Cover Area
- Proposed Vehicular Bridge
- Pedestrian Overhead Bridge
- Existing Vegetated Area
- Sungei Pang Sua
- Pang Sua Canal
- Stream
- Drain

Habitat Types

- Mangrove
- Exotic-dominated Secondary Forest
- Scrubland
- Urban Vegetation
- Others

Other Specimens of Value

- Other
- Raptor Nest

Rev.	Date	By	Description	Chk'd	App'd
-	Aug 2024	JT	Environmental Study Report	NHT	JAG

Qualified Person Endorsement :
N/A

LTA Endorsement :
N/A

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title :
CONTRACT 9175
ADVANCE ENGINEERING STUDY FOR THE PROPOSED DOWNTOWN LINE 2 EXTENSION AND A NEW STATION ON EXISTING NORTH-SOUTH LINE

Figure Title :
DISTRIBUTION OF OTHER SPECIMENS OF VALUE IN THE STUDY AREA

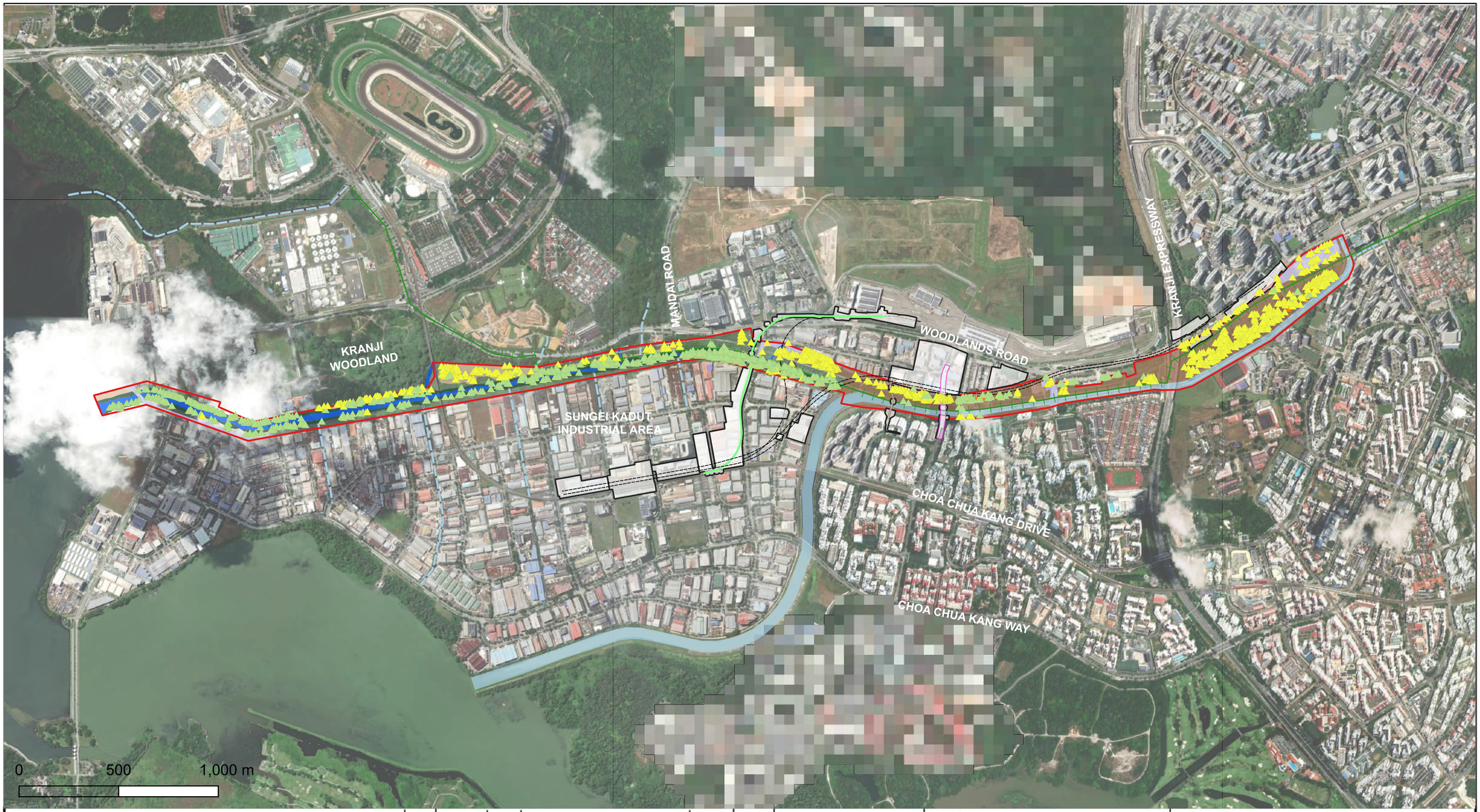
Designed	Checked	Approved	Figure No. :	Rev.	Sheet
HHL	NHT	JAG	7-29	-	1 of 1
	Drawn JT	Date Aug 2024	CAD File Name :N/A		A3

Note: Source of basemap - OneMap and Open Street Map

7.3.1.2.4 Tree Mapping Findings

A total of 1,762 specimens belonging to 56 species and 1 species group (i.e., *Syzygium* cf *malaccense*) were tagged and recorded during tree mapping (Appendix F; Figure 7-30). Altogether, all species belong to 18 families. As some specimens occur in clusters, i.e., within 1 – 2 m of each other, they were recorded under the same tree tag and only one specimen was tagged.

More than half (52.2%; 920 specimens) of these trees are exotic, 47.3% (833 specimens) are native and the remaining 0.5% (9 specimens) are cryptogenic. Almost half of the total number of trees tagged were contributed by *Avicennia alba* (266 specimens), *Sonneratia caseolaris* (250 specimens), rain tree (*Samanea saman*; 159 specimens), and *Khaya senegalensis* (154 specimens). Three hundred and ten specimens belonged to five species of conservation significance, namely, *Dolichandrone spathacea* (2 specimens), *Lumnitzera littorea* (1 specimen), *Lumnitzera racemosa* (1 specimen), nipah palm (*Nypa fruticans*; 56 specimens), and *Sonneratia caseolaris* (250 specimens). The majority of these specimens are *S. caseolaris* with girth sizes that ranges between 0.3 m – 2.0 m.



Legend

- Biodiversity Study Area
- Proposed DTL2e Tunnel Alignment
- Potential Future Infrastructure
- Proposed Cut and Cover Area
- Proposed Vehicular Bridge
- Pedestrian Overhead Bridge
- Existing Vegetated Area
- Sungei Pang Sua
- Pang Sua Canal
- Stream
- Drain

Habitat Types
- Mangrove
- Exotic-dominated Secondary Forest
- Scrubland
- Urban Vegetation
- Others

Large Plant Specimens
- Palm
- Strangler
- Tree
- Tree (Khaya)
- Tree (Raintree)

Rev.	Date	By	Description	Chk'd	App'd
-	Aug 2024	JT	Environmental Study Report	NHT	JAG

Qualified Person Endorsement :
N/A

LTA Endorsement :
N/A

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title :
CONTRACT 9175 ADVANCE ENGINEERING STUDY FOR THE PROPOSED DOWNTOWN LINE 2 EXTENSION AND A NEW STATION ON EXISTING NORTH-SOUTH LINE

Figure Title :
DISTRIBUTION OF ALL TREES MAPPED IN THE STUDY AREA

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
HHL	NHT	JAG	7-29	-	1 of 1
	Drawn JT	Date Aug 2024	CAD File Name :N/A		A3

Note: Source of basemap - OneMap and Open Street Map

7.3.2 Faunistic Baseline Results

7.3.2.1 Overall

The field assessment recorded a total of 293 faunal species (Table 7-8; Appendix G), which are broadly categorised into 228 terrestrial species (odonates, butterflies, birds, herpetofauna and mammals, terrestrial grastropod) and 65 aquatic species (fish, decapod crustaceans, mollusc and limulids). The terrestrial fauna community is dominated by birds (99 species) and butterflies (59 species), while the aquatic fauna community is dominated by molluscs (37 species). The aquatic fauna comprised 11 freshwater species and 54 intertidal/marine species. The full list of recorded species is provided in Appendix G. The data from fauna survey and camera trapping are provided in Appendix H and Appendix I respectively.

Table 7-8 Summary of faunal species recorded

Faunal Group	Total Number of Recorded Species	Number of Recorded Species of Conservation Significance
Odonates	27	0
Dragonflies	23	0
Damselflies	4	0
Butterflies	59	0
Herpetofauna	23	0
Amphibians	11	0
Reptiles	12	0
Birds	99	18
Mammals	19	1
Non-volant Mammals	12	1
Bats	7	0
Fish	18	0
Molluscs	37	0
Decapods and Limulidae	11	2
Total	**293**	**21**

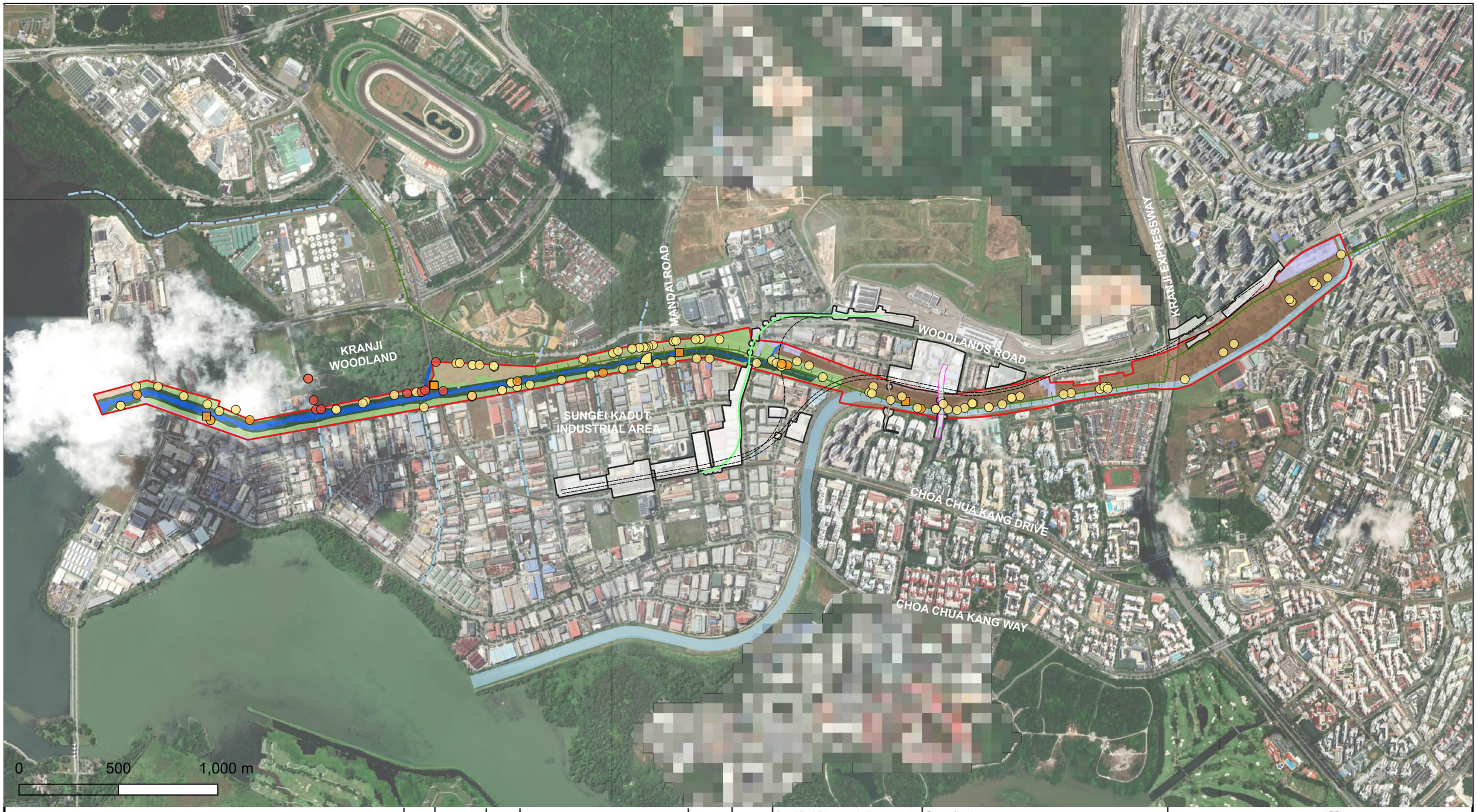
7.3.2.2 Species of Conservation Significance

Twenty-one species of conservation significance were recorded (Table 7-9). This comprised 18 bird, 1 non-volant mammal, 1 decapod and 1 horseshoe crab species. Species of conservation significance were recorded which are distributed across the Study Area, although there appears to have higher records from the central to northern part of the Study Area (Figure 7-31). It should be noted that Figure 7-31 excludes mud lobster mounds which is observed throughout Sungei Pang Sua.

Table 7-9 List of faunal species of conservation significance recorded

Taxa	Scientific Name	Common Name	Global Status	National Status
Bird	*Haliaeetus ichthyaetus*	Grey-headed fish eagle	Near Threatened	Vulnerable
Bird	*Nisaetus cirrhatus*	Changeable hawk-eagle	Least Concern	Vulnerable
Bird	*Acrocephalus orientalis*	Oriental reed warbler	Least Concern	Vulnerable
Bird	*Alcedo atthis*	Common kingfisher	Least Concern	Vulnerable

Taxa	Scientific Name	Common Name	Global Status	National Status
Bird	*Halcyon pileata*	Black-capped kingfisher	Least Concern	Vulnerable
Bird	*Ardea alba*	Great egret	Least Concern	Vulnerable
Bird	*Ardea purpurea*	Purple heron	Least Concern	Endangered
Bird	*Ixobrychus sinensis*	Yellow bittern	Least Concern	Vulnerable
Bird	*Nycticorax nycticorax*	Black-crowned night heron	Least Concern	Endangered
Bird	*Corvus macrorhynchos*	Large-billed crow	Least Concern	Vulnerable
Bird	*Lanius cristatus*	Brown shrike	Least Concern	Vulnerable
Bird	*Copsychus saularis*	Oriental magpie-robin	Least Concern	Vulnerable
Bird	*Ploceus philippinus*	Baya weaver	Least Concern	Vulnerable
Bird	*Psittacula longicauda*	Long-tailed parakeet	Vulnerable	Near Threatened
Bird	*Pycnonotus zeylanicus*	Straw-headed bulbul	Critically Endangered	Endangered
Bird	*Actitis hypoleucos*	Common sandpiper	Least Concern	Vulnerable
Bird	*Strix seloputo*	Spotted wood owl	Least Concern	Vulnerable
Bird	*Zosterops simplex*	Swinhoe's white-eye	Least Concern	Vulnerable
Mammal	*Lutrogale perspicillata*	Smooth-coated otter	Vulnerable	Endangered
Decapod	*Thalassina* spp.*	Mud lobster	Not Assessed	Endangered
Xiphosurid	*Carcinoscorpius rotundicauda*	Mangrove horseshoe crab	Data Deficient	Vulnerable
Note: *Presence of mud lobster mounds				



Legend

- Biodiversity Study Area
- Proposed DTL2e Tunnel Alignment
- Potential Future Infrastructure
- Proposed Cut and Cover Area
- Proposed Vehicular Bridge
- Pedestrian Overhead Bridge
- Existing Vegetated Area
- Sungei Pang Sua
- Pang Sua Canal
- Stream
- Drain

Habitat Types

- Mangrove
- Exotic-dominated Secondary Forest
- Scrubland
- Urban Vegetation
- Others

Species of Conservation Significance

- Critically Endangered
- Endangered
- Vulnerable
- Bird
- Mammal
- Horseshoe crab

Rev.	Date	By	Description	Chk'd	App'd
-	Aug 2024	JT	Environmental Study Report	NHT	JAG

Qualified Person Endorsement :
N/A

LTA Endorsement :
N/A

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title :
CONTRACT 9175 ADVANCE ENGINEERING STUDY FOR THE PROPOSED DOWNTOWN LINE 2 EXTENSION AND A NEW STATION ON EXISTING NORTH-SOUTH LINE

Figure Title :
DISTRIBUTION OF ALL FAUNAL SPECIES OF CONSERVATION SIGNIFICANCE WITHIN THE STUDY AREA

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
HHL	NHT	JAG	7-31	-	1 of 1
	Drawn JT	Date Aug 2024	CAD File Name :N/A		A3

Note: Source of basemap - OneMap and Open Street Map

7.3.2.3 Taxon Sampling Curves

Sample coverage of most faunal groups (odonates, butterflies, amphibians, reptiles and birds) along terrestrial sampling routes were above 90% (Table 7-10; Figure 7-32). Mammals had a coverage of 77.6%. Bats have been excluded from analysis due to low sample size for robust analysis. Sample coverage for mollusc at aquatic sampling points is at a relatively high coverage of 79.0% (Table 7-10; Figure 7-33).

Table 7-10 Summary of taxon sampling analysis

Faunal group	Sample coverage (%)	Observed Richness	Estimated Richness (± s.e)
Terrestrial sampling route			
Odonates	93.8	24	27.5 ± 3.7
Butterflies	92.6	57	78.9 ± 13.5
Amphibians	100.0	11	11 ± 0.65
Reptiles	96.9	9	10.9 ± 3.6
Birds	96.6	77	98.9 ± 13.5
Mammals	77.6	7	16.7 ± 9.8
Aquatic sampling points			
Mollusc	79.0	25	42.6 ± 13.8

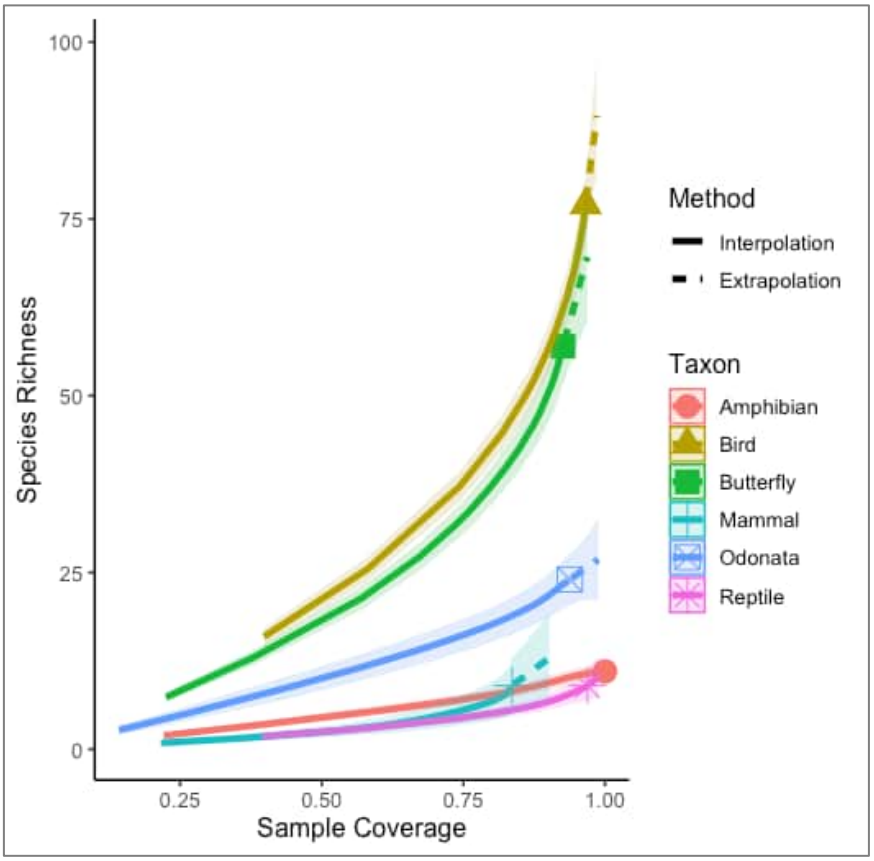


Figure 7-32 Sample coverage of terrestrial surveys

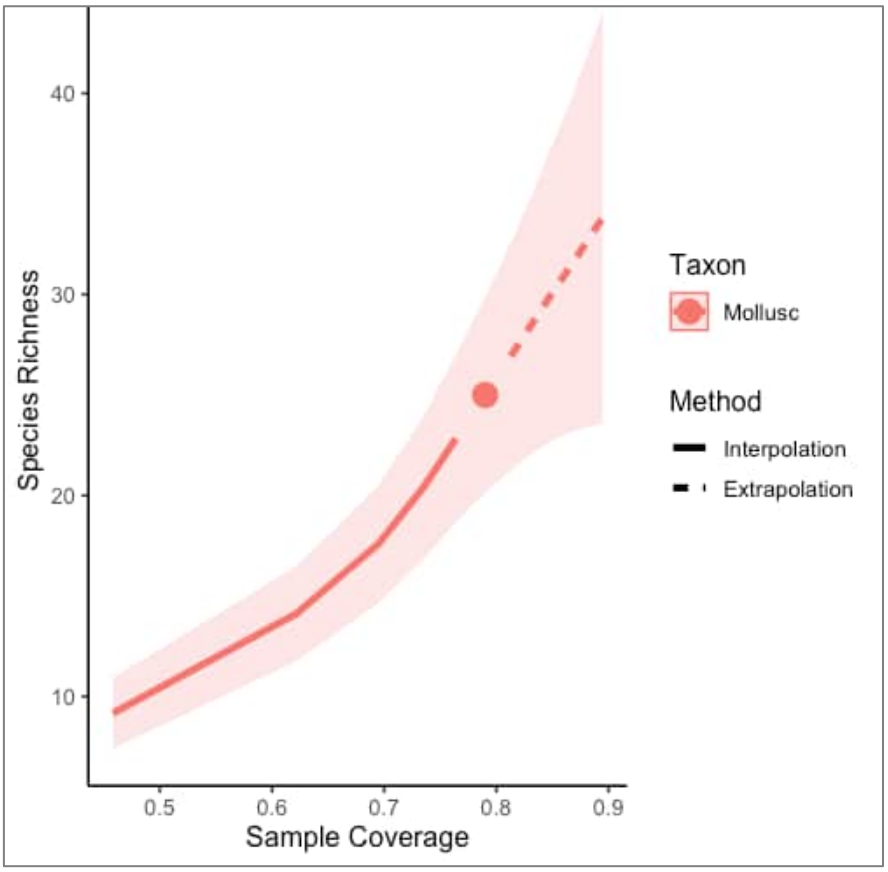


Figure 7-33 Sample coverage of mollusc at aquatic sampling points

7.3.2.3.1 Odonates

The field assessment recorded 27 odonate species, comprising 23 dragonfly and 4 damselfly species (Table 7-8; Appendix G). All species are considered widespread and common, except for three which are considered uncommon. The most frequently recorded species were the common parasol (*Neurothemis fluctuans*), common scarlet (*Crocothemis servilia*) and variable wisp (*Agriocnemis femina*). The three uncommon species are – shorttail (*Onychargia atrocyana*), the dingy duskhawker (*Gynacantha subinterrupta)*, and the banded skimmer (*Pseudothemis jorina*).

7.3.2.3.2 Butterflies

The field assessment recorded 59 butterfly species, including 51 common or moderately common species and 6 moderately rare species (Table 7-8; Appendix G) and two not identified to genus level. No species of conservation significance were recorded.

Most of the recorded species are typically found in degraded secondary forests, parks, gardens and urban areas. The most abundantly recorded species are the tailless line blue (*Prosotas dubiosa lumpura*), chocolate pansy (*Junonia hedonia ida*) and grey pansy *(Junonia atlites atlites*). Majority of the species (51 species) recorded are considered common or moderately common. Only six species were considered moderately rare. This includes the full stop swift (*Caltoris cormasa*), common redeye (*Matapa aria*), detached dart (*Potanthus trachala tytleri*), dark caerulean, (*Jamides bochus nabonassar*), palm king (*Amathusia phidippus phidippus*) and common evening brown (*Melanitis leda leda*).

7.3.2.3.3 Amphibians

The field assessment recorded 11 amphibian species, comprising seven native and three non-native species, none of which have conservation significance (Table 7-8; Appendix G). All recorded species were considered widespread and common, with the exceptions of the restricted and rare (but non-native) East Asian ornate chorus frog (*Microhyla mukhlesuri*) and widespread but uncommon Guenther's frog (*Sylvirana guentheri*).

7.3.2.3.4 Reptiles

The field assessment recorded 12 reptilian species, comprising six lizards, five snakes and one turtle (Table 7-8; Appendix G). No species of conservation significance was recorded. All species recorded have a widespread distribution in Singapore, except for the twin-barred gliding snake that is restricted and rare [P-2]. This species was recorded incidentally on a dirt trail under the train track from Woodlands Road, about 200 m outside of the Study Area. The twin-barred gliding snake is a diurnal species and largely arboreal. It is reported to "occur mainly in the Central Catchment Nature Reserve, with isolated reports from other forested parts of the island and Pulau Ubin" [P-2]. The presence of this species at this location may be explained by the proximity to Kranji woodland, which is the most extensive forested patch in the surrounding area.

7.3.2.3.5 Birds

The field assessment recorded 99 species, of which 63 are residents (63.6%), 12 are introduced (12.1%) and 22 are migrants (22.2%) (Table 7-8; Appendix G). Two species (*Aerodramus* sp. and *Ardeola* sp.) were only identifiable to genus level and was thus not classified by its native status.

Eighteen species of conservation significance were recorded in the field assessment (Table 7-9). Records of bird species of conservation significance were distributed across the Study Area (Figure 7-35).

The straw-headed bulbul (*P. zeylanicus*) is listed as nationally Endangered. Due to its melodious and attractive songs, it is highly sought-after for the songbird trade. This rapid deterioration of global population resulted in a revision of its global conservation status in 2018 from Endangered to Critically Endangered [W-86]. In Singapore, while the estimated population size is slightly over 200 birds, possibly making up one-third of the global population [P-48], habitat loss to development continues to remain a primary threat. Even though this species is not fastidious in its nesting habitat requirements, having been observed to nest on trees in wooded areas in urban parks and gardens, they mostly occur in secondary forest and woodlands patches near rivers, suggesting that they prefer these habitats [P-48]. There were eight records of the straw-headed bulbul (*P. zeylanicus*) during the field assessment and they were mainly recorded around the Kranji woodland (Figure 7-35). It has been recorded in green spaces and forest patches adjacent to the Study Area, including Bukit Mandai forest, Bukit Batok Nature Park, Toh Tuck forest, Kranji woodland [P-42; P-49]. This species requires wooded corridors, such as Rail Corridor, to move between habitats [P-35; P-48].

The nationally Endangered black-crowned night heron (*Nycticorax nycticorax;* Figure 7-34A) was recorded at five locations along Sungei Pang Sua (Figure 7-35). It was observed on three occasions at night in the northern end, and once in the day in the southern end of Sungei Pang Sua (Figure 7-35). The black-crowned night heron is crepuscular and typically leave its roost site to forage in the evenings [P-49]. This species inhabits a wide range of aquatic environments, including mangroves, ponds, mudflats, canals and well-vegetated reservoir fringes [P-49]. It has been observed feeding in urban canals at night within Singapore [P-49]. It is threatened by disturbance to nesting sites [P-49]. No nesting/roosting sites were observed in the Study Area. However, observations of this species in the day suggests that it may be roosting in the Study Area.

The nationally Endangered purple heron (*Ardea purpurea*; Figure 7-34C) was observed within the Sungei Pang Sua, which is a known resident of mangrove and mudflat habitats. There were three records of purple heron in the central and southern end of Sungei Pang Sua (Figure 7-35). This species is more typically observed inland [P-49]. Though not nationally threatened, the grey heron (*Ardea cinerea;* Figure 7-34D) was also recorded several times along the Sungei Pang Sua. The Sungei Pang Sua is a suitable roosting and foraging habitat for the purple heron and grey heron.

Both the nationally Vulnerable grey-headed fish eagle (*Haliaeetus ichthyaetus*) and changeable hawk-eagle (*Nisaetus cirrhatus*), make use of large trees to hunt and nest [P-42]. The grey-headed fish eagle was heard once incidentally outside of the Study Area, approximately 150 m away (Figure 7-35). It is known to use forest and scrubland adjacent to inland waterbodies. It prefers to fish in freshwater habitats rather than brackish waters, hence more likely to fish in the deeper sections of Pang Sua Canal rather than Sungei Pang Sua. The changeable hawk-eagle was recorded on three occasions (Figure 7-35). All records were along the edge of the Kranji woodland. Two raptor nests are known from the Kranji woodland that borders the Study Area, belonging to changeable hawk-eagle and white-bellied sea eagle. A nest of a pair of changeable hawk-eagle is located approximately 30 m away from the Study Area (Figure 7-35) and was last observed at the nest in February 2021. However, since this species is known to re-use its nest, it is likely to occupy the existing nest. The nest of a white-bellied sea eagle is located approximately 40 m from the Study Area (Figure 7-35, it was seen flying out from its nest in February 2022.

The nationally Vulnerable spotted wood owl (*Strix seloputo*; Figure 7-34B) is an uncommon resident that has been observed in secondary forests, forest edge and urban parklands [P-49]. It was seen once in the central part of the Study Area along the Rail Corridor (Figure 7-35).

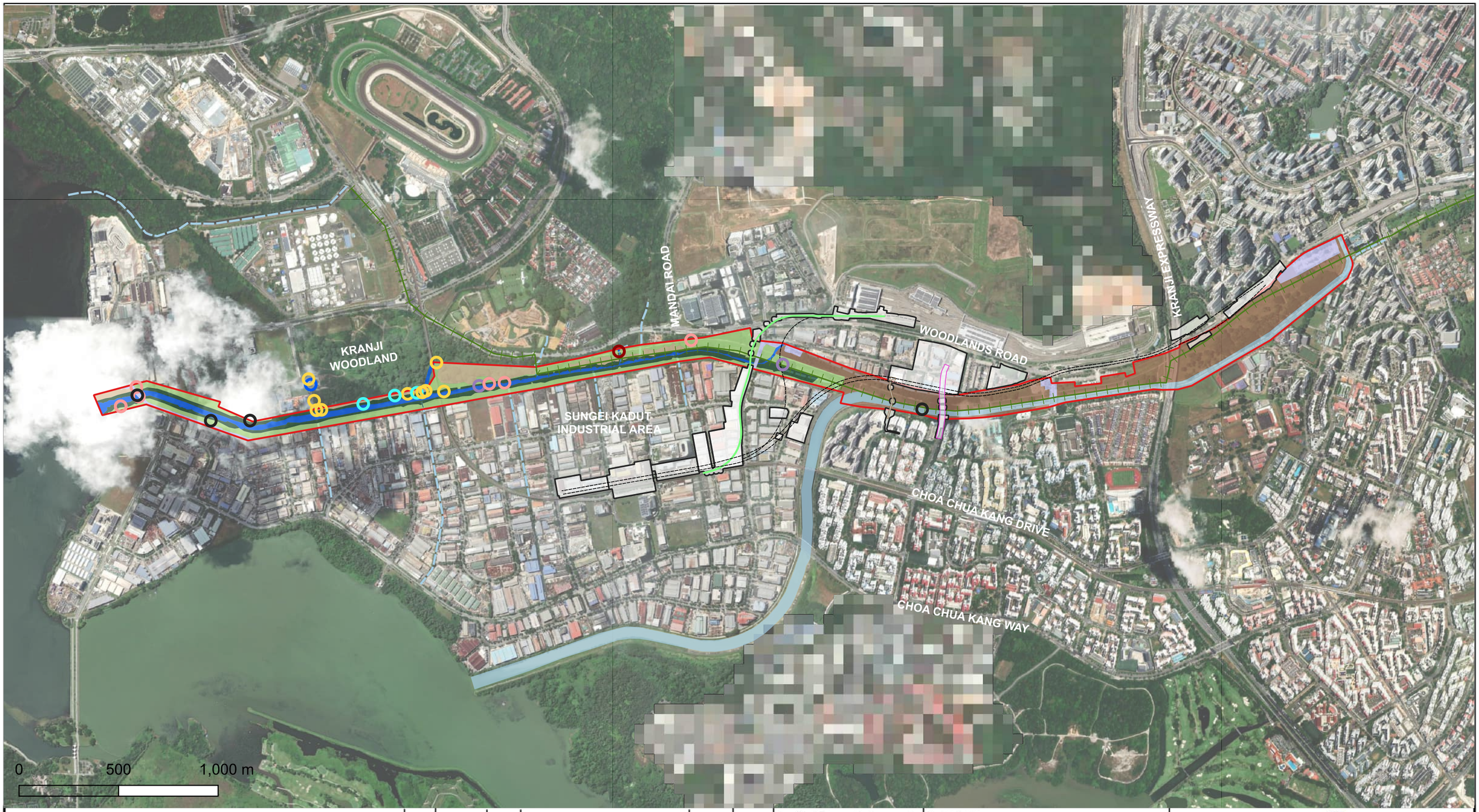
Several species were distributed across the Study Area. This includes the globally Vulnerable long-tailed parakeet (*Psittacula longicauda*), nationally Vulnerable brown shrike (*Lanius cristatus*), oriental magpie-robin (*Copsychus saularis*), Swinhoe's white-eye (*Zosterops simplex*) and common sandpiper (*Actitis hypoleucos*) that were frequently seen and heard along the entire Study Area. The long-tailed parakeet is a globally Vulnerable species but is regarded as common in Singapore.

The nationally Vulnerable oriental reed warbler (*Acrocephalus orientalis*) and black-capped kingfisher (*Halcyon pileata*) which are winter visitors, were both heard once towards the northern part of Sungei Pang Sua. The nationally Vulnerable common kingfisher (*Alcedo atthis*) also observed thrice along Sungei Pang Sua. Like the black-capped kingfisher, it is typically found near waterbodies (Yong et al., 2017).

The nationally Vulnerable great egret (*Ardea alba*) was observed at the northern tip of Sungei Pang Sua. It is typically found in wetlands, mangroves and mudflats (Yong et al., 2017). The nationally Vulnerable yellow bittern (*Ixobrychus sinensis*) was observed twice in the central part of the Study Area, slightly south of the Sungei Pang Sua. The nationally Vulnerable large-billed crow (*Corvus macrorhynchos*) and baya weaver (*Ploceus philippinus*) was observed several times in the central part of the Study Area.

Twenty-two migratory species were recorded in the Study Area including 16 common or abundant species, 5 uncommon species and 1 rare species. The rare yellow-browed warbler (*Phylloscopus inornatus*) was heard once in the southern part of the Study Area. It is a rare migrant and usually found in forest habitats, and sometimes seen in parklands [P-23]. The breeding range of these migratory species lie at the northern latitudes, in countries such as China, Taiwan and Japan. They migrate south during winter to the warmer latitudes. Singapore lies along a major migratory path known as the East Asian-Australasian Flyway, and receives a high number of migratory species shifting between northern breeding grounds and southern overwintering haunts [P-49]. These migratory species may use the Rail Corridor to move between forested patches in Singapore as wintering grounds.

Figure 7-34 Bird species of conservation significance. (A) Black-crowned night heron (*Nycticorax* nycticorax); (B) Spotted wood owl (*Strix seloputo*), (C) Purple heron (*Ardea pupurea*) and (D) Grey heron (*Ardea cinerea*)



Legend

- Biodiversity Study Area
- Proposed DTL2e Tunnel Alignment
- Potential Future Infrastructure
- Proposed Cut and Cover Area
- Proposed Vehicular Bridge
- Pedestrian Overhead Bridge
- Existing Vegetated Area
- Sungei Pang Sua
- Pang Sua Canal
- Stream
- Drain

Habitat Types

- Mangrove
- Exotic-dominated Secondary Forest
- Scrubland
- Urban Vegetation
- Others

Bird species of conservation significance

- Ardea cinerea
- Ardea purpurea
- Haliaeetus ichthyaetus
- Nisaetus cirrhatus
- Nycticorax nycticorax
- Pycnonotus zeylanicus
- Strix seloputo

Rev.	Date	By	Description	Chk'd	App'd
-	Aug 2024	JT	Environmental Study Report	NHT	JAG

Qualified Person Endorsement : N/A

LTA Endorsement : N/A

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title :

CONTRACT 9175 ADVANCE ENGINEERING STUDY FOR THE PROPOSED DOWNTOWN LINE 2 EXTENSION AND A NEW STATION ON EXISTING NORTH-SOUTH LINE

Figure Title :

DISTRIBUTION OF BIRD SPECIES OF CONSERVATION SIGNIFICANCE WITHIN THE STUDY AREA

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
HHL	NHT	JAG	7-35	-	1 of 1
	Drawn JT	Date Aug 2024	CAD File Name :N/A		A3

Note: Source of basemap - OneMap and Open Street Map

7.3.2.3.6 Mammals (Non-volant)

The field assessment recorded 12 non-volant mammal species (Table 7-8; Appendix G). Only one species of conservation significance, the globally Vulnerable and nationally Endangered smooth-coated otter (*Lutrogale perspicillata*) was recorded across the Study Area (Table 7-9). Presence of the smooth-coated otter was detected at four locations, within Sungei Pang Sua and Pang Sua Canal (Figure 7-37). A family of five individuals (Figure 7-36A) was seen on camera trap in the northern part of Sungei Pang Sua (CT12) during the study (Figure 7-37). One individual was also seen on camera trap in the southern part of Sungei Pang Sua (CT07; Figure 7-37). A family of seven individuals was also spotted foraging within the Pang Sua Canal incidentally in Feb 2021. According to OtterWatch, a group that shares significant news of otters in Singapore, the otters sighted in the Study Area may have been the Pang Sua family that was first sighted in the Pang Sua estate in 2017 [W-85]. The family has been observed to use Pang Sua Canal to move between Kranji Reservoir and the Pang Sua pond [W-85]. A spraint site was observed adjacent to Sungei Pang Sua that borders the Kranji woodland (Figure 7-37). Fresh spraints were regularly observed during the study (Figure 7-36B).

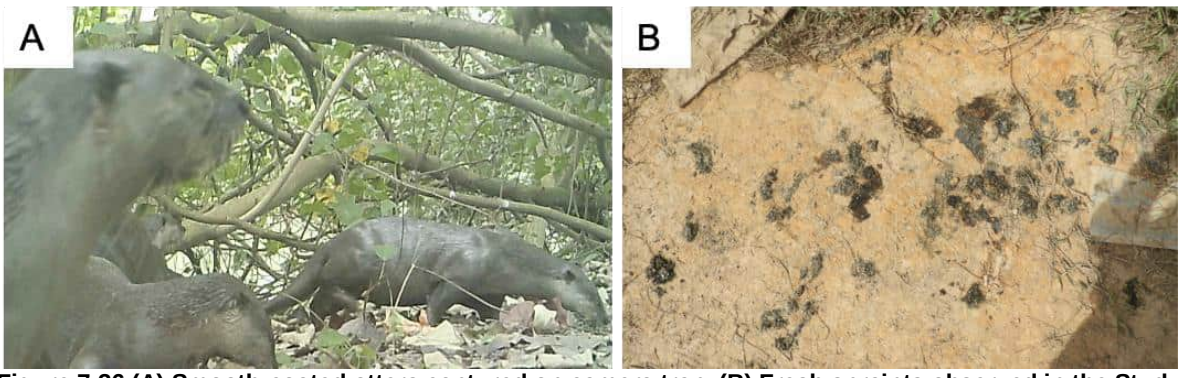


Figure 7-36 (A) Smooth-coated otters captured on camera trap. (B) Fresh spraints observed in the Study Area

While not recorded, the globally and nationally Critically Endangered Sunda pangolin (*Manis javanica*) is expected to occur within the Study Area. Sightings have been made in adjacent areas, such as in the canal south of the Study Area [P-11]. The pangolin is usually observed in nature reserves and degraded forest fragments of Singapore [P-32]. According to unpublished data by ACRES [P-33], this species has also been seen in public areas as some individuals, especially sub-adult males, disperse in search of a home range. Hence, explains their possible presence at the Study Area. Singapore is a stronghold for the Sunda pangolin, with the species being able to utilise green areas within nature reserves as well as degraded forests and manmade structures such as roads and drains [P-23]. However, threats to the local population remain, with road-related mortality reducing the population size, and habitat loss, degradation and fragmentation, threatening the genetic diversity of the Singapore's population [P-23]. Increasing sustainability and connectivity between habitats is considered a key measure for the conservation of this species [P-22]. Therefore, habitats that provide connectivity for this species, such as that of the Study Area, to safely travel between fragmented habitats helps to reduce road-related mortality, and contribute to the overall conservation of this species.

All other recorded species were considered widespread and common except for the Sumatran palm civet (*Paradoxurus musangus*) which is considered widespread but uncommon.

The 13 camera traps yielded 620 independent detections, with 10 species of identified non-volant mammals over 768 trap-nights (Table 7-11). The most commonly recorded non-volant mammalian species was the Eurasian wild boar (*Sus scrofa*), with 182 independent detections, followed by the plantain squirrel (*Callosciurus notatus*) with 171 independent detections (Table 7-12). There was a total of three independent sightings of smooth-coated otter on camera traps between Dec 2021 to Mar 2022. CT07 recorded the highest number of non-volant mammal species (9 species). It is located inland of Sungei Pang Sua. The highest detection rate of non-volant mammal species is at CT09, in the forested patch adjacent to Study Area (Table 7-11).

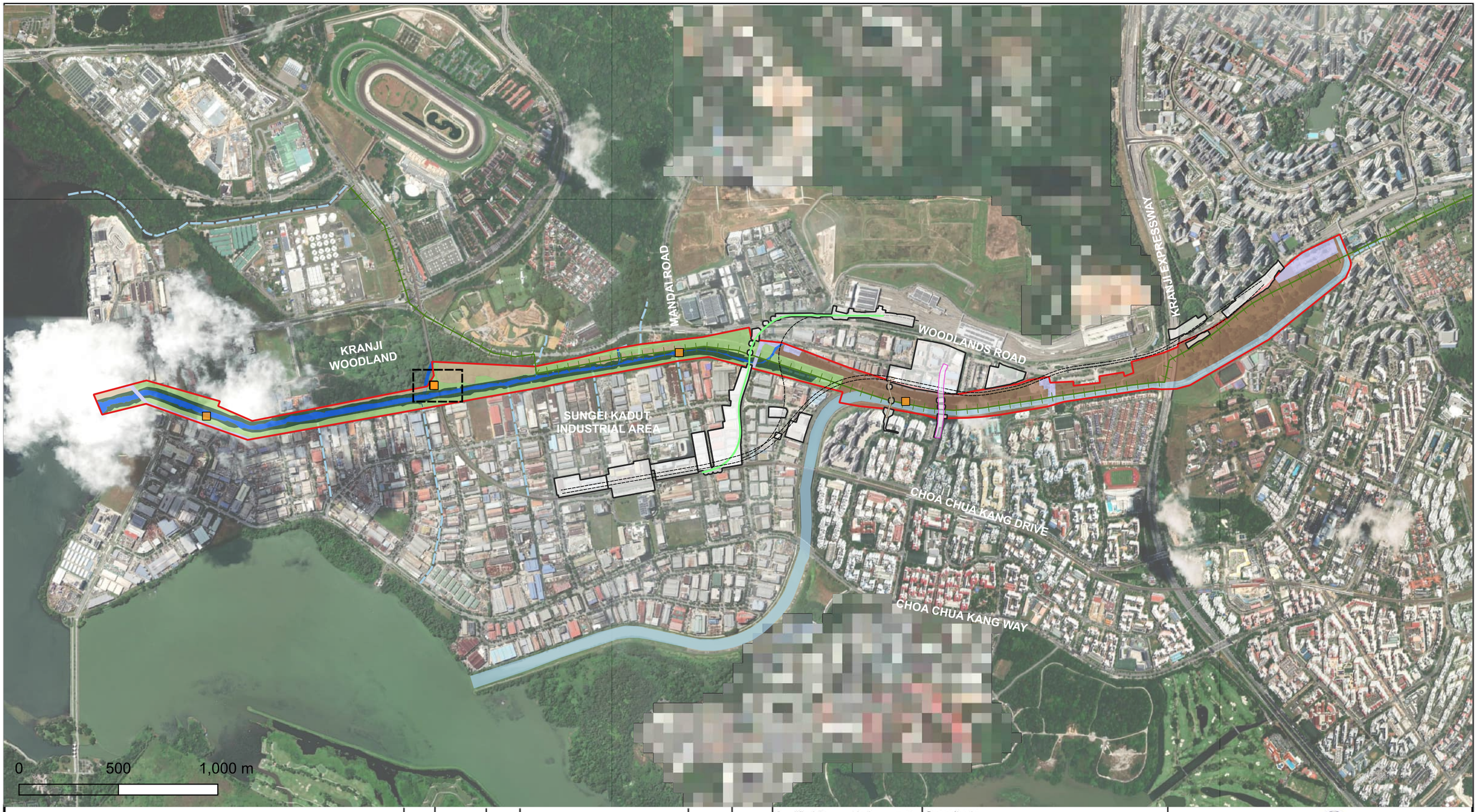
Table 7-11 Summary of trap-nights and number of independent detections of mammal species at each camera trap

Station	Number of Trap Night	Number of Non-volant Mammal Species	Detection Rate of Non-volant Mammal Species
CT01	64	3	0.91
CT02	64	1	0.08
CT03	64	4	0.61
CT04	64	3	0.31
CT05	60	5	0.83
CT06	60	6	1.40
CT07	60	9	1.32
CT08	56	4	0.41
CT09	27	4	4.33
CT10	63	3	0.86
CT11	62	4	0.84
CT12	61	5	0.49
CT13	63	1	0.14

Table 7-12 Location of and number of independent detections of mammal species across all camera traps

Scientific Name	Common Name	Global Status	National Status	Station	Number of Independent Detections
Sus scrofa	Eurasian wild boar	Least Concern	Least Concern	CT06–CT12	182
Callosciurus notatus	Plantain squirrel	Least Concern	Not Assessed	All except CT13	171
Canis lupus familiaris	Feral dog	Not Assessed	Not Assessed	All except CT02 and CT08	90
Suncus murinus	House shrew	Least Concern	Not Assessed	CT05–CT07	60
Rattus tanezumi	Asian house rat	Least Concern	Least Concern	CT03, CT05–CT07	39
Tupaia glis	Common treeshrew	Least Concern	Not Assessed	CT05, CT07–CT09, CT11	36
Rattus tiomanicus	Malaysian wood rat	Least Concern	Least Concern	CT06, CT07 and CT12	26
Paradoxurus musangus	Sumatran palm civet	Least Concern	Least Concern	CT01, CT03, CT04 and CT08	10
Lutrogale perspicillata	Smooth-coated otter	Vulnerable	Endangered	CT07, CT12	3
Felis cactus	Feral cat	Not Assessed	Not Assessed	CT07	3

*Independent detection cannot be calculated since it was not identified to species level



Legend

- Biodiversity Study Area
- Proposed DTL2e Tunnel Alignment
- Potential Future Infrastructure
- Proposed Cut and Cover Area
- Proposed Vehicular Bridge
- Pedestrian Overhead Bridge
- Existing Vegetated Area
- Sungei Pang Sua
- Pang Sua Canal
- Stream
- Drain

Habitat Types
- Mangrove
- Exotic-dominated Secondary Forest
- Scrubland
- Urban Vegetation
- Others

Species of Conservation Significance
- Lutrogale perspicillata
- Spraint site

Rev.	Date	By	Description	Chk'd	App'd
-	Aug 2024	JT	Environmental Study Report	NHT	JAG

Qualified Person Endorsement : N/A

LTA Endorsement : N/A

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title :
CONTRACT 9175 ADVANCE ENGINEERING STUDY FOR THE PROPOSED DOWNTOWN LINE 2 EXTENSION AND A NEW STATION ON EXISTING NORTH-SOUTH LINE

Figure Title :
DISTRIBUTION OF MAMMALIAN SPECIES OF CONSERVATION SIGNIFICANCE WITHIN THE STUDY AREA

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
HHL	NHT	JAG	7-37	-	1 of 1
	Drawn JT	Date Aug 2024	CAD File Name :N/A		A3

Note: Source of basemap - OneMap and Open Street Map

7.3.2.3.7 Mammals (Bats)

Seven bat species were recorded during the field assessment, including one fruit bat and six insectivorous bats (Table 7-8; Appendix G).

All species recorded are widespread and common, except for two. The black-bearded tomb bat (*Taphozous melanopogon*) is widespread but rare, and the glossy horseshoe bat (*Rhinolophus refulgens*) that is considered restricted but common. One individual of the glossy horseshoe bat was caught in the harp trap along Sungei Pang Sua.

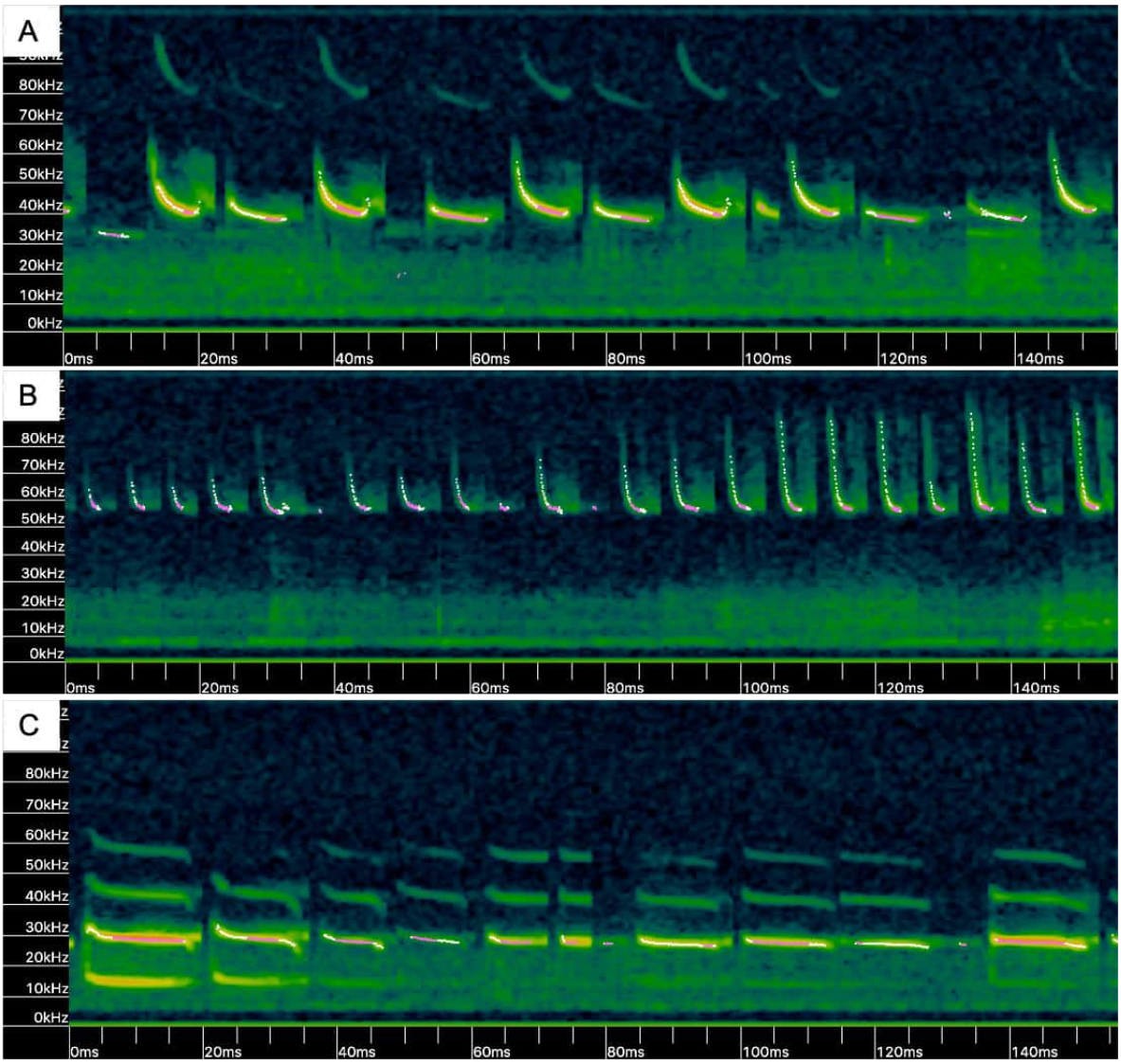


Figure 7-38 Spectrograms of insectivorous bat species recorded. (A) Lesser Asian house bat (Scotophilus *kuhlii*), (B) Asian whiskered myotis (*Myotis muricola*) and (C) Black-bearded tomb bat (*Taphozous melanopogon*)

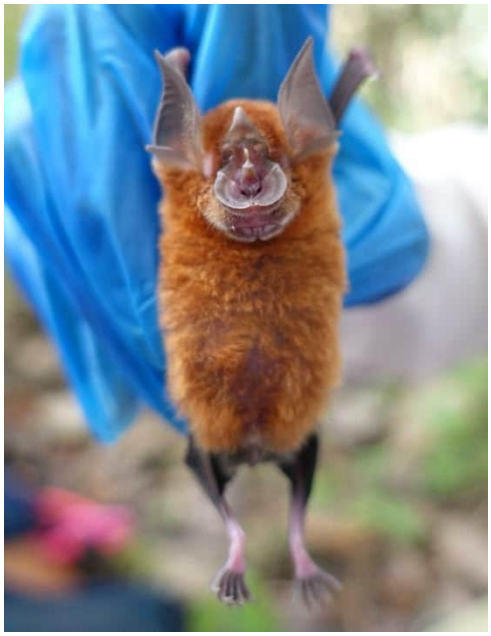


Figure 7-39 Glossy horseshoe bat (Rhinolophus *refulgens*) caught during bat trapping

7.3.2.3.8 Fish

The field assessment recorded 18 fish species, with none of conservation significance (Table 7-8; Appendix G). It includes 6 freshwater fish, 11 intertidal fish and 1 marine fish. Along Sungei Pang Sua, the fish community is characterized by species from a continuum of freshwater to brackish aquatic conditions, due to freshwater conditions inland and tidal influence at the mouth. Freshwater specialists include species such as the giant snakehead (*Channa micropeltes*) and the Mayan cichlid (*Cichlasoma urophthalmum*). These species were found inland with lower salinity levels due to greater freshwater influence. Along Sungei Pang Sua, species observed are those adapted to brackish water and/or higher salinity levels due to tidal influence nearer to the coast. This include the Sunda pygmy halfbeak (*Dermogenys collettei;* Figure 7-40D) and the Javanese ricefish (*Oryzias javanicus*) which are highly tolerant of fluctuations in salinity. Nearer to the coast, mangrove species and those adapted to higher salinity conditions were observed, including as the gudgeon (*Butis* sp.; Figure 7-40A), banded archerfish (*Toxotes jaculatrix;* Figure 7-40C) and gobies, such as the robust mangrove goby (*Acentrogobius janthinopterus;* Figure 7-40B) and barcheek goby (*Rhinogobius similis*).

At the mouth of Sungei Pang Sua, the globally Endangered honeycomb ray (*Himantura uarnak*) may occur although it was not recorded. It is typically found in marine environments.

Along Pang Sua Canal, freshwater fish species recorded were all non-native species such as the guppy (*Poecilia reticulata*) and and Malayan tiger barb (*Puntigrus partipentazona*).

Figure 7-40 Fish observed during surveys. (A) Gudgeon (*Butis* sp.); (B) Robust mangrove goby (*Acentrogobius janthinopterus*), (C) Banded archerfish (*Toxotes jaculatrix)* and, (D) Sunda pygmy halfbeak (*Dermogenys collettei*)

7.3.2.3.9 Molluscs

The field assessment recorded 37 mollusc species (Table 7-8; Appendix G) with most of the species being comprised of those typical of mangrove and muddy intertidal areas such as Venus clams, mussels and ear shells (Ellobidae). It includes 4 freshwater gastropod, 18 intertidal bivalve, 14 intertidal gastropod and 1 terrestrial gastropod. There are no species of conservation significance.

Due to the continuum of Sungei Pang Sua, which progresses from mostly freshwater in the inland section, down to brackish/marine at the mouth, the benthic community shows a similar shift according to this salinity gradient. Furthest inland, the community is primarily characterised by the presence of one dominant species, i.e, the quilted melania (*Tarebia granifera*) or the Lokan (*Geloina* sp.) (*Geloina expansa* or *G. coaxans*; Figure 7-41A), that is high in abundance across Sungei Pang Sua. It is a common resident of such muddy mangrove habitat [P-36]. Commonly observed was also the *Melanoides tuberculata* (Figure 7-41B), possibly the most ubiquitious freshwater snail in Singapore, which is adapted to a large range of waterbodies [P-47]. Further downstream, species tolerant of brackish conditions, such as the *Sermyla riquetii,* were frequently seen. It is a common inhabitant of estuarine canals, drains and muddy areas within the mangrove [P-47]. The community changes towards the coast as the ocean and tides bring in other intertidal species and environmental conditions become more saline. Mangrove, back mangrove and mudflat species, such as the ear shells (*Ellobium aurisjudae* and *Ellobium aurismidae;* Figure 7-41C), mud whelk (*Nassarius jacksonianus*) and chut-chut (*Cerithidea obtusa*) were also seen.

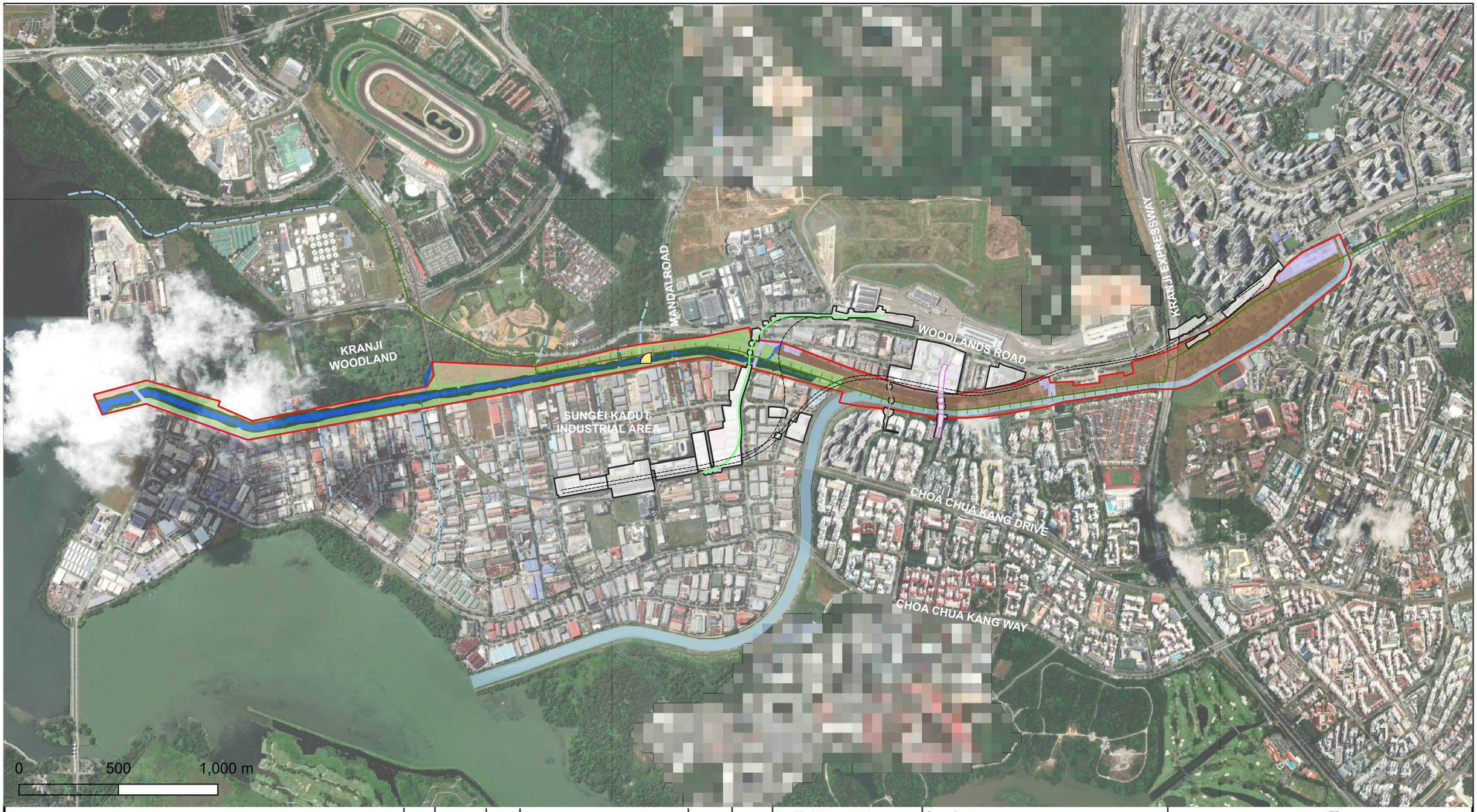
Figure 7-41 Molluscs found during surveys in the Study Area. (A) Lokan (*Geloina* sp.); (B) cf. *Melanoides tuberculata*; and (C) Juda's Ear Shell (*Ellobium aurisjudae*)

7.3.2.3.10 Decapods and Limulids

The field assessment recorded 11 decapod crustaceans and one limulid (horseshoe crab) (Table 7-8; Appendix G). It includes 1 freshwater shrimp, 8 intertidal crab, 1 horseshoe crab and 1 mud lobster (mound). Of which, the limulid, the mangrove horse crab (*Carcinoscorpius rotundicauda*) and mud lobster (*Thalassina* spp.) are of conservation significance.

The nationally Vulnerable mangrove horse crab was seen once inland at A02 (Figure 7-42; Figure 7-43). This was a single dead adult individual. It is likely that this individual was washed in by the tides, as the Mandai Mangrove and Mudflats, where an established population of this species is found [P-4]. In addition, benthic surveys in the locality did not find any individuals of smaller classes sizes (e.g., juveniles or young), yet the survey period was in the known breeding period of the mangrove horseshoe crab [P-4]. Therefore, the presence of a local breeding population within the Sungei Pang Sua seems unlikely. However, given the close proximity to Mandai Mangrove and Mudflats which is a stronghold for this species, it is likely that more individuals of this species will be found in the mudflat adjacent to the Sungei Pang Sua, outside of the study boundary.

Figure 7-42 A dead mangrove horseshoe crab (*Carcinoscorpius rotundicauda)* observed during survey



Legend

- Biodiversity Study Area
- Proposed DTL2e Tunnel Alignment
- Potential Future Infrastructure
- Proposed Cut and Cover Area
- Proposed Vehicular Bridge
- Pedestrian Overhead Bridge
- Existing Vegetated Area
- Sungei Pang Sua
- Pang Sua Canal
- Stream
- Drain

Habitat Types

- Mangrove
- Exotic-dominated Secondary Forest
- Scrubland
- Urban Vegetation
- Others

Species of Conservation Significance

- Carcinoscorpius rotundicauda

Rev.	Date	By	Description	Chk'd	App'd
-	Aug 2024	JT	Environmental Study Report	NHT	JAG

Qualified Person Endorsement :
N/A

LTA Endorsement :
N/A

Consultant : AECOM

Land Transport Authority
We Keep Your World Moving

Project Title :
CONTRACT 9175
ADVANCE ENGINEERING STUDY FOR THE PROPOSED DOWNTOWN LINE 2 EXTENSION AND A NEW STATION ON EXISTING NORTH-SOUTH LINE

Figure Title :
LOCATION OF HORSESHOE CRAB OF CONSERVATION SIsignificance WITHIN THE STUDY AREA

Designed	Checked	Approved
HHL	NHT	JAG
	Drawn: JT	Date: Aug 2024

Figure No. : 7-43 | Rev. : - | Sheet : 1 of 1

CAD File Name :N/A | A3

Note: Source of basemap - OneMap and Open Street Map

All decapod crustaceans recorded are those typical of mangrove and mudflat habitats. Common inhabitants of the mangrove forest include the tree climbing crab (*Episesarma chentongense*) and face-banded sesarmine crab (*Perisesarma eumolpe)* which are often seen climbing on the mangrove trees. At the mudflats, species preferring the muddy habitat can be seen. The crabs, *Baruna trigranulum* and *Paracleistostoma depressum*, are typically observed on the muddy substrate.

Although the mud lobsters (*Thalassina* spp.) were not visually observed during surveys, they were deemed present within Sungei Pang Sua based on the presence of their mounds. Mud lobsters are nocturnal and primarily located in the back mangroves. They prefer to stay within their burrows, and are known to build mounds up to 3 m high and 2.5 m deep [P-20; P-28; P-38]. The mud lobsters feed on organic matter in the mud [P-37]. Due to their burrowing habitats, they are also considered important ecosystem engineers to help alter, maintain and create new habitats [P-28]. They are rarely encountered above ground as they spend most time within their burrows, and therefore, the presence of their mounds was instead used as an indication of their presence and abundance along Sungei Pang Sua.

Mud lobsters typically inhabit back mangrove [P-28]. There are two species of mud lobsters (*Thalassina* spp.) that are expected to occur at Sungei Pang Sua – *T. anomala* and *T. gracilis.* Both are listed as nationally Endangered [P-8]. T. gracilis appears to prefer clayey-fine sand substrate while the T. anomala prefers areas with silt and high organic matter [P-28].

A total of 416 mud lobster mounds were mapped within mangrove forest of Sungei Pang Sua. The density of mud lobster is estimated at 37.7 individuals/ha (total number of mounds divided by area of mangrove forest in Sungei Pang Sua, i.e., 11.04 ha). There are no density estimates available for other sites in Singapore. In comparison to density estimates reported from Indonesia and Malaysia (530–4600 individuals/ha) [P-20; P-29], the density along Sungei Pang Sua appears lower. This may be because the back mangrove habitat along Sungei Pang Sua is relatively thin. Nevertheless, mud lobsters (*Thalassina* spp.) are considered nationally threatened, and therefore, mud lobster mounds are considered of conservation significance.

Along Sungei Pang Sua, the density of mud lobster mounds was higher at the inland sections, approximately 500 m away from the Sungei Kadut Avenue (Figure 7-44). Factors influencing the distribution of mud lobster (and its mounds) include sediment characteristics, tidal inundation and salinity [P-28]. Within Sungei Pang Sua, the height of mud lobster mounds were up to 2 m, which falls within the range documented in literature [P-20; P-28].

Legend

- Biodiversity Study Area
- Proposed DTL2e Tunnel Alignment
- Potential Future Infrastructure
- Proposed Cut and Cover Area
- Proposed Vehicular Bridge
- Pedestrian Overhead Bridge
- Existing Vegetated Area
- Sungei Pang Sua
- Pang Sua Canal
- Stream
- Drain

Habitat Types

- Mangrove
- Exotic-dominated Secondary Forest
- Scrubland
- Urban Vegetation
- Others

Density of mud lobster mound

Low — High

Rev.	Date	By	Description	Chk'd	App'd
-	Aug 2024	JT	Environmental Study Report	NHT	JAG

Qualified Person Endorsement : N/A

LTA Endorsement : N/A

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title :
CONTRACT 9175 ADVANCE ENGINEERING STUDY FOR THE PROPOSED DOWNTOWN LINE 2 EXTENSION AND A NEW STATION ON EXISTING NORTH-SOUTH LINE

Figure Title :
DENSITY OF MUD LOBSTER MOUNDS ALONG SUNGEI PANG SUA

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
HHL	NHT	JAG	7-44	-	1 of 1
	Drawn JT	Date Aug 2024	CAD File Name :N/A		A3

Note: Source of basemap - OneMap and Open Street Map

7.3.3 Ecological Significance and Connectivity

The Study Area is part of the Rail Corridor and serves as a passageway for the dispersal of wildlife along the Rail Corridor [P-13]. Species using the surrounding green spaces (e.g., Kranji woodland, Bukit Mandai forest to the northeast and Bukit Gombak forest to the south) may use the Rail Corridor as an ecological corridor to move to other green spaces (Figure 7-45).

0 5 10 km

Legend

- Study Area
- Rail Corridor
- Kranji Reservoir
- Green Space

N

Rev.	Date	By	Description	Chk'd	App'd
-	AUG 2022	JT	Draft Final Report	NHT	JAG

Qualified Person Endorsement :
N/A

LTA Endorsement :
N/A

Consultant : AECOM

Land Transport Authority
We Keep Your World Moving

Project Title :
CONTRACT 9175
ADVANCE ENGINEERING STUDY FOR THE PROPOSED DOWNTOWN LINE 2 EXTENSION AND A NEW STATION ON EXISTING NORTH-SOUTH LINE

Figure Title :
CONNECTIVITY OF STUDY AREA TO SURROUNDING GREEN SPACES

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
HHL	NHT	JAG	7-45	-	1 of 1
	Drawn JT	Date AUG 2022	CAD File Name :N/A		A3

Note: Source of basemap - OneMap and Open Street Map

7.4 Assessment of Ecological Value

Habitats and species within the Study Area were assessed for their ecological value. Habitats and species accorded with higher ecological value were regarded of greater importance for conservation relative to other habitats and species, respectively, within the Study Area. Those of high ecological value were assigned the Priority 1 sensitivity level, while those of moderate or low ecological value were assigned the Priority 2 or 3 sensitivity levels, respectively. The assessment was carried out using biodiversity baseline findings.

The ecological value assessment framework for habitats is described in Table 7-13. The ecological value assessment framework for plant and faunal species is described below, as well as Table 7-14 for plant species.

Table 7-13 Criteria for assessing the ecological value of habitats

Criterion	Definition	Classification		
		High	Medium	Low
Size	Area occupied by the habitat relative to the study area or length of a stream	≥40%	10–40%	≤ 10%
Naturalness	Degree to which the habitat has been modified or disturbed as a result of human activities	Habitat with minimal human disturbance	Moderately disturbed habitat that has been modified to some extent	Highly disturbed habitat that has been modified to a large extent
Abundance of species of conservation significance	Number of plant specimens recorded within the habitat relative to the Study Area; number of recorded faunal species of conservation significance that able to utilise the particular habitat type in the Study Area	≥40%	10–40%	≤ 10%
Abundance of large and other plant specimens of value	Number of large and other plant specimens of value recorded within the habitat relative to the Study Area	≥40%	10–40%	≤ 10%
Ecological linkage	The value of a habitat increases if it lies in close proximity and/or links functionally to a highly valued habitat of any type	Able to connect to high valued habitats within the Study Area	Able to connect to habitats within the Study Area	Not able to connect to habitats within the Study Area, i.e., isolated.
Difficulty in recreatability	Level of difficulty in re-constructing the habitat through human intervention	Very difficult	Moderately difficult	Easy

All plant species were first accorded with a tentative ecological value, i.e., high, medium, or low, based on the following basic framework:

- High ecological value (Priority 1): Species of conservation significance
- Medium ecological value (Priority 2): All other native species
- Low ecological value (Priority 3): Exotic and cryptogenic species

Species that were tentatively assigned medium (all other native species) or low (exotic and cryptogenic species) ecological value were then evaluated individually based on the criteria listed in Table 7-14. The evaluation of individual species served to either maintain or raise the pre-assigned ecological value. The following paragraphs detail how each criterion was considered in the evaluation.

Association with important fauna (native, exotic, and cryptogenic species): The ecological value of plant species that directly support the growth and survival of important fauna at one or various life cycle stages were raised to high, irrespective of plant species origin, cultivation intensity and effects, as well as national distribution. Examples of such plant species include caterpillar host plants for rare butterfly species and bamboos that are refugia for nationally threatened bamboo bats. The ecological value of plant species without associations with important fauna was maintained at the original level, i.e., medium or low.

Cultivation intensity and effects (native species only): The ecological value of all native species previously or presently cultivated and/or with populations of relics or escapees, respectively, present in the secondary forests of Singapore were maintained at the medium level. Otherwise, those that are associated with important fauna were raised to high ecological value.

National distribution (non-cultivated native species only): The ecological value of non-cultivated native plant species with restricted national distribution—i.e., largely found in certain forest patches in Singapore or offshore islands, such as the primary and old growth secondary forests of the CCNR—were raised from the original medium level to high. On the other hand, that of non-cultivated plant species that are nationally widespread—i.e., occur at several secondary forest patches throughout Singapore—were maintained at the medium level.

There are, however, a few exceptions in which the highest ecological value was automatically assigned to species regardless of the criteria listed below. They are (1) species endemic to Singapore and (2) species planted for reforestation and/or previously thought to be extinct and are planted for species reintroduction. Exotic rain tree (*Samanea saman*) was also automatically raised from low to medium ecological value given that it often supports the growth of epiphytes that provide habitats for fauna species.

Finally, keystone species, such as *Ficus* spp. and true mangrove species, are also allocated with the highest ecological value during the assessment. Keystone species is defined as “important plants that other animal in the community depend heavily on” [P-72]. Essentially, the removal of these species can potentially may cause an extirpation of dependent animals, such as pollinators and seed dispersers [P-73] and possibly re-shape or collapse the existing ecosystem. *Ficus* spp., or figs, regarded as keystone species as monoecious figs (i.e., species that bear both male and female reproductive organs within the same individual), are able to produce fruits all year round. This makes figs an important food source for many frugivores, especially during the time of the year where no other fruits are available. As for dioecious figs, they provide food for numerous avian insectivores that feeds on fig wasps [P-72]; [P-73].

According to Yang et al. (2013), there are a total of 36 true mangrove species that can be found in Singapore [P-81]. Altogether, these species make up the mangrove forest habitat. Mangrove species contribute to the ecological services crucial to numerous terrestrial, estuarine and marine organisms [P-81; P-78; P-79; P-70; P-82; P-1]. Hence, the loss of individual mangrove species contribute may lead-to the loss of marine biodiversity and the marine and coastal ecosystems [P-75].

Table 7-14 Criteria for assessing the ecological value of flora species

Criterion	Definition
Conservation Significance	Listed as nationally threatened, i.e., Vulnerable, Endangered, Critically Endangered, or Extinct, and are considered of conservation significance in this study
Association with Important Fauna	Directly associated with the survival of important fauna at one or various life cycle stages
Cultivation Intensity and Effects	Cultivated previously or presently—for various purposes such as reforestation, landscaping, species reintroduction, commercial sale, etc—and populations of relics and/or escapees are present/absent in forests
National Distribution	Extent of spread and/or occurrence at one or multiple forest patches in Singapore
Keystone Species	Important species that other animal in the community depend heavily on [P-72]. Removal of these species would most likely cause an extirpation of dependent animals and possibly re-shape or collapse the existing ecosystem [W-103].

All recorded faunal species were accorded an ecological value based on its conservation significance and species origin:

- High ecological value (Priority 1): Species of conservation significance
- Medium ecological value (Priority 2): All other native and migratory bird species, and species of indeterminate status
- Low ecological value (Priority 3): Exotic species

7.4.1.1 Habitat

The ecological value of four terrestrial habitats and three waterbodies within the Study Area was assessed. For the assessment of terrestrial habitats, the abundance of flora species of conservation significance and habitat preference of terrestrial fauna were considered, and likewise for the assessment of aquatic habitats. No large plant specimen and other plant specimens of value were recorded from aquatic habitats.

One terrestrial habitat (mangrove) and one aquatic habitat (Sungei Pang Sua) were assessed to have overall high ecological value, i.e., Priority 1. Two terrestrial habitats (scrubland and exotic-dominated secondary forest) and one aquatic habitat (stream) were assessed to have overall medium ecological value, i.e., Priority 2. One terrestrial habitat (urban vegetation) and one aquatic habitat (Pang Sua Canal) were assessed to have overall low ecological value, i.e., Priority 3. A summary of the assessment of ecological value is detailed in Table 7-15. The paragraphs below summarise assignation of ecological value for each habitat type.

7.4.1.1.1 Mangrove (High Ecological Value; Priority 1)

The mangrove occupies 11.04 ha (11.99 %). It is minimally disturbed and considered to have high naturalness.

This habitat harbours the greatest abundance of plant species of conservation significance and the second greatest abundance of faunal species of conservation significance. Mangroves in Singapore are uncommon due to anthropogenic pressures such as land reclamation and coastal developments. Majority of plant species of conservation significance in the Study Area are concentrated within the mangrove including the nationally Critically Endangered *Sonneratia caseolaris.* The species is in high density with high recruitment near the potential future infrastructure and stretches approximately 800 m. The highest density of *Sonneratia caseolaris* was observed south of the potential future infrastructure. Other examples of plant species of conservation significance in the mangrove habitat are nationally Critically Endangered *Finlaysonia obovata* and nationally Endangered *Lumnitzera racemosa*. The highest abundance (57.5%) of large and other plants of value also occurs in this habitat. This includes a 3.8m girth *Avicennia alba,* which is considerd uncommonly seen.

Example of faunal species recorded in the mangrove is the nationally Endangered smooth-coated otter (*Lutrogale perspicillata*). Moreover, the highest density of mud lobster mounds is in the mangrove. Mud lobsters, *Thalassina* spp., are nationally Endangered. Mud lobster mounds were observed throughout Sungei Pang Sua, except for the portion that is south of the potential future infrastructure. The highest density of mud lobster mound was observed approximately 800 m north of the potential future infrastructure.

The mangrove also connects terrestrial and marine habitats along Sungei Pang Sua allowing faunal species to traverse both habitats, therefore, scoring high under ecological linkage. It also drains out to the Mandai Mangrove and Mudflat, a nature park, which is also one of the most biodiverse wetlands in Singapore. Finally, as the complexities of mangroves are very difficult to reconstruct through human intervention, it scores high on the criterion of recreatability.

Mangrove is ranked high for four criteria (naturalness; abundance of species of conservation significance; and abundance of large and other plant specimens of value, ecological linkage, ease of recreatability) and medium for one criterion (size). Overall, the mangrove is assessed to be of high ecological value, i.e., Priority 1.

7.4.1.1.2 Exotic-Dominated Secondary Forest (Medium Ecological Value; Priority 2)

This habitat type occupies only 6.93% (6.38 ha) of the Study Area. Although only moderately disturbed, this habitat contains a low abundance of plant (0.20%) and faunal (8.9%) species of conservation significance, and large plants and other plants of value (8.5%). However, this habitat type has moderate connectivity as it is part of the linkage between Sungei Pang Sua, scrubland and mangrove habitats. In term of ease of recreatability, it is moderately difficult,

Exotic-dominated secondary forest is ranked medium for three criteria (naturalness, ecological linkage and ease of recreatability) and low for three criteria (size; abundance of species of conservation significance; and abundance of large and other plant specimens of value). Overall, this habitat type is assessed to be of medium ecological value, i.e., Priority 2.

7.4.1.1.3 Scrubland (Medium Ecological Value; Priority 2)

The scrubland is second highest in size (19.51 ha, 21.19%) within the Study Area. In terms of naturalness, it is moderately disturbed. Abundance of species of conservation significance is medium with flora at 10.0% and fauna 45.9%. Faunal species of conservation significance recorded from this habitat are mostly along the western back of Sungei Pang Sua. Examples are the nationally Vulnerable red-legged crake and nationally Endangered oriental magpie-robin. The habitat is low in abundance for large and valuable plant specimens.

Due to its position in the central section of the Study Area, the scrubland performs a high linkage function to create a contiguous greenery between the exotic-dominated secondary forest to urban vegetation, and along the banks of Sungei Pang Sua. It also forms a continuous greenery to the adjacent Kranji woodland where nests of white-bellied sea eagle and the nationally Endangered changeable hawk-eagle were observed. As a habitat, it is easy to recreate.

Hence scrubland is overall assessed (two high values, two medium values, two low values) to be of medium ecological value, Priority 2.

Scrubland is ranked high for two criteria (size and ecological linkage), medium for two criteria (naturalness and abundance of species of conservation significance) and low for two criteria (abundance of large and other plant specimens of value; and ease of recreatability). Overall, the scrubland is assessed to be of medium ecological value, i.e., Priority 2.

7.4.1.1.4 Urban Vegetation (Low Ecological Value; Priority 3)

The urban vegetation along western bank of Pang Sua Canal is the biggest habitat (33.74 ha; 26.65%) in the Study Area. However, it is a highly disturbed landscape with low abundance of species of conservation significance. As a human-modified landscape, it is easy to recreate.

A large proportion (61.6%) of large trees are found in this habitat. They are mainly Senegal mahogany (*Khaya senegalensis*), raintree (*Samanea saman*) and strangler fig (*Ficus macrocarpa*) with one individual of 15m spread. In terms of ecological linkage, the urban vegetation is moderately connected to the adjacent scrubland.

Urban vegetation is ranked high for one criterion (size), medium for two criteria (abundance of large and other plant specimens of value; and ecological linkage), and low for three criteria (naturalness, abundance of species of conservation significance, and ease of recreatability). Overall, the urban vegetation is assessed to be of low ecological value, i.e., Priority 3.

7.4.1.1.5 Sungei Pang Sua (High Ecological Value; Priority 1)

Sungei Pang Sua, as a linear waterbody, is small in size. It occupies 7.63% (7.02 ha) of the Study Area. Proportion of CS species is also low at 9% (fauna only) but the nationally endangered Smooth-coated otter was seen on camera traps at the southern and northern ends of Sungei Pang Sua suggesting the river is a foraging ground.

As a mangrove river with tidal influence and minimal human disturbance, it scores high for naturalness and very difficult to recreate. It is also intrinsically connected to the ecologically important Mandai Mudflat at its mouth whereby sediment deposits from the river contributes of the mudflat habitat.

Sungei Pang Sua is ranked high for three criteria (naturalness, ecological linkage and ease of and recreatability) and low for two criteria (size and abundance of species of conservation significance). Overall, Sungei Pang Sua is assessed to be of high ecological value, i.e., Priority 1.

7.4.1.1.6 Stream (Medium Ecological Value; Priority 2)

Stream comprised <0.1% (<0.1 ha) of the Study Area. The majority portion of the stream lies outside of the Study Area. It has lower level of salinity and drains out towards Sungei Pang Sua (refer to Section 8.4.2.2). It is a moderately disturbed habitat that has been modified to some extent. No plant species of conservation significance is present. Only one species of fauna species of conservation significance, the nationally Vulnerable red-legged crake was observed in the stream. Since is it well connected to Sungei Pang Sua, it is considered highly connected, and therefore, scores high on ecological linkage.

The stream is ranked high for one criterion (ecological linkage), medium for two criteria (naturalness and ease of recreatability) and low for two criteria (size and abundance of species of conservation significance). Overall, the stream is assessed to be of medium ecological value, i.e., Priority 2.

7.4.1.1.7 Pang Sua Canal (Low Ecological Value; Priority 3)

Pang Sua Canal is the largest of three waterbodies, and medium (9.55 ha; 10.37%) in size relative to other habitats in the Study Area. It is highly-modified with concrete embankment to a large extent. Situated along a housing estate, there is high human disturbance and low connectivity to other habitats. Correspondingly, it is low in CS species although seven individuals of Smooth-coated otters were observed in Feb 2021. As a largely man-made habitat, it is easy to recreate.

Pang Sua Canal is ranked medium for one criterion (size) and low for four criteria (naturalness; abundance of species of conservation significance; ecological linkage; and ease of recreatability). Overall, Pang Sua Canal is assessed to be of low ecological value, i.e., Priority 3.

Table 7-15 Assessment of ecological value of each habitat type within the Study Area

Criterion	Mangrove	Exotic-Dominated Secondary Forest	Scrubland	Urban Vegetation	Waterbodies		
					Sungei Pang Sua	Pang Sua Canal	Stream
Size	**Medium:** 11.99% (11.04 ha)	**Low:** 6.93% (6.38 ha)	**High:** 21.19% (19.51 ha)	**High:** 26.65% (33.74 ha)	**Low**: 7.63% (7.02 ha)	**Medium:** 10.37% (9.55 ha)	**Low**: <0.1% (<0.1 ha)
Naturalness	**High**: Habitat with minimal human disturbance	**Medium**: Moderately disturbed habitat that has been modified to some extent	**Medium**: Moderately disturbed habitat that has been modified to some extent	**Low**: Highly disturbed habitat that has been modified to a large extent	**High**: Habitat with minimal human disturbance	**Low**: Highly disturbed habitat that has been modified to a large extent	**Medium**: Moderately disturbed habitat that has been modified to some extent
Abundance of species of conservation significance	**High**: Flora: 84.1 % (338) Fauna: 34.6 % (89)	**Low:** Flora: 0.2 % (1) Fauna: 8.9 % (23)	**Medium:** Flora: 10.0 % (40) Fauna: 45.9 % (118)	**Low:** Flora: 0.2 % (1) Fauna: 6.6 % (17)	**Low:** Flora: — Fauna: 3.5 % (9)	**Low**: Flora: — Fauna: —	**Low**: Flora: — Fauna: 0.4 % (1)
Abundance of large and other plant specimens of value (including keystone species)	**High**: Large: 32 (14.8%) Others: 278 (86.1%) Total: 57.5 % (310)	**Low:** Large: 37 (17.1%) Others: 9 (2.8%) Total: 8.5 % (46)	**Low:** Large: 14 (6.5%) Others: 23 (7.1%) Total: 6.9 % (37)	**Medium**: Large: 133 (61.6%) Others: 13 (4.0%) Total: 27.1 % (146)	—	—	—
Ecological linkage	**High**: Highly connected	**Medium**: Moderately connected	**High**: Highly connected	**Medium**: Moderately connected	**High**: Highly connected	**Low:** Minimally connected	**High**: Highly connected
Ease of recreatability	**High**: Very difficult	**Medium**: Moderately difficult	**Low**: Easy	**Low**: Easy	**High**: Very difficult	**Low**: Easy	**Medium**: Moderately difficult
Total	**High × 5** Medium × 1	**Medium × 3** Low x 3	High × 2 **Medium × 2** Low x 2	High × 1 Medium × 2 **Low × 3**	**High × 3** Low × 2	Medium × 1 **Low × 4**	High x 1 **Medium × 2** Low × 2
Sensitivity	**Priority 1**	Priority 2	Priority 2	Priority 3	**Priority 1**	Priority 3	Priority 2

7.4.1.2 Flora

A total of 204 species and 2 species groups were assessed for their ecological value in the overall Study Area. Of all flora species, 32 were assessed with a Priority 1 sensitivity level, with high ecological value; 63 was assessed with a Priority 2 sensitivity level, with medium ecological value and the remaining 110 were assessed with Priority 3 sensitivity level, with low ecological value.

Flora of Conservation Significance
All 16 flora species of conservation significance were assessed with Priority 1 sensitivity level.

Association with Important Fauna
The sensitivity level of one flora species (i.e., *Bambusa* cf *heterostachya*) was raised from Priority 3 to Priority 1 due to its association with nationally Vulnerable bamboo bats (*Tylonycteris* spp.). Although no bamboo bats were recorded, they are considered to be potential habitats for these bats.

Keystone Species
Ten native flora species that are regarded as true mangrove species in Singapore (Section 7.3.3) had their sensitivity level raised from Priority 2 (i.e., medium ecological value) to Priority 1 (i.e., high ecological value). Similarly, the sensitivity level of four native *Ficus* spp. (*F. heteropleura, F. microcarpa*, *F. punctata*, and *F. variegata*) was raised level raised from Priority 2 to Priority 1. As for exotic *Ficus* sp. such as *F. benjamina*, *F. elastica* and *F. religiosa,* their sensitivity level was raised from Priority 3 to Priority 1.

7.4.1.3 Fauna

The ecological value of 293 faunal species—228 terrestrial and 65 freshwater/brackish—recorded from the baseline assessment were assessed. All 24 faunal species of conservation significance were accorded a Priority 1 sensitivity level, and deemed to be of high ecological value. For terrestrial species, 183 species were assessed to be of Priority 2 sensitive level, with medium ecological value, and 22 species with a Priority 3 sensitivity level, with low ecological value. For aquatic species, 51 species were assessed to be of Priority 2 sensitivity level, with medium ecological value, and 13 species with Priority 3 sensitivity level, with low ecological value. All species of conservation significance deemed of probable occurrence were also assessed to be of high ecological value. This list of 82 species assessed and its ecological value is presented in Appendix J.

7.5 Identification of Sensitive Receptors

7.5.1 Habitat

Based on the assessment of ecological value for habitats (Section 7.4.1.1), all habitats within the worksite and within 30 m from the proposed worksite area were identified as the sensitive receptors for habitats (see Figure 7-46).

7.5.2 Flora

Following the assessment of ecological value for all plant species (Section 7.4.1.2), some were selected for the assessment of ecological impacts. The selection was based on the following: (1) species of conservation significance, large specimens, other specimens of value, and/or trees found inside and within 30 m from the proposed worksite area, (2) keystone species, as defined in Section 7.3.3), (3) species associated with important fauna, and (4) species that make up ≤ 1% of the total number of specimens of conservation significance.

7.5.3 Fauna

Following the assessment of ecological value for faunal species (Section 7.4.1.3), all species with a Priority 1 sensitivity level were identified as the sensitive receptors. Species of conservation significance deemed of probable occurrence were also identified as sensitive receptors with the only exception being the unidentified

bamboo bat (*Tylonycteris* sp.). As species-level identification was not possible, both bamboo bat species (*Tylonycteris fulvida* and *T. malayana*) in Singapore were identified as sensitive receptors instead, as both species are threatened, and were deemed of probable occurrence.

A total of 79 sensitive receptors were identified, of which 22 were recorded from the field assessment, and 57 were deemed of probable occurrence. The sensitive receptors comprised 33 birds, 12 butterfly, 12 decapod, 1 horseshoe crab, 6 mollusc, 6 odonata, 4 bat, 3 non-volant mammal, 1 reptile and 1 fish species. This list of faunal species receptors is presented in Appendix L.

7.6 Potential Sources of Impacts

Potential impacts to biodiversity arising from construction and operational activities are assessed in this section. The impacts for the construction and operational phases were separately assessed for biodiversity sensitive receptors identified in Section 7.5, with a description of potential impacts given in Table 7-16 and Table 7-17.

There are two main categories in which the impacts fall into: (1) direct, i.e., impacts to habitats and species within the worksites and (2) indirect, i.e., impacts to habitats and species outside the worksites but within the impact zone. Impact zones for habitat and species receptors are defined as areas within 30 m from worksites of the proposed development (Figure 7-46), even though there are some studies that found edge effects affecting vegetation up to 150 m from forest boundaries [P-9, P-27, P-36, P-43]. The 30-m impact zone is based on the assumption that edge effects in habitats directly adjacent to worksites are the greatest within 30 m from the worksites.

7.6.1 Construction Phase

Potential biodiversity impacts during construction phase are presented in Table 7-16.

Table 7-16 List of potential biodiversity impacts during construction phase

Receptor	Impact Type	Description	Impact Category
Construction Phase			
Habitats	Loss of vegetation	Direct removal of vegetation (with extensive underground root systems that protect against soil erosion) to create space for construction activities	Direct
	Habitat degradation	Improper disposal of construction waste, accidental release of hazardous materials (such as construction slurry, paint, and/or solvents), increase in dust, noise, and light levels, changes in hydrology	Indirect
	Change in species composition	Formation of forest edge habitats that favour the growth of certain exotic plants and fauna, and accidental introduction of exotic species from construction materials (such as soil with seeds or bio-degradable erosion blankets with insect eggs)	Indirect
Plant Species	Injury and/or Mortality	Direct removal of vegetation to create space for construction activities or injury from mechanical damages from construction machineries	Direct
	Impediment to seedling recruitment	Pollution of habitats from improper disposal of construction waste and accidental release of hazardous materials (such as construction slurry, paint, and/or solvents)	Indirect
	Competition from exotic plant species	Formation of forest edge habitats that favour the growth of certain exotic plants and accidental	Indirect

Receptor	Impact Type	Description	Impact Category
		introduction of exotic species from construction materials (such as soil with seeds)	
	Decline in plant health and survival	Changes in microclimatic conditions (i.e., dust, noise, and light, temperature, and humidity) and surface water quality	Indirect
Faunal Species	Loss of/reduction in habitats and food sources	Direct removal of vegetation, nests or roost sites to create space for construction activities	Direct
	Accidental injury or mortality	Collisions with machineries, entrapments in construction materials (such as non-biodegradable erosion control blankets) and structures (such as exposed pits or drains), and accidental kills by construction personnel, including roadkills	Direct
	Human-wildlife conflict	Negative consequences of human-wildlife interactions, such as deliberate killing and depopulation of faunal species perceived as nuisances or threats by construction personnel	Indirect
	Loss/reduction of ecological connectivity for faunal movement	Habitat fragmentation from the removal of vegetation	Indirect
	Light disturbances	Increase in light levels from construction activities	Indirect
	Human disturbances	Increase in human traffic flow, such as workers and site personnel	Indirect

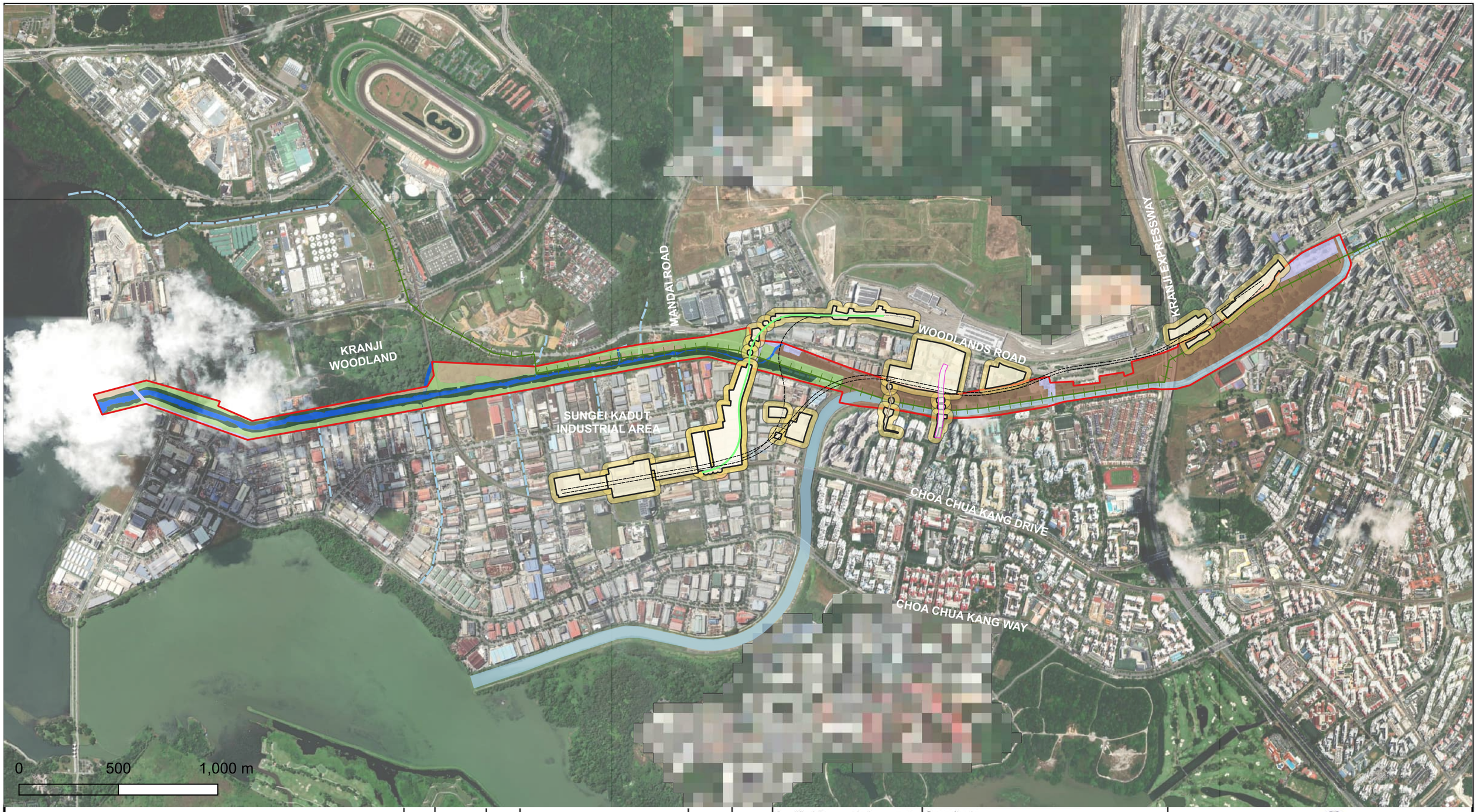
7.6.2 Operational Phase

Potential biodiversity impacts during operational phase are presented in Table 7-17.

Table 7-17 List of potential biodiversity impacts during operational phase

Receptor	Impact Type	Description	Impact Category
Operational Phase			
Habitat	Change in species composition	Long-term changes in light, temperature, and humidity in habitats surrounding facility structures	Indirect
	Habitat degradation	Trampling on vegetation, pollution (e.g., contamination of surface waterbodies, dust, litter) from increased human activities	Indirect
Plant Species	Mortality	Plant mortality due to long-term changes in microclimate	Direct
	Poaching	Stealing/poaching of plants by humans due to ethnobotanical value (e.g., ornamental, medicinal, food, craft)	
	Competition from exotic plant species	Accidental and/or intentional release of exotic plants by humans. Eventual colonisation of invasive or 'self-sustaining' exotic plant species within bare/sparsely vegetated area which was previously cleared during construction phase.	Indirect
Faunal Species	Accidental injury or mortality	Navigation failures into the wrong areas and entrapment in facility structures, including bird	Direct/ Indirect

Receptor	Impact Type	Description	Impact Category
		collision into buildings (distorted perceptions of reflective surfaces on buildings as flyways, greenery, and/or water) and roadkills	
	Human-wildlife conflict	Negative consequences of human-wildlife interactions, such as deliberate killing and depopulation of faunal species perceived as nuisances or threats by members of the public	Direct
	Poaching	Poaching of fauna by humans	Direct
	Loss of ecological connectivity for faunal movement	Impediment to faunal movement by presence of buildings, infrastructure, and human activity	Indirect
	Light disturbances	Increase in light levels from development	Indirect
	Human disturbances	Increase in human traffic flow, such as residents and visitors	Indirect



Legend

- Biodiversity Study Area
- Proposed DTL2e Tunnel Alignment
- Potential Future Infrastructure
- Proposed Cut and Cover Area
- Proposed Vehicular Bridge
- Pedestrian Overhead Bridge
- Existing Vegetated Area
- Sungei Pang Sua
- Pang Sua Canal
- Stream
- Drain

Habitat Types

- Mangrove
- Exotic-dominated Secondary Forest
- Scrubland
- Urban Vegetation
- Others
- 30-m impact zone

Rev.	Date	By	Description	Chk'd	App'd
-	Aug 2024	JT	Environmental Study Report	NHT	JAG

Qualified Person Endorsement : N/A

LTA Endorsement : N/A

Consultant : AECOM

Land Transport Authority — We Keep Your World Moving

Project Title :

CONTRACT 9175 ADVANCE ENGINEERING STUDY FOR THE PROPOSED DOWNTOWN LINE 2 EXTENSION AND A NEW STATION ON EXISTING NORTH-SOUTH LINE

Figure Title :

IMPACT ZONE FOR HABITAT AND FLORAL SPECIES RECEPTORS

Designed	Checked	Approved	Figure No. :	Rev.	Sheet
HHL	NHT	JAG	7-46	-	1 of 1
	Drawn JT	Date Aug 2024	CAD File Name :N/A		A3

Note: Source of basemap - OneMap and Open Street Map

7.7 Minimum Control Measures

This section lists biodiversity-specific minimum controls commonly implemented in Singapore for similar construction and operational activities. These are assumed to be implemented for the impact assessment. Minimum controls for each potential impact occurring from the construction and operational phases are listed in Table 7-18 and Table 7-19 respectively. These measures should be proposed in tandem with other environmental receptors (e.g., air and noise). Generally, the minimum control has also considered design optimization detailed in Section 3.2.1.

7.7.1 Construction Phase

Biodiversity-specific minimum controls during construction phase are presented in Table 7-18.

Table 7-18 Description of biodiversity minimum controls implemented during construction phase

Work Activities	Minimum Controls
Construction phase	
General	Install hoarding to delineate worksite. Avoid fogging by implementing preventive measures for mosquito to remove sources of stagnant water or water-bearing receptacles, e.g., Providing well-maintained pitched roof, clearing discarded items daily, store materials appropriately, level up ground depression/uneven surfaces, ensure effective drainage flow. Daily checks by Environmental Manager on site. Execute wildlife response plan when a trapped/ injured/ dead/ dangerous animal is encountered around or within the worksite according to Section 10 of Wildlife Act [refer to Section 5]
Vegetation Clearance	Set up Tree Protection Zones (TPZs) around trees or other plant specimens to be retained within the worksites, within which no construction works are allowed. This should be executed by certified arborists and in accordance with NParks' guidelines [R-64]. Conduct inspections of fauna prior to felling or removal of vegetation. This should be done by an ecologist who is able to identify wildlife and/or active nesting structures, such as bird nests, tree hollows and/or burrows, and bamboo clusters. Implement soil erosion control measures as soon as vegetation has been removed and soil is exposed (refer to Section 8 on Water Quality).
Earthworks (Excavation, above and below ground construction)	Implement soil erosion control measures (refer to Section 8 on Water Quality). Ensure proper storage of materials likely to leach harmful chemicals and fuel-powered equipment by storing them away from waterbodies and/or sensitive habitats (refer to Section 8 on Water Quality). Implement dust control measures (refer to Section 9 on Air Quality). Ensure noise levels are within approved limits, and to implement noise barriers where required (refer to Section 10 on Airborne Noise).

7.7.2 Operational Phase

Biodiversity-specific minimum controls during construction phase are presented in Table 7-19.

Table 7-19 Description of biodiversity minimum controls implemented during operational phase

Work Activities	Minimum Controls
Operational phase	

Work Activities	Minimum Controls
General	Ensure noise levels are within approved limits (refer to Section 10 on Airborne Noise). Ensure dust levels are within approved limits (refer to Section 9 on Air Quality). Avoid fogging by implementing preventive measures for mosquito to remove sources of stagnant water or water-bearing receptacles, e.g., Providing well-maintained pitched roof, clearing discarded items daily, store materials appropriately, level up ground depression/uneven surfaces, ensure effective drainage flow.

7.8 Prediction and Evaluation of Biodiversity Impacts

In this section, the identified biodiversity sensitive receptors were evaluated based on impact intensity and likelihood, in order to derive the impact significance. The various levels of impact intensity and likelihood for each impact type during the construction and operational phases were defined for the biodiversity sensitive receptors. Some assumptions were made in defining the levels of impact intensity, and are detailed in the respective sections below.

For both construction and operational phases, the full list of the priority level, impact intensity, impact consequence, impact likelihood, as well as the resulting impact significance for all biodiversity sensitive receptors is provided in Appendix J.

7.8.1 Construction Phase

The definitions for impact intensity and likelihood of occurrence for habitat receptors are given Table 7-20 and Table 7-21. Two assumptions were made in defining the levels of impact intensity and the likelihood of direct and indirect impacts for habitat receptors:

1. Habitats within 30 m from the worksites are assumed to experience the greatest extent of edge effects, though some studies have shown that edge effects could be up to 150 m (refer to Section 7.6 for the definition of impact zone).
2. The likelihood of habit degradation [i.e., improper disposal of construction waste, accidental release of hazardous materials (such as construction slurry, paint, and/or solvents), increase in dust, noise, and light levels, changes in mangrove forest hydrology; refer to Table 7-21] is presumed to be **Less Likely** for habitat receptors, based on the assumption that all minimum controls (Section 7.7.1) are adequately and properly implemented.

Table 7-20 Definitions of each level of impact intensity for habitat receptors during construction

Impact Type	Negligible	Low	Medium	High
Loss of vegetation	The habitat does not overlap with the worksites	≤ 10% of the habitat overlaps with the worksites	10–40% of the habitat overlaps with the worksites	> 40% of the habitat overlaps with the worksites Worksite overlaps with waterbody.
Habitat degradation	The habitat does overlap with areas 30 m from the worksites	≤ 10% of the habitat overlaps with areas 30 m from the worksites	10–40% of the habitat overlaps with areas 30 m from the worksites	> 40% of the habitat overlaps with areas 30 m from the worksites
Change in species composition				

Table 7-21 Definitions of each level of likelihood for habitat receptors during construction

Likelihood	Loss of Vegetation	Habitat Degradation	Change in Species Composition
Unlikely/Remote	The habitat does not overlap with the worksites	N.A.	No formation of forest edges (i.e., construction activities are fully underground and/or in existing built-up areas outside the forest)
Less Likely/ Rare	N.A.	N.A. (see assumption above)	Formation of scrubland edges in scrubland areas only
Possible/ Occasional	N.A.	N.A.	Formation of some forest and scrubland edges in a mix of managed vegetation, scrubland and forested areas
Likely/ Regular	N.A.	N.A.	Formation of new forest edges (i.e., complete clearance within forested areas)
Certain/ Continuous	The habitat overlaps with the worksites	N.A.	N.A.

The definitions for impact intensity and likelihood of occurrence for flora receptors are given in Table 7-22 and Table 7-23. Two assumptions were made in defining the levels of impact intensity and likelihood for certain plant species receptors during the construction phase:

1. For some mangrove species (i.e., common native species that are not trees that are known to be locally widespread) and common native fig climbers, the impact intensity was assessed as **Low** as it is assumed that less than 50% of the population will be impacted by all direct and indirect impacts. As for the likelihood, they were assessed as **Possible** for most impacts as it is possible that these species are located within the proposed worksite or within the 30 m buffer.
2. The likelihood of impediment to seedling recruitment [i.e., improper disposal of construction waste, accidental release of hazardous materials (such as construction slurry, paint, and/or solvents— refer to Table 7-21) is presumed to be **Less Likely** for plant species receptors that lies within 30 m from the proposed construction, based on the assumption that all minimum controls (Section 7.7.1) are adequately and properly implemented.

Table 7-22 Definitions of each level of impact intensity for flora receptors during construction

Impact Type	Negligible	Low	Medium	High
Injury/ Mortality	No plant specimens of this species are within the worksites	Less than 50% of all plant specimens of this species are within the worksites	More than or exactly 50% of all plant specimens of this species are within the worksites	All plant specimens of this species are within the worksites
Impediment to seedling recruitment	No specimens of this species are within 30 m from the worksites	Less than 50% of all plant specimens of this species are within 30 m from the worksites	More than or exactly 50% of all plant specimens of this species are within 30 m from the worksites	All specimens of this species are within 30 m from the worksites
Competition from exotic species				
Decline in plant health and survival				

Table 7-23 Definitions of each level of likelihood for flora receptors during construction

Likelihood	Injury/Mortality	Impediment To Seedling Recruitment	Competition From Exotic Species	Decline In Plant Health and Survival
Unlikely/Remote	No plant specimens of this species are within the worksites	Plants species are epiphytes and/or do not grow on soil (including seaweeds and seagrasses if there are no developments in the marine areas) or Plants specimens of this species are not within 30 m from the proposed worksite.	No formation of forest edges (i.e., construction activities are fully underground and/or in existing built-up areas outside the mangrove or forest)	No formation of forest edges (i.e., construction activities are fully underground and/or in existing built-up areas outside the mangrove or forest) that changes the existing microclimate conditions No changes to surface water quality to associated waterbody.
Less Likely/ Rare	Plants specimens of this species located in the worksite is less likely to be inflicted with mechanical injuries during construction	Plant species with dispersal methods that are not restricted, i.e., they disperse via wind and/or water (e.g., true mangrove species).	Formation of scrubland edges in scrubland areas only	Formation of scrubland edges in scrubland areas only. Minor changes to surface water quality to associated waterbody.
Possible/ Occasional	No count data and/or locations of specimens of this species is available, but specimens could possibly be within the worksites or Plants specimens of this species located in the worksite could possibly be inflicted with mechanical injuries during construction	Plant species that grows on soil and whose dispersals are dependable on terrestrial fauna.	Formation of some forest and scrubland edges in urban vegetation, scrubland and/or mangrove/forested areas	Formation of some forest and scrubland edges in urban vegetation, scrubland and/or mangrove/forested areas. Moderate changes to surface water quality to associated waterbody
Likely/ Regular	N.A.	N.A.	N.A.	N.A.
Almost Certain/ Continuous	Plant specimens of this species located within the	Plants that grow on soil whose dispersals are restricted owing to environmental	Formation of new forest edges (i.e., complete clearance within	Formation of new forest edges (i.e., complete clearance within

Likelihood	Injury/Mortality	Impediment To Seedling Recruitment	Competition From Exotic Species	Decline In Plant Health and Survival
	worksite are cleared	factors and/or growth strategies (e.g., bamboos that propagate via underground rhizomes and ground orchids)	mangrove/forested areas)	mangrove/forested areas) or Major changes to surface water quality to associated waterbody.

The definitions for impact intensity and likelihood for faunal species are presented in Table 7-24 and Table 7-25 respectively.

Table 7-24 Definitions of each level of impact intensity for faunal receptors during construction

Impact Type	Negligible	Low	Medium	High
Loss of/ reduction in habitats and food sources	No loss of original habitat, nests, or roosts	Loss of <10% of original habitat, nests, or roosts	Loss of 10–40% of original habitat, nests, or roosts	Loss of >40% of original habitat, nests, or roosts
Accidental injury or mortality	Species with negligible susceptibility to accidental injury/mortality from construction activities (large vehicles, excavation, piling, etc,) and roadkills	Species with low susceptibility to accidental injury/mortality from construction activities (large vehicles, excavation, piling, etc.) and roadkills: – Volant species (e.g., odonates, butterflies, highly volant birds, raptors and most bats) – Aquatic species (most fishes, crabs, shrimps)	Species that are mobile but possibly susceptible to accidental injury/mortality from construction activities (large vehicles, excavation, piling, etc.) and roadkills: – Less volant birds – All amphibians – Some mammals (e.g., squirrels, shrews)	Species with high susceptibility to accidental injury/mortality from construction activities (large vehicles, excavation, piling, etc.) and roadkills: – Reptiles – Some mammals (e.g., Sunda pangolin, long-tailed macaque, smooth-coated otter) – Migratory birds – Nesting birds – Bamboo bats
Human-wildlife conflict	Species that are not perceived as nuisances or threats by construction personnel – Odonates – Butterflies – Most birds – Aquatic species	Species that are possibly perceived as both nuisances and threats by construction personnel, less tolerant of human presence and urban environments: – Some reptiles – Most amphibians	Species that are typically perceived as nuisances and possibly as threats by construction personnel, highly tolerant of human presence and urban environments, and frequently implicated	Species that are typically perceived as both nuisances and threats by construction personnel, highly tolerant of human presence and urban environments, and are frequently

Impact Type	Negligible	Low	Medium	High
		– Most bats	in human-wildlife conflict: – Smooth-coated otter – Aculeate hymenopterans	implicated in human-wildlife conflict: – Long-tailed macaque – Some snakes
Loss of/reduction in of ecological connectivity for faunal movement	Not dependent on connected habitats for dispersal and able to traverse urban infrastructure	Slightly dependent on connected habitats for dispersal and adaptable to traverse urban infrastructures if needed	Dependent on connected habitats for dispersal	Highly dependent on connected habitats for dispersal
Light disturbances	Species that are not sensitive to changes in light levels: aculeate hymenopterans, most aquatic and marine species	Species that are slightly sensitive to changes in light levels: odonates, butterflies	Species that are sensitive to changes in light levels: diurnal birds, reptiles and mammals	Species that are extremely sensitive to changes in light levels: nocturnal, crepuscular fauna and nesting/hatching sea turtle species
Human disturbances	Species that are not sensitive to human presence	Species that are slightly sensitive to human presence	Species that are sensitive to human presence	Species that are extremely sensitive to human presence, and nesting birds

Table 7-25 Definitions of each level of likelihood for faunal receptors during construction

Likelihood	Loss of/ reduction in habitats and food sources	Accidental injury or mortality	Human-wildlife conflict	Loss of/ reduction in ecological connectivity for faunal movement	Light disturbances	Human disturbances
Unlikely/Remote	Impact is not expected to happen during the construction phase of the project					
Less Likely/ Rare	Impact is not likely to happen during the construction phase of the project					
Possible/ Occasional	Impact could possibly happen or known to occur during the construction phase of the project					
Likely/ Regular	Impact is a common occurrence during the construction phase of the project					
Almost Certain/ Continuous	Impact is a continual or repeated process during the construction phase of the project					

7.8.1.1 Habitats

Three construction phase impacts were identified and assessed for the habitat receptors: (1) loss of vegetation, (2) habitat degradation, and (3) change in species composition. The impact significance ranged from **Negligible** to **Moderate**. Moderate impact is expected to the mangrove and Sungei Pang Sua, minor impacts are expected to scrubland and urban vegetation, and negligible impacts are expected for the exotic-dominated secondary forest, Pang Sua Canal and stream. A summary of the habitat receptors impacted during construction phase is shown in Table 7-27.

Loss of vegetation

Vegetation clearance will occur in two habitat types: scrubland and urban vegetation. Based on the area of vegetation clearance, the impact intensity is **Low** for scrubland and urban vegetation, and **Negligible** for the remaining habitats. The likelihood of occurrence is Certain for scrubland and urban vegetation, and **Unlikely** for the remaining habitats. However, since the mangrove is located in very close proximity to the worksite, some clearance of mangrove habitat is considered possible, and therefore, the likelihood was raised to **Less likely**. The impact significance is **Minor** for scrubland and urban vegetation, and **Negligible** for the remaining habitat receptors.

Habitat degradation

Consequence from habitat degradation range from **Imperceptible** to **Low** for all habitat receptors as ≤ 10% of the habitat overlaps with areas 30 m from the worksites.

The likelihood of habitat degradation for habitat receptors were deemed to be **Less Likely** (see assumption above). Although minimum control measures act to reduce erosion and minimise the likelihood of contaminants entering these habitats, environmental conditions, such as heavy rainfall, may still result in contaminants entering the waterway. Any waste entering the waterway upstream, e.g., construction waste or hazardous materials (such as construction slurry, paint, and/or solvents) would affect the surface water quality, thus impacting downstream habitats (see Section 8.7.1.1.2). Three habitat receptors are connected, i.e., mangrove, Sungei Pang Sua, and the stream, and therefore, degradation occurring at one location will likely be observed across these habitats. Underground tunnelling may also impact aboveground waterbodies. Habitat degradation was hence qualitatively raised to **Likely** for these three connected habitats, resulting in an impact significance of **Moderate** for mangrove and Sungei Pang Sua, and **Negligible** for stream. The impact significance is **Negligible** for the other habitats.

Change in species composition

Consequence from change in species composition range from **Imperceptible** to **Low** for all habitat receptors as ≤ 10% of the habitat overlaps with areas 30 m from the worksites and most of the construction is underground tunnelling. The likelihood is **Possible** for mangrove and **Likely** for scrubland as piling works for potential future infrastructure columns may create new habitat edges. Likelihood is **Unlikely** for the other habitats. The impact significance is **Minor** for scrubland and mangrove, and **Negligible** for the remaining habitats.

Table 7-26 Biodiversity habitat receptors experiencing direct and indirect impacts within the Study Area during construction phase

Habitat receptor	Priority level and other relevant status	Direct impact (% of total habitat type within study area)	Indirect impact (% of total habitat type within study area)	Most Severe Impact Significance
Mangrove	Priority 1	0 ha	0.11 ha (1.0%)	**Moderate**
Exotic-Dominated Secondary Forest	Priority 2	0 ha	0 ha	**Negligible**
Scrubland	Priority 2	0.13 ha (0.67%)	0.97 ha (5.0%)	**Minor**
Urban vegetation	Priority 3	0.50 ha (1.49%)	3.38 ha (10.0%)	**Minor**
Sungei Pang Sua	Priority 1	0 ha	0.03 ha (0.48%)	**Moderate**
Pang Sua Canal	Priority 3	0 ha	0.54 ha (5.63%)	**Negligible**
Stream	Priority 2	0 ha	0	**Negligible**

7.8.1.2 Flora

Four impacts were identified and assessed during the construction phase for flora species receptors: (1) impediment to seedling recruitment, (2) decline in plant health and survival, (3) injury/mortality, and (4) competition from exotic species. The impact significance ranged from **Negligible** to **Minor**.

A total of 40 sensitive plant species receptors recorded in the Study Area were selected for the assessment of ecological value impacts. A summary of the impact to flora receptors is provided in Table 7-27.

Table 7-27 Summary of construction phase impacts to flora species receptors

Impact Type	No. of Species			
	Major	Moderate	Minor	Negligible
Impediment to seedling recruitment	—	—	15	25
Decline in plant health	—	—	11	28
Injury/Mortality	—	—	7	33
Competition from exotic species	—	—	6	34

Impediment to Seedling Recruitment

Fifteen species are likely to experience with **Minor** impact significance, owing to impediment to seedling recruitment. Of the 15 species, 11 species have less than 50% of specimen count within the worksite area, which gives an impact intensity of **Low**. Only one species, *Syzygium polyanthum* was assessed with a **Medium** impact intensity as 1 out 2 specimens (i.e., 50% of specimen count) in the Study Area is located within the 30 m buffer. Four species with no data count was given **Low** impact intensity (Section 7.8.1).

The likelihood of this impact occurring for all abovementioned species, except for *Avicennia alba*, is **Less likely** thus resulting in an impact significance of **Minor**. For mangrove species, since their propagules can be dispersed by water via Sungei Pang Sua, the likelihood was assessed as **Less likely** as there is a higher chance for the propagules to be dispersed beyond the 30 m buffer.

The remaining 25 species are likely to experience **Negligible** impacts significance as they are least likely to be impacted by impediment to seedling recruitment since the specimens are located beyond the 30 m buffer.

Decline in Plant Health and Survival

Eleven species are likely to experience **Minor** impact significance owing to the impact of decline in plant health and survival, while the remaining 28 species are assessed with **Negligible** impact significance.

For this impact type, twelve species were assessed with a **Low** impact intensity. Four species (*Elaeis guineensis*, *L. leucocephala*, *S. campanulata* and *Terminalia catappa*), the formation of some forest or scrubland edge is expected since most specimens are located either within the mangrove forest, exotic-dominated secondary forest or within the urban vegetation. Hence, the likelihood is **Possible** for these species**.**

Four true mangrove species (i.e., *Acanthus* sp*. Avicennia alba, Sonneratia alba* and *S. caseolaris*) that are found within the 30 m buffer may be impacted by hydrological changes should a change in surface water quality occur during the construction phase, even with minimum controls in place. As for species with no data count, since they could be located within the 30 m buffer, it is possible that they could also be affected by changes in microclimatic conditions. Hence, these species mentioned above were assessed with **Possible** likelihood.

Only *S. polyanthum* was assessed with a **Medium** impact intensity. However, the likelihood of competition from exotic species and decline in plant health is **Less likely** as the specimen is located within the scrubland habitat and only the formation of scrubland edges is expected to happen.

Injury/Mortality

Seven species are likely to experience **Minor** impact significance due to injury/mortality. Of these species, three were assessed with high ecological value, one has medium ecological value and the remaining two have low ecological value.

Based on the proposed footprint, working space and construction method of the potential future infrastructure, it is assumed that no specimens of *Sonneratia caseolaris* lie within the worksite, and will not be directly affected by vegetation clearance. Thus, the impact intensity was assessed as **Negligible**. However, it is possible for this species to be injured during the construction due to its close proximity to the potential future infrastructure. Hence, the likelihood was assessed as **Possible**, resulting in **Minor** impact significance.

Three species with no data count (i.e., *Acanthus ilicifolius*, *Ficus heteropleura* and *F. punctata*) were assessed with a **Possible** likelihood for this impact type as it is possible that the specimens are located within the construction footprint. As such, they are also assessed with a **Minor** impact significance.

For the remaining three exotic species, *Leucaena leucocephala*, *Samanea saman* and *Spathodea campanulata,* less than 50% of the total specimens will be directly affected by the working space of the launch/ retrieval shafts, or the construction of the elevated pedestrian bridge and vehicular bridge. They were assessed with **Low** impact intensity. Since the likelihood of their mortality is **Certain**, this led them to be assessed with **Minor** impact significance.

Competition from Exotic Species

Six species are likely to experience **Minor** impact significance owing to competition from exotic species, while the remaining 37 species are assessed with **Negligible** impact significance.

All species were assessed with a **Low** impact intensity, except for one species, *Syzygium polyanthum*, as 1 out of 2 specimens (50%) is lies within 30 m from the proposed worksite, which contributed to a **Medium** impact intensity. Formation of some forest or scrubland edge is expected since most specimens are located either within the mangrove forest, exotic-dominated secondary forest or within the urban vegetation. Hence, the likelihood is **Possible** for all species. As for the one specimen of *S. polyanthum*, it will '**Less Likely'** be affected by this impact type since formation of scrubland edges is only expected.

7.8.1.3 Fauna

Six construction phase impacts were identified and assessed for faunal receptors: (1) loss of or reduction in habitats and food sources, (2) accidental injury or mortality, (3) light disturbances, (4) human disturbances, (5) loss of/reduction in ecological connectivity for faunal movement and (6) human-wildlife conflict. The impact significance ranged from **Negligible** to **Moderate**. The more substantial impacts arising from each impact type is briefly summarised below. A summary of the impact to fauna receptors is given in Table 7-28**.** In addition to this, the impacts from airborne noise and groundborne vibration to fauna during construction phase are assessed in Sections 10.7.1 and 11.8.1 respectively.

Several assumptions were made for the impact assessment to fauna:

- A 30-m wide vegetation across the Rail Corridor could not be achieved at all times due to beam launching for the construction of pedestrian linkbridge and vehicular bridge.
- No night works will be conducted for critical safety works which is expected to be rare. While working hours will be from 0700h to 1900h, only housekeeping works (i.e., minimal or low lighting levels) will be conducted from 0700h to 0800h and 1800h to 1900h.

Table 7-28 Summary of construction phase impacts to fauna receptors

Impact Type	No. of Species			
	Major	Moderate	Minor	Negligible
Loss/reduction of ecological connectivity for faunal movement	–	20	32	27
Accidental injury or mortality	–	5	–	74
Human disturbances	–	–	39	40
Loss of/reduction in habitats and food sources	–	–	36	43
Human-wildlife conflict	–	–	2	77

Loss of/reduction in ecological connectivity for faunal movement

Consequence from the loss of or reduction in ecological connectivity for faunal movement ranged from **Medium** to **High** for most species depending on their ability to disperse across disconnected habitats and urban environment. For the majority of these species the likelihood is **Possible** or **Likely** as works across Rail Corridor will result in impediment of faunal movement, since there is no corridor for fauna to move through. This includes species such as the Sunda pangolin (*Manis javanica*), and birds such as the common kingfisher (*Alcedo atthis*) and brown shrike (*Lanius cristatus*). Therefore, the impact significance is **Moderate** for 20 species, and **Negligible** to **Minor** for the remaining 59 species.

Accidental Injury or Mortality

Accidental injury or mortality of fauna during the construction phase was deemed to be of L**ow** intensity and **Unlikely** for species that are mobile and can move quickly to avoid such threats, example highly volant birds and butterflies. The smooth-coated otter, long-tailed macaque and Sunda pangolin are mobile, but they may be able to enter the construction site, thus risking entrapment. For the aforementioned three species, the likelihood is **Possible.** Mud lobster mounds are present at Sungei Pang Sua where potential future infrastructure construction will take place. Injury or mortality from excavation activities are considered **Possible** due to proximity of the activities. Vibration may cause possible collapse of the mud lobster mound, and displacement of the mud lobster from vibration disturbances, as detailed further in Section 11.8. There are two mud lobster species potentially present in the Study Area. Therefore, the impact significance for these five species is **Moderate.**

Overall, the impact significance is considered **Moderate** for the aforementioned five species, and **Negligible** for the remaining 74 species.

Light disturbances

Since no night works will be carried unless in emergency situations, likelihood is **Unlikely** and therefore impact significance is **Negligible** or **Minor** for all species.

Human Disturbances

Consequence from human disturbance at the construction phase is **Very Low** for aquatic fauna and species not particularly sensitive to human presence such as butterflies. The consequence ranges from **Medium** to **High** for the remaining bird and mammal species. The likelihood ranges from **Unlikely** to **Less likely**, resulting in impact significance to be **Negligible to Minor** for all species.

Loss of/or Reduction in Habitats and Food Sources

Site clearance will affect two habitat types: scrubland and urban vegetation. For species who utilise the affected habitat types, the likelihood for this impact type was assigned as **Certain** for species who only use or

predominately use the above habitat. For other species, the impact intensity is **Negligible** or **Low** as the loss is <10% of original habitat. The likelihood of **Possible** is assigned for species who do not solely use affected habitat.

Overall, this impact significance is **Negligible to Minor** for all species.

Human-wildlife Conflict

Human-wildlife conflict between faunal species and construction site personnel is deemed to be **Very Low** in consequence and likelihood as **Unlikely** for almost all species as they are not perceived to be nuisances or threats by construction personnel. It is considered Less likely for three species – long-tailed macaque, smooth-coated otter, and estuarine crocodile. However, biodiversity awareness training is part of the minimum control measures to minimise human-wildlife conflict, the likelihood is considered Less likely. Therefore, impact significance for human-wildlife conflict range from **Negligible** to **Minor** for all species.

7.8.2 Operational Phase

The definitions for impact intensity and likelihood of occurrence for habitat receptors are given in Table 7-29 and Table 7-30.

Table 7-29 Definitions of each level of impact intensity for habitat receptors at the operational phase

Impact type	Negligible	Low	Medium	High
Habitat degradation	Developed area is not accessible to public and no long-term degradation is expected. E.g., core conservation areas with no public access, infrastructure works with no public access	Developed area is designed with the intention for the public to use or visit and will increase human accessibility to the surrounding natural habitats. Limited or controlled degradation is expected near areas of higher human activity. E.g., nature parks	Developed area is designed for members of the public to visit. E.g., parks. Degradation is expected to occur within at least 50% of the habitat	Developed area and surroundings are designed for large groups of people to live or work in the long run. Degradation is expected to occur throughout 100% of the habitat. E.g., residential estates
Change in plant species composition	Development footprint is temporary and/or operational activities are fully underground (e.g., train alignment)	Development footprint is permanent and small relative to the size of the surrounding habitats (i.e., ≤ 10%)	Development footprint is permanent and medium-sized relative to the size of the surrounding habitats (i.e., 10-40%)	Development footprint is permanent and large-sized relative to the size of the surrounding habitats (i.e., ≥ 40%)

Table 7-30 Definitions of each level of likelihood for habitat receptors at the operational phase

Likelihood	Habitat Degradation	Change in Species Composition
Unlikely/Remote	Surrounding natural habitats are not accessible to public	Development is largely green and human activity is limited (e.g., Thomson Nature Park). The habitat is already exotic-dominated such that introduction of exotic species has no impact on the habitat.
Less likely/Rare	Surrounding natural habitats are accessible but public use is restricted/controlled	Development involves the building of urban structures but will be heavily landscaped (e.g., Gardens by the Bay).

Likelihood	Habitat Degradation	Change in Species Composition
		The habitat is already exotic-dominated such that introduction of exotic species has some impact on the habitat.
Possible/Occasional	Surrounding natural habitats are accessible and have infrastructure for the public to use, such as boardwalks (but people can still stray off track)	Development involves the building of structures that are designed to release heat, light, noise or dust (e.g., ventilation shafts). Introducing exotic species will change the balance of exotic vs native species within the habitat.
Likely/Regular	Surrounding natural habitats are easily accessible and do not have infrastructure for the public to use, such as boardwalks (thus public are off track)	Development involves the building of extensive pavements, structures, and other infrastructure with surfaces that absorb and retain heat, constantly produce dust and noise disturbances (e.g., residential estate). Introducing exotic species will be detrimental to the native-dominated habitat and its surrounding native-dominated habitats.
Certain/ Continuous	N.A.	N.A.

The definitions for impact intensity and likelihood of occurrence for flora receptors are given in Table 7-31 and Table 7-32. Three assumptions were made in defining the levels of impact intensity and likelihood for plant species receptors in the operational phase:

The impact intensity of competition from exotic plant species is assumed to be **Negligible** for all mangrove species and seagrass species as landscaping works will not take place in the mangrove habitat and/or marine areas.
The impact likelihood of competition from exotic plant species is **Unlikely** for all mangrove species as these species grow in brackish environments; other plants without the physiological adaptations will not be able to grow alongside the mangrove species and compete with them.
The impact likelihood of competition from exotic plant species is **Less likely** for species with no data count as these species are most likely not located in areas with sparse and or bare areas that were caused by the construction works.

Table 7-31 Definitions of each level of impact intensity for flora receptors at the operational phase

Impact Type	Negligible	Low	Medium	High
Mortality	No microclimatic changes within the remaining habitat are expected, no plant specimens are expected to be impacted.	Microclimatic changes within the remaining habitat affect less than 50% of the specimens.	Microclimatic changes within the remaining habitat affect more than or exactly 50% of the specimens.	Microclimatic changes within the remaining habitat affect all specimens. (i.e., the habitat is expected to no longer be the same as the original condition and is not favourable for species of interest)
Poaching	No plant specimens of this species are removed from site (i.e., no extrinsic	Less than 50% of plant specimens of this species can be removed from site	More than or exactly 50% of all plant specimens of this species can be	All plant specimens of this species can be removed from site (i.e., charismatic

Impact Type	Negligible	Low	Medium	High
	ethnobotanical value), plant locations are not published or inaccessible, plants that are too large to remove from site (i.e., large plants)	(i.e., species has some ethnobotanical value such as common ornamental plants)	removed from site (i.e., charismatic plants such as orchids, pitcher plants with seemingly higher extrinsic ethnobotanical value)	plants such as orchids, pitcher plants with seemingly higher extrinsic ethnobotanical value)
Competition from Exotic Species	Species is cryptogenic, or exotic and listed as "Naturalised"	Species is exotic and listed as "Casual" or not assessed	Species is exotic and listed as "Cultivated Only"	Species is native

Table 7-32 Definitions of each level of likelihood for flora receptors at the operational phase

Likelihood	Mortality	Poaching	Competition from Exotic Species
Unlikely/Remote	Long term microclimate of habitat is expected to be the same as pre-development conditions	Species not known to have been stolen before	Original vegetation mostly retained with no new landscaping
Less Likely/Rare	N.A.	N.A.	Some original vegetation retained with some new landscaping using only native species, or original vegetation mostly cleared with new large-scale landscaping using both native and exotic species
Possible/Occasional	Habitat is expected to remain similar but may experience edge effects, some mortality of individuals is expected	Flowering species known to have been stolen before	Some original vegetation retained with some new landscaping using exotic species
Likely/Regular	N.A.	N.A.	Original vegetation mostly cleared with new large-scale landscaping using exotic species or Original vegetation was mostly cleared; bare areas are only turfed without any new large-scale landscaping
Certain/Continuous	Long term microclimate is expected to be completely different such that the species are unable to adapt to new conditions	"Charismatic species" known to be stolen most of the time (i.e., pitcher plants and orchids)	N.A.

The definitions for impact intensity and likelihood of occurrence for faunal receptors are given in Table 7-33 and Table 7-34.

Table 7-33 Definitions of each level of impact intensity for faunal receptors at the operational phase

Impact Type	Negligible	Low	Medium	High
Accidental injury or mortality	Species with negligible susceptibility to accidental injury/mortality from operation activities, roadkills, and collision with buildings	Species with low susceptibility to accidental injury/mortality from operation activities, roadkills, and collision with buildings: – Birds with low susceptibility to collision with buildings – Volant species (e.g., odonates, butterflies, raptors and bats) – Aquatic species (most fishes, crabs, shrimps)	Species that are mobile but possibly susceptible to accidental injury/mortality from operation activities and roadkills, and collision with buildings: – Birds that are possibly susceptible to collision with buildings (e.g., resident species with known records of bird-building collisions [P-80] – All amphibians – Some mammals (e.g., squirrels, shrews)	Species with high susceptibility to accidental injury/mortality from operation activities and roadkills, and collision with buildings: – Birds with high susceptibility to collision with buildings (e.g., forest-edge frugivores [P-80], migratory species) – Reptiles – Some mammals (e.g., Sunda pangolin, long-tailed macaque, smooth-coated otter)
Human-wildlife conflict	Species that are not perceived as nuisances or threats by members of the public – Odonates – Butterflies – Most birds – Aquatic species	Species that are possibly perceived as both nuisances and threats by members of the public, less tolerant of human presence and urban environments: – Some reptiles – Most amphibians – Most bats	Species that are typically perceived as nuisances and possibly as threats by members of the public, highly tolerant of human presence and urban environments, and frequently implicated in human-wildlife conflict: – Smooth-coated otter – Red junglefowl – Aculeate hymenopterans	Species that are typically perceived as both nuisances and threats by members of the public, highly tolerant of human presence and urban environments, and are frequently implicated in human-wildlife conflict: – Long-tailed macaque – Some snakes
Poaching	Species with negligible	Species with low susceptibility to	Species that are possibly susceptible	Species that are highly susceptible

Impact Type	Negligible	Low	Medium	High
	susceptibility to poaching	poaching; not commonly known to be traded as pets	to poaching; commonly traded as pets	to poaching; listed on CITES Appendix I or II
Loss of/reduction in ecological connectivity for faunal movement	Not dependent on connected habitats for dispersal and able to traverse urban infrastructure	Slightly dependent on connected habitats for dispersal and adaptable to traverse urban infrastructure if needed	Dependent on connected habitats for dispersal	Highly dependent on connected habitats for dispersal
Light disturbances	Species that are not sensitive to changes in light levels: aculeate hymenopterans, aquatic and marine species	Species that are slightly sensitive to changes in light levels: odonates, butterflies	Species that are sensitive to changes in light levels: diurnal birds, reptiles, and mammals	Species that are highly sensitive to changes in light levels: nocturnal, crepuscular fauna
Human disturbances	Species that are not sensitive to human presence	Species that are slightly sensitive to human presence	Species that are possibly sensitive to human presence	Species that are sensitive to human presence

Table 7-34 Definitions of each level of likelihood for faunal receptors at the operational phase

Likelihood	Accidental injury or Mortality	Human-wildlife conflict	Poaching	Loss of/ reduction in ecological connectivity for faunal movement	Light disturbances	Human disturbances
Unlikely/Remote	Impact is not expected to happen during the operational phase of the project					
Less Likely/Rare	Impact is not likely to happen during the operational phase of the project					
Possible/ Occasional	Impact could possibly happen or known to occur during the operational phase of the project					
Likely/Regular	Impact is a common occurrence during the operational phase of the project					
Certain/ Continuous	Impact is a continual or repeated process during the operational phase of the project					

7.8.2.1 Habitat

Two operational phase impacts were identified and assessed for habitat receptors: (1) habitat degradation, and (2) change in plant species composition. The impact significance of both is **Negligible.**

Habitat degradation

The consequence of habitat degradation for all habitats is assessed to range from **Imperceptible** to **Low** because both the potential future infrastructure and pedestrian bridge are over Sungei Pang Sua and Pang Sua Canal respectively. Thus public access into more sensitive habitats like mangrove and Sungei Pang Sua will be very limited. Moreover, there is already public access along the existing Rail Corridor across much of the Study Area so public footprint to these habitats are not expected to increase significantly from this development. As such the likelihood is either **Unlikely** or **Less Likely** for all habitats so overall habitat degradation impact significance is **Negligible** for all habitat types.

Change in species composition

Since the potential future infrastructure and pedestrian bridge is overhead while DTL2e is underground, the consequence for change in species composition is either **Imperceptible** or **Very Low** across all habitat types. Correspondingly the likelihood is **Unlikely** rendering this impact significance as **Negligible** for all habitats.

Table 7-35 Biodiversity habitat receptors experiencing indirect impacts within the Study Area during operational phase

Habitat receptor	Priority level	Indirect impact (% of total habitat type within study area)	Most Severe Impact Significance
Mangrove	Priority 1	0.09 ha (0.8%)	Negligible
Exotic-Dominated Secondary Forest	Priority 1	0 ha	Negligible
Scrubland	Priority 2	0.2 ha (2.8%)	Negligible
Urban vegetation	Priority 3	1.43 ha (4.2%)	Negligible
Sungei Pang Sua	Priority 3	0.05 ha (0.8%)	Negligible
Pang Sua Canal	Priority 1	0.37 ha (3.9%)	Negligible
Stream	Priority 1	0 ha	Negligible

7.8.2.2 Flora

Three impacts were identified and assessed for flora species receptors: (1) mortality, (2) poaching and (3) competition from exotic species. A total of 40 sensitive plant species receptors recorded in the Study Area were selected for the assessment of ecological value impacts. A summary of the impact to flora receptors is provided in Table 7-36.

Table 7-36 Summary of operational phase impacts to flora receptors

Impact Type	No. of Species			
	Major	**Moderate**	**Minor**	**Negligible**
Competition from Exotic Species	—	3	3	34
Poaching	—	—	2	38
Mortality	—	—	—	40

Competition from Exotic Species

'Exotic' species are regarded as those which are invasive or 'self-sustaining' species. These species would most likely establish themselves quickly in bare areas that are not planted back or in areas that are less dense.

It is assumed that native and casual exotic species (i.e., species that "do not form self-replacing populations and rely on repeated introductions or limited asexual reproduction for persistence) will only be planted within operational areas for landscaping purposes, such as the station box which will be situated outside the Study Area. Further assumption is also made whereby the initial working space that was cleared during the construction phase will only be turfed. As such, flora receptors that lie in close proximity (i.e., within 30 m) to these turfed areas would most likely face with competition from exotic species.

Three (3) native flora species receptors (i.e., *Cerbera odollam*, *Terminalia catappa* and *Hibiscus tilaceus)* with medium sensitivity level were assessed with **Moderate** impact significance. These species are located within close proximity to the initial work areas of the construction. Hence, it is likely that these species will be invaded by fast-growing and/or invasive exotics.

Two native common fig climbers with no species count (*F. heteropleura* and *F. punctata*) were assessed with **High** impact consequence, owing to it being a keystone species (i.e., high sensitivity level). Hence, with the assumptions made on their assessment of likelihood mentioned in Section 7.8.2, these species were assessed with **Minor** impact significance. As for *Syzygium polyanthum,* it is less likely for this species to be affected by this impact type. Hence, the impact significance is also **Minor**.

Poaching

Only two flora receptors (*Finlaysonia obovata* and *Sonneratia caseolaris*) are assessed with **Minor** impact significance. *F. obovata* bears attractive inflorescence and produces unique fruits that resembles to buffalo horn [P-1]. It is also reported that this species has a potential to be cultivated as an ornamental plant, owing to its attractive foliage and interesting-looking fruits. Since this species grows in a dry and rather open habitat, it can be cultivated in urban areas [P-1].

As for S*. caseolaris,* this species bears attractive inflorescence with bright pink to red and white stamens that resembles to a 'pom-pom' [P-50]. Hence, these attractive characteristics may contribute to the possibility for smaller specimens of this species to be poached.

The impact significance for the remaining flora species receptors is **Negligible**.

Mortality

All flora species receptors are assessed with **Negligible** impact significance as it is assumed that these specimens will **Unlikely** be affected by any major changes to microclimatic conditions during the operational phase since most of the operational zones (station boxes) are located outside the Study Area. As for the pedestrian and vehicular bridges, since it will be elevated above the existing urban vegetation that is relatively open (i.e., similar to the condition of a scrubland habitat with exotic trees), it is assumed that the operational phase microclimate of the habitat is expected to be the same as pre-development conditions.

7.8.2.3 Fauna

Six operational phase impacts were identified and assessed for faunal receptors: (1) human-wildlife conflict, (2) accidental injury or mortality, (3) light disturbances, (4) poaching, (5) loss of/reduction in ecological connectivity for faunal movement and (6) human disturbances. The impact significance ranged from **Negligible** to **Moderate**. Only the most substantive impact for each impact type is presented below. A summary of the impact to fauna receptors is given in Table 7-37. In addition to this, the impacts from airborne noise and ground-borne vibration to fauna during operational phase are assessed in Sections 10.7.2 and 11.8.2.

Table 7-37 Summary of operational phase impacts to faunal receptors

Impact Type	No. of Species			
	Major	Moderate	Minor	Negligible
Human-wildlife conflict	–	2	0	77
Accidental injury or mortality	–	–	57	22
Light disturbances	–	–	10	69
Poaching	–	–	–	79

Impact Type	No. of Species			
	Major	Moderate	Minor	Negligible
Loss/reduction of ecological connectivity for faunal movement	–	–	–	79
Human disturbances	–	–	–	79

Human-wildlife Conflict

Majority of species are not known to be involved in human-wildlife conflict, as such their consequence for this impact is **Very low** except three species, the smooth-coated otter, long-tailed macaque and estuarine crocodile, that have been perceived as nuisances and possibly as threats by some members of the public. The consequence for these species is **Medium** or **High**. In terms of likelihood, its **Unlikely or Less likely** for most species and **Possible** for the long-tailed macaque and smooth-coated otter.

Overall, the impact significance is **Moderate** for 2 species (long-tailed macaque and smooth-coated otter) and **Negligible** for 77 species.

Accidental Injury or Mortality

Consequence of accidental injury or mortality to faunal species during the operational phase was deemed to be **Low** for aquatic species, and volant insects like butterflies. Since the aboveground station box at operational phase has very little glass façade, the likelihood of bird-building collisions is considered **Less likely**. Therefore, impact significance is **Negligible** or **Minor**.

Overall, the impact significance is considered **Minor** for 57 species, and **Negligible** for the remaining 22 species.

Light Disturbances

Consequence of light disturbance is **Medium** or **High** for most species as they are either diurnal or nocturnal in nature. During operational phase, the source of artificial light at night would be from the pedestrian bridge and occasional train traversing along the potential future infrastructure. Given that they are both elevated, the likelihood of light pollution on the species receptors is **Less Likely** for nocturnal species and, **Unlikely** for diurnal and/or aquatic species. The new street level MRT box station would be lighted at night for a certain period before closing, but as a relatively small infrastructure light pollution is expected to be **Less Likely**.

Overall, the impact significance is **Minor** for 10 species and **Negligible** for 69 species.

Poaching

The consequence of poaching is deemed to be **Negligible** for majority of species as they are not known to be in the wildlife trade as pets. However, the straw-headed bulbul is susceptible to poaching and is a species listed on CITES Appendix II. Given Singapore's stance of zero-tolerance towards illegal wildlife trade, and the urbanised environment of the Study Area whereby there is no hidden locations for illegal poaching, the impact significance of poaching for all species is **Negligible.**

Loss of/reduction in ecological connectivity for faunal movement

For all species, the consequence of the loss of or reduction in ecological connectivity for faunal movement was deemed to be **Very Low** to **Medium**. However, since the potential future infrastructure and pedestrian bridge are overhead so impediment of faunal movement is not expected, as a result, the impact significance is **Negligible** for all species receptors.

Human disturbances

Given that the increase in human footprint would be on the elevated overhead bridge across urban vegetation, human disturbance at the operational phase was deemed to be **Unlikely** for all species. Therefore, the impact significance is **Negligible.**

7.9 Recommended Mitigation Measures

7.9.1 Design Phase

7.9.1.1 Avoid

Impacts: (1) Loss of vegetation to habitat receptors, (2) loss of/reduction in habitats and food sources to faunal species receptors, and (3) loss of/reduction in ecological connectivity for faunal movement.

Early efforts made during the design phase involved re-designing of footprint to avoid sensitive habitats (i.e., Sungei Pang Sua and Rail Corridor). This included i) aligning underground tunnel below Sungei Pang Sua mangrove in area with minimal trees and ii) designing footing or columns of the potential future infrastructure away from the banks of Sungei Pang Sua and in a location with relative clearance between mangroves. The working space of the potential future infrastructure will be at least 5 m away from the banks of Sungei Pang Sua.

Although only **Negligible** to **Low** impacts are expected from the removal of vegetation, it is recommended to minimize clearance of vegetation, especially adjacent to habitats of high ecological value. This includes the Sungei Pang Sua mangrove and Rail Corridor. By avoiding these areas, other than removing impacts from direct vegetation loss, it can also minimise indirect impacts such as habitat degradation and changes in species composition as the development moves away from these sensitive habitats.

7.9.1.2 Minimise

Impacts: (1) Accidental injury or mortality to faunal species receptors, (2) human-wildlife conflict

Given the development's proximity to sensitive nature areas, an impact significance of **Moderate** owing to bird-building collisions during the operational phase may occur if birds fail to perceive the glass surfaces of the newly constructed buildings, resulting in the unnecessary death of birds (see Section 7.8.2.3). Moderate impacts owing to roadkills may also occur due to the movement of vehicles along the new roads, as well as the construction of a new pick-up/drop-off area close to Marsiling Park. Particularly susceptible are ground-dwelling animals such as the smooth-coated otter (*Lutrogale perspicillata*).

Solution 1: Integrate road-calming measures

During construction phase, vehicular traffic is expected to increase from the development. Speed limits should be adhered to strictly.

Solution 2: Prevent human-wildlife conflicts

Human-wildlife conflicts occur when there are negative interactions between humans and wildlife, e.g., human injury caused by wildlife. One key driver of human-wildlife conflict is access to anthropogenic food sources. Food is a major attractant for wildlife, and anthropogenic sources of food, e.g., rubbish, tend to be easily accessible, of high yields, and a reliable food source for animals. Wildlife attracted to these food sources may come into contact with humans, thus increasing the likelihood of negative human-wildlife interactions. Reducing human-wildlife conflicts would require proper trash management within the development. Wildlife may also accidentally enter the development area, resulting in situations that escalate into conflicts.

The design of the development should hence consider proper trash management:

- For all bins situated outdoors, use wildlife-proof bins.
- Enclose waste management centres to reduce wildlife access to it.

It is important to increase staff's biodiversity awareness, and educate site personnel on how to safely interact with wildlife. It is also important to establish a Wildlife Response Plan in consultation with NParks Animal Management Centre, to be executed during encounters with trapped, injured or dead wildlife, as well as incidents of human-wildlife conflict within the development, and ensure that this information is disseminated to staff members.

Impact: (3) Light disturbances to faunal species receptors

The following details the lighting strategies to be considered if nights works are needed, or for the station design.

Any level of artificial light above that of moonlight masks the natural rhythms of lunar sky brightness and can thus disrupt the patterns of foraging, mating, as well as the circadian rhythm of wildlife [P-81]. Artificial lighting at night (ALAN) can disorient birds, bats, and insects, altering their behaviour that results in them being more vulnerable to predation and other risks. For example, ALAN may repel light-adverse bats from lit areas and restrict their use of commuting or feeding space. **Moderate** impact from light disturbances is expected to some species during the construction phase.

While light disturbance from intermediate station, pedestrian bridge and vehicular bridge is expected to be minimal during operational stage, the following strategies to minimise ecological light pollution are included below.

Solution: Minimise ecological light pollution

Light disturbance impacts at the operational stage can be minimised by incorporating proper lighting strategies. While these strategies should be throughout the site, they are especially important in areas facing Rail Corridor. Lighting strategies are detailed below and summarised in Figure 7-47:

- Use adaptive light controls to manage light timing, intensity, and colour, where appropriate.
    - Install smart-controlled LED lights.
    - Minimise the use of lights during hours just before dawn and after dusk when crepuscular and nocturnal animals are the most active.
- Minimise light spills, i.e., light that falls outside the area intended to be lit.
    - Optimise the placement of lights by lighting only the object or area intended, and keeping lights close to the ground, directed, and shielded. Accessories such as baffles, hoods or louvres can be used to reduce light spill and direct it only to where it is needed [P-67]. Lights to be pointed downwards as much as possible to reduce upwards light spillage.
    - Configure the location, orientation, and height of buildings and structures (e.g., streetlights).
    - Provide screening through landscaping or hard structures (e.g., walls, fences, bunds). Fences can be overplanted with climbers to soften its appearance and provide a vegetated feature for fauna to use, but should never be relied on as the sole means of attenuating light spill.
    - Use a minimal number of luminaires while achieving the necessary lighting levels.
    - Avoid artificial illumination within the nature areas, unless necessary for safety reasons.
    - Direct permanent artificial lightings away from the nature areas.
- Use wildlife-friendly light properties or features.
    - Use low-glare lighting and lights with reduced or filtered blue, violet, and ultraviolet wavelengths. Short wavelength light (blue) scatters more readily in the atmosphere and therefore contributes more to sky glow than longer wavelength light. Furthermore, most wildlife is sensitive to short wavelength (blue/violet) light. Therefore, as a rule, only lights with little or no short wavelength (400–500 nm) violet or blue light should be used to avoid unintended effects.
    - Employ warm colour temperature light sources to be preferably at < 2,700 Kelvin.
    - Use non-reflective, dark-coloured surfaces to reduce contribution to sky glow.

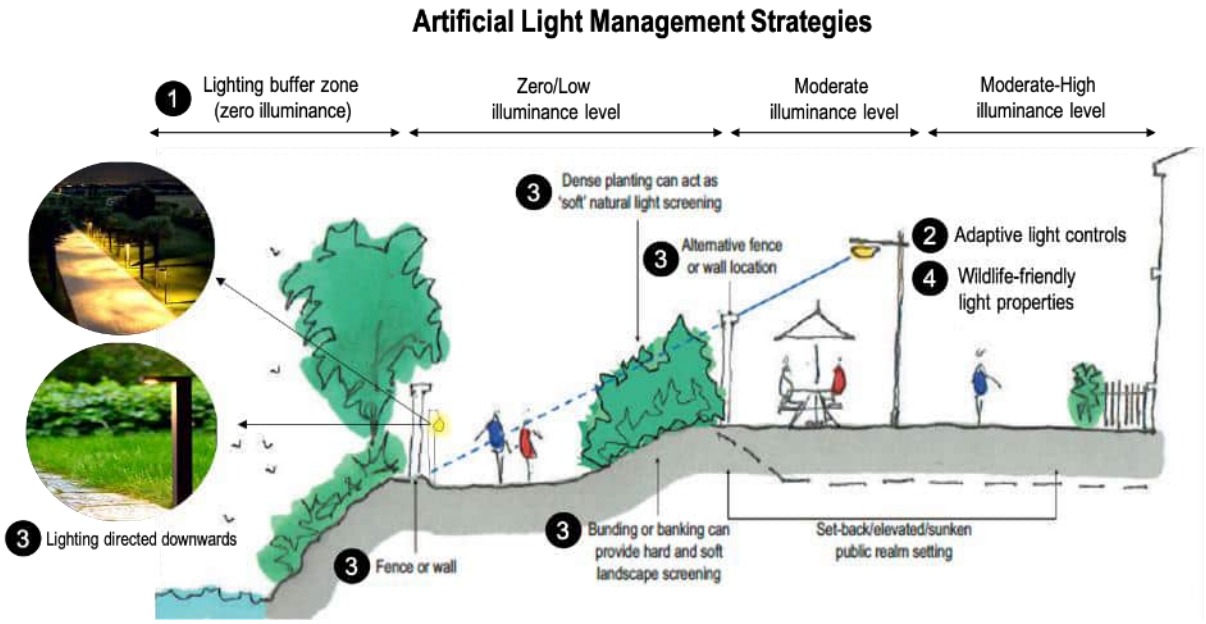


Figure 7-47 Summary of artificial light management strategies (adapted from P-81)

7.9.2 Advance Works

The proximity of development to sensitive habitats, such as the Sungei Pang Sua mangrove and Rail Corridor mean that the ecological receptors there may experience impacts due to the construction works. Key measures to avoid and minimise these impacts are described below and should be implemented as part of the Environmental Monitoring and Management Plan (EMMP) during the advance works.

7.9.2.1 Minimise

Table 7-38 Key recommended measures to avoid biodiversity impacts during advance works

Receptor	Impact Types	Mitigation Measures
Faunal species	Light disturbances	• Avoid night-time works to prevent disturbances to nocturnal fauna and nocturnal-migrating species; restrict working hours to 0700h–1900h, with artificial lighting only 0800h–1800h • Avoid night-time works during bird migratory season (September to February) • Where night-time works are unavoidable, adopt the following measures: • Review construction method statements and site lighting plan with the EMMP Specialist and Ecologist before the commencement of night works and where necessary • Reduce light spillage into adjacent areas by adopting the following measures: ▪ Worksite hoarding to be opaque, and dark-coloured where possible ▪ Increase the height of worksite hoarding, especially in areas adjacent to natural areas ▪ Ensure that no light sources are directly visible from the forest edge as much as possible ▪ Ensure that lighting is only used where really necessary; remainder of worksite to remain dark as much as possible ▪ Lighting to be directed downwards to reduce light spillage upwards, as it may impact migratory birds

Receptor	Impact Types	Mitigation Measures
		• To establish a wildlife response plan to be executed when fauna (e.g., disoriented birds) is found on-site during night-time works • For lighting equipment, consider: ▪ Using warm lighting where possible during construction works after 6 pm (i.e., soft white and warm white light bulbs, preferably at < 2,700 K) ▪ Avoid using high UV and broad-spectrum lights (except for safety reasons)

7.9.3 Main Civil Works

The proximity of development to sensitive habitats, such as the Sungei Pang Sua mangrove and Rail Corridor mean that the ecological receptors there may experience impacts due to the construction works. Key measures to avoid and minimise these impacts are described below and should be implemented as part of the Environmental Monitoring and Management Plan (EMMP) during the construction phase.

7.9.3.1 Avoid

In addition to minimum controls in Section 7.7.1, Table 7-39 provides a summary of the key recommended measures to avoid biodiversity impacts during the construction phase.

Table 7-39 Key recommended measures to avoid biodiversity impacts during construction phase

Receptors	Impact Types	Mitigation Measures
• **Habitats** • **Flora species** • **Faunal species**	• Loss of vegetation • Loss of/reduction in habitats and food sources • Injury/Mortality of floral receptors • Loss of/reduction in ecological connectivity for faunal movement	• Ensure no works outside of worksite or agreed working space. This includes additional clearance of vegetation for material storage, access routes, trampling and vegetation damage, outside of worksite. This is especially so for sensitive habitats, i.e., Sungei Pang Sua, mangrove and its adjacent habitats. • Engage arborists and flora specialists to clearly mark out areas and plants with conservation value before the start of works. This would avoid clearing unnecessary working space, eliminate the need of removing specimens of value and plants of conservation significance as much as possible.
• **Habitats**	Habitat degradation	• Ensure no works outside of worksite or agreed working space. This includes additional clearance of vegetation for material storage, access routes, and associated works, outside of worksite. This is especially so for sensitive habitats, i.e., Sungei Pang Sua, mangrove and its adjacent habitats. • Ensure that minimum control measures as well as engineering controls are in place to prevent contamination and siltation into the sensitive habitats and waterways, i.e., Sungei Pang Sua, mangrove and its adjacent habitats (see Section 8.8.1). • Ensure any associated slope stabilisation and grading works will not impact topography of areas outside worksite and, water quality and hydrology of the waterbodies within the Study Area.

7.9.3.2 Minimise

In addition to minimum controls in Section 7.7.1, Table 7-40 below provides a summary of the key recommended measures to minimise biodiversity impacts during the construction phase. Due to overlapping measures for habitat and flora species receptors, they are combined in Table 7-40.

Table 7-40 Key recommended measures to minimise biodiversity impacts during construction phase

Receptors	Impact Types	Mitigation Measures
• **Habitat** • **Flora species**	• Loss of vegetation • Habitat degradation • Injury/Mortality of floral receptors • Decline in plant health	• Conduct regular inspections to ensure contractor compliance to the EMMP, with oversight by LTA • Implement dust control measures such as dust screens and water suppression systems • Retain ground cover for as long as possible before removal. When ground cover is removed, ECM is to be in place. • Conduct close supervision during the construction of the potential future infrastructure to ensure that machineries, such as cranes, will not cause any injury towards the tree specimens in proximity during the launching of the pre-cast cross head. • Conduct regular monitoring at Sungei Pang Sua to ensure no impacts to mangrove *and Sonneratia caseolaris* cluster • Engage with a certified arborist if topping/pruning is needed for any tree specimens to avoid the entire tree specimen during the construction of the potential future infrastructure. • Ensure that TPZs around tree and keystone specimens to be retained around worksites are installed properly as part of the minimum control measures (refer to Section 7.7). Conduct regular arboricultural inspections to monitor the health of the retained specimens.
Faunal species	• Loss of/reduction in ecological connectivity for faunal movement • Accidental injury or mortality • Human-wildlife conflict	• Ensure that there is a continuous strip of 30-m wide vegetation maintained along the Rail Corridor at all times. This is to allow faunal movement along the Rail Corridor, including terrestrial mammals such as Sunda pangolin and Eurasian wild boars. • Establish a Wildlife Response Plan in consultation with NParks Animal Management Centre, to be executed during encounters with trapped, injured or dead wildlife, as well as incidents of human-wildlife conflict • Conduct regular inspections to ensure contractor compliance to the EMMP and identify potential faunal entrapments • Retain ground cover for as long as possible before removal • Use only fully biodegradable erosion control blankets (ECB) to avoid trapping fossorial fauna such as snakes • Adopt road calming measures such as speed bumps and speed limits to minimise roadkill accidents • Train site personnel on biodiversity awareness and actions to take when encountering wildlife • Ensure good housekeeping controls such as provision of wildlife-proof bins and eating areas • Conduct regular monitoring to identify possible collapse of mud lobster mounds around potential future infrastructure.
	• Light disturbances	• Avoid night-time works to prevent disturbances to nocturnal fauna and nocturnal-migrating species; restrict working hours to 0800h–1800h • Avoid night-time works during bird migratory season (September to February)

Receptors	Impact Types	Mitigation Measures
		• Where night-time works are unavoidable, adopt the following measures: ○ Review construction method statements and site lighting plan with the EMMP Specialist and Ecologist before the commencement of night works and where necessary ○ Reduce light spillage into adjacent areas by adopting the following measures: ▪ Worksite hoarding to be opaque, and dark-coloured where possible ▪ Increase the height of worksite hoarding, especially in areas adjacent to natural areas ▪ Ensure that no light sources are directly visible from the forest edge as much as possible ▪ Ensure that lighting is only used where really necessary; remainder of worksite to remain dark as much as possible ▪ Lighting to be directed downwards to reduce light spillage upwards, as it may impact migratory birds ○ To establish a wildlife response plan to be executed when fauna (e.g., disoriented birds) is found on-site during night-time works ○ For lighting equipment, consider: ▪ Using warm lighting where possible during construction works after 6 pm (i.e., soft white and warm white light bulbs, preferably at < 2,700 K) ▪ Avoid using high UV and broad-spectrum lights (except for safety reasons)
	Human disturbances	No entry of site personnel to vegetated areas outside of the agreed working space, especially Sungei Pang Sua mangrove.

7.9.4 Commissioning Phase

During the commission phase, habitat and tree monitoring is recommended in the first three months to observe possible impacts of potential future infrastructure at Sungei Pang Sua mangrove, especially for the *Sonneratia caseolaris* cluster.

7.9.4.1 Minimise/ Rehabilitate

In addition to minimum controls in Section 7.7.2, below provides a summary of the key recommended measures to minimise biodiversity impacts during the commissioning phase.

Table 7-41 Key recommended measures to minimise biodiversity impacts during the commissioning phase

Receptors	Impact Types	Mitigation Measures
Floral Receptors	Change in plant species composition Competition from exotic species	• Unused areas and/or areas which was cleared for works during the construction should be replanted. Adopt a native planting palette considering the existing and surrounding vegetation**.** • Execute in-fill planting or dense planting using native species and mangrove/back mangrove species, especially in areas with forest gaps or areas with bare or sparse undergrowth • Conduct monitoring to observe possible impacts of potential future infrastructure at Sungei Pang Sua mangrove, especially for the *Sonneratia caseolaris* cluster.

Receptors	Impact Types	Mitigation Measures
Faunal Receptors	Human-wildlife conflict	• Design and administrative measures (proper waste disposal and management); see **Section 7.8.1.2**

7.9.5 Operational Phase

The same measures apply as for the commissioning phase above.

7.10 Residual Impacts

7.10.1 Construction Phase

7.10.1.1 Habitat

Three impacts were identified and assessed for seven habitat receptors: (1) loss of vegetation, (2) habitat degradation, and (3) change in species composition.

Prior to implementation of mitigation measures, a **Moderate** impact may result from habitat degradation, affecting Sungei Pang Sua and the mangrove. With the implementation of mitigation measures, i.e., locating the footprint and working space of potential future infrastructure at least 5m away from the banks of Sungei Pang Sua, the likelihood of the habitat degradation was deemed to be **Less Likely**, thus reducing the impact significance to **Minor**.

7.10.1.2 Flora

Four impacts were identified and assessed for 40 flora receptors: (1) impediment to seedling recruitment, (2) decline in plant health, (3) injury/mortality and (4) competition of exotic species. The residual impact significance for all species is either **Negligible** or **Minor**. A summary of the impact to flora receptors is provided in Table 7-42.

Injury/Mortality

Pre-mitigation impact significance was assessed for 40 flora species, of which, seven are assessed with **Minor** impact significance. With the implementation of the mitigation measure mentioned in Section 7.9, this would reduce the likelihood of injury/mortality for *Sonneratia caseolaris* from **Possible** to **Less likely.** Hence the residual impact significance for *S. caseolaris* was reduced to **Negligible**.

The residual impact significance remains as **Minor** for the remaining six species

Impediment to Seedling Recruitment, Competition of Exotic Species and Decline in plant health

There is no change to the residual impact significance for all 40 flora receptors. It remains as **Negligible** or **Minor** (Section 7.8.1.2; Appendix J), as these three aforementioned impacts has been reduced to a level that is as low as reasonably practicable.

Table 7-42 Summary of construction phase residual impacts to flora receptors

Impact Type	No. of Species			
	Major	Moderate	Minor	Negligible
Impediment to seedling recruitment	—	—	15	25
Decline in plant health	—	—	11	28

Impact Type	No. of Species			
	Major	Moderate	Minor	Negligible
Injury/Mortality	—	—	6	34
Competition from exotic species	—	—	6	34

7.10.1.3 Fauna

Six impact types were identified and assessed for the faunal receptors: (1) light disturbances, (2) loss/reduction of ecological connectivity for faunal movement, (3) human disturbances, (4) loss of/reduction in habitats and food sources, (5) accidental injury or mortality, (6) human-wildlife conflict, and.

With implementation of mitigation measures, i.e., road-calming measures and provision of 30-m wide corridor along the Rail Corridor at all times, the likelihood for accidental injury or mortality and loss/reduction of ecological connectivity for faunal movement were reduced to Less likely respectively, therefore, resulting in **Minor** impact significance. The likelihood for the remaining impact types remains the same as it was already reduced to a low level in the pre-mitigating stage. A summary of residual impacts to fauna receptors is given in Table 7-41. In addition to this, the residual impacts from airborne noise and groundborne vibration to fauna during construction phase are assessed in Sections 10.9.1 and 11.10.1.

Table 7-43 Summary of construction phase residual impacts to faunal receptors

Impact Type	No. of Species			
	Major	Moderate	Minor	Negligible
Light disturbances	_	–	61	18
Loss/reduction of ecological connectivity for faunal movement	–	–	47	32
Human disturbances	–	–	39	40
Loss of/reduction in habitats and food sources	_	–	36	43
Accidental injury or mortality	–	–	5	74
Human-wildlife conflict	–	–	2	77

7.10.2 Operational Phase

7.10.2.1 Habitat

During the operational phase, only **Negligible** to **Minor** are expected. Since it cannot be mitigated further, the impact significance remains.

7.10.2.2 Flora

Three impacts were identified and assessed for 43 flora receptors: (1) competition of exotic species, (2) poaching, and (3) mortality. The residual impact significance for all species is either **Negligible** or **Minor**. A summary of the impact to flora receptors is provided in Table 7-44.

Competition from Exotic Species

Assuming that the recommended mitigation measures mentioned in Section 7.9.4.1 (e.g., planting of native species at the unused and/or bare areas that were cleared for works, execute in-fill planting or dense planting) are carried out, this would reduce the likelihood of three flora receptors (i.e., *Cerbera odollam*, *Terminalia catappa* and *Hibiscus tilaceus)* from **Likely** to **Less likely.** Hence, this reduces their impact significance from **Moderate** to **Minor**.

Mortality and Poaching

The residual impact of these two impacts mentioned above remains the same as their assessed pre-mitigation impact significance for all flora species receptors since these impacts has been reduced to a level that is as low as reasonably practicable, i.e., **Minor**.

Table 7-44 Summary of operational phase residual impacts to flora species receptors

Impact Type	No. of Species			
	Major	Moderate	Minor	Negligible
Competition from Exotic Species	—	—	6	34
Poaching	—	—	2	38
Mortality	—	—	—	40

7.10.2.3 Fauna

Six operational phase impacts were identified and assessed for faunal receptors: (1) accidental injury or mortality, (2) light disturbances, (3) human-wildlife conflict, (4) poaching, (5) loss of/reduction in ecological connectivity for faunal movement, and (6) human disturbances. The impact significance ranged from **Negligible** to **Minor**. A summary of the impact to fauna receptors is given in Table 7-45.

By adopting appropriate design and administrative measures, the likelihood of human-wildlife conflict for one species, the long-tailed macaque, may be reduced to **Less Likely**, thus reducing the impact significance to **Negligible** to **Minor**. In addition to this, the residual impacts from airborne noise and ground-borne vibration to fauna during operational phase area assessed in Sections 10.9.2 and 11.10.2.

Table 7-45 Summary of operational phase residual impacts to faunal receptors

Impact Type	No. of Species			
	Major	Moderate	Minor	Negligible
Accidental injury or mortality	–	–	57	22
Light disturbances	–	–	10	69

Impact Type	No. of Species			
	Major	Moderate	Minor	Negligible
Human-wildlife conflict	–	–	2	77
Poaching	_	–	–	79
Loss/reduction of ecological connectivity for faunal movement	–	–	–	79
Human disturbances	–	–	–	79

7.11 Cumulative Impacts with Other Concurrent Projects

7.11.1 Construction Phase

Two major concurrent developments have been identified in Section 3.5.2 to be in the vicinity of the Project. The cumulative impact on biodiversity during construction phase is elaborated in sections below.

7.11.1.1 HDB CCK N1 Construction

HDB CCK N1 will have an overlapping construction timeline with the construction of the Project's docking shaft near HDB Senja for approximately 1 – 2 years. The site clearance for HDB CCK N1 project was scheduled to begin in 2023 and building construction completed in 2028. At current stage, the Project's docking shaft ERSS works are planned to start only in second half of 2026. The overlap is considered minimal as by the time the Project commences work, HDB CCK N1 would already be at tail end of its construction period while the Project's docking shaft would have only started its commencement. Therefore, cumulative impact was assessed to be a **insignificant** increase in impacts to the habitats, flora and fauna within the Study Area. For dust and noise cumulative impacts to the fauna species within Study Area, please refer to Section 9.10.1 and Section 10.10.1, respectively.

7.11.1.2 JTC Woodlands Road Realignment

The timeline for this development is not confirmed at the time of writing. However, it may happen during the timeline of the current project.

Impacts to habitats and flora: Direct impacts such as vegetation removal is likely to occur for the vegetation within the central part of the Study Area. Indirect impacts such as habitat degradation, impediment to seedling recruitment and possibly decline in plant health and survival may occur on the remaining habitats and flora within the Study Area. Therefore, cumulative impact was assessed to be **some** impacts to the habitats and flora within the Study Area.

Impacts to fauna: Similarly, direct impacts from vegetation removal would result in loss/reduction in habitat for fauna, while indirect impacts such as habitat degradation, increase in noise and dust would also impact fauna species utilising Study Area. For dust and noise cumulative impacts to the fauna species within Study Area, please refer to Section 9.10.1 and Section 10.10.1, respectively. Therefore, cumulative impact was assessed to be a **significant** increase to the fauna within the Study Area.

7.11.2 Operational Phase

7.11.2.1 HDB CCK N1 Construction

During operational phase, residential buildings and a corridor is expected to be present within the southern Study Area.

Impacts to habitats and flora: Assuming that the planting palette would include some ornamentals and exotic species, there may be **some** impacts to flora species from competition from exotic species.

Impacts to fauna: The development is possibly high-rise and likely to result in increased light and noise levels, therefore, the impacts were assessed to be **significant**.

7.11.2.2 JTC Woodlands Road Realignment

During operational phase, the road would be realigned.

Impacts to habitats and flora: Since vegetation clearance is unlikely in this stage, impacts are considered **insignificant**.

Impacts to fauna: The development is expected to cause increased in noise, light and vibration levels, in greater proximity to the Rail Corridor, therefore, the cumulative impacts were assessed to be **significant** increase to the fauna within the Study Area.

7.12 Summary of Key Findings

7.12.1 Flora Findings

The Study Area comprises six habitat types. The largest habitat is urban vegetation (33.74 ha; 36.65%), followed by scrubland 19.51 ha; 21.19%, mangrove forest (11.04 ha; 11.99%), and exotic-dominated secondary forest (6.38 ha; 6.93 %). Altogether, spontaneous vegetation takes up 40.12 % (36.93 ha) of the Study Area. The remaining non-vegetated habitats are waterbodies, such as Pang Sua Canal (9.55 ha; 10.37%), Sungei Pang Sua (7.02 ha; 7.63%), and a natural stream. Other infrastructure and amenities take up (4.82 ha; 5.24%) of the Study Area.

Of the 206 species that were recorded, 16 were considered species of conservation significance. All 16 species are associated with coastal and/or mangrove habitats, except for the nationally Vulnerable *Digitaria longiflora.* The distribution of the species of conservation significance was recorded mostly within the mangrove forest. Some of these species are Critically Endangered *Sonneratia caseolaris, Finlaysonia obovata,* nationally Endangered *Ceriops zippeliana, Halophila beccarii, Lumnitzera littorea, Lumnitzera racemosa,* and nationally Vulnerable *Nypa fruticans*. Specimens of *Sonneratia caseolaris* largely contributes to the total number of specimens of species of conservation significance that was recorded in the Study Area, of which, a higher number of seedlings and young saplings were recorded inland. The population was observed to be thriving and propagating. With only less than 20 specimens found outside of Sungei Pang Sua in Singapore, such as woodlands Town Garden, Sungei Buloh Wetland Reserve and Pulau Ubin [P-50; W-77], it is highly likely that the mangrove forest in the Study Area is currently the stronghold for this species, with more than 200 specimens recorded in the Study Area. The highest density of *Sonneratia caseolaris* was observed inland of Sungei Pang Sua. Clusters of nationally Endangered of *Halophila beccarii* were recorded near the mouth of Sungei Pang Sua. This species is also globally Vulnerable due to anthropogenic threats [W-78], such as the rapid increase of coastal developments and reclamation activities [W-79]. Only one specimen of *Ceriops zippeliana* was recorded at the bank of Sungei Pang Sua near the river mouth. It was officially declared as a new record of mangrove species in Singapore only in the recent years [P-39]. As for *Lumnitzera littorea* and *Lumnitzera racemosa,* only one specimen was recorded for the former and three specimens were recorded for the latter. The conservation status of these two species is most likely the product of the decrease in their population as they possess timber that is deemed highly valuable [W-73; W-74]. Lastly, *Nypa fruticans* is the second most abundant mangrove species that were recorded within the mangrove forest. Aside from the extensive loss of mangrove habitat over the years

in Singapore [P-46], the national population of this species could have also declined as this species is a widely utilised mangrove species for commercial purposes in the past [P-44].

A total of 226 large plant specimens are recorded in the Study Area, of which, 163 specimens are exotic, 61 are native and two are cryptogenic. With 47 individuals recorded, Senegal mahogany (*Khaya senegalensis*), forms the majority of large plant species, followed by raintree (*Samanea saman*) with 42 individuals recorded. The largest specimens recorded are two Malayan banyan (*Ficus microcarpa*) with a spread of 15 m and with a height of 25 m and 20 m respectively, while a noteworthy observation to highlight would be an *Avicennia alba,* with a girth size of 3.8 m. Eight specimens were identified as other specimens of value, of which six were bamboo clusters and two were albizia trees *(Falcataria falcata*) with raptor nest belonging to changeable hawk eagle (*Nisaetus cirrhatus)* and white-bellied sea eagle (*Haliaeetus leucogaster*) respectively. Finally, a total of 1,762 specimens belonging to 56 species and 1 species group (i.e., *Syzygium* cf *malaccense*) were tagged and recorded during tree mapping survey. More than half (52.2%; 920 specimens) of these trees are exotic, 47.3% (833 specimens) are native and the remaining 0.5% (9 specimens) are cryptogenic. Almost half of the total number of trees tagged were contributed by *Avicennia alba* (266 specimens), *Sonneratia caseolaris* (250 specimens), rain tree (*Samanea saman*; 159 specimens), and *Khaya senegalensis* (154 specimens). Of the 1,762 specimens, 310 of them specimens belonged to five species of conservation significance, of which, the majority of these specimens are *S. caseolaris* with girth sizes that ranges between 0.3 m – 2.0 m.

A total of 40 flora species receptors were identified for impact assessment. This includes (1) species of conservation significance, large specimens, other specimens of value, and/or trees found inside and within 30 m from the proposed worksite area, (2) keystone species, as defined in Section 7.3.3), (3) species associated with important fauna, and (4) species that make up ≤ 1% of the total number of specimens of conservation significance.

Four impacts were assessed for the flora species receptors during construction phase, namely i) injury/mortality, ii) impediment to seedling recruitment, iii) competition from exotic species and iv) decline in plant health. The impact significance ranged from Negligible to Minor. While impacts are considered Minor, mitigation measures were proposed to further minimise ecological impacts. This includes (but not limited to) proper installation of silt fences and earth control measures, engaging arborist for pruning of tree specimens, salvaging and harvesting of trees/saplings of conservation significance and monitoring of plant health. The residual impact significance remains **Negligible** to **Minor**.

Three impacts were assessed for the operational phase, namely i) mortality, ii) poaching and iii) competition from exotic species. Impact significance ranged from Negligible to Moderate. Three (3) flora species receptors (i.e., *Cerbera odollam*, *Syzygium polyanthum*, *Terminalia catappa* and *Hibiscus tilaceus)* were assessed with Moderate impact significance for the impact of competition from exotic species. Proposed mitigation measures include replanting unused cleared or bare areas with native planting palette, as well as in-fill or dense planting. With implementation of mitigation measures, impacts from competition from exotic species were reduced to Minor. The residual impact significance for the remaining flora species receptors of all impact type remains as **Negligible to Minor**, as they have been reduced to a level that is as low as reasonably practicable.

7.12.2 Fauna Findings

The faunistic field assessment recorded 293 faunal species within the Study Area, including 228 terrestrial species and 65 aquatic species. The terrestrial fauna community is dominated by birds (99 species) and butterflies (59 species), while the aquatic fauna community is dominated by molluscs (37 species). Terrestrial fauna observed are typical of secondary forest, woodland and scrubland habitats. Aquatic fauna observed is characterized by species from a continuum of habitat from slightly brackish to mostly marine, with tidal influence. This is because Sungei Pang Sua receives both freshwater inputs inland and tidal influence at the coast.

Twenty-one species of conservation significance were recorded. This comprised 18 bird, 1 non-volant mammal, 1 decapod and 1 horseshoe crab species. Species of conservation significance were distributed across the Study Area, although there appears to have higher records from the central to northern part of the Study Area.

Bird species of conservation significance recorded include waterbirds, such as the purple heron (*Ardea purpurea*) and yellow bitter (*Ixobrychus sinensis*); raptors such as the white-bellied sea eagle (*Haliaeetus leucogaster*) and changeable hawk-eagle (*Nisaetus cirrhatus*); passerine birds such as the oriental magpie-robin (*Copsychus saularis*) and the spotted wood owl (*Strix seloputo*). A nest of a pair of white-bellied sea eagle and a changeable hawk-eagle were observed within the Kranji woodland located just outside of the Study Area. Twenty-two migratory birds were recorded, including 16 common or abundant species such as the arctic warbler (*Phylloscopus borealis*); 5 uncommon species such as the black-capped kingfisher (*Halcyon pileata*); and 1 rare migrant, the yellow-browed warbler (*Phylloscopus inornatus*). These records show that the Study Area has value in supporting species of conservation significance and migratory birds.

A family of smooth-coated otter (*Lutrogale perspicillata*), with up to seven individuals, was seen within the Study Area. A spraint site of the otter was observed under the train track adjacent to Sungei Pang Sua. While not recorded in this study, the globally and nationally Critically Endangered Sunda pangolin (*Manis javanica*) was deemed likely to occur in the Study Area. The Study Area lies partially along the Rail Corridor can serve as a passageway for the dispersal of these wildlife.

Sungei Pang Sua is also home to mangrove- and mudflat-associated species. A dead mangrove horsecrab (*Carcinoscorpius rotundicauda*) was also observed, although local breeding population is unlikely present. Yet, it is home to nationally Endangered mud lobsters (*Thalassina* spp.). While not observed in this study due to its cryptic nature, the presence of active mounds suggests its presence. The highest density of mud lobster mounds was observed inland of Sungei Pang Sua. Although only striated heron (*Butorides striata*) was observed roosting within Sungei Pang Sua, it is a potential roosting habitat for other ardeids, such the black-crowned night heron (*Nycticorax nycticorax*), purple heron and grey heron, which were also observed in the Study Area. On the other hand, Pang Sua Canal is poor in aquatic life but may provide connectivity for some aquatic species such as the otters, and birds to move between waterways.

A total of 79 faunal receptors of Priority 1 were identified for impact assessment. These include species of conservation significance, of which, 22 were recorded during field assessment. The remaining 57 species were fauna deemed of probable occurrence.

Six impacts were assessed for the faunal species receptors during construction phase. The impact significance ranged from Negligible to Moderate. Moderate impacts were expected from accidental injury and mortality for 5 species that are either susceptible to roadkill or entrapment in construction site. Proposed mitigation measures for design and construction phase include integrating speed-calming measures. With the implementation of mitigation measures, impacts from accidental injury or mortality was reduced to **Minor**. Moderate impacts from loss/reduction of ecological connectivity for faunal movement was mitigated with a 30-m wide corridor that will be maintained on site for faunal movement, therefore, impact significance was reduced to **Minor**.

During operational phase, impact significance ranged from Negligible to Moderate. Moderate impact was expected from human-wildlife conflict for 2 species (long-tailed macaque and smooth coated otter). Proposed mitigation measures include proper waste management. With implementation of mitigation measures, impacts were reduced to **Minor**.

Table 7-46 Summary of Biodiversity Impact Assessment

Sensitive Receptors and Phases	Impact Significance with minimum controls	Residual Impact Significance with mitigation measures (if required)
Construction Phase		
Habitat	Negligible to Moderate	**Negligible to Minor**
Flora	Negligible to Minor	**Negligible to Minor**
Fauna	Negligible to Moderate	**Negligible to Minor**

Sensitive Receptors and Phases	Impact Significance with minimum controls	Residual Impact Significance with mitigation measures (if required)
Operational Phase		
Habitat	Negligible to Minor	**Negligible to Minor**
Flora	Negligible to Moderate	**Negligible to Minor**
Fauna	Negligible to Moderate	**Negligible to Minor**