

8 Surface Water Resources

8.1 Introduction

This section includes the assessment of baseline conditions of surface water resources (i.e. hydrology and water quality) within the Study Area (as defined in Section 6.2.1), as well as the evaluation of the potential impacts on them, arising from activities during Project's construction and operational phases. Based on the analysis of primary (e.g. visual observations during site reconnaissance and surveys, hydrological surveys [i.e. dry and wet weather conditions] and surface water quality sampling, etc.) and secondary data (e.g. publicly-available secondary data and data provided by the Client) baseline conditions have been established and presented. These findings were subsequently used to analyse the changes that might occur due to the impacts associated with assumed activities during construction and operational phases of the Project (refer to Section 3 of this report). Sensitive receptors were identified and classified according to the sensitivity categorisation as defined in Section 6.2.2 of this Report. As part of impact prediction, potential sources of impact from the Project that could affect the identified sensitive receptors and the minimum controls put in place to reduce them were also described. Based on the baseline survey, an impact evaluation (refer to Section 8.7) and EMMP development (refer to section 12) were carried out.

The scope of work of the hydrological and surface water quality impact assessment consisted of:

- Review of data provided by the Client and desktop research of publicly available data to understand the topographic characteristics of the Study Area;
- Site reconnaissance survey for a better understanding of the Study Area's topography, hydrology, land cover and existing watercourses with their properties (i.e. locations, water flow conditions and bank characteristics);
- Identification of sampling locations for in-situ and ex-situ surface water quality analysis of existing watercourses located within the Study Area;
- Hydrological and surface water quality impact analysis to assess the potential impacts of the Project during construction and operational phases;
- Proposal of mitigation measures to mitigate the potential impacts; and
- Proposal of EMMP to manage and monitor potential impacts of the Project during construction and operational phases.

8.2 Methodology and Assumptions

This section details the methodology used on surface water resources for

- Baseline study; and
- Impact assessment.

8.2.1 Surface Water Resource Baseline Study

Hydrology and surface water quality baseline study was carried out by the combination of desktop research (i.e. review of publicly available secondary data, data provided by the Client, previous studies carried out within the Study Area or its vicinity) and field surveys (including the collection and analysis of primary data such as surface water quality and visual observations during site surveys). Subsequently, this data was collated, analysed and compared to the selected criteria, where applicable (refer to the section 8.4.2.1.2). Following sub-sections detail the methodologies used for data collection and analysis of the collected baseline data.

8.2.1.1 Data Collection Methodology

8.2.1.1.1 Desktop Research

Desktop research consisted of a review of secondary data (including existing topographic data, vegetation cover, existing land use and development activities, satellite images, etc.) which aided in determining the location of existing watercourses within the Study Area. The topographic survey data provided by the Client and surveyor, as well as catchment map (i.e. the source of water flow to existing reservoirs) from PUB website [W-1] were used to

support the findings of the hydrological survey. The information, retrieved during the desktop research, comprised of publicly available data from government and technical agencies, existing available data (e.g. online satellite images), as well as published books, relevant articles, and other online sources. This also includes LTA's Environmental Impact Study (EIS) for CRL2 (CR2005) [R-2, R-3, R-4], which has study locations overlapping with this Study.

8.2.1.1.2 Field Survey and Sampling Events

The activities performed as part of the field assessment included the following:

- Evaluate the accessibility of the watercourses through existing tracks;
- Verify the information collected from the available topographic surveys and satellite images;
- Identify and map out the location of existing watercourses within the Study Area;
- Determine the flow conditions and bank characteristics of the identified watercourses during dry and wet weather conditions; and
- Observe water quality indicators in existing watercourses within the Study Area (e.g. physical parameters such as colour, turbidity, odour, etc).

8.2.1.1.2.1 Hydrological Survey Methodology

The hydrological survey was conducted by casual exploration methods to identify and outline existing watercourses within the Study Area. The watercourse conditions, such as stream bank characteristics (e.g. natural bank or artificial bank), and flow velocity were identified based on visual observations and professional experience. A Global Positioning System (GPS) device was used to track the hydrological survey route. The GPS data was then synchronised with the photos taken on-site to identify the exact location of identified watercourses.

Secondary topographic data from the concurrent study as well as the topographic survey results from this Project have been referenced for the hydrological analysis. Using the available topographic data, ArcGIS software was used to develop elevation and slope maps for the site to support the hydrological analysis. Topographic data were also used for catchment delineation, to understand the catchment characteristics (i.e. water sources and flow direction of watercourse within the site), through which the catchment map was also generated.

8.2.1.1.2.1.1 Stream Mapping

Stream mapping was conducted by capturing the stream lines of the identified major waterbodies with biodiversity values within the Study Area using GPS along the stream. For each major stream, the characteristics of the stream including bank types (e.g. natural bank or artificial bank), stream length and depth, channel wetted width, stream bed substrate, estimated flow velocity was recorded based on visual observations and professional experience. Furthermore, the riparian vegetation was also surveyed and recorded. Cross sections were recorded at 20m intervals for natural stream sections.

8.2.1.1.2.2 Surface Water Quality Sampling Methodology

As mentioned in the sub-section above, the watercourses present in the Study Area were identified during hydrological site surveys. Subsequently, sampling locations were selected at identified watercourses to collect surface water samples that would accurately represent the baseline surface water quality.

In order to get comprehensive data that is representative of baseline conditions of surface water quality and to capture the possible changes in water quality parameters over time and different events, identified watercourses were sampled during both dry weather and wet weather conditions. Dry weather conditions are defined as conditions after a continuous 48-hour period of no-rain, while wet-weather conditions are defined as a rainfall event having more than 10 mm of rainfall, with samples to be collected within three (3) hours after the rain stops. Two (2) dry weather ("normal conditions") and one (1) wet weather samples were collected from majority of water quality stations.

Surface water samples were collected and were tested in-situ and ex-situ for a range of physical and chemical parameters.

In-situ water quality parameters assessed in this study were all measured using a calibrated multi-parameter digital sensor (YSI ProDSS) with United States Environmental Protection Agency (USEPA) approved testing methods for water quality parameters and included:

- Temperature;

- pH;
- Salinity/Conductivity;
- Turbidity;
- Dissolved oxygen (DO); and
- Total Dissolved Solids (TDS).

The ex-situ parameters that were analysed by Marchwood Laboratory Services Pte Ltd (MLS) are listed below:

- Total Nitrogen (TN);
- Total Phosphorus (TP);
- Nitrates (NO₃-N);
- Total Ammonia Nitrogen (NH₄-N and NH₃-N);
- Orthophosphate (PO₄-P);
- Total Suspended Solids (TSS);
- Total Organic Carbon (TOC);
- Metals aluminium, antimony, arsenic, barium, beryllium, boron, cadmium, chromium, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, tin, and zinc;
- Cyanide;
- Sulphide; and
- *Enterococcus*.

8.2.2 Baseline Data Analysis and Assessment Methodology

The activities performed as part of the analysis and assessment of baseline data included the following:

- Analysis and manipulation of collected data by using various specialised software programmes;
- Evaluation of the accuracy of collected primary data and comparison and coupling with relevant available secondary data;
- Development of maps and figures for better understanding and comparison of data; and
- Comparison of data to selected criteria.

8.2.2.1 Topography and Hydrology Baseline Data Assessment

The elevation and slope maps of the Study Area were developed based on surveyed topographic survey data using GIS technique. In order to determine the exact locations of each of the identified watercourses, GPS data from surveys was synchronised with the photos taken on site. Catchment analysis was conducted based on surveyed topographic data, and publicly available catchment map of Singapore developed by PUB [W-1]. Catchment delineation is considered to be very important information in order to identify the main sources of water that feed each of the watercourses within the Study Area and also to understand how the runoff flows within the site.

8.2.2.2 Water Quality Baseline Assessment Criteria

The baseline water quality of the identified watercourses located within the Study Area was determined by comparing the selected parameters against the NEA Trade Effluent Discharge Limits for Controlled watercourses [R-23]. This comparison could be used to determine whether the existing baseline water quality of the watercourses within the Study Area complies with NEA limits or already exceeds these limits. However, the NEA Trade Effluent Discharge limits does not provide criteria for the preservation and growth of aquatic life locally. To assess whether the surface water quality within the Study Area is suitable for aquatic life, selected parameters were compared to water quality criteria for aquatic life from other countries (i.e. United States (USEPA) [R-17], Australia & New Zealand [R-19], Canada [R-20], Philippines [R-21], and Malaysia [R-22], as well as criteria set up by international organisations including United Nations Economic Commission for Europe [R-15] and World Health Organization [R-16]. The relevant limits and guidelines for water quality parameters were summarised in Table 8-1.

Table 8-1 Water quality guidelines and criteria

Parameter	Unit	NEA Trade Effluent Limits ¹	International Aquatic Life ² Criteria
Temperature (T)	°C	45	-
pH	-	6 – 9	6 – 9
Conductivity	µS/cm	-	-
Turbidity	NTU	-	2 – 200
Total Dissolved Solids (TDS)	mg/L	1000	1000
Dissolved Oxygen (DO)	mg/L	-	> 4
Total Nitrogen (TN)	mg/L	-	8
Total Phosphorus (TP)	mg/L	-	0.1
Nitrate as NO ₃ -N	mg/L	4.516 (equal to 20 NO ₃ -mg/L)	7
Total Ammonia Nitrogen (TAN)	mg/L	-	1
Phosphate as PO ₄ -P	mg/L	0.65 (equal to 2 PO ₄ -mg/L)	0.033
Total Suspended Solids (TSS)	mg/L	30	150
Total Organic Carbon (TOC)	mg/L	-	25
Aluminium as Al	mg/L	-	60
Antimony as Sb	mg/L	-	Acute: 9 Chronic: 1.6
Arsenic as As	mg/L	0.01	Acute: 0.34 Chronic: 0.15
Barium as Ba	mg/L	1	Acute: 1.1 Chronic: 0.62
Beryllium as Be	mg/L	0.5	Acute: 0.13 Chronic: 0.0053
Boron as B	mg/L	0.5	0.94
Cadmium as Cd	mg/L	0.003	0.1
Chromium as Cr (trivalent and hexavalent)	mg/L	0.05	0.016
Copper as Cu	mg/L	0.1	Acute: 0.018 Chronic: 0.012
Iron as Fe	mg/L	1	1
Lead as Pb	mg/L	0.1	Acute: 0.065 Chronic: 0.0025
Manganese as Mn	mg/L	0.5	0.1
Mercury as Hg	mg/L	0.001	Acute: 0.0014 Chronic: 0.00077
Molybdenum as Mo	mg/L	-	0.034
Nickel as Ni	mg/L	0.1	Acute: 0.47 Chronic: 0.052
Selenium as Se	mg/L	0.01	0.25
Silver as Ag	mg/L	0.1	0.05
Tin as Sn	mg/L	5	0.004
Zinc as Zn	mg/L	0.5	Acute: 0.12 Chronic: 0.12
Cyanide as CN ⁻	mg/L	0.1	0.060
Sulphide as S ²⁻	mg/L	0.2	0.050
<i>Enterococcus</i> ³	cfu/100mL	-	-
Note:			
1. NEA Trade Effluent Discharge Limits for discharge into a controlled watercourse.			

Parameter	Unit	NEA Trade Effluent Limits ¹	International Aquatic Life ² Criteria
2.	The sources of international water quality criteria for aquatic life include United Nations Economic Commission for Europe [R-22], World Health Organization [R-23], United States Environmental Protection Agency [R-18], Australian & New Zealand [R-25], Canada [R-26], Philippines [R-27], and Malaysia [R-28]		
3.	Singapore's Water Quality Guidelines for Recreational Beaches and Fresh Water Bodies requires that the <i>Enterococcus</i> count should be less than or equal to 200 counts per 100 millilitres of water at 95% of the time		

8.2.3 Methodology for Impact Assessment

The potential impacts from Project on hydrology and surface water quality will be assessed through qualitative approach based on primary and secondary data, technical experiences on previous projects and the understanding of the Project's activities of construction and operational phases. The potential sources of Project impacts and the potential environmental parameter affected, and associated Impacts will be identified accordingly based on planned Project's activities. To collect primary and secondary data, the baseline condition of Study Area will be studied through site reconnaissance and surveys as well as existing information provided by the Client. Subsequently, potential sensitive receptors will be identified based on the baseline study. Each sensitive receptor will be assessed, and each impact will be evaluated its significance based on assessment criteria as provided in Section 6.4.

8.3 Potential Sources of Surface Water Resources Impacts

This section discusses the potential environmental impacts arising from the construction and operational phases of the Project.

8.3.1 Construction Phase

Nearby watercourses could be potentially exposed to hydrological flow change and surface water contamination due to the activities taking place during the Project's construction phase. The sources that could potentially impact on the watercourses' quality and quantity include, but are not limited to, those listed in Table 8-2.

Table 8-2 Potential hydrology and water quality impacts during the construction phase

Environmental Parameter	Potential Source of Impacts	Potential Associated Impacts
Hydrology	Land clearing, earthworks and excavation activities leading to changes in existing hydrological and flow conditions. Temporary and/ or permanent land use change with more impervious surfaces.	• Increase in impervious surfaces which leads to the reduction in water seepage into the ground and increased stormwater runoff peak flow and quantities, which could cause alterations in current dry and wet weather flow conditions. • Increased water levels within watercourses and consequent potential flooding of adjacent areas. • Increased water flow velocity within the water courses could lead to erosion along the watercourses. • Disruption of regular on-site activities due to localised flooding. • Changes in dry and wet weather flow conditions may cause disruptions in the existing habitats.
Surface Water Quality	Land clearing, earthworks and excavation activities leading to increased loads of sediments, suspended solids and contaminants. The potential sources of such contaminants are: • Run-off from exposed soil surface, earth working areas, soil stockpiles. • Stormwater/ groundwater pumped out from excavated areas. • Release of grouting and cement materials. • Run-off from dust suppression sprays. • Elevated suspended solids (e.g. silt and sediment) in site run-off due to heavy rain. • Excavation works leading to soil generation, handling and transport. • Heavy rain during construction. • Altering existing drainage system within the Project Site. Building construction activities (inclusive of activities that might have indirect impact such as road widening, holding areas and site offices activities etc.) leading to: • Improper handling, transfer and storage of construction materials and wastes.	• Solid waste generated can result in elevated levels of suspended solids leading to increased turbidity and sedimentation rates. They can contaminate watercourses via run-off or improper waste handling / disposal. They can also block the temporary drains leading to contamination of receiving watercourses. • Improper storage, handling, disposal or leakage of toxic waste generated at temporary work areas can lead to water contamination. • Inappropriate discharge of the liquid effluent (wastewater) generated during the construction works to watercourses will result in contamination in nearby water sources. • Inappropriate discharge of the domestic sewage and poor maintenance of the portable chemical toilet (e.g. overflow or overload) can result in run-off to nearby water sources and potentially contaminate the watercourses located adjacent to the construction sites. • Contaminated stormwater due to improper storage/disposal/transport of

Environmental Parameter	Potential Source of Impacts	Potential Associated Impacts
	- Release of grouting and cement materials. - Heavy rain during construction. - Change in land use due to proposed development (increase in impervious surface).	chemical materials handled and stored on site leading to an increase in the levels of oil, grease and other chemical substances in the nearby watercourses. Fuel and lubricant spillage from the maintenance of construction vehicles and mechanical equipment can also lead to elevation in levels of oil in the nearby watercourses.
	Storage and disposal of solid wastes leading to improper handling, transfer, storage and disposal of spoil and solid waste (e.g. excavated earth, construction debris).	
	Storage and disposal of liquid wastes leading to: - Improper management of sewage effluents from on-site. - Inappropriate discharge of domestic sewage and poor maintenance of the portable chemical toilet, storage tanks and septic tanks (e.g. overflow or overload).	
	Storage and disposal of toxic wastes leading to improper handling, transfer and storage of toxic waste (e.g. contaminated excavated earth, chemical waste).	
	Use and storage of chemical substances, and refuelling activities leading to: - Improper handling, transfer and storage of chemical substances. - Accidental spill and leaks. - Fuel and lubricant spillage from the maintenance of construction vehicles and mechanical equipment.	

8.3.2 Operational Phase

Watercourses can potentially be exposed to hydrological flow change and surface water contamination due to the activities taking place during the Project's operational phase. The sources that could potentially impact on watercourses' quality and quantity include but are not limited to those listed in Table 8-3.

Table 8-3 Potential hydrology and water quality impacts during the operational phase

Environmental Parameter	Potential Source of Impacts	Potential Associated Impacts
Hydrology	Permanent land use change with more impervious surfaces.	- Increased stormwater peak flow contributions to the channel can lead to increased water level and subsequent flooding of surrounding areas adjacent to the stream/ drain, affecting activities of future residents and/or visitors. - Altered dry weather flow in watercourses that can lead to impact on downstream aquatic habitats. - Stormwater run-off from exposed and unstable slopes may cause soil erosion. - Localised flooding which may obstruct regular activities of future residents and/ or visitors.

Environmental Parameter	Potential Source of Impacts	Potential Associated Impacts
Surface Water Quality	- Heavy rain and stormwater wash-off pollutants built-up in the new development area and discharge into surrounding watercourses. - Improper management of liquid and solid wastes.	Elevated suspended solids (e.g. silt and sediment), pollutants (e.g. heavy metals and nutrients) and solid wastes (e.g. improper littering from human activities) in site run-off. Inappropriate discharge of liquid and solid wastes may flow into watercourses, resulting in contamination of watercourses.

8.4 Surface Water Resource Baseline

This report is based on the site surveys and surface water samples collected until January 2024.

8.4.1 Baseline Monitoring Personnel

The assessment and site surveys were conducted by the following AECOM personnel:

- Dr. Liang Liang (Hydrology and Surface Water Quality Technical Lead);
- Ms. Hanisah Binte Sukarji (Hydrology and Surface Water Quality Specialist);
- Mr. Grujica Sarenac (Hydrology and Surface Water Quality Specialist);
- Ms. Tan Yi Leng (Hydrology and Surface Water Quality Specialist);
- Ms. Jovina Lew (Hydrology and Surface Water Quality Specialist); and
- Ms. Yang Zhangduanyi (Hydrology and Surface Water Quality Specialist).

8.4.2 Baseline Findings

Based on the previous studies [R-2] and site reconnaissance, the team has identified multiple watercourses within Study Area, including natural and naturalised streams, concrete canals and drains, and ponds. For the purposes of this Study, the identified major watercourses were selected for sampling and are considered to be representative of baseline conditions according to hydrological baseline findings as described below. The watercourses and their sampling locations are shown in Figure 8-1. Photographic record (refer to Table 8-4) of different water resources was made during every site survey.

8.4.2.1 Hydrological Conditions

The baseline hydrological conditions in the Study Area were analysed based on site observations (refer to Table 8-4) and recent and past surveyed topographic data [R-2]. Elevation and slope maps of the site were developed based on topographic data using GIS technique. They were then overlaid with hydrological network as shown in Figure 8-2 and Figure 8-3.

8.4.2.1.1 Existing Elevations, Slope, Catchment Areas and Flow Conditions

Site A has a relatively higher overall elevation and an undulating terrain with a valley that runs from the north to the south of the site. The two highest points within Site A are located near the southwest and northeast of the site, at 46.0 mSHD and 50.0 mSHD, respectively. The southwestern hill decreases in elevation towards the east and south of the site. It can be observed that the natural stream (D1) was formed along a V-shaped valley, between areas with higher elevations and has relatively steep slopes on either bank. A man-made earth drain (D3) and a concrete drain (D5) as ephemeral watercourses, and unmanaged pond (D4) are located at areas with comparatively lower elevations, and thus collect runoff during storm events.

The locations of the watercourses in Site B are closely related to the elevations of the site. Along the eastern half of Site B, the elevation decreased from both the north and south, towards the central low-lying region. During storm events, an ephemeral concrete drain conducts runoff from the surrounding vegetation and urban area southwards, and discharges into the central low-lying region, i.e. the naturalised stream D6. The overall elevation also generally decreases from the east to the west of Site B, and the area with the lowest elevation is an elongated zone of low elevation, which is located just outside of the western boundary of Site B. Given the comparatively lower elevation of this zone, it is unsurprising that a perennial naturalised stream D7 is present in this area.

There are relatively steep slopes sloping downwards to the centre of Site D, where a man-made earth drain (D11) is located as shown in Figure 8-3. The lowest elevation in the Study Area (7.8 mSHD) is located at the downstream of this earth drain (D11), which is located at the southern end Site D.

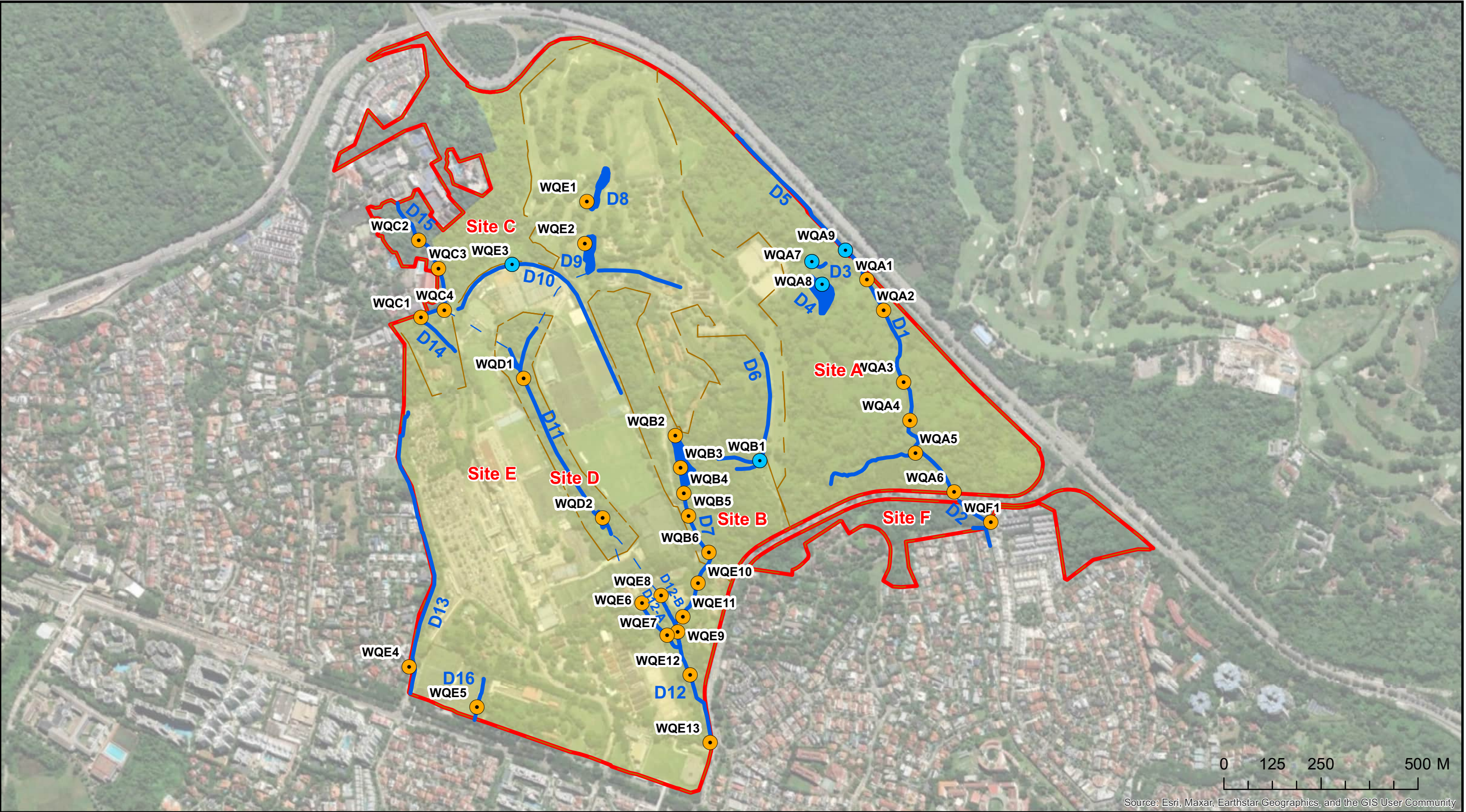
As shown in Figure 8-2, the northernmost region of Site C is significantly higher than the rest of the Study Area. The elevation of the peak at the northern region of Site C is 90.9 mSHD, which is also the highest elevation point in the Study Area. The elevation generally decreases southwards from this point, and since water flows towards low-lying areas, it is expected that the watercourses are located near the south of these sites. A perennial naturalised stream (D15) is located southwest from this peak, and flows southwards towards the boundary of Site C. The southern-most section of Site C has elevation decreasing from the southwest towards northeast. A perennial

man-made earth drain (D14) flows northwards, towards the strip of lower elevation, where it discharges into a perennial concrete drain, which flows towards the east. It then joins with the perennial naturalised stream (D15) at the confluence point and subsequently flowing out of the Study Area through an underground drain.

Site E is the largest site, with elevations ranging from 6.4 mSHD to 50.6 mSHD. The highest elevations occur at the northern area of the site, near to Bukit Tinggi and around the golf course. The elevations in the golf course are highest along the perimeter of the golf course, and decrease internally as well as southwards, where two man-made ponds D8 and D9 can be found. Similarly, in the centre of Site E, elevations decrease inwards towards Site D, where the man-made earth drain D11 can be found. However, Elevations generally decrease southwards throughout the site, and hence majority of the watercourses (naturalised streams D7, D12-A, D12-B, D12 and D16, and drain D13,) flows southwards within Site E.

Elevations in Site F range between 8.53 – 31.26 mSHD (Figure 8-2). The lowest elevations of the Site F (from 8.53 mSHD) coincide with the only drain in Site F, flowing in the southeast direction, close to the centre of Site F. There are several local peaks within Site F, occurring in the west, central and east, with highest points being 31.26, 27.99 and 26.58 mSHD respectively. Elevations decrease southwards in the western half of Site F, while elevations decrease radially from the highest point in the east. In the centre, elevations decrease centrally inwards towards the canal.

Based on generated elevation and slope maps, catchment delineation was conducted to further understand catchment characteristics of the Study Area. A catchment map was then developed as shown in Figure 8-4. The Study Area is divided into twenty-seven (27) catchment areas. Catchment C2 feeds into the natural stream (D1) in Site A, which will flow into canal D2 via a culvert under Eng Neo Avenue. Catchment C3 contributes into the ephemeral man-made earth drain (D5). Catchment C4 contributes to the unmanaged pond D4. Catchment C5 contributes to roadside concrete drain (D5). Based on the detailed drainage plan shared by PUB, it is understood that the runoff flowing into the roadside drain D5 along the PIE are directed into two different directions: the runoff in the northern section of D5 flows towards the CCNR via an underground culvert under the PIE, while the runoff in the southern section of roadside drain D5 flows towards Marina Reservoir. In addition, based on topographic survey and hydrological analysis, the surface runoff from the man-made earth drain (D3) and concrete drain (D5) will discharge to the upstream of natural stream D1. Catchment C7 contributes to roadside drain D6, while Catchment C8 feeds the perennial naturalised stream D7. Catchment C9 contributes to perennial man-made earth drain D11, which flows via an underground drainage system into naturalised streams D12-A and D12-B. Catchment C10 contributes to naturalised stream D15, and Catchment C11 feeds to perennial man-made earth drain cum concrete drain D14. Catchments C6 and C18 contribute to the southern and northern ponds in the golf course respectively. These two ponds are linked, flowing from north to south, and potentially discharge into D11 via underground drainage. Catchments C12 flow westwards towards concrete drain D13. Runoff from catchment C15 flows into perennial naturalised stream D12-A, while runoff from catchment C16 flows into perennial naturalised stream D12-B. Runoff from catchment C17 generally flows southwards, into perennial naturalised stream D12 (if nearby the stream), which becomes a concrete drain downstream, or it flows towards roadside drains along Vanda Link, which eventually merges with D12 at the end, at the junction of Vanda Link and Eng Neo Avenue. Runoff in catchments C19, C21 and C22 flow southwards, out of the Study Area into roadside drains that will flow into Rochor River. While runoff in catchment C20 also flows southwards, it flows into perennial naturalised stream D16 before flowing out of the Study Area and into Bukit Timah Canal. The other catchments C13 and C14 flow out of the Study Area. Runoff in catchments C1 and C25 flows out of the Study Area into roadside drains along Eng Neo Avenue, which will recombine at the end of perennial canal D2 before flowing out of Site F. Catchments C23, C24, and C26 contribute to roadside drains. Catchment C27 is the main catchment contributing directly to canal D2. Roadside drain D10 captures runoff from the adjacent Turf Club Road (not shown on map due to small catchment).



Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Legend

Site Demarcation

EIA Study Area

Project Site

Waterbodies

Watercourses

Surface

Underground

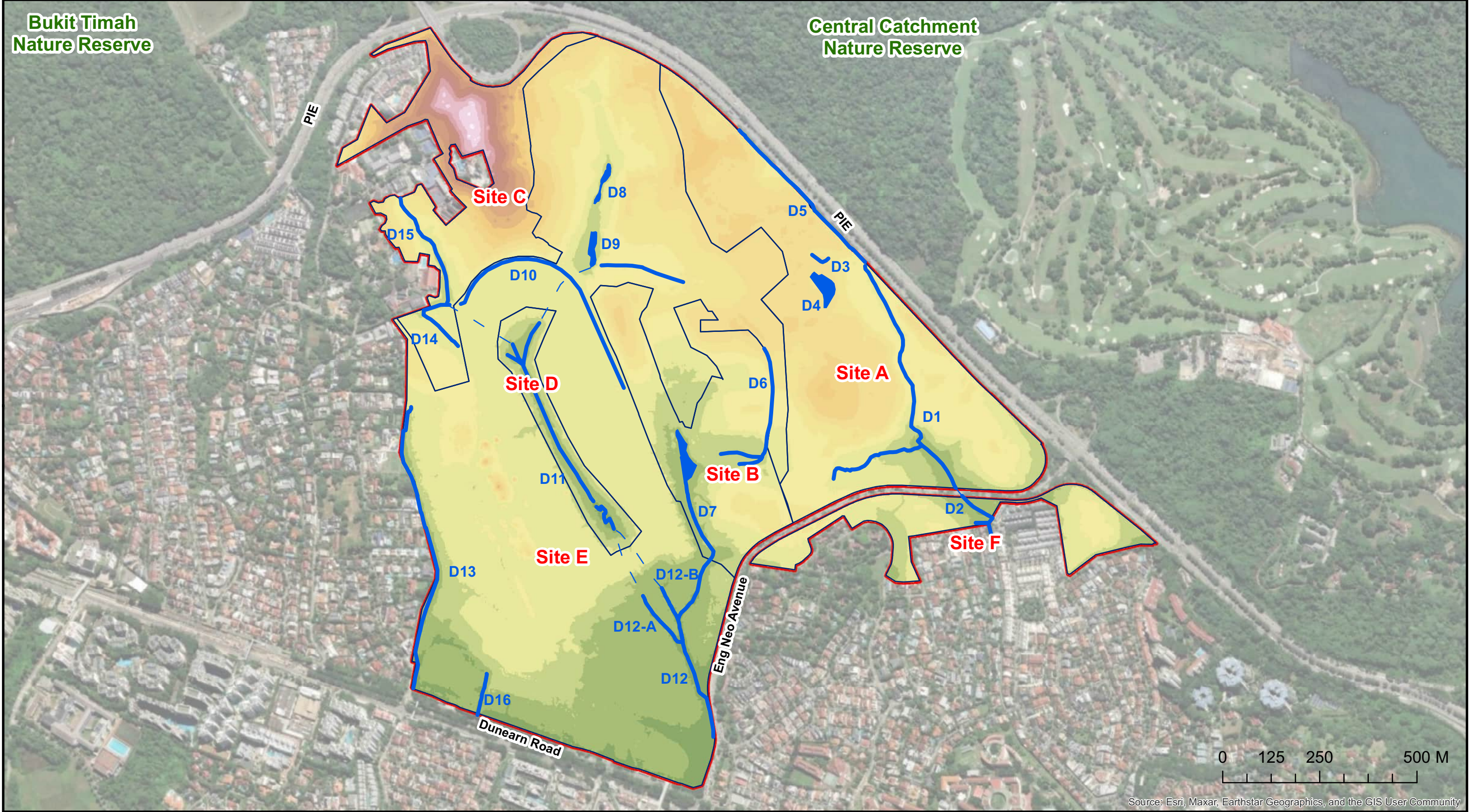
Water quality sampling locations

Dry and wet

Wet

N

							Qualified Person Endorsement : NA	Consultant : AECOM	Client: 					
							URA Endorsement : NA	Project Title : CONTRACT URA/T/22/031 ENVIRONMENTAL IMPACT ASSESSMENT (EIA) FOR FORMER TURF CLUB AT BUKIT TIMAH			Figure Title : Watercourses and sampling locations within/surrounding the Study Area			
								Designed HBS	Checked LAL	Approved JAG	Figure No. : 8 - 1		Rev. -	Sheet 1 of 1
									Drawn HBS	Date MAY 2024	CAD File Name : NA			A3
Rev.	Date	By	Description	Chk'd	App'd									
-	MAY 2024	HBS	Turf Club EIA	LAL	JAG									



EIA Study Area

Demarcated sites

Waterbodies

Watercourses

Surface

Underground

Elevation (mSHD)

< 5

5 - 10

10 - 15

15 - 20

20 - 25

25 - 30

30 - 35

35 - 40

40 - 45

45 - 50

50 - 55

55 - 60

60 - 65

65 - 70

70 - 75

75 - 80

80 - 85

85 - 90

> 90

N

						Qualified Person Endorsement : NA
						URA Endorsement : NA
-	MAY 2024	HBS	Turf Club EIA	LAL	JAG	
Rev.	Date	By	Description	Chk'd	App'd	

Consultant :
AECOM

Project Title :
**CONTRACT URA/T/22/031
ENVIRONMENTAL IMPACT
ASSESSMENT (EIA) FOR
FORMER TURF CLUB AT BUKIT TIMAH**

Designed
HBS

Checked
LAL

Approved
JAG

Client:
UR URBAN
REDEVELOPMENT
AUTHORITY

Figure Title :
**Digital elevation map with watercourses
of the Study Area**

Figure No. :
8 - 2

Rev.
-

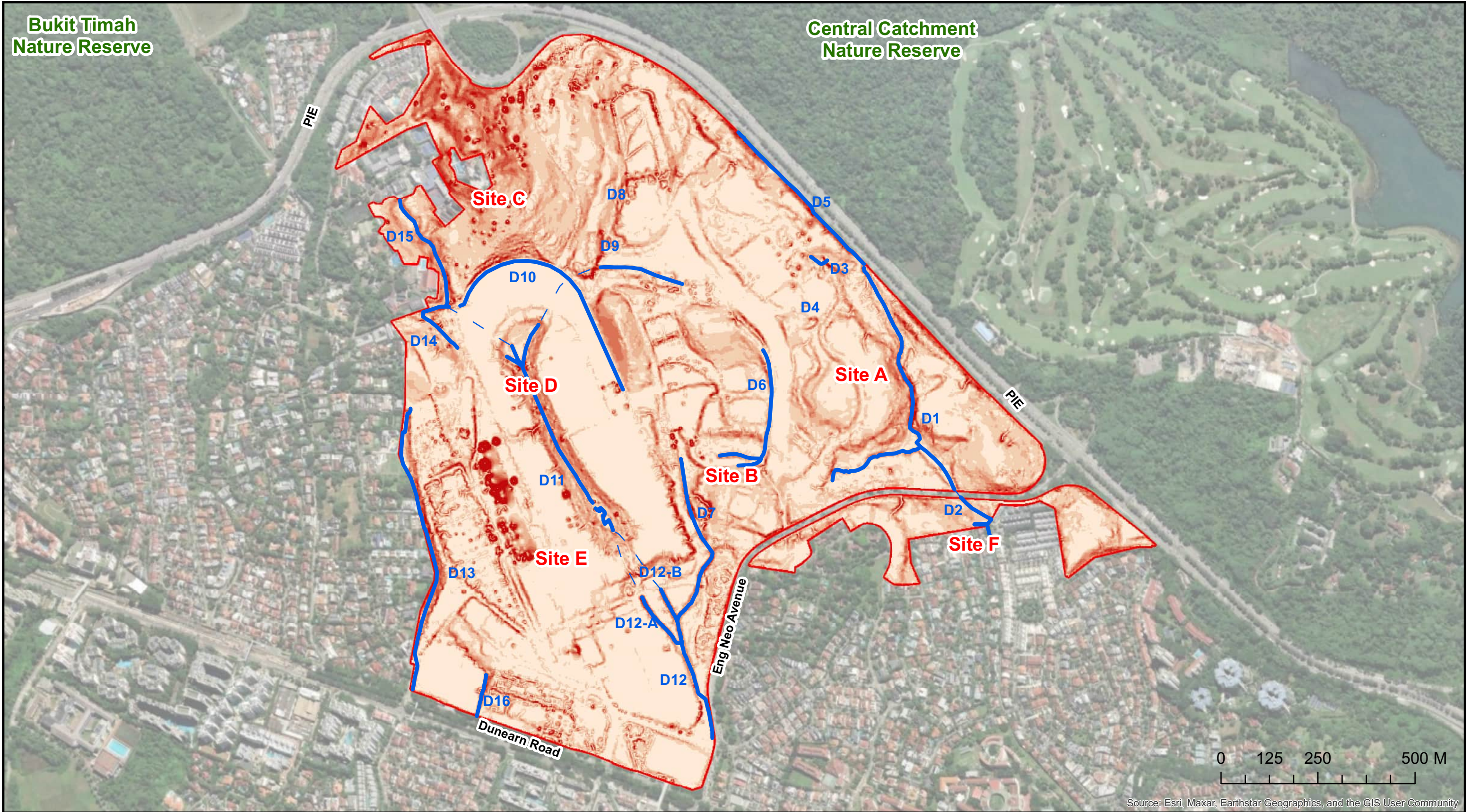
Sheet
1 of 1

CAD File Name : NA

A3

Note: Source of basemap - Google Earth Map

THIS DRAWING IS COPYRIGHT



Legend EIA Study Area Waterbodies Watercourses Surface Underground Slope (%) < 10 10 - 20 20 - 30 30 - 40 40 - 50 50 - 60 60 - 70 > 70 N							Qualified Person Endorsement : NA	Consultant : AECOM	Client: URA URBAN REDEVELOPMENT AUTHORITY						
										Project Title : CONTRACT URA/T/22/031 ENVIRONMENTAL IMPACT ASSESSMENT (EIA) FOR FORMER TURF CLUB AT BUKIT TIMAH	Figure Title : Slope map with watercourses of the Study Area				
									URA Endorsement : NA		Designed HBS	Checked LAL	Approved JAG	Figure No. : 8 - 3	Rev. -
											Drawn HBS	Date MAY 2024	CAD File Name : NA		A3
		Rev.	Date	By	Description	Chk'd	App'd								
		-	MAY 2024	HBS	Turf Club EIA	LAL	JAG								

Table 8-4 Description of water quality sampling points within the Study Area

Watercourses	Bed and Bank Characteristics	Water Flow and Quality Conditions	Photos	
D1	Upstream pond area of D1 is a waterbody with earth banks. Bed is soft with leaf litter. The midstream is a natural stream with dense vegetation. The tributary that feeds into the natural stream is a natural stream with dense vegetation. The downstream is a concrete discharge outlet (weir), which connects to D2 via a culvert under Eng Neo Avenue. Estimated stream length is 673 m.	• Originates from surrounding vegetation in Site A • Perennial flow During dry weather condition: <u>Upstream</u> • Almost no flow as stagnant • Approximate 0.7 – 1 m water depth and width of 5 - 6 m at time of survey • Water is yellowish brown <u>Midstream 1</u> • Almost stagnant, with flow estimated to be < 0.01 m/s • Approximate 18 cm water depth and width of 2.65 m at time of survey • Water has a slight yellowish hue <u>Midstream 2</u> • Water flow observed of approximately 0.14 – 0.2 m/s • Approximate 5 – 11 cm water depth and width of 1.55 m at time of survey • Water has a slight yellowish hue <u>Midstream 3</u> • Water flow observed of approximately 0.17 m/s • Approximate 5 - 10 cm water depth and width of 0.7 m at time of survey • Water is relatively clear <u>Tributary</u> • Slow water flow observed of approximately < 0.01 m/s	Water Quality Station WQA1 (Upstream)	
			During Dry Weather	During Wet Weather
				
			Water Quality Station WQA2 (Midstream 1)	
			During Dry Weather	During Wet Weather
				

Watercourses	Bed and Bank Characteristics	Water Flow and Quality Conditions	Photos	
		- Approximate 30 cm water depth and width of 125 cm at time of survey - Water is relatively clear <u>Downstream</u> - Fast water flow (0.2 – 0.3 m/s) observed during one dry weather, and slower water flow observed of approximately 0.04 m/s during second dry weather - Approximate 28 cm water depth at time of survey and width of water is 2 – 3 m - Water is slightly yellow During wet weather condition: <u>Upstream</u> - Estimated to be 0.015 m/s - Approximate 1.2 m water depth and widest width of 6.5 – 7 m at time of survey - Waters were turbid <u>Midstream 1</u> - Slow water flow observed of approximately 0.08m/s - Approximate 30 cm water depth and width of 3.26 m at time of survey - Waters were turbid <u>Midstream 2</u> - Water flow observed at approximately 0.33 m/s - Approximate 39 cm water depth (at deepest point observed) and width of 1.4 m at time of survey <u>Midstream 3</u>	Water Quality Station WQA3 (Midstream 2)	
			During Dry Weather	During Wet Weather
				
			Water Quality Station WQA4 (Midstream 3)	
			During Dry Weather	During Wet Weather
				
			Water Quality Station WQA5 (Tributary)	
			During Dry Weather	During Wet Weather

Watercourses	Bed and Bank Characteristics	Water Flow and Quality Conditions	Photos	
		- Water flow observed at approximately 0.25 m/s - Approximate 19 cm water depth and width of .2 m at time of survey <u>Tributary</u> - Water flow observed at approximately 0.13 m/s - Approximate 8 - 19 cm water depth and width of 1.4 m at time of survey <u>Downstream</u> - Water flow observed at approximately 0.25 m/s - Approximate 50 – 60 cm water depth at time of survey and overall width is 176 cm		
			Water Quality Station WQA6 (Downstream)	
			During Dry Weather 	During Wet Weather 

Watercourses	Bed and Bank Characteristics	Water Flow and Quality Conditions	Photos	
Concrete Canal D2	Trapezoidal concrete canal with bank Estimated canal length is 88 m.	- Originated from D1, which passes through culvert underground of Eng Neo Avenue) - Receives roadside runoff from along Eng Neo Avenue - Runoff from the forested areas of Site F also enters D2 - Flowing perennially During dry weather condition: - Water flow estimated at 0.25 m/s. - Approximate depth was 7.5 cm with an approximate width of 1.35 m, at time of survey - Observed water was slightly yellowish. During wet weather condition: - Water flow (estimated at 0.31 m/s) - Approximate depth was 18 cm with an approximate width of 1.4 m, at time of survey - Observed water flow had leaf litter and rubbish on surface	Water Quality Station WQF1	
			During Dry Weather	During Wet Weather ¹
				
D3	Earth drain covered by dense vegetation. Estimated drain length is 70 m.	- Originates from runoff from Eng Neo Avenue Forest and Bukit Timah Saddle Club - Ephemeral flow During dry weather condition: - Completely dry During wet weather condition¹:	Water Quality Station WQA7	
			During Dry Weather	During Wet Weather

Watercourses	Bed and Bank Characteristics	Water Flow and Quality Conditions	Photos	
		- Flow was estimated to be 0.15 – 0.17 m/s - Water had approximately 24 cm in depth with width of 1.21 m, at time of survey - Water was a pinkish-beige during time of survey		
D4	Fully covered by green algae and filled with shrubs and bushes.	Stagnant unmanaged pond.	Water Quality Station WQA8	
			During Dry Weather 	During Wet Weather 
			Water Quality Station WQA9	

Watercourses	Bed and Bank Characteristics	Water Flow and Quality Conditions	Photos	
Concrete Drain D5	Concrete roadside drain with artificial banks. Estimated drain length is 471 m.	- Originates from runoff from forest in Eng Neo Avenue Forest and urban areas - Ephemeral flow During dry weather condition: - Almost no flow During wet weather condition¹: - Wet weather flow estimated at 0.4 m/s - Water had approximately 3.5 cm flow depth with width of 26 cm along the drains, at time of survey	During Dry Weather	During Wet Weather
				
D6	Naturalised stream connecting concrete roadside drain with artificial banks at its upstream Length of drain is estimated to be 286 m.	- Originates from stormwater runoff from forested area north of Site B. - This concrete drain is located at the upstream of an old concrete drain system (i.e. naturalised stream), where downstream of the watercourse within the forested area in the racetrack oval remains inundated and forms shallow streams within the eastern part of Site B. - Ephemeral flow in the concrete drain and perennial flow in the naturalised stream (detailed hydrological condition was surveyed for the concrete drain as it is the water source) During dry weather condition: - Almost no flow	Water Quality Station WQB1	
			During Dry Weather	During Wet Weather
				

Watercourses	Bed and Bank Characteristics	Water Flow and Quality Conditions	Photos	
		During wet weather condition: - Water flow observed at approximately 0.33 m/s - Approximately 8 cm water depth and width of 40 – 45 cm at time of survey		
D7	Naturalised stream with artificial banks, and surrounded by dense vegetation. Upstream (WQB2) had concrete banks and bed, surrounded by dense vegetation. Midstream WQB3 had vegetated soil-sand banks, and a soft soil-clay bed covered in orange filaments.	- Collects water from surrounding forest in Site B and also urban areas along Turf Club Road - Waterlogged/swampy ground upstream and a discharge outlet discharging flow from forested areas east of Site B. Flows southwards to merge with naturalised stream D12 - Perennial flow During dry weather condition: <u>Upstream (WQB2)</u> - Water was almost stagnant - Pond measured around 4 m wide and was 1.6 m wide downstream where water flowed out. Depth measured at 0.82 m	Water Quality Station WQB2 (Upstream)	
			During Dry Weather	During Wet Weather
				
			Water Quality Station WQB3 (Midstream 1)	
			During Dry Weather	During Wet Weather

Watercourses	Bed and Bank Characteristics	Water Flow and Quality Conditions	Photos	
	Midstream WQB4 has root soil banks on the left and concrete banks on the right. The bed is concrete covered in sand.	- Strands of orange biofilm observed along the banks - Fishes were observed		
	Midstream (before culvert) WQB5 had vegetated clay on top of concrete bank. Bed was also concrete.	<u>Midstream (WQB3)</u> - Water flow was very low, < 0.02 m/s - Width was measured to be 1.83 – 1.96 m while depth was measured to be 26 – 37 cm - Strands of orange biofilm observed along the banks and orange specks observed in water. Some surface film also observed on the water surface - Fishes were observed		
	Midstream (after culvert) WQB6 had vegetated soil bed and banks.	<u>Midstream (WQB4)</u> - Water flow was approximately 0.02 – 0.07 m/s - Width was measured to be 1.25 – 1.3 m while depth was measured to be 42 – 55 cm - Strands of orange biofilm observed along the banks, and orange specks observed floating in water - Some fishes were observed	Water Quality Station WQB4 (Midstream 2)	
	Midstream WQE10 had banks covered in vegetated soil, while the bed was covered in leaf litter and rubbish.	<u>Midstream (WQB5)</u> - Water flow was estimated to be < 0.01 m/s - Width was measured to be 2.33 m while depth was measured to be 40 cm - Water was relatively clear	During Dry Weather 	During Wet Weather 
	Downstream WQE11 had earth banks and a sandy soil bed.	<u>Midstream (WQB6)</u>	Water Quality Station WQB5 (Prior Culvert)	
		During Dry Weather	During Wet Weather	

Watercourses	Bed and Bank Characteristics	Water Flow and Quality Conditions	Photos	
	Estimated length is 536 m.	- Water flow was estimated to be < 0.01 m/s - Width was measured to be 3.06 m while depth was measured to be 61 cm - There was lots of leaf litter surrounding - Small fishes were observed		
		<u>Midstream (WQE10)</u>		
		- Water had very low flow and was almost stagnant - Width was estimated 4 – 4.7 m while depth varied between 41 – 84 cm, with leaf litter observed covering half the stream bed - Fishes were observed	Water Quality Station WQB6 (After Culvert)	
		<u>Downstream (WQE11)</u>		
		During wet weather condition: <u>Upstream (WQB2)</u>	Water Quality Station WQE10 (Midstream 5)	
		- Water flow was between 0.17 – 0.2 m/s - Pond measured approximately 5 – 5.5 m wide and had overflowed		

Watercourses	Bed and Bank Characteristics	Water Flow and Quality Conditions	Photos
		the concrete banks. Depth measured at 1.2 – 1.3 m - Orange specks observed in water, likely to be the mixed-in orange strands <u>Midstream (WQB3)</u> - Water flow was approximately 0.07 m/s - Width was measured to be 1.75 m while depth was measured to be 62 cm - Water was slightly cloudy but not turbid - Strands of orange biofilm observed along the banks and roots in water <u>Midstream (WQB4)</u> - Water flow was approximately 0.06 m/s - Width was measured to be 1.36 m while depth was measured to be 69 cm - Water was slightly cloudy - Strands of orange biofilm observed along the banks with orange specks floating in water <u>Midstream (WQB5)</u> - Water flow was between 0.17 – 0.2 m/s - Width was measured to be 3 – 3.5 m while depth was measured to be 91 cm - Water was turbid and silty and had lots of floating plant debris <u>Midstream (WQB6)</u>	 Water Quality Station WQE11 (Downstream) During Dry Weather  During Wet Weather 

Watercourses	Bed and Bank Characteristics	Water Flow and Quality Conditions	Photos	
		- Water flow was slow to almost stagnant - Width was measured to range between 2 – 3.32 m while depth was measured to range between 50 – 64 cm - Water was turbid <u>Midstream (WQE10)</u> - Water flow was approximately 0.01 m/s - Width was estimated to be 3.8 m while depth was measured to be 85 cm - Water was turbid <u>Downstream (WQE11)</u> - Water flow was approximately 0.09 m/s - Width was measured to be 2.74 m while depth was measured to be 93 cm - Water was observed to be slightly turbid		
D8	Northern pond in golf course. Tall grass growing on half of the pond banks, with taller vegetation such as trees on the other half. Bed is soft and clay-like. Water surface is covered in water lilies in the	- Originated from runoff from the golf course - Pond water observed to flow out into a discharge pipe at southern end of the pond During dry weather condition: - Relatively stagnant water throughout pond, but gently flowing into pipe at southern edge of pond - Depth measured between 0.7 – 1 m	Water Quality Station WQE1	
			During Dry Weather	During Wet Weather

Watercourses	Bed and Bank Characteristics	Water Flow and Quality Conditions	Photos
	southern half of the pond.	During wet weather condition: - Water was stagnant throughout pond, with a flow of approximately 0.14 m/s at discharge pipe - Depth measured to be 0.84 – 1.25 m at the sides but is possibly deeper in the centre - Water was observed to be turbid and otters were spotted within the ponds	
D9	Southern pond in golf course, surrounded by vegetation. Tall grass growing on half of the pond banks, with taller vegetation such as trees on the other half. Bed is soft with leaf-litter. Water surface had a few water lilies.	- Originated from runoff from the golf course - Potentially receives inflow from northern pond in golf course (D8) - Stagnant water in the pond - Water potentially flows out and into earth drain D11 via underground pipe(s)	Water Quality Station WQE2
			During Dry Weather  During Wet Weather 
		During dry weather condition: - Water was almost stagnant - Depth measured at 1.34 m at the sides but is possibly deeper in the centre - Water was slightly yellow and humic	
		During wet weather condition: - No flow was observed - Depth measured to be 1.09 m at the sides but is possibly deeper in the centre	

Watercourses	Bed and Bank Characteristics	Water Flow and Quality Conditions	Photos
		Water was observed to be slightly turbid, and has a slight greenish hue in one sampling occasion	
D10	Roadside concrete drain	- Roadside drain - Receives runoff from Turf Club Road During dry weather condition: - Drain is dry During wet weather condition: - Water flow was approximately 0.15 m/s - Water width and depth measured at 24.5 cm and 5.5 cm respectively	Water Quality Station WQE3
			During Wet Weather 
D11	Manmade earth drain. Upstream (WQD1) had vegetated banks and clay-like bed. Downstream (WQD2) had clay bed and vegetated clay banks.	- Originates from the surrounding vegetation and urban areas in Site D, flowing from north to south - Three tributaries emerging from underground, potentially from discharge from watercourses in Site C (D14 and D15) and ponds from the golf course (D8 and D9) via underground drainage. However, unable to confirm as underground data is unavailable. - Perennial flow During dry weather condition: <u>Upstream (WQD1)</u>	Water Quality Station WQD1 (Upstream)
			During Dry Weather  During Wet Weather 

Watercourses	Bed and Bank Characteristics	Water Flow and Quality Conditions	Photos
		- Water flow varied between 0.01 – 0.63 m/s, with higher flow rates occurring in shallower and narrower waters - Width was measured to range between 2 – 3.25 m while depth was measured to range between 40 – 50 cm - Water was slightly yellowish, but no odour was observed <u>Downstream (WQD2)</u> - Water flow varied between 0.1 – 0.25 m/s, with higher flow rates occurring in shallower and narrower waters - Width was measured to range between 1.67 – 2.1 m while depth was measured to range between 5 – 25 cm - Water was slightly yellowish, but no odour was observed During wet weather condition: <u>Upstream (WQD1)</u> - Water flow was approximately 0.29 m/s - Width was measured to be 2.75 m while depth was measured to be 51 cm - Water was yellowish <u>Downstream (WQD2)</u> - Water flow was approximately 0.4 m/s	Water Quality Station WQD2 (Downstream) During Dry Weather  During Wet Weather 

Watercourses	Bed and Bank Characteristics	Water Flow and Quality Conditions	Photos	
		- Width was measured to be 2.5 m while depth was measured to be 73 cm - Water was yellowish and small amount of leaf litter observed on surface		
D12-A	Natural/Naturalised (western) tributary of D12 Upstream (WQE6) had soil root banks and a sandy bed. Downstream (WQE7) was similar with soil banks slightly covered in roots and a sandy bed. Estimated length is 155 m.	- Originated from D11 (continued underground) - Perennial flow During dry weather condition: <u>Upstream (WQE6)</u> - Water flow was approximately 0.02 m/s - Width was measured to range between 5.18 – 6.03 m while depth was measured to range between 115 – 142 cm - Water was slightly yellowish and turbid with an organic smell - Small fishes were observed <u>Downstream (WQE7)</u> - Water flow varied between 0.03 – 0.06 m/s - Width was measured to range between 3.07 – 3.33 m while depth was measured to range between 53 – 70 cm - Water was slightly yellowish with some leaf litter floating on the surface During wet weather condition: <u>Upstream (WQE6)</u>	Water Quality Station WQE6	
			During Dry Weather	During Wet Weather
				
			Water Quality Station WQE7	
			During Dry Weather	During Wet Weather

Watercourses	Bed and Bank Characteristics	Water Flow and Quality Conditions	Photos	
		- Water flow was observed to be very low - Width was estimated to be 5 m while depth was measured to be at least 110 cm - Water was observed to be turbid <u>Downstream (WQE7)</u> - Water flow was approximately 0.07 m/s - Width was measured to be 3.57 m while depth was measured to be 106 cm - Water was observed to be turbid		
D12-B	Natural/Naturalised (eastern) tributary of D12. Upstream (WQE8) had vegetated earth banks and a clay-like bed. Downstream (WQE9) was similar with soil banks, but had a sandy bed Estimated length is 150 m.	- Originated from D11 (continued underground) - Perennial flow - Merges with D7 midstream During dry weather condition: <u>Upstream (WQE8)</u> - Water was stagnant - Water was stagnant - Width was estimated to be 4 m while depth was between 30 – 40 cm on average - Water had an orange film on surface. Rubbish and leaf litter also floating on surface. Water had an odour that smelled similar to flatulence <u>Downstream (WQE9)</u> - Water flow was very low, almost stagnant	Water Quality Station WQE8 (Upstream)	
			During Dry Weather	During Wet Weather
				
			Water Quality Station WQE9 (Downstream)	
			During Dry Weather	During Wet Weather

Watercourses	Bed and Bank Characteristics	Water Flow and Quality Conditions	Photos	
		- Width was measured to be 5.38 m while depth was measured to range between 1.45 – 1.7 m - Water was slightly turbid During wet weather condition: <u>Upstream (WQE8)</u> - Water flow was estimated to be < 0.01 m/s - Width was measured to be 3.93 m while depth was measured to range between 34 – 41 cm at various points - Water was relatively clear with lots of organic debris and trash on the surface of the bed <u>Downstream (WQE9)</u> - Water flow was approximately 0.28 m/s - Width was estimated to range between 6 – 7 m while depth was measured to range between 140 – 170 cm - Water was observed to be orange and turbid		
D12	Naturalised stream that receives inflow	Receives flow from tributaries D12-A, D12-B	Water Quality Station WQE12 (Upstream)	
			During Dry Weather	During Wet Weather

Watercourses	Bed and Bank Characteristics	Water Flow and Quality Conditions	Photos
	from D12-A and D12-B. Upstream (WQE12) has concrete banks, with the left bank covered in soil. The bed is concrete with sand on top. Downstream (WQE13) is a concrete drain. Estimated length is 143 m.	- Also collects runoff from the surrounding forested areas and urban areas - Perennial flow During dry weather condition: <u>Upstream (WQE12)</u> - Water flow varied between 0.17 – 0.22 m/s - Width was measured to range between 1.06 – 1.3 m while depth was measured to range between 15 – 22 cm - Water was relatively clear <u>Downstream (WQE13)</u> - Water flow varied between 0.39 – 0.4 m/s - Width was measured to range between 0.68 – 0.85 m while depth was measured to range between 7 – 18 cm - Water was relatively clear with small bits of plant debris inside During wet weather condition: <u>Upstream (WQE12)</u> - Water flow was approximately 0.36 m/s - Width was measured to 2.08 m while depth was measured to be 51 cm - Water was turbid <u>Downstream (WQE13)</u> - Water flow was approximately 0.84 m/s	 Water Quality Station WQE13 (Downstream) During Dry Weather  During Wet Weather 

Watercourses	Bed and Bank Characteristics	Water Flow and Quality Conditions	Photos	
		- Width was measured to 4 m while depth was measured to be 44 cm at the deepest point - Water was turbid with some leaves and twigs in the water		
D13	Concrete drain, with upstream being surrounded by dense vegetation. Some dead leaves strewn in the drain.	- Receives runoff from the surrounding vegetation, and urbanised areas including the Grandstand carpark and also residential areas in the west. - Perennial flow During dry weather condition: - Water flow measured approximately 0.33 m/s - Water flow width measured at 40 cm while depth measured at 6 cm - Observed water was clear with a slight yellow tinge During wet weather condition: - Water flow measured approximately 0.5 m/s - Water width measured at 2.3 m and depth at 0.35 m in the centre	Water Quality Station WQE4	
			During Dry Weather 	During Wet Weather 
D14	Upstream is an earth drain with earth banks, surrounded by dense vegetation. From midstream, it becomes a concrete drain with artificial banks. Its	Originates from urban area outside of Site C and from surrounding forested areas within Site C. Concrete drain D14 receives flow from upstream earth drain, and will eventually join with the naturalised stream D15 downstream at the confluence point, before subsequently flowing out of Site C through an underground drain.	Water Quality Station WQC1	
			During Dry Weather	During Wet Weather

Watercourses	Bed and Bank Characteristics	Water Flow and Quality Conditions	Photos
	downstream (near the confluence point with the naturalised stream D15) consists of naturalised concrete drain.	- Perennial flow During dry weather condition: - Extremely slow flow, nearly stagnant - Approximate 10 - 20 cm water depth and width of 1 – 2 m at time of survey - Oily sheen observed on surface during one sampling event, characteristic of iron-utilising bacteria During wet weather condition: - Water flow was approximately 0.2 m/s - Width measured to be 1.22 m and the depth measured to be 29 cm - Water was orangey and turbid	 
D15	Naturalised stream consisting of alternating stretches of natural bed substrate with earth banks, naturalised concrete drain and concrete drains Estimated overall stream length is 327 m.	- Originates from surrounding forested area of Bukit Tinggi - Flows southwards and eventually joins with concrete drain D14 at the confluence point and subsequently flows out of Site C into an underground drain - Perennial flow During dry weather condition: <u>Upstream</u> - Slow water flow observed of approximately 0.25 – 0.33 m/s - Approximate 8 - 15 cm water depth and width of 68 cm at time of survey	Water Quality Station WQC2 (Upstream) During Dry Weather  During Wet Weather 

Watercourses	Bed and Bank Characteristics	Water Flow and Quality Conditions	Photos
		- Water was clear and no odour was detected <u>Midstream</u> - Water flow varied between dry samplings, from < 0.01 m/s to 0.25 m/s. Lower flow rates were observed when the width was wider (1 – 2 m) - Water depth was up to 10 cm and width of 0.8 – 2 m at time of survey - Water was clear and no odour was detected <u>Downstream</u> - Water flow observed of approximately 0.17 – 0.25 m/s - Approximate 8 – 21 cm water depth at time of survey and width of 0.74 – 1 m at time of survey - Water was clear and no odour was detected During wet weather condition: <u>Upstream</u> - Water flow was approximately 0.44 m/s - Width measured to be 1.34m and the depth measured to be 15 cm - Water was observed to be cloudy and slightly orange, with sandbags around <u>Midstream</u> - Water flow was approximately 0.2 m/s	Water Quality Station WQC3 (Midstream) During Dry Weather  During Wet Weather 
			Water Quality Station WQC4 (Downstream) During Dry Weather  During Wet Weather 

Watercourses	Bed and Bank Characteristics	Water Flow and Quality Conditions	Photos	
		- Width measured to be 2.04m and the depth measured to range between 10 – 12 cm - Water was observed to be slightly turbid with lots of fallen trees around and clay lumps present under the sand <u>Downstream</u> - Water flow was approximately 0.25 – 0.33 m/s - Width measured to range between 1.5 – 2 m and the depth measured to be 88 cm - Water was observed to be turbid and orange		
D16	Concrete drain with vegetation growing on banks and a thick layer of fine sediment and dead leaves on the bottom of the drain.	- Collects runoff from the neighbouring Merlion Sports City Field and forest - Perennial flow During dry weather condition: - Water was stagnant - Water in drain was 1.41 m wide and 20 – 29 cm deep (up till the leaf litter at bed) - Water was clear and with a slight organic smell During wet weather condition: - Water flow was approximately 0.033 m/s - Water measured at 1.5 m wide and 40 cm deep (up till the leaf litter at bed)	Water Quality Station WQE5	
			During Dry Weather 	During Wet Weather 

Watercourses	Bed and Bank Characteristics	Water Flow and Quality Conditions	Photos	
		Water was relatively clear with no odour		

8.4.2.1.2 Stream Mapping

One natural stream in Site A (D1), one naturalised stream in Site C (D15), and one naturalised stream D12 (and tributary D7) in Site E and Site B were identified within the Study Area for stream mapping. These watercourses were mainly selected due to their potential ecological significance and their relatively natural/naturalised stream conditions.

This section provides the summary of the stream mapping findings. Photographs and detailed description of stream conditions at each mapped interval are provided in Appendix O.

Site A

The natural stream in Site A (D1) is an approximately 673 m long watercourse that is continuously fed by a tributary located near the southwest of Site A. This watercourse was studied at a total of thirty-three (33) cross-sections at intervals of about 20 – 70 m along the stream (see Figure 8-5) based on the key changes along the stream. The natural stream in Site A has natural earth banks throughout the entire length of the stream. The upstream of the natural stream (D1) is a pond area, which receives runoff from the surrounding forested areas, concrete and earth drains during storm events (refer to Table 8-4 for details) and discharges southwards to the downstream of the natural stream (D1). The stream width varies along this watercourse, with up to 10 m width at the upstream (AW1 – AW8), slightly narrower in the midsection at 1 – 3 m (AW9 – AW15), and slightly wider again at the downstream to approximately 3 – 5 m near the downstream discharge outlet. For the banks and bed substrate characteristics of the natural stream D1, the upstream generally has earth banks with gentle slopes and the stream bed was filled with a thick layer of dead leaves. The central midsection is also characterised by steep earth banks with numerous medium to large rocks along the stream bed. The downstream section is slightly wider than the midstream, and has mostly gently sloping/ flat earth banks and a sandy bed with many smaller rocks. The natural stream (D1) eventually discharges via an outlet in the south and flows through an underground culvert across Eng Neo Avenue, to the wide concrete drain located outside of Site A. Besides, the natural stream (D1) splits into two distributaries near the lower midstream section (at AW15), where one distributary subsequently joins with western tributary at confluence point AW16 and the other distributary continues flowing downstream (AW17, AW18). The flow from both distributaries eventually merges together again (at the confluence point AW19). The western tributary of the natural stream (AW24 – AW33) was mostly stagnant at its upstream (AW24 – AW29) but had slow flow from midsection onwards (AW30 – AW33).

Site B

The naturalised stream in Site B (D7) located west of the site flows south towards the western boundary of Site B. The total length of portion of the naturalised stream in Site B is approximately 350 m long and receives waters from the surrounding forests, urban areas along Turf Club Road and the naturalised stream in Site F (D6). This watercourse was studied at a total of eighteen (18) cross-sections at intervals of about 15 to 40 m along the stream (refer to Figure 8-8) based on the key changes along the stream. The stream is much wider in the upstream portion than downstream. At upstream (BW1 – BW3), stream width ranges between 2.1 m to 3.8 m. Further downstream (BW4 – BW5), the stream then widens significantly into a flooded marshland more than 5 m wide. The narrowest point of the stream follows (BW6), with stream width of 0.5 m. Midstream (BW7 – BW12), stream width ranges from 0.9 m to 1.8 m. Downstream (BW13 – BW18), the stream width is generally wider than midstream, ranging from 1.5 m to 3.5 m. The stream velocity is low throughout the naturalised stream, with many portions of the stream being stagnant at upstream (BW2), midstream (BW9) and downstream (BW14 – BW16). Water velocity in the stream generally ranged from 0.02 m/s to 0.09 m/s, with a single exception of 0.16 m/s recorded near upstream (BW4). The naturalised stream in Site B (D7) has varying bank and bed conditions. It is a concrete pond at the most upstream point that flows into a natural portion. The watercourse then continues into a concretised section that shows signs of degradation at mid-point. The watercourse is characteristic of a natural stream at downstream where it then flows into Site E. The most upstream point of the naturalised stream (BW1) is a concrete pond with concrete banks and bed. Following this point (BW2 – BW3), the stream banks and stream bed were observed to be clayey. Further downstream (BW 4 – BW6), the stream widens into a flooded grassland, and the clayey stream banks and stream bed are overgrown with vegetation and roots. The next portion of the stream (BW7) was observed to have root banks and sandy stream bed, with large rocks strewn within the watercourse. At mid-to-downstream (BW8 – BW16), the stream had concrete banks and a concrete bed, apart from a degraded portion at mid-point (BW11) with soil banks and sandy stream bed. At downstream (BW17 – BW18), the watercourse had characteristics of a natural stream, clayey banks were observed to be covered by large amounts of leaf litter and the stream bed was noted to be sandy with presence of gravel. At downstream, the naturalised stream (D7) continues beyond the border of Site B, flowing into Site E and eventually merges with the naturalised stream in Site E (D12).

Site C

The naturalised stream in Site C (D15) is an approximately 327 m long watercourse with alternating stretches of natural bed substrate with earth banks, naturalised concrete drain and concrete drains. Its hydrological conditions were studied at a total of fifteen (15) cross-sections at intervals of about 20-40 m along the stream based on the key changes along the stream (Figure 8-6). The upstream of this naturalised stream (CW1 – CW4) consists of naturalised concrete drains with gently sloping/ flat banks with shallow and small flow. The upper midstream (CW5 – CW6) had natural sandy bed substrate and the earth banks started to increase in gradient. The central midstream (CW7 – CW8) has steep earth banks with narrower width and deeper water depth. The lower midstream (CW9 – CW10) has moderately steep earth banks with slightly widened and deeper stream. The water from this natural section of the stream then flows into a concrete drain just downstream of CW10. The subsequent downstream (CW11 – CW14) consists of concrete drains and naturalised concrete drains (i.e. broken drains). The final confluence point (CW15) is where the flow from D15 and the perennial concrete drain (D15) merges at the boundary of Site C, and subsequently discharges out of the site.

Site E

The naturalised stream in Site E (D12) flows from two tributaries (D12-A and D12-B) located south-east of the site and is also fed by a naturalised stream flowing from Site B (D7), east of the site, that joins one of the tributaries (D12-B) midstream. The total length of the naturalised stream (comprising D12 and downstream of D7 which lies in Site E) is approximately 630 m long watercourse. This watercourse was studied at a total of thirty-four (34) cross-sections at intervals of about 15 to 30 m along the stream (refer to Figure 8-7), based on the key changes along the stream. The western tributary (D12-B), eastern tributary (D12-A) and a portion of the naturalised stream flowing from site B (D7) that merges with the eastern tributary were all studied at nine (9) cross-sections each. The main stream (D12) was studied at eight (8) cross-sections.

The section of naturalised stream D7 flowing in Site E from Site B is approximately 178 m. This stream flows south-west towards a tributary of another stream (D12), receiving waters from the surrounding forests. The stream width varies along this watercourse, it is narrowest upstream (EW26 – EW28) at 1.2 m to 1.8 m, gradually widening to widest point midstream (EW31) at 5 m and narrows slightly downstream to approximately 3 m. The flow is generally low throughout the stream, with sections that are almost stagnant upstream (EW32 – EW34). The earth banks are gently sloped and well vegetated, the stream bed is sandy and abundantly covered with leaf litter. This portion of the naturalised stream (D7) discharges into midstream of a tributary (D12-B).

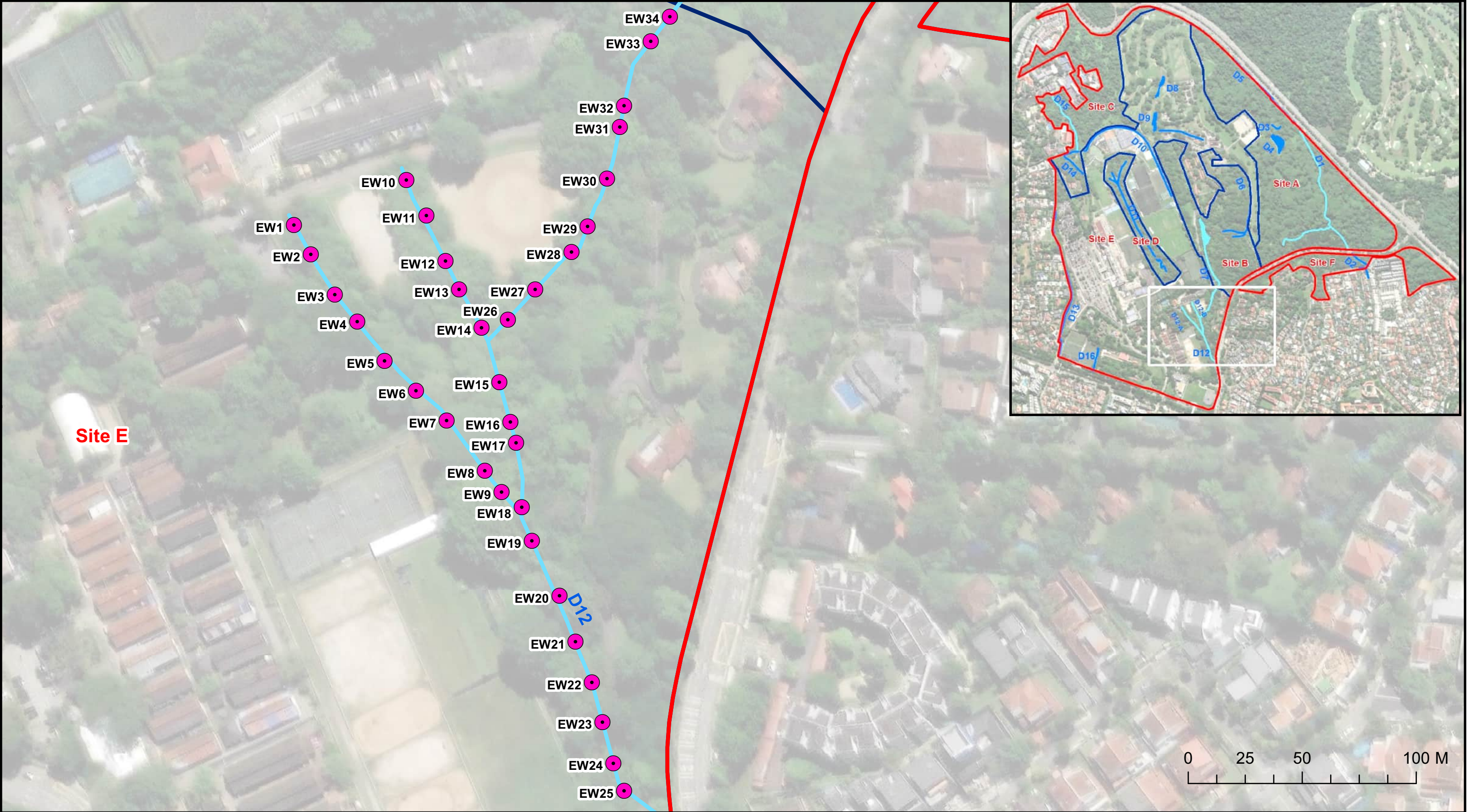
The pair of naturalised tributaries of the main stream (D12-A and D12-B) in Site E flow parallel to each other, southwards from Turf Club Road, till they merge into the main stream (D12) in a Y-shape. The eastern tributary (D12-B) is around 150 m long while the western tributary (D12-A) is approximately 155 m in length. Both tributaries collect water from the surrounding forested area, and possibly roadside discharge from Turf Club Road.

The naturalised eastern tributary (D12-B) receives water midstream from the naturalised stream in site B (D7) as well. The starting point of the eastern tributary is approximately 3 m in width, then narrows considerably to around 0.7 m to 1.1 m upstream (EW11 – EW13) and widens midstream to downstream (EW15 – EW17) to approximately 4.6 m wide. The tributary is stagnant or has very low flow upstream to midstream (EW10 – EW14) and has low velocity approximating 0.02 m/s downstream (EW15 – EW17). The highest velocity recorded is 0.22 m/s, at the point where the stream measured narrowest (EW11). The eastern tributary is a naturalised stream, with concrete banks at certain points. Upstream (EW10 – EW13), the streambed is observed to be sandy, containing gravel, while the bank characteristics of the stream vary greatly. At the starting point (EW10), the earth banks are vegetated, but further down (EW11), concrete banks are observed on the left while the right bank remains vegetated. Moving downstream (EW12), the stream bank is observed to be a mix of earth, sand and clay before concrete banks are once again observed on the left bank while the right bank retains sandy and clayey characteristics (EW13). At midstream (EW14), the stream banks compose of vegetated earth, and the stream bed is clayey, with a layer of leaf litter cover. Downstream (EW15 – EW17), where the stream is at its widest, vegetated, sandy root banks are observed, and the stream bed is sandy, with trees growing within the watercourse.

The western tributary (D12-A) has varying stream width throughout. It measures the widest at the most upstream point (EW1) at 5.5 m, followed by the narrowest portion of the stream (EW2 – EW3), ranging from 0.8 m to 1.8 m. Midstream (EW4 – EW8), the tributary widens gradually from 2.5 m to 4.3 m. Downstream (EW9), the tributary narrows to 2.2 m before joining the main stream (D12). The tributary is almost stagnant at its most upstream point (EW1) but has relatively fast flow once the stream narrows past the most upstream point, with velocity ranging from 0.13 m/s to 0.29 m/s at midstream (EW 2 – EW6). Following this portion of the stream (EW7), the velocity is once again almost stagnant and downstream (EW8 – EW9) the velocity slows to approximately 0.12 m/s to 0.15 m/s.

The bank and bed conditions are fairly consistent, the tributary begins as a concrete pond that is then degraded into a natural state. At the most upstream point (EW1), the banks are concrete, and the stream bed is observed to be sandy. Mid-to-downstream (EW2 – EW9), the stream banks are predominantly sand, with clayey substrate mixed in under the layer of sand. The stream bed was observed to be sandy throughout. The only exceptions to these observations are at two points midstream (EW4 and EW7) where bricks were also observed in the stream bank of the more upstream point (EW4) and root banks were also noted at the more downstream point (EW7).

The western tributary (D12-A) and eastern tributary (D12-B) merge into the main stream (D12) where it flows southwards to the boundary of the Study Area, collecting water from the surrounding forest. The main stream is a naturalised stream approximately 143 m in length. It is the widest at its most upstream point and generally narrows as it flows downstream. At the most upstream point (EW18), the stream width is 4.6 m, which decreases slightly to 4.2 m a little further downstream (EW19). At mid-to-downstream (EW20 – EW24), the stream width diminishes gradually from 2.9 m to 0.65 m, which is the smallest width recorded along the stream. At the most downstream point (EW25), the stream width doubles to 1.5 m. The water velocity increases downstream. Upstream (EW18 – EW20), the velocity ranged from 0.02 m/s to 0.06 m/s, with the lowest velocity recorded at the most upstream point (EW18). At midstream (EW21 – EW23), velocity ranged from 0.25 m/s to 0.33 m/s and at downstream (EW24 – EW25) the velocity increased from 0.40 m/s to 0.67 m/s, the highest velocity recorded at the most downstream point (EW25). The stream was observed to be natural upstream but concretised downstream. At the start of the stream (EW18), at the point of merger with the western and eastern tributary, root banks were observed, and both the stream bank and bed were sandy and well vegetated, with trees growing in the watercourse. Consequently (EW19 – EW20), the stream bank and bed continued to be sandy. At midstream (EW21), concrete banks were observed on the right and sandy root banks were observed on the left. The streambed remained sandy. Further downstream, the natural stream became concretised. Sloping concrete banks and concrete beds that were covered by a layer of sand were observed from mid-to-downstream (EW22 – EW25). The main stream (D12) then discharges into roadside drains along Eng Neo Avenue.



Legend

Study Area

Site Demarcation

Stream mapping points

Watercourses

WQ survey and stream mapping

WQ survey only

Waterbodies

WQ survey only

WQ survey and stream mapping

-	MAY 2024	TYL	Turf Club EIA	LAL	JAG	
Rev.	Date	By	Description	Chk'd	App'd	

Qualified Person Endorsement :
NA

URA Endorsement : NA

Consultant :

AECOM

Project Title :

CONTRACT URA/T/22/031
ENVIRONMENTAL IMPACT
ASSESSMENT (EIA) FOR
FORMER TURF CLUB AT BUKIT TIMAH

Designed
HBS

Checked
LAL

Approved
JAG

Drawn
TYL

Date
MAY 2024

Client:

URA

URBAN
REDEVELOPMENT
AUTHORITY

Figure Title :

Stream mapping points along
naturalised stream D12 (and its tributary D7)
in Site E

Figure No. :

8 - 7

Rev.

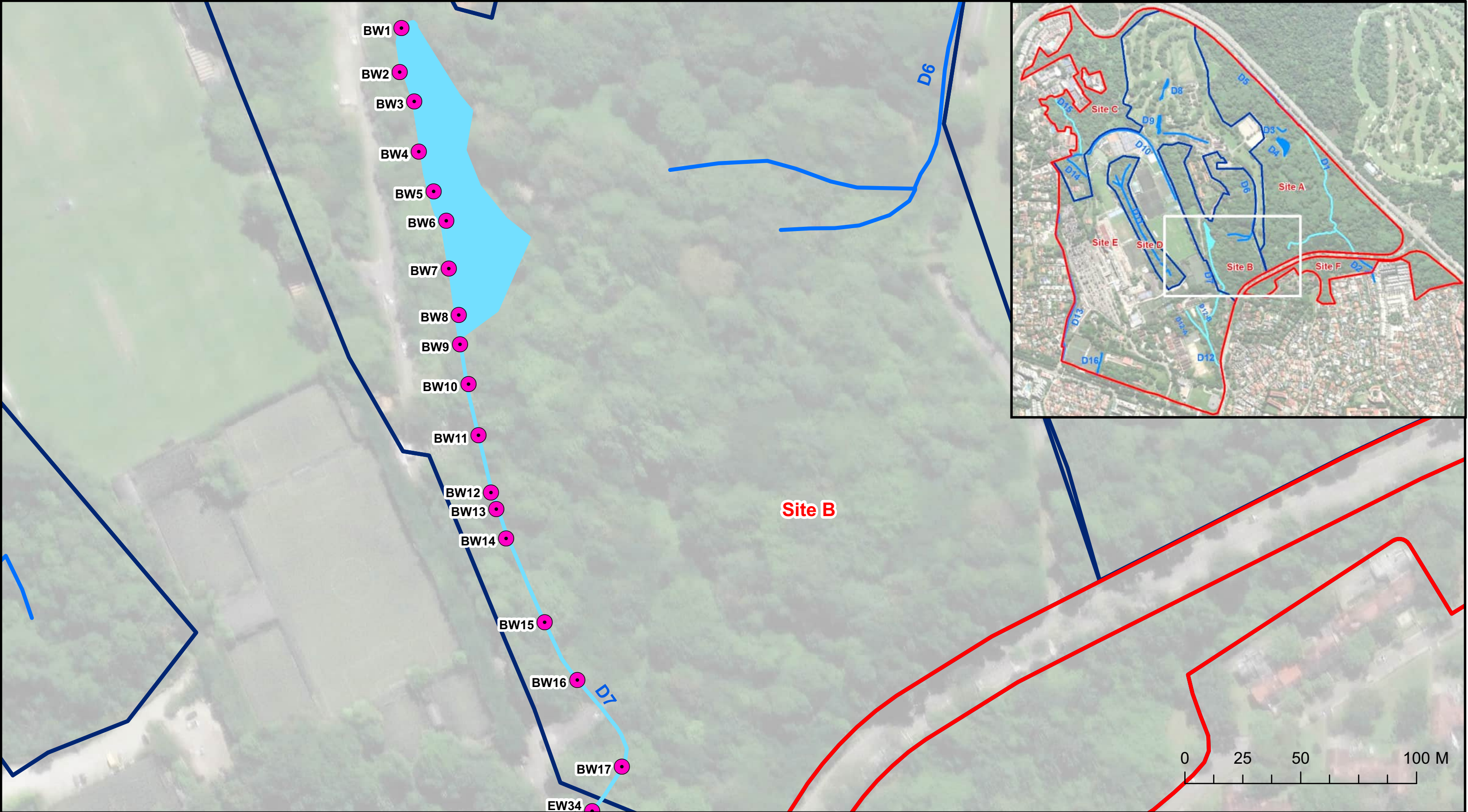
-

Sheet

1 of 1

CAD File Name : NA

A3



Legend

Study Area

Site Demarcation

Stream mapping points

Watercourses

WQ survey and stream mapping

WQ survey only

Waterbodies

WQ survey only

WQ survey and stream mapping

-	MAY 2024	TYL	Turf Club EIA	LAL	JAG	
Rev.	Date	By	Description	Chk'd	App'd	

Qualified Person Endorsement :
NA

URA Endorsement : NA

Consultant :
AECOM

Project Title :
**CONTRACT URA/T/22/031
ENVIRONMENTAL IMPACT
ASSESSMENT (EIA) FOR
FORMER TURF CLUB AT BUKIT TIMAH**

Designed
HBS

Checked
LAL

Approved
JAG

Date
MAY 2024

Client:
UR URBAN
REDEVELOPMENT
AUTHORITY

Figure Title :
**Stream mapping points along
naturalised stream D7 in Site B**

Figure No. :
8 - 8

Rev.
-

Sheet
1 of 1

CAD File Name : NA

A3

Note: Source of basemap - Google Earth Map

THIS DRAWING IS COPYRIGHT

8.4.2.2 Water Quality Conditions in the Study Area

Surface water samples were collected at thirty-five (35) water quality stations strategically located along identified surface water resources within the Study Area as detailed in Figure 8-1 and Table 8-4. Figure 8-1 shows the exact location of water quality stations within the Study Area, while Table 8-4 summarises the rationale for the selection of each of the water quality sampling stations. All surface water samples were collected during both dry and wet weather conditions, except at sampling stations WQA7, WQA8, WQA9, WQB1 and WQE3, which were only collected during wet weather due to their ephemeral nature. Table 8-6 shows the dates of each of the sampling events.

The surface water quality results were summarised and presented in Table 8-7. Photos showing dry and wet weather conditions at each of the sampling stations were presented in Table 8-4. Surface water quality results were assessed against NEA Trade Effluent Limits (Controlled Watercourse) (hereby referred to as NEA Limits) and International Water Quality Criteria for Aquatic Life (as mentioned in section 8.2.2.2) (henceforth referred to as Aquatic Criteria). The relevant limits and guidelines for water quality parameters were summarised in Table 8-1; however, where no guidelines exist, the monitored results would be considered as the baseline. It should be noted that the surface water quality of any runoff generated from the Project's activities during both construction and operational phases should comply with the NEA Limits into a controlled watercourse.

Table 8-5 Rationale for the selection of water quality sampling locations with photos

Site	Station S/N	Monitoring Location	Justification	Photo of Monitoring Location
A	WQA1	Upstream pond area of natural stream D1 near the centre of the Site A.	To capture the water quality of the receiving runoff from drain D3 and D5 as well as the surrounding forested area in the southern half of Site A.	
	WQA2	Midstream of natural stream D1 in the forested area of Site A.	To capture the water quality of the stream D1 flowing south, through Site A and to support biodiversity findings.	
	WQA3	Midstream of natural stream D1 in the forested area of Site A.	To capture the water quality of the stream D1 flowing south, through Site A and to support biodiversity findings.	
	WQA4	Midstream of natural stream D1 in the forested area of Site A.	To capture the water quality of the stream D1 flowing south, through Site A. and to support biodiversity findings.	

Site	Station S/N	Monitoring Location	Justification	Photo of Monitoring Location
	WQA5	Tributary that feeds into natural stream D1 in the forested area of Site A.	To capture the water quality of the tributary feeding into the stream D1 near south end of Site A and to support biodiversity findings.	
	WQA6	Discharge outlet (weir) of natural stream D1 in the forested area of Site A.	To capture the water quality of the stream D1 discharging out of Site A and to support biodiversity findings.	
	WQA7	Earth drain D3 located in forested area of Site A.	To capture the water quality of runoff from forested areas in the north of Site A.	
	WQA8	Unmanaged pond D4 located within forested area of Site A.	To capture the water quality of unmanaged pond in Site A, which will also be used to support the biodiversity findings.	

Site	Station S/N	Monitoring Location	Justification	Photo of Monitoring Location
	WQA9	Roadside concrete drain D5 located along the edge of the forested area of Site A.	To capture the water quality of runoff from north-eastern forested area of Site A and nearby urban areas (i.e. PIE).	
B	WQB1	Roadside concrete drain at the upstream of naturalised stream D6 located near the edge of the forested area of Site B.	To capture the water quality of runoff from northern forested areas of Site B and nearby urban areas (i.e. road) before it discharges into the forested area of Site B.	
	WQB2	Naturalised stream D7 in the forested area of Site B.	To capture the upstream water quality of naturalised stream D7 flowing south through Site B.	
	WQB3	Naturalised stream D7 in the forested area of Site B.	To capture the water quality of naturalised stream D7 flowing south through Site B.	

Site	Station S/N	Monitoring Location	Justification	Photo of Monitoring Location
	WQB4	Naturalised stream D7 in the forested area of Site B.	To capture the water quality of naturalised stream D7 flowing south through Site B.	
	WQB5	Naturalised stream D7 in the forested area of Site B.	To capture the water quality of naturalised stream D7 flowing south through Site B.	
	WQB6	Naturalised stream D7 in the forested area of Site B.	To capture the water quality of naturalised stream D7 flowing south through Site B.	
C	WQC1	Downstream of earth drain D14 in forested area of Site C.	To capture the water quality of earth drain D14 flowing north of Site C and to support biodiversity findings.	

Site	Station S/N	Monitoring Location	Justification	Photo of Monitoring Location
	WQC2	Upstream of naturalised stream D15 in the forested area of Site C.	To capture the water quality of naturalised stream D15 flowing south of Site C.	
	WQC3	Midstream of naturalised stream D15 in the forested area of Site C.	To capture the water quality of naturalised stream D15 flowing south of Site C.	
	WQC4	Downstream of naturalised stream D15 in the forested area of Site C.	To capture the water quality of naturalised stream D15 flowing south of Site C.	
D	WQD1	Upstream of earth drain D11 in Site D.	To capture the upstream water quality of earth drain D11 flowing south of Site D.	

Site	Station S/N	Monitoring Location	Justification	Photo of Monitoring Location
	WQD2	Downstream of earth drain D11 in Site D.	To capture the downstream water quality of earth drain D11 flowing south of Site D.	
E	WQE1	Northern pond D8 in Champions Public Golf Course.	To capture the water quality of runoff from the golf course.	
	WQE2	Southern pond D9 in Champions Public Golf Course.	To capture the water quality of runoff from the golf course.	
	WQE3	Concrete drain D10 along Turf Club Road.	To capture the water quality of runoff from Site E.	

Site	Station S/N	Monitoring Location	Justification	Photo of Monitoring Location
	WQE4	Concrete drain D13 at Swiss Club Road near Dunearn Road.	To capture the water quality of concrete drain D13 before discharging out of the Study Area.	
	WQE5	Concrete drain D16 in forest adjacent to Merlion Sports City Field.	To capture the water quality of from the forest and field and support biodiversity findings.	
	WQE6	Natural stream tributary of D12 (D12-A) next to Rosebrook Developmental Centre.	To capture the water quality upstream of the tributary D12-A emerging from underground.	
	WQE7	Midstream of natural tributary of D12 D12-A).	To capture the water quality midstream of the tributary D12-A.	

Site	Station S/N	Monitoring Location	Justification	Photo of Monitoring Location
	WQE8	Natural stream tributary of D12 opposite of La Petite Ecole (D12-B).	To capture the water quality of the tributary D12-B emerging from underground.	
	WQE9	Midstream of tributary of D12-B (D12-B).	To capture the water quality of the tributary D12-B after merging with D7.	
	WQE10	Midstream of naturalised stream D7.	To capture the water quality midstream of naturalised stream D7.	
	WQE11	Downstream of naturalised stream D7.	To capture the water quality downstream of naturalised stream D7 before merging with D12-B.	

Site	Station S/N	Monitoring Location	Justification	Photo of Monitoring Location
	WQE12	Midstream of D12.	To capture the water quality of D12 after the parallel tributaries D12-A and D12-B merge.	
	WQE13	Roadside drain D12 along Eng Neo Avenue.	To capture the water quality of D12 before discharging out of the Study Area.	
F	WQF1	Concrete canal D2 emerging out of Site F.	To capture the water quality of D2 before discharging out of the Study Area.	

Table 8-6 Baseline sampling schedule for water quality monitoring stations

Date	WQ																																				
	A1	A2	A3	A4	A5	A6	A7	A8	A9	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	D1	D2	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	F1		
	Dry																																				
25-07-2023	√	√	√	√	√	√	–	–	–	–						√	√	√		√	√			–													
10-08-2023							–	–	–	–						√	√	√		√	√			–													
21-09-2023							–	–	–	–					√								–														
05-10-2023							–	–	–	–						√	√	√	√	√	√			–													
06-10-2023	√	√	√	√	√	√	–	–	–	–														–													
20-10-2023							–	–	–	–	√			√	√									–													
26-10-2023							–	–	–	–												√	√	–	√	√										√	
16-11-2023							–	–	–	–	√	√	√	√									–						√	√	√	√					
23-11-2023							–	–	–	–													–				√	√	√	√			√	√			
05-12-2023							–	–	–	–		√	√										–				√	√			√	√	√	√			
23-01-2024							–	–	–	–									√					–	√	√											
	Wet																																				
20-10-2023											√			√												√	√										
17-11-2023																				√	√				√	√											
28-11-2023																				√	√			√												√	
06-12-2023	√	√					√	√	√	√																											
12-12-2023																						√	√														
19-12-2023																											√	√					√	√			
21-12-2023												√	√		√																	√			√		
26-12-2023																														√	√		√				
27-12-2023			√	√	√	√																															
28-12-2023																√	√	√	√																		
18-01-2024																						√	√													√	
Legend: √: Sampled – : Not sampled due to ephemeral nature of watercourse																																					

Table 8-7 Surface water quality results

Parameter	Site	A									B						C				D		E																F	NEA Limit s ^a	Aquatic Criteria ^b	
		D1						D3	D4	D5	D6	D7						D14	D15				D11		D8	D9	D10	D13	D16	D12-A		D12-B		D7		D12		D2				
		WQA 1	WQA 2	WQA 3	WQA 4	WQA 5	WQA 6	WQA 7	WQA 8	WQA 9	WQB 1	WQB 2	WQB 3	WQB 4	WQB 5	WQB 6	WQC 1	WQC 2	WQC 3	WQC 4	WQD 1	WQ D2	WQE 1	WQE 2	WQE 3	WQE4	WQE5	WQE 6	WQE7	WQE 8	WQE9	WQE 10	WQE 11	WQE 12	WQE 13	WQF 1	Ac ute	Chr oni c				
Temperature (°C)	Dry	28.0	27.4	27.0	27.1	26.8	27.1	-	-	-	-	27.6	27.2	26.7	26.8	26.6	26.9	27.1	27.0	26.6	27.5	27.1	28.1	27.0	-	27.8	27.0	26.9	27.0	27.8	26.6	26.3	26.4	26.7	26.7	26.8	45	-				
	Wet	27.1	26.4	26.4	26.3	25.6	26.1	27.0	27.0	26.3	26.1	27.4	27.3	26.9	25.6	26.7	26.9	26.5	26.3	26.3	27.2	26.9	27.6	27.5	28.7	27.5	27.2	27.4	27.3	27.4	26.6	26.9	26.6	26.9	27.2	27.2						
pH	Dry	6.76	7.00	6.90	7.59	7.26	7.28	-	-	-	-	6.27	6.66	6.64	6.60	6.62	6.16	5.61	5.84	6.43	6.63	6.95	6.19	6.21	-	7.27	6.66	6.85	6.87	6.36	6.79	6.66	6.83	6.99	7.07	7.39	6 – 9	6 to 9				
	Wet	7.14	7.28	7.22	7.78	7.76	7.77	7.41	6.94	6.98	6.96	6.45	7.00	6.96	7.22	6.77	6.67	6.34	6.35	6.61	7.21	7.42	6.15	6.33	7.53	7.20	6.57	7.16	7.00	6.78	7.09	6.85	7.07	7.02	6.86	7.33						
Conductivity (µS/cm)	Dry	277.1	299.2	300.5	314.1	569.7	350.8	-	-	-	-	186.8	201.4	239.5	226.4	218.3	175.5	64.9	87.6	82.3	117.3	120.9	108.0	94.2	-	215.0	183.9	172.2	175.8	357.1	230.9	228.4	228.3	192.3	193.4	363.2	-	-				
	Wet	266.4	353.0	340.9	361.5	475.6	392.3	381.2	130.0	416.9	125.6	139.6	192.2	197.8	71.9	228.5	182.9	55.4	83.5	131.1	121.0	104.2	84.1	107.4	21.9	75.1	165.0	123.3	87.3	371.4	214.8	205.7	221.3	147.4	168.1	256.8						
Turbidity (NTU)	Dry	14.6	23.7	17.6	13.3	7.7	12.5	-	-	-	-	645.3	8.2	1391.4	10.4	16.3	9.2	6.8	11.5	13.1	54.3	47.7	25.9	17.6	-	8.1	6.8	17.6	21.7	16.7	8.7	9.7	6.2	14.3	13.1	11.7	-	2-200				
	Wet	50.7	56.2	18.4	26.7	29.3	38.5	153.2	9.5	57.6	52.7	496.1	14.0	15.2	197.4	19.3	78.0	77.2	46.9	95.8	147.9	180.8	86.8	23.8	10.6	17.0	10.2	194.8	107.0	24.5	47.2	19.2	32.8	92.0	96.9	44.3						
TDS (mg/L)	Dry	170.5	186.0	188.0	196.3	358.5	219.2	-	-	-	-	115.5	127.1	150.8	141.8	137.5	109.9	40.5	55.0	51.9	72.6	75.5	64.9	83.1	-	132.7	117.9	108.0	114.2	204.2	150.9	152.5	144.5	120.7	121.5	228.3	1,000	1,000				
	Wet	166.5	223.6	216.0	229.0	306.0	250.2	238.7	81.5	264.0	80.0	87.0	120.4	126.5	46.0	143.0	114.9	35.0	53.0	83.1	75.7	65.1	52.9	66.6	13.0	58.2	103.0	77.0	58.6	231.0	151.2	129.0	139.4	84.4	102.4	160.9						
DO (mg/L)	Dry	1.08	2.27	3.12	6.49	4.03	6.17	-	-	-	-	3.34	2.96	2.63	2.00	2.90	1.97	6.66	6.38	6.63	6.47	6.84	2.04	0.82	-	8.08	1.48	5.93	5.92	0.33	3.03	3.38	3.85	5.90	6.43	7.33	-	4				
	Wet	6.17	4.33	4.17	7.38	6.94	7.31	5.69	1.41	6.92	7.52	5.24	4.61	5.36	7.86	3.79	6.42	7.37	7.24	7.47	7.39	7.59	4.25	4.68	7.00	7.74	1.73	6.84	6.89	0.21	5.45	4.80	5.77	6.21	5.77	7.20						
TN (mg/L)	Dry	0.71	0.98	1.33	1.22	1.15	1.14	-	-	-	-	0.75	0.54	0.46	0.54	0.57	0.43	0.74	1.19	0.91	0.72	0.67	0.57	0.66	-	0.84	0.51	0.95	0.90	1.32	0.71	0.59	0.51	0.81	0.79	1.09	-	8				
	Wet	0.93	0.99	0.72	0.69	0.75	0.70	0.86	1.69	3.52	0.65	0.96	0.54	0.49	1.47	0.61	0.80	0.58	0.71	0.89	1.32	1.47	0.58	0.53	0.41	0.96	1.04	1.02	0.83	1.04	0.63	0.62	0.61	0.79	0.81	1.32						
TP (mg/L)	Dry	0.12	0.14	0.16	0.15	0.19	0.22	-	-	-	-	0.05	0.06	0.05	0.05	0.05	0.04	0.05	0.05	0.04	0.11	0.06	0.06	0.05	-	0.05	0.06	0.06	0.06	0.08	0.06	0.06	0.09	0.07	0.07	0.09	-	0.1				
	Wet	0.09	0.11	0.13	0.16	0.16	0.15	0.13	0.09	0.13	0.07	0.04	0.11	0.12	0.05	0.10	0.05	0.05	0.05	0.05	0.05	0.07	0.04	0.05	0.06	0.06	0.07	0.09	0.09	0.11	0.12	0.12	0.14	0.09	0.09	0.06						
NO ₃ -N (mg/L)	Dry	0.08	0.05	0.05	0.69	0.65	0.57	-	-	-	-	0.23	0.27	0.23	0.16	0.25	0.11	0.71	0.89	0.77	0.36	0.41	0.12	0.19	-	0.61	0.24	0.52	0.50	0.01	0.36	0.25	0.26	0.47	0.48	0.60	4,516 (equivalent to 20 NO3)	7 (NO3-N)				
	Wet	0.45	0.38	0.28	0.37	0.37	0.41	0.24	0.01	2.71	0.10	0.45	0.31	0.28	0.87	0.34	0.44	0.34	0.60	0.60	0.48	0.50	0.32	0.21	0.15	0.61	0.63	0.49	0.46	0.22	0.40	0.30	0.42	0.46	0.41	0.75						
TAN (mg/L)	Dry	0.39	0.68	1.05	<0.49	0.17	0.16	0.00	0.00	0.00	-	0.46	0.09	0.16	0.20	0.18	0.25	ND	<0.44	0.10	0.28	0.22	0.18	0.16	-	0.08	0.07	0.38	0.34	1.18	0.26	0.13	0.09	0.26	0.25	0.15	-	<1				
	Wet	0.14	0.26	0.33	0.23	0.20	0.17	0.10	0.04	0.21	0.14	0.26	0.17	0.10	0.09	0.14	0.07	0.01	0.02	0.06	0.32	0.22	0.15	<0.09	0.05	0.02	ND	0.33	0.13	0.73	0.07	0.14	0.09	0.15	0.30	0.15						
PO ₄ -P (mg/L)	Dry	0.045	0.072	0.081	0.086	0.105	0.092	-	-	-	-	0.030	0.032	0.032	0.035	0.035	0.036	0.042	0.048	0.031	0.054	0.056	0.032	0.028	-	0.021	0.029	0.034	0.034	0.062	0.039	0.032	0.033	0.035	0.057	0.65 (equivalent to 2 PO4)	0.033 (0.1 as PO4)					
	Wet	0.037	0.041	0.125	0.133	0.134	0.133	0.053	0.016	0.069	0.017	0.025	0.099	0.098	0.034	0.081	0.046	0.030	0.045	0.048	0.029	0.033	0.031	0.030	0.022	0.015	0.045	0.049	0.102	0.075	0.096	0.076	0.079	0.087	0.053							
TSS (mg/L)	Dry	7.3	14.9	8.6	7.8	<2.8	39.7	-	-	-	-	17.1	2.9	3.9	12.1	77.7	16.2	10.3	11.1	8.0	27.9	18.8	31.0	9.4	-	3.4	<1	7.2	7.4	46.7	2.3	3.9	2.6	5.1	3.8	12.7	30	150				
	Wet	26.3	17.7	7.4	17.4	9.1	38.7	81.0	6.7	14.7	27.7	19.7	13.7	6.4	263.3	12.0	38.6	29.8	52.9	62.4	147.0	190.0	15.7	18.0	16.7	11.3	5.0	141.3	81.0	8.2	28.7	7.2	18.8	55.0	63.0	28.0						
TOC (mg/L)	Dry	2.10	3.27	3.57	3.46	3.78	3.56	-	-	-	-	1.85	1.37	1.65	1.62	1.98	1.54	ND	<1.186	<1.084	1.40	1.86	1.22	2.25	-	1.47	1.29	1.48	1.65	1.52	1.90	1.47	1.64	1.76	1.68	3.49	-	25				

Parameter	Site	A										B						C				D		E														F	NEA Limit s ^a	Aquatic Criteria ^b	
	Water course	D1						D3	D4	D5	D6	D7					D14	D15				D11		D8	D9	D10	D13	D16	D12-A		D12-B		D7		D12		D2				
	Monito ring locatio n	WQA 1	WQA 2	WQA 3	WQA 4	WQA 5	WQA 6	WQA 7	WQA 8	WQA 9	WQB 1	WQB 2	WQB 3	WQB 4	WQB 5	WQB 6	WQC 1	WQC 2	WQC 3	WQC 4	WQD 1	WQ D2	WQE 1	WQE 2	WQE 3	WQE4	WQE5	WQE 6	WQE7	WQE 8	WQE9	WQE 10	WQE 11	WQE 12	WQE 13	WQF 1					
Cd (mg/L)	Dry	ND	ND	ND	ND	ND	ND	-	-	-	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND					
	Wet	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.003	0.1			
Cr (III and VI) (mg/L)	Dry	0.0008	0.0007	0.0009	0.0007	0.0007	0.00011	-	-	-	-	0.0006	0.0006	0.0007	0.0006	0.0009	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0007	-	0.0008	0.0007	0.0008	0.0008	0.0007	0.0007	0.0008	0.0007	0.0008	0.0007	0.0009	0.0007	0.0007			
	Wet	0.0012	0.0011	0.0006	0.0006	0.0007	0.0007	0.0015	0.0006	0.0015	0.0009	0.0007	0.0008	0.0008	0.0016	0.0008	0.0014	0.0011	0.0016	0.0019	0.0015	0.0011	0.0007	0.0007	0.0009	0.0012	0.0015	0.0006	0.0006	0.0009	0.0006	0.0009	0.0008	0.0008	0.00032	0.0008	0.0010	0.05	0.016	0.011	
Cu (mg/L)	Dry	0.0020	0.0009	0.0009	0.0015	0.0014	0.0022	-	-	-	-	0.0011	0.0009	0.0012	0.0019	0.0047	0.0013	<0.003	0.0014	0.0008	0.0013	0.0013	0.0019	0.0009	-	0.0019	<0.00867	0.0013	0.0013	0.0019	0.0005	0.0009	0.0011	0.0024	0.0012	0.0010					
	Wet	0.0036	0.0039	0.0014	0.0017	0.0017	0.0020	0.0026	0.0012	0.0050	0.0038	0.0019	0.0032	0.0024	0.0046	0.0023	0.0215	0.0038	0.0489	0.0051	0.0068	0.0046	<0.001222	<0.00882	0.0042	0.0078	0.0043	0.0013	0.0014	0.0011	0.0020	0.0015	0.0018	0.0021	0.0013	0.0037	0.1	0.018	0.012		
Fe (mg/L)	Dry	1.85	2.02	1.95	0.93	0.79	1.05	-	-	-	-	1.54	0.53	0.99	1.22	1.21	1.13	0.08	0.08	0.20	0.76	0.73	1.76	1.63	-	0.46	0.18	1.28	1.15	3.50	0.58	0.61	0.54	0.94	0.93	1.13					
	Wet	1.37	1.44	1.21	0.97	1.10	1.09	1.24	0.38	1.16	0.89	1.03	0.62	0.57	0.97	0.92	0.95	0.66	0.16	1.33	1.01	0.91	1.04	1.08	0.12	0.29	0.21	0.49	0.78	1.15	0.77	0.60	0.85	0.95	0.85	1.28	1		1		
Pb (mg/L)	Dry	ND	ND	<0.001	ND	ND	ND	-	-	-	-	ND	ND	ND	ND	ND	ND	0.0009	<0.001	ND	ND	ND	ND	0.0005	-	0.0023	ND	<0.000615	<0.000555	<0.000715	<0.001116	ND	ND	ND	<0.000578	ND					
	Wet	0.0006	0.0009	ND	0.0005	ND	0.0007	0.0010	0.0006	0.0008	0.0015	ND	0.0010	0.0008	0.0022	0.0005	0.0017	0.0033	0.0008	0.0028	0.0016	0.009	<0.00078	ND	ND	0.0013	ND	ND	ND	0.0006	0.0007	ND	0.0007	ND	ND	<0.001123	0.1	0.065	0.025		
Mn (mg/L)	Dry	0.126	0.147	0.155	0.041	0.050	0.069	-	-	-	-	0.043	0.027	0.043	0.064	0.064	0.047	0.017	0.016	0.012	0.057	0.043	0.033	0.024	-	0.020	0.009	0.046	0.033	0.092	0.045	0.040	0.041	0.032	0.027	0.070					
	Wet	0.064	0.050	0.045	0.035	0.037	0.031	0.028	0.117	0.216	0.024	0.033	0.007	0.005	0.021	0.021	0.027	0.022	0.061	0.029	0.016	0.014	0.023	0.018	0.004	0.009	0.006	0.021	0.017	0.063	0.013	0.013	0.016	0.017	0.031	0.033	0.5	0.1			
Hg (mg/L)	Dry	ND	ND	ND	ND	ND	ND	-	-	-	-	<0.000973	<0.000575	<0.000836	<0.000434	0.00005	<0.00054	<0.000581	<0.000528	ND	<0.000512	<0.000497	ND	ND	-	ND	ND	<0.000073	ND	ND	ND	<0.000093	<0.0000919	<0.0000623	ND	ND					
	Wet	0.00020	0.00017	ND	ND	ND	ND	0.00016	0.00017	0.00017	0.00010	0.00007	ND	ND	0.00007	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.001	0.014	0.007	
Mo (mg/L)	Dry	0.0020	0.0129	0.0099	0.0105	0.0094	0.0086	-	-	-	-	0.0009	0.0009	0.0015	0.0010	0.0012	<0.001	ND	ND	ND	<0.001	ND	ND	0.0011	-	0.0006	<0.00067	0.0008	0.0007	ND	0.0010	0.0009	0.0009	0.0010	0.0009	0.0090					
	Wet	0.0042	0.0110	0.0141	0.0148	0.0192	0.0146	0.0082	0.0007	0.0019	0.0011	0.0006	0.0008	0.0005	0.0012	0.0013	0.0010	0.0005	0.0013	0.0007	0.0013	0.0017	ND	<0.000754	ND	0.0007	0.0017	0.0023	0.0020	ND	0.0020	0.0006	0.0002	0.0027	0.0013	0.0069	-	0.034			
Ni (mg/L)	Dry	0.0020	0.0014	0.0014	0.0014	0.0013	0.0022	-	-	-	-	<0.001691	<0.001073	ND	<0.0011	0.0013	<0.002	<0.003	<0.002	<0.002	<0.003	<0.003	ND	ND	-	<0.000644	ND	0.0011	ND	<0.001026	0.0024	ND	<0.001329	<0.001146	<0.002077	ND					
	Wet	0.0008	0.0009	0.0006	0.0007	0.0006	0.0011	0.0009	0.0009	0.0010	0.0009	0.0011	0.0013	0.0007	0.0012	0.0007	0.0007	0.3500	0.0013	0.0010	ND	0.0008	0.0021	ND	0.0027	0.0034	0.0007	ND	0.0011	0.0009	0.0005	0.0011	0.0022	0.0007	0.0010	0.1	0.47	0.052			
Se (mg/L)	Dry	ND	<0.00062	<0.00054	ND	ND	ND	-	-	-	-	<0.000438	ND	<0.0002215	<0.0004374	0.0026	ND	ND	ND	ND	ND	ND	ND	ND	-	<0.000147	ND	ND	ND	ND	ND	ND	<0.0001475	ND	ND	ND	0.0013				
	Wet	ND	ND	ND	ND	ND	ND	0.0020	ND	ND	ND	0.0023	ND	ND	0.0014	-	0.0009	ND	ND	ND	ND	ND	ND	<0.000736	ND	ND	ND	ND	ND	ND	0.0008	ND	ND	ND	ND	<0.000944	0.01	0.25			
Ag (mg/L)	Dry	ND	ND	ND	<0.000742	ND	ND	-	-	-	-	ND	<0.0005	ND	ND	ND	ND	<0.000617	ND	ND	ND	ND	ND	ND	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND				
	Wet	0.0007	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	ND	ND	0.0006	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.1	0.05		
Sn (mg/L)	Dry	<0.00062	ND	ND	ND	ND	ND	-	-	-	-	<0.000113	ND	ND	<0.00098	0.0009	ND	ND	ND	<0.001156	ND	ND	ND	ND	-	<0.00097	<0.000567	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND				
	Wet	0.0005	0.0006	0.0006	0.0005	0.0006	0.0005	ND	ND	0.0006	ND	0.0008	0.0010	0.0009	0.0010	0.0008	0.0006	0.0008	0.0006	0.0008	0.0006	ND	ND	ND	<0.000636	0.0010	ND	ND	0.0022	0.0015	0.0009	0.0008	0.0007	0.0008	0.0012	0.0011	ND	5	0.004		
Zn (mg/L)	Dry	0.018	0.010	0.014	0.013	0.010	0.016	-	-	-	-	0.011	0.008	0.008	0.006	0.012	0.009	0.013	0.015	0.014	0.009	0.011	0.009	0.008	-	0.015	0.008	0.012	0.011	0.011	0.008	0.007	0.008	0.012	0.013	0.010					
	Wet	0.017																																							

Site A

Watercourse D1, D3, D4 and D5

At Site A, a total of nine (9) water quality stations were sampled. The water quality stations are located along the natural stream D1 (WQA1 – WQA6), the earth drain D3 (WQA7), the unmanaged pond D4 (WQA8) and the concrete drain D5 (WQA9). D1 was sampled during both wet and dry weather conditions while D3, D4 and D5 were sampled during wet weather conditions only.

The natural stream D1 was sampled upstream (WQA1), midstream (WQA2 – WQA4), at the tributary of D1 (WQA5) and downstream (WQA6). Generally, there was minimal variation in temperature and pH, ranging from 25.6 °C – 28.0 °C and pH 6.8 – pH 7.8 respectively. Readings for Total Dissolved Solids and Turbidity remained within their respective guidelines. Conductivity parameters had no designated guideline values but readings showed a generally increasing trend flowing downstream, with values ranging from 277.1 µS/cm – 569.7 µS/cm during dry weather conditions and 130.0 µS/cm – 475.6 µS/cm during wet weather conditions. Dissolved Oxygen (DO) measured during dry weather was low upstream and midstream (i.e. 1.08 mg/L at WQA1, 2.27 mg/L at WQA2 and 3.12 mg/L at WQA3), below the Aquatic Criteria of 4.0 mg/L. This could be due to the low flow conditions observed at these sampling locations. The large amounts of decomposing leaf litter upstream of the natural stream (WQA1) likely caused the depletion of DO at that point as well. The unmanaged pond D4 (WQA8) also had DO concentrations lower than the Aquatic Criteria of 4.0 mg/L at 1.41 mg/L. This low value is expected given the stagnant water condition and green algae covering the surface of the pond. Large amounts of decomposing wood were also observed in the pond, further depleting the scarce oxygen stores available in the pond.

Along natural stream D1, Total Phosphorous (TP) levels were higher than the Aquatic Criteria of 0.1 mg/L at all sampling locations during both dry and wet weather, except for a borderline value upstream of the natural stream during wet weather (0.09 mg/L at WQA1). TP levels ranged from 0.09 mg/L – 0.22 mg/L along the stream, where levels generally increased downstream. Similarly, Orthophosphate (PO₄-P) levels were above the Aquatic Criteria of 0.033 mg/L at all sampling locations during both wet and dry weather conditions, with concentrations ranging from 0.037 mg/L – 0.134 mg/L, also with generally increasing concentrations further downstream. TAN concentrations are low across all sampling points during wet and dry weather conditions along the natural stream D1, with the exception of a slightly higher value than the Aquatic Criteria of 1.0 mg/L recorded midstream (i.e. 1.05 mg/L at WQA3) during dry conditions. Along the earth drain D3 (WQA7) and concrete drain D5 (WQA9), both TP and PO₄-P levels were also found to be higher than the Aquatic Criteria. Along the earth drain, the elevation of the concentrations is relatively small, TP concentration measured at 0.13 mg/L and PO₄-P concentration was 0.053 mg/L. Along the concrete drain, TP and PO₄-P levels were recorded at 0.13 mg/L and at 0.069 mg/L respectively. These elevated values of TP, PO₄-P and TAN are likely contributed by the decomposition of organics and detritus from the surrounding vegetation. Based on observations from AECOM's past studies of forested areas in Singapore, relatively high levels of nutrients observed are typical of forest stream conditions such as natural stream D1, earth drain D3 and concrete drain D5 that not only collects run-off from the surrounding forest but likely also collects runoff from the nearby urbanised areas (i.e. PIE), which may also contribute nutrients to the drain.

The Total Suspended Solids (TSS) downstream of natural stream D1 (WQA6) exceeded the NEA Limits of 30 mg/L during both wet weather (38.7 mg/L) and dry weather (39.7 mg/L) conditions. Given the high velocity of water as well as the sandy banks observed at this sampling location during site surveys, the high TSS values are likely due to the resuspension of sediments and sandy runoff from the stream bank. TSS recorded along the earth drain D3 (WQA7) also exceeded the NEA Limits and reached at 81 mg/L. This exceedance is likely due to the silty surface run off from the surrounding forest during the storm event.

For metals, only Aluminium, Iron and Manganese levels showed elevated concentrations. As these metals are naturally occurring minerals abundant in soil, the high levels observed could be contributed from soil leachate. Along natural stream D1, Aluminium concentrations were above the Aquatic Criteria of 0.060 mg/L marginally during dry weather conditions upstream and downstream of the natural stream D1 (0.068 mg/L at WQA1 and WQA6). During wet weather, even higher concentrations were recorded around the upstream and downstream (0.267 mg/L at WQA1, 0.208 mg/L at WQA2, 0.111 mg/L at WQA5 and 0.119 mg/L at WQA6). The compounded Aluminium concentrations observed during wet weather conditions are likely due to great volumes of surface run off. Aluminium concentrations recorded are highest upstream (WQA1 and WQA2), likely due to the almost stagnant flow in that area, leading to accumulation of the pollutants. Similarly, along earth drain D3 (WQA7), unmanaged pond D4 (WQA8) and the concrete drain D5 (WQA9), Aluminium concentrations were all higher than the Aquatic Life Criteria at 0.638 mg/L, 0.236 mg/L and at 0.777 mg/L respectively.

Iron levels were in exceedance of both the NEA Limits and the Aquatic Criteria of 1.0 mg/L along many points of the natural stream D1. During dry weather, exceedances ranging from 1.05 mg/L - 2.02 mg/L were observed at all points except at midstream (WQA4 and WQA5). With the highest concentration of Iron observed close to upstream areas of the natural stream at WQA2. During wet weather, Iron concentrations exceeded guideline limits at all sampling points except at midstream (WQA4), with values ranging from 1.09 mg/L to 1.44 mg/L. The high levels of Iron observed along the natural stream is likely due to leaching from soil or Iron-oxidising bacteria that was observed in the stream [W-35]. During both wet and dry weather conditions, the highest concentration of Iron was recorded at midstream point WQA2, likely due to the low flow conditions at that point leading to accumulation of the metals. Along the earth drain D3 (WQA7), Iron recorded exceeded both NEA Limits and Aquatic Criteria of 1.0 mg/L at 1.24 mg/L. Along the concrete drain D5 (WQA9), Iron levels were also in exceedance of the guidelines and concentrations were recorded at 1.16 mg/L. As Aluminium and Iron are naturally occurring minerals abundant in soil, the high concentrations could be due to leaching from soils into the earth drain.

For natural stream D1, Manganese levels were observed to be higher than the Aquatic Criteria of 0.1 mg/L during dry weather at upstream to midstream (0.126 mg/L at WQA1, 0.147 mg/L at WQA2 and 0.155 mg/L at WQA3). Manganese levels recorded in the unmanaged pond D4 (WQA8) and concrete drain D5 (WQA9) were likewise higher than the Aquatic Criteria at 0.117 mg/L and 0.216 mg/L respectively. As Manganese is a mineral naturally present in soils [W-41] these elevated levels are possibly due to leaching from soils into the natural stream.

Enterococcus counts were also relatively high upstream of the natural stream D1 during wet weather conditions (7,500 CFU/100mL at WQA1 and 8,500 CFU/100mL at WQA2) likely due to the run-off from the forest containing animal waste accumulating where the stream has an almost stagnant flow. In the earth drain D3 (WQA7), *enterococcus* counts were high, measuring at 17,000 CFU/100mL. The high level recorded in the earth drain could also similarly be contributed by the surface run-off from the surrounding forest containing large amounts of animal waste.

Site B

Concrete roadside drain D6 was sampled at WQB1 and represents the runoff water quality from the northern forested areas of Site B and nearby urban areas (road runoff of Fairways Drive).

Naturalised stream D7 was sampled at seven (7) locations. This includes WQB2 (upstream), WQB3 (midstream 1), WQB4 (midstream 2), WQB5 (midstream (prior culvert)), WQB6 (midstream (after culvert)), WQE10 (midstream 5), and WQE11 (downstream). WQE10 and WQE11 are discussed separately in Site E findings.

The temperature of the watercourses in Site B had no significant variations during dry and wet weather conditions, ranging from 25.6°C to 27.6°C, which is below the NEA Limits of 45°C. The pH of watercourses in Site B ranged from 6.27 to 7.22, which is within the Aquatic Criteria and NEA Limits (both criteria: pH 6 – 9). While conductivity had no guidelines, it was relatively similar throughout the site, ranging between 71.9 – 239.5 µS/cm. Total dissolved solids (TDS) concentrations were also within both guidelines (both criteria: 1000 mg/L), ranging from 46 – 150.8 mg/L. Meanwhile, turbidity and DO had some exceedances.

During dry weather conditions, turbidity at upstream (WQB2, i.e. 645.3 NTU) and midstream 2 (WQB4, i.e. 1,391.4 NTU) of naturalised stream D7 exceeded the Aquatic Criteria of 200 NTU. The water at WQB2 was observed to have orange filaments present which could be the cause for the high turbidity readings during dry weather conditions. The turbidity readings for WQB4 on the two separate dry sampling occasions were 2,775 NTU and 7.69 NTU. From Figure 8-9, there is a noticeable difference in the amount of orange iron bacteria present in the water between the first (left) and second (right) dry weather sampling event. TSS levels during dry weather conditions at midstream 2 (WQB4) recorded to be low (i.e. 3.9 mg/L), showing that the high turbidity is not likely due to TSS. The high turbidity reading on the first dry weather sampling event could be attributed to the sizeable amount of orange iron bacteria observed in the water. During wet weather conditions, turbidity at upstream (WQB2, i.e. 496.1 NTU) of naturalised stream D7 also exceeded the Aquatic Criteria. This may be due to flushing of solids from urban area and vegetation. It could also be because of the turbulent effects resulting in increased flow in the watercourse, leading to suspension of solids in the watercourse during wet weather sampling. Furthermore, orange specks were observed in the water, likely to be the mixed-in orange filaments, which could also contribute to the higher turbidity readings.



Figure 8-9 Photo of first (left) and second (right) dry weather sampling at midstream 2 (WQB4) of naturalised stream D7

For all monitoring locations along naturalised stream D7, the DO level was below the Aquatic Criteria of 4 mg/L during dry weather conditions. DO levels ranged from 1.97 – 3.34 mg/L. This could be due to the almost stagnant to very low flow observed along naturalised stream D7. During wet weather conditions, DO level at midstream (after culvert) (WQB6, i.e. 3.79 mg/L) of naturalised stream D7 was below the Aquatic Criteria. This could also be due to the very low flow and lots of leaf litter in the surroundings observed at WQB6 during wet weather conditions. However, despite the low DO recorded, there were observations of small fishes in the water for most of the monitoring locations along naturalised stream D7. To support this observation, a previous study has shown DO below 4 mg/L among Singapore natural streams, indicating that freshwater aquatic life may have adapted to such low DO environment in Singapore [P-86].

During dry weather conditions, total suspended solid (TSS) levels at midstream (after culvert) (WQB6, i.e. 77.7 mg/L) of naturalised stream D7 exceeded NEA Limits of 30 mg/L. This could possibly be due to the construction waste observed in the area. During wet weather conditions, TSS levels at midstream (prior culvert) (WQB5, i.e. 263.3 mg/L) of naturalised stream D7 exceeded both the Aquatic Criteria of 150 mg/L and NEA Limits. The higher TSS levels might be due to runoff originating from soil, vegetated and urbanised areas which may have contributed TSS into the watercourse.

TP and PO₄-P concentration also exceeded the Aquatic Criteria (TP – 0.1 mg/L, PO₄-P – 0.033 mg/L) at midstream 1 (WQB3, i.e. TP – 0.11 mg/L, PO₄-P – 0.099 mg/L), and midstream 2 (WQB4, i.e. TP – 0.12 mg/L, PO₄-P – 0.098 mg/L) of naturalised stream D7 during wet weather conditions. At midstream (prior culvert) (WQB5, i.e. dry – 0.035 mg/L, wet – 0.034 mg/L) and midstream (after culvert) (WQB6, i.e. dry – 0.035 mg/L, wet – 0.081 mg/L) of naturalised stream D7, PO₄-P concentration exceeded the Aquatic Criteria during both dry and wet weather conditions. Although this may suggest possible eutrophication conditions, the water was observed to have no sign of algae.

Metals are generally below both the guidelines except for aluminium, arsenic, and iron. Aluminium concentrations exceeded the Aquatic Criteria of 0.06 mg/L at roadside drain D6 (WQB1, i.e. 0.321 mg/L) in wet weather conditions and naturalised stream D7, upstream (WQB2, i.e. dry – 0.421 mg/L, wet – 0.087 mg/L) and midstream (after culvert) (WQB6, i.e. dry – 0.114 mg/L, wet – 0.25 mg/L) during both dry and wet weather conditions and at all monitoring locations (ranging from 0.25 – 0.921 mg/L) along naturalised stream D7 during wet weather conditions. This could be due to natural leaching from soil or also from the vehicular traffic [P-126] which is eventually washed into the watercourses. Arsenic concentrations had borderline exceedance of the NEA Limits of 0.01 mg/L at upstream (WQB2, i.e. 0.0128 mg/L) of naturalised stream D7 during dry weather conditions which could be due to the anthropogenic activities in the vicinity of Site B. It could also be due to naturally occurring arsenic in soil and sediments [P-81]. Furthermore, the almost stagnant conditions at WQB2 could result in contamination accumulation. Iron concentrations exceeded both the Aquatic Criteria and NEA Limits (both criteria: 1 mg/L) at upstream (WQB2, i.e. dry – 1.54 mg/L, wet – 1.03 mg/L) of naturalised stream D7 during both dry and wet weather conditions and at midstream (prior culvert) (WQB5, i.e. 1.22 mg/L) and midstream (after culvert) (WQB6, i.e. 1.21 mg/L) of naturalised stream D7 during dry weather conditions. This could be attributed to the iron oxidizing bacteria observed in the water.

Enterococcus along naturalised stream D7 was generally lower during dry weather (9 – 2,920 CFU/100mL) than wet weather (1,000 – 21,000 CFU/100mL), while *Enterococcus* in roadside drain D6 was 9,000 CFU/100mL during

wet weather, similar to that of naturalised stream D7. Storm runoff flowing into the watercourse likely contained animal faecal matter from surrounding forest area in Site B.

Site C

Earth drain D14 was sampled at one location (WQC1, upstream of the watercourse) while naturalised stream D15 was sampled at three locations (upstream: WQC2, midstream: WQC3 and downstream, which also receives water flow from D14: WQC4).

In-situ parameters measured within Site C saw temperature, turbidity, total dissolved solids and temperature within their respective guidelines. While conductivity had no guidelines, it was relatively similar throughout the site, ranging between 55 – 131 $\mu\text{S}/\text{cm}$. However, pH and DO have some exceedances.

DO of the watercourses were generally between 6 – 8 mg/L, except earth drain WQC1, which had an average DO of 1.97 mg/L during dry weather, which is lower than the Aquatic Criteria (> 4 mg/L). This could be due to the relatively stagnant waters observed at the location.

pH of watercourses in Site C was generally slightly acidic (< 7) in both wet and dry weather, with upstream and midstream of naturalised stream D15 (WQC2 and WQC3) being lower than the NEA Limits and Aquatic Criteria (both criteria: 6 – 9) during dry weather at 5.61 – 5.84. The lower pH is likely due to the organic humic acids from the surrounding forests of Site C.

Nutrients TN, TP, nitrate and TAN in Site C were lower than their respective NEA Limits and Aquatic Criteria. Orthophosphate phosphorus exceeded the Aquatic Criteria at almost all locations in all weather, except for WQC2 in wet weather (0.03 mg/L), albeit it was close to the guideline limits (0.033 mg/L). The high phosphate concentrations are possibly due to the runoff from the surrounding forest being rich in nutrients. While TOC had no NEA Limits or Aquatic Criteria, TOC was always lower than 5 mg/L in Site C, implying relatively clean waters when compared to drinking water quality (25 mg/L) [W-36].

TSS did not exceed NEA Limits (30 mg/L) in dry weather but exceeded in wet weather at all locations except WQC2 (38.6 – 62.4 mg/L). The high TSS in wet weather is likely due to high sediment being carried in runoff from the forest. TSS did not exceed Aquatic Criteria for all locations and weather.

Metals antimony, arsenic, barium, beryllium, boron, cadmium, chromium, manganese, mercury, molybdenum, selenium, silver, tin and zinc were all below their NEA Limits and Aquatic Criteria. However, aluminium exceeded the Aquatic Criteria (0.06 mg/L) at all locations in wet weather (0.36 – 1.03 mg/L) and at WQC2 and WQC3 (naturalised stream D15) in dry weather (0.08 – 0.15 mg/L). These higher concentrations may be due to nearby infrastructures or may be naturally present in the ground [W-34]. Copper, lead and nickel in wet weather conditions exceeded the (chronic) Aquatic Criteria at various monitoring locations in Site C, but not in dry weather conditions. Of these five exceedances, only midstream of naturalised stream D15, WQC3, truly exceeded the (chronic) Aquatic Criteria when averaged dry and wet weather conditions (for copper and nickel, Aquatic Criteria at 0.012 mg/L and 0.052 mg/L respectively). For the acute Aquatic Criteria, copper exceeded at WQC1 and WQC3 (0.022 mg/L and 0.049 mg/L respectively, compared to acute criteria of 0.018 mg/L). These high metal concentrations could be due to runoff flushing of roads nearby, as vehicles could release such metals [P-169]. The only metal that has exceeded both NEA Limits and Aquatic Criteria is iron (1 mg/L) at upstream of earth drain D14, WQC1, in dry weather (1.13 mg/L), and downstream of naturalised stream D15, WQC4, in wet weather (1.33 mg/L). The exceedance could likely come from iron naturally occurring in groundwater [W-35].

Cyanide and sulphide are both undetected in all samples in Site C while *Enterococcus* ranges from 55 – 56,000 cfu/100mL in Site C, with generally higher concentrations during wet weather. The higher concentrations are likely be due to flushing from the surrounding forest.

Site D

The ravine's stream D11 was sampled at two locations, WQD1 (upstream) and WQD2 (downstream). In-situ parameters measured within D11 saw temperature, turbidity, total dissolved solids, and DO within their respective guidelines. While conductivity had no guidelines, it was relatively similar throughout the site, ranging between 104 – 121 $\mu\text{S}/\text{cm}$.

During wet weather, TSS in stream D11 exceeds NEA Limits (30 mg/L) at both locations, and the Aquatic Criteria (150 mg/L) at the downstream location (194 mg/L). This is likely due to the ravine having steep slopes, causing forest sediment to be washed into the watercourse with storm runoff.

At both locations, the water phosphate content was high in dry weather (0.054 – 0.056 mg/L), exceeding the Aquatic Criteria (0.033 mg/L). This could be due to the high nutrient content from the surrounding forest of the ravine. However, TP only just exceeds (0.11 mg/L) the eutrophic limit (0.1 mg/L) in dry weather at WQD1, located upstream of D11. Nitrogen parameters (TAN, nitrate and TN) did not exceed their guidelines. TOC was also low, with a maximum of 5.33 mg/L measured.

Metals in the ravine stream are generally lower than any of their respective guidelines, except for iron and aluminium. Iron just exceeds both guidelines (1 mg/L) at WQD1 (upstream of D11) during wet weather at 1.01 mg/L and may have been leached from soil through groundwater [W-35]. On the other hand, at both locations, aluminium exceeds the Aquatic Criteria (0.06 mg/L) during dry weather (0.07 – 0.08 mg/L) and increases greatly during wet weather (0.052 – 0.084 mg/L). Aluminium is a naturally occurring mineral and may have leached from the soil [W-34].

Cyanide and sulphide are generally not detected (i.e. less than 0.005 mg/L and 0.05 mg/L respectively) in the watercourse. *Enterococcus* is lower in dry weather (420 – 1,410 cfu/100mL) and increases in wet weather (31,000 – 40,000 cfu/100mL). This can also be attributed to runoff from the forest, which may be home to many animals.

Site E

Site E is largely a mix of urbanised and forested land, with a total of thirteen (13) sampling locations.

All in-situ parameters (temperature, pH, turbidity, and TDS) saw no exceedances of their respective guidelines in Site E. Site E saw 9 occurrences of DO lower than the Aquatic Criteria (4 mg/L). These occurred at WQE1, WQE2, WQE9, WQE10, (dry weather exceedances only) WQE11, WQE8, and WQF5 (dry and wet weather exceedances) with a range of 0.21 – 3.85 mg/L. Dry weather exceedances only are likely due to the stagnant conditions of the watercourses at the monitoring locations, while the dry and wet weather exceedances have an added element of lots of organic matter such as leaf litter accumulation in the stream bed.

None of the nitrogen-based nutrients (TN, nitrate and TAN) exceeded any guidelines at Site E monitoring locations, except for TAN at WQF8 (upstream of naturalised tributary 12-B), which exceeded the Aquatic Criteria. The location is stagnant with high organic matter floating on the water surface, consequently creating a low DO environment, where nitrogen is more likely to stay in its reduced form, TAN. For nutrient phosphorus, orthophosphate exceeded the Aquatic Criteria (0.033 mg/L) at majority of the sites in wet weather (0.045 – 0.102 mg/L) and some sites in dry weather (0.034 – 0.062 mg/L). These exceedances occurred at naturalised streams D7, D12-A, D12-B, D12 and D16, all of which receives flow from surrounding forests, which usually has high nutrient content. Consequently, at naturalised streams D7 and D12-B, TP also exceeds the Aquatic Criteria (0.1 mg/L) during wet weather (0.11 – 0.14 mg/L). TOC at all locations were < 6 mg/L, implying clean water quality compared to the drinking water quality standards for TOC at 25 mg/L [W-36].

TSS in Site E exceeded the NEA Limits (30 mg/L) at locations naturalised streams D12-A (WQE6 and WQE7) and D12 (WQE12 and WQE13) in wet weather (55 – 141 mg/L), which may be due to forest runoff carrying high suspended solids, while TSS in golf course pond D8 (WQE1; 31 mg/L) and upstream of naturalised stream D12-B (WQE6; 46.7 mg/L) exceeded in dry weather, and may be due to the high vegetation growth within the pond and decomposing leaf litter respectively (see Table 8-4 for photo of monitoring locations).

Metals antimony, arsenic barium, beryllium, boron, cadmium, chromium, copper, lead, manganese, molybdenum, nickel, selenium, silver, tin and zinc were within their respective guidelines in Site E. Metal aluminium exceeded the Aquatic Criteria (0.06 mg/L) at nearly all locations in wet weather and some locations in dry weather (0.065 – 0.305 mg/L), while iron exceeded both guidelines (1 mg/L) in five locations in dry weather and two locations in wet weather (1.04 – 3.50 mg/L). Aluminium and iron are naturally occurring metals in soils and could have leached into watercourses [W-34, W-35], which may explain the exceedances.

Similar to other sites in Turf, cyanide and sulphide were very low and below the guidelines. *Enterococcus* ranged from 11 to 43,000 cfu/100mL in Site E, with lower counts (< 100 cfu/100mL) only occurring during dry weather. Majority of the locations had *Enterococcus* counts higher than the NEA recreational beach guidelines of 200 cfu/100mL [W-37], although these watercourses are not expected to be used recreationally. The high *Enterococcus* counts is likely due to flushing from nearby forests and golf course (for ponds D8 and D9).

Site F

One sampling location is chosen at the end of the main canal (watercourse D2) in Site F. The canal had no exceedances of NEA Trade Effluent criteria and Aquatic Criteria for in-situ parameters (temperature, pH, turbidity,

TDS and DO) in all weather conditions. Conductivity was also had a similar range to its upstream water source (natural stream D1 in Site A).

Nutrients (TN, TP, nitrate, and TAN) in the canal are generally low, within the comparative guidelines. Only nutrient orthophosphate exceeded the guidelines (Aquatic Criteria 0.033 mg-P/L) in both wet (0.053 mg/L) and dry (0.057 mg/L) weather. However, the orthophosphate content in the canal is generally lower than its upstream watercourse, which is the natural stream D1 in Site A. Hence, the high orthophosphate content may have been from upstream.

Only metals aluminium, arsenic and iron exceeded one or more of the guidelines in at least one weather condition, as shown in Table 8-7 (guidelines of aluminium: 0.06 mg/L, arsenic: 0.01 mg/L, iron: 1 mg/L compared to observed values of aluminium: 0.14 mg/L, arsenic: > 0.015 mg/L, iron: > 1.13 mg/L). The canal D2 is situated nearby Eng Neo Avenue and also receives roadside runoff from it. High traffic along Eng Neo Avenue may be the cause of the high metal concentrations in canal D2 [P-169]. Other metals antimony, barium, beryllium, boron, cadmium, chromium, copper, lead, manganese, molybdenum, nickel, selenium, silver, tin and zinc are all within their respective guidelines.

Cyanide and sulphide were not detected in canal D2 in all weather. *Enterococcus* concentrations in dry weather was 580 cfu/100mL, and increased to 9,050 cfu/100mL in wet weather. This is likely due to flushing from the forest in Site F.

8.5 Identification of Surface Water Resource Sensitive Receptors

Receptor screening for surface water resources was conducted for the Study Area for both construction and operational phases. The criteria detailed in Table 6-2 was used to determine the sensitivity of the surface water resource receptors presented in Table 8-8 and Table 8-9. As some of the watercourses/bodies identified in the Study Area will be occupied by future construction worksite (under construction phase) or be entirely replaced by future urban drainage (under operational phase), only the retained water resources will be considered as sensitive receptors.

8.5.1 Construction Phase

During construction phase, the human and ecological receptors are identified and classified based on sensitivity classification (Table 6-2) as shown in Table 8-8.

Table 8-8 Classification of surface water resource sensitive receptors identified within the Study Area for construction phase

Sensitive Receptor	Environmental Parameter	Receptor Description	Receptor Classification	Impact Assessment Type
Human Receptors				
Future residents and visitors in the vicinity of the Project Site developments	Hydrology	Regular activities of humans may be disrupted due to localised flooding within/nearby the Project Site	Priority 2	Qualitative (refer to Section 8.7.1.1).
All local residents and visitors	Surface Water Quality	Water will flow into reservoirs and eventually be used for drinking by local residents and visitors (humans)	Priority 1	Qualitative (refer to Section 8.7.1.2).
Ecological Receptors				
Natural stream D1	- Hydrology - Surface Water Quality	- Natural stream D1 serves the habitat and biocenosis of Eng Neo Avenue Forest, which is identified to be of high ecological value - One sighting of the nationally Vulnerable firey coral-tail (<i>Ceriatrigon chaoi</i>) and two sighting of the nationally Endangered crescent betta (<i>Betta imbellis</i>) at natural stream D1	Priority 1	Qualitative (refer to Section 8.7.1).
Unmanaged pond (D4) in Site A	- Hydrology - Surface Water Quality	While not home to many aquatic species, the pond is a viable spot for birds and odonates	Priority 1	Qualitative (refer to Section 8.7.1).

Sensitive Receptor	Environmental Parameter	Receptor Description	Receptor Classification	Impact Assessment Type
		Multiple sightings of the nationally Vulnerable firey coral-tail (<i>Ceriatrigon chaoi</i>) near this pond		
Streams in Bukit Tinggi (Naturalised stream D15 and earth drain D14)	- Hydrology - Surface Water Quality	- Naturalised stream D14 and D15 serve the habitats and biocenosis of Bukit Tinggi - Based on the biodiversity baseline study findings (Section 7.3 of this Report), habitats and biocenosis of Bukit Tinggi are identified to be of high ecological value.	Priority 1	Qualitative (refer to Section 8.7.1)
Naturalised stream D7	- Hydrology - Surface Water Quality	- Naturalised stream D7 lies on the edge of the nearby forest in Site B - Based on the biodiversity baseline study findings (Section 7.3 of this Report), habitats and biocenosis of this forest are identified to be of medium ecological value.	Priority 2	Qualitative (refer to Section 8.7.1).

8.5.2 Operational Phase

During operational phase, the human, ecology and water-dependent socio-economic receptors are identified and classified based on sensitivity classification (Table 6-2) as shown in Table 8-9.

Table 8-9 Classification of hydrology sensitive receptors identified within the Assessment Area for operational phase

Sensitive Receptor	Environmental Parameter	Receptor Description	Receptor Classification	Impact Assessment Type
Human Receptors				
Residents and visitors within and surrounding the proposed development	Hydrology	The permanent land use change may cause flooding risk to the urbanised area such as residential areas or other development and temporarily affect human activities	Priority 2	Qualitative (refer to Section 8.7.2.1)
All local residents and visitors	Surface Water Quality	Water will flow into reservoirs and eventually be used for drinking by local residents and visitors (humans)	Priority 1	Qualitative (refer to Section 8.7.2.2)
Ecological Receptors				
Natural stream D1	- Hydrology - Surface Water Quality	- Natural stream D1 serves the habitat and biocenosis of Eng Neo Avenue Forest, which is identified to be of high ecological value - One sighting of the nationally Vulnerable firey coraltail (<i>Ceriatrigon chaoi</i>) and two sighting of the nationally Endangered crescent betta (<i>Betta imbellis</i>) at natural stream D1	Priority 1	Qualitative (refer to Section 8.7.2).
Unmanaged pond (D4) in Site A	- Hydrology - Surface Water Quality	- While not home to many aquatic species, the pond is a viable spot for birds and odonates - Multiple sightings of the nationally Vulnerable firey coraltail (<i>Ceriatrigon chaoi</i>) near this pond	Priority 1	Qualitative (refer to Section 8.7.2).
Streams in Bukit Tinggi (Naturalised stream D15 and earth drain D14)	- Hydrology - Surface Water Quality	- Naturalised stream D14 and D15 serve the habitats and biocenosis of Bukit Tinggi - Based on the biodiversity baseline study findings (Section 7.3 of this Report), habitats and biocenosis of Bukit Tinggi are identified to be of high ecological value.	Priority 1	Qualitative (refer to Section 8.7.2).
Naturalised stream D7	- Hydrology - Surface Water Quality	- Naturalised stream D7 lies on the edge of the nearby forest in Site B - Based on the biodiversity baseline study findings (Section 7.3 of this Report), habitats and biocenosis of this forest are identified to be of medium ecological value.	Priority 2	Qualitative (refer to Section 8.7.2).

8.6 Minimum Control Measures

This section proposes minimum controls, or standard practices, commonly implemented in Singapore for similar construction and operational activities, that have been assumed to be implemented for the purposes of impact assessment.

8.6.1 Construction Phase

Table 8-10 has a non-exhaustive list of minimum controls for each potential impact identified in Section 8.3.1 for construction phase.

Table 8-10 Minimum controls during the construction phase applicable to hydrology and surface water quality impact assessment

Source / Activity	Impacted Parameter	Minimum Controls
Stormwater Runoff Generation During storms at the construction site.	Hydrology	- Runoff within, upstream of, and adjacent to the work site will be effectively drained away without causing flooding in the vicinity. - Potential increase of peak-flow due to the change in the land use at the worksite can be mitigated by providing detention tanks or ponds within the worksite. Detention tanks or ponds can capture stormwater during heavy storm events to reduce the peak runoff. - Geotechnical aspect of site's slope stability (such as Earth Retaining and Stabilising structures (ERSS)) to be included in detailed design engineering for the construction stage. - The design engineers for detailed design may need to ensure that ERSS are proposed when the site is cleared and excavated. Concurrently the ECO must ensure that these measures are implemented in the construction phase, as cutting of slopes may result in slope instability.
	Water Quality	- ECM measures include but are not limited to minimisation of formation of bare soil, coverage of all bare/erodible surfaces, concrete cut-off drains, silt fences/traps along the perimeter cut-off drain, turbidity curtains for works adjacent to watercourses (drains and streams), etc. - Adequate drainage, piping and/or channelling of stormwater runoff to be assured through detailed design for capture and treatment at ECM tanks/ponds before discharge into watercourses. - Regular and dedicated procedures for the inspection and maintenance of stormwater collection, storage, and treatment infrastructure, such as pipes, oil water separation, silt screens, etc. - Regular and dedicated procedures for the management of stormwater collection, settling, testing and eventual discharge of 'clean' water to watercourses. This should also include associated measures required to prevent high sediment concentration stormwater drainage to watercourses.
Chemical Substances E.g. fuels, paints, glues, used for construction.	Water Quality	- Development of Standard Operation Procedure (SOP) for safe handling, transfer and storage of toxic waste; housekeeping checks once a day to ensure all toxic waste is cleared from site. - Appropriate tests to ascertain the presence/absence of contamination of the excavated earth and sand. - Appropriate fully sheltered storage area with storage volume to be 110% of the largest volume of chemical substances to be stored (kerb up and enclosed on at least 3 sides, covered and with adequate ventilation). - Appropriate construction material for toxic waste storage containers with leak detection tests conducted periodically. - Provision of secondary containment for all toxic waste stored in bulk as per the requirements in the COPPC/SS593. - Preparation of an emergency response plan, training of the emergency response team (ERT) to be competent in the response mechanism and provision of response kits for any spillages. - Consignment notification/tracking system and transport emergency response plan for transport of toxic waste.

Source / Activity	Impacted Parameter	Minimum Controls
		Appropriate disposal of toxic waste as per required in the Environmental Public Health (Toxic Industrial Waste) Regulations by licensed waste operator/collector.
Domestic Wastes Generated from workers on-site	Water Quality	- Provision of portable toilets and on-site septic tank. - Regular cleaning of the portable toilets and clearing of sanitary waste. - Appropriate location of toilet facilities away from any nearby watercourse. - Inspections and audits to ascertain the hygienic conditions on-site. - The toilet facilities will be placed at least 30 m away from any nearby watercourse. - Training of workers on the best practices to contribute to environmental protection. - Appropriate disposal of any waste listed in the Environmental Public Health (General Waste Collection) Regulations by licensed waste operator/collector regardless the wastes to be disposed off-site or discharged to public sewer.
Construction Wastewater Generated from excavation, dewatering, etc.	Water Quality	- A full inventory of all anticipated wastewater streams and volumes should be finalised before the onset of the construction works. - No unmanaged discharge of wastewater stream permitted. - Reduce, reuse, and recycle hierarchy principle to be applied to wastewater on-site. - Regular audits on environmental management procedures will be carried out on-site. - No hazardous liquids to be sent to the detention pond/tank. - Hazardous wastewater, such as oily water, thinners, solvents, or paints, should be stored on hard stand, under shelter with a kerb around the storage area. The wastewater should be removed for treatment and disposal off-site by an approved Waste Management Contractor. Hazardous liquids to be handled as Hazardous Waste. - Containment pond/kerbs will be of impervious material and be designed with sufficient capacity to hold volumes of wastewater produced on-site and potential fire-fighting wastewater. - ECM tanks/ponds will be designed in sufficient capacity to hold the turbid stormwater prior to treatment at the ECM treatment plant. - Temporary storage volumes should be provided for overflow situations of untreated wastewater. Temporary storage with sufficient capacity will capture any expected additional volumes ensure untreated wastewater is not released to watercourses unless it complies with Singapore NEA Guidelines on trade effluent discharge concentrations. - A responsible person (e.g. ECO) to be assigned to oversee the efficient operation of the containment pond/kerbs where 'Good Housekeeping' practices would be adhered to. Also, the area would be carefully managed to avoid spills, leaks, and odour issues, with the containment pond/kerbs checked at least daily to ensure proper functionality. - Daily record volume of wastewater, as well as volumes of sludge and other produced wastes. - Contractor will need to seek approval from relevant authorities (i.e. PUB & NEA) as per PUB Sewerage and Drainage (Trade Effluent) Regulations if the wastewater will be disposed to public sewer or NEA's Trade Effluent Discharge Limits to controlled watercourse if the treated trade effluent will be disposed to surface watercourses. If such discharges are not approved, the trade effluent will be stored, treated or recycled on site and finally disposed off-site. - Contractor will seek for comment and approval from relevant authorities (e.g. SCDF and NEA) on the treated wastewater to be used for firefighting purposes. - The discharge of pumped dewatered groundwater or other wastewaters to sensitive aquatic habitats will be prohibited. - The containment pond/kerbs, as well as wastewater generating areas on-site, to be equipped with spill clean-up kits.

Source / Activity	Impacted Parameter	Minimum Controls
		- Adequate drainage, cut-off drains sump pit, road kerb, piping and toe wall will be designed for channelling of construction process wastewater streams (e.g., concrete batching, wash water, etc.) and stormwater runoff separately through detailed design for capture and treatment in the containment pond/kerbs. Where applicable (e.g., in the vicinity of liquid storage or refuelling areas), this infrastructure will include oil-water separators to capture inadvertent spills or leaked oils or greases. - Implement a construction EMMP and ensure full preparation of associated plans and procedures including the following: - EMMP to include SOPs, an Emergency Response Plan (ERP), an inventory of wastewater streams, training of staff as well as an inspection, maintenance and audit schedule; and - Full development of EMMP Wastewater Management Procedures to include dedicated management and monitoring procedures that covers all eventualities related to the proper operation of containment pond/kerbs, or any other wastewater discharge location/equipment. - Regular and dedicated procedures for the inspection and maintenance of wastewater (i.e. trade effluent) collection, storage, and treatment infrastructure, such as pipes, oil water separators, silt screens, etc. - Regular and dedicated procedures for the management of stormwater collection, settling, testing and eventual discharge of 'clean' water to watercourse. - A training programme for all on-site workers, including sub-contractors, in relation to their obligations for ensuring proper water quality management.
Solid Wastes Generated during activities such as site clearance, excavation, soil mixing, building of permanent and temporary structures including diversion drains. These may be temporarily stored on-site before disposal.	Water Quality	- Development of a SOP for safe handling, transfer, storage and disposal of solid waste. - Effective ECM and monitoring implemented as recommended in the Code of Practice on Surface Water Drainage to ensure that discharge into the stormwater drainage system does not contain TSS in concentrations greater than the prescribed limits under the Sewerage and Drainage (Surface Water Drainage) Regulations. - ECM measures include but are not limited to minimisation of formation of bare soil, coverage of all bare/erodible surfaces, slope stability, concrete cut-off drains, silt fences/traps along the perimeter cut-off drain, turbidity curtains for works adjacent to watercourses, etc. - Implementation of CCTV including SIDS at the public drain to monitor the surface runoff discharges from the sites as per the PUB's circular on Preventing Muddy Waters from the Construction Sites (October 2015). - Provision of enclosed bins and waste disposal facilities cleared up as often as necessary to prevent build-up. Housekeeping checks will be carried out once a day to ensure all litter is cleared from site. - Hazardous substances and toxic wastes should be stored on hard stand, under shelter with a kerb around the storage area. - All wastes will be disposed only in the designated waste disposal facilities and appropriately separated, i.e. by trained workers to properly sort and label the different types of waste (reusable and recyclable waste, toxic and non-toxic waste, etc.). - Appropriate disposal of any waste listed in the Environmental Public Health (General Waste Collection) Regulations by licensed waste operator/collector. - Surface Water Drainage, to be endorsed by a QECP and submitted to PUB. - Implementation of the ECM plan before the start of any construction work. - Runoff within, upstream of, and adjacent to the work site will be effectively drained away without causing flooding in the vicinity. - Manholes should always be adequately covered and temporarily sealed.

Source / Activity	Impacted Parameter	Minimum Controls
		- Protection of stockpiles with erosion blanket coverage and proper scheduling of the demolition and earthworks to reduce the quantity of stockpiles to be stored on-site. - Coverage of temporary/open storage of excavated materials. - All vehicles should run via wheel washing process before leaving the site to ensure no earth, mud, debris, etc., is deposited on roads; and the wastewater hence generated should be stored and removed for treatment and disposal off-site by an approved Waste Management Contractor. - Appropriate permits for discharge to be obtained from relevant authority prior to discharge. No trade effluent other than that of a nature or type approved by NEA Director-General will be discharged into any watercourse or land.

8.6.2 Operational Phase

Table 8-11 has a non-exhaustive list of minimum controls for each potential impact identified in Section 8.3.2 for operational phase.

Table 8-11 Minimum controls during the operational phase applicable for hydrology and surface water quality impact assessment

Potential Source of Impact	Environmental Parameter Potentially Affected	Minimum Control
Stormwater Runoff Generation (Contamination due to landuse change)	Water Quality	Regular and dedicated procedures for the inspection and maintenance of stormwater collection and storage infrastructure, such as drains.
Stormwater Runoff Generation (Altered Stormwater runoff quantity)	Hydrology	- Potential increase of peak-flow due to the change in the land use at the new developments can be mitigated by providing detention and retention structures, such as detention ponds and bioretention basins within the Project Site to reduce the peak run-off. As required by PUB, the storage system needs to be in place to reduce the peak flow at the operational phase to be the same or less than that of the existing condition; - Geotechnical aspect of site's slope stability (such as ERSS) to be included in detailed design engineering for the operational stage; - Providing more softscape area should be considered in the design of the development to reduce the run-off coefficient which will help to reduce the peak flow and reduce flood risk at downstream area; and - Provide more pervious areas to increase the seepage of surface water into the soil.
Improper management of liquid and solid wastes	Water Quality	- To prepare sufficient disposal bins surrounding of the Project to avoid improper disposal of waste; - To conduct regular inspection on wastes' storage system of the Project; - To monitor the proposed watercourses and its surroundings with CCTV surveillance regularly to ensure no contamination occurred; - To develop an emergency response plan and conduct adequate training to maintenance workers to cope the accidental water contamination; and - Raising awareness of various stakeholders with community/stakeholder engagement (e.g. signage boards, warning signs, etc.)

8.7 Prediction and Evaluation of Surface Water Resource Impacts

During construction phase, potential surface water resource impact on the sensitive receptors such as humans within and in the vicinity of the Project Site, the streams in Bukit Tinggi and Eng Neo Avenue Forest, unmanaged pond D4, naturalised stream D7, and humans (reservoirs) were assessed qualitatively using the risk matrix method that has been presented in Section 6.4. For operational phase, the sensitive receptors such as resident and visitors within and in the vicinity of the proposed developments, as well as the streams in Bukit Tinggi and Eng Neo Avenue Forest, unmanaged pond D4, naturalised stream D7, and humans (reservoirs) are sensitive receptors. The details of sensitive receptors could be referred to Section 8.5.

8.7.1 Construction Phase

As described in Section 8.3, major sources of impacts on hydrology and water quality during construction phase are stormwater runoff generation, chemical substances, domestic wastes, construction wastewater and solid wastes. Stormwater runoff generation will impact both hydrological conditions and water quality, while the rest of the impact sources will mostly have an impact on water quality.

Following sub-sections present the impact prediction and evaluation on hydrology and surface water quality during construction phase.

8.7.1.1 Hydrology

8.7.1.1.1 Stormwater Runoff Generation

Human Impact

Land use modification due to land clearing during construction phase may affect existing hydrological conditions of the Study Area. Due to the proposed construction activities which will include site clearance and excavations, the quantity of the vegetation on the ground will reduce, exposing bare soil. Such changes may increase stormwater surface runoff generated and reduce the time of runoff propagation over the land. Subsequently this could lead to rapid and significant increase of water levels and possible flooding of surrounding during the heavy storm events. Hence, catchment area and existing hydrological conditions could be affected significantly. With minimum controls, it is assessed that the impact intensity on the human receptors would be **Negligible** as drainage systems should be provided to minimise the peak flow, and the areas should be drained effectively. Since the human receptors have been categorised as Priority 2 sensitive receptors, impact consequence would be **Imperceptible** (refer to Table 6-5). Likelihood for this source of impact is determined as **Less Likely** as extreme heavy storms resulting in floods are rare and hence the impact significance would be **Negligible** (based on Impact Significance Matrix [Table 6-7]). This should occur for all phases of development.

Ecological Impact

Based on the proposed landuse, majority of Eng Neo Avenue Forest and Bukit Tinggi will be retained. Hence, an estimated more than 80% of the catchment area of natural stream D1 (in Site A) and naturalised stream D15 (in Site C) will be retained during the construction of the Project Site, with only small changes in catchment areas upstream of tributary of natural stream D1 and as such, the hydrological impact intensity onto the streams is classified as **Negligible**. Since these ecological receptors are classified as Priority 1 receptors, their impact consequence is **Very Low**. The change in catchment area is **Certain** to occur, and thus the impact significance is **Minor**. For naturalised stream D14 (in Site C), the catchment will reduce by an estimated 40% due to the developments nearby, affecting primarily the upstream portion which is normally dry. Hence, impact intensity is **Low**. As D14 is a Priority 1 receptor, the impact consequence is **Low**. The catchment area change is **Certain** to occur, and thus impact significance is **Moderate**.

Due to the developments close to the unmanaged pond (D4) and the naturalised stream D7, their catchments will be reduced by more than half. Hence, the impact intensity on the hydrology of these streams' catchments will be **High**. As pond D4 is Priority 1 and naturalised stream D7 is Priority 2, the impact consequence on both watercourses are **High** and **Medium** respectively. The catchment change is **Certain** to occur, making the impact significance on pond D4 and naturalised stream D7 **Major**.

8.7.1.2 Surface Water Quality

8.7.1.2.1 Stormwater Runoff Generation

Human Impact

Rainfall over the construction site will generate runoff of a different quality than the baseline due to land use change (more bare soil as compared to the current forested conditions). The elevated suspended solids may lead to increased turbidity and water quality contamination. However, the minimum controls are implemented to ensure that the suspended solids are reduced prior to discharge to comply with NEA Limits, and hence, a **Low** impact intensity to the watercourses is expected on humans (local residents and visitors). Consequently, the impact consequence is **Low** on local residents and visitors (Priority 1). As the likelihood of contaminated stormwater to affect humans is **Unlikely**, the impact significance is assessed to be **Negligible** on the local residents and visitors.

Ecological Impact

Runoff flowing into watercourses can cause elevated TSS which has a **Low** impact intensity on ecology. As watercourses/bodies D4 and D15 are Priority 1, the impact consequence is **Low**. As Bukit Tinggi is located on a higher elevation compared to the surrounding Study Area, runoff flowing from the construction site into Bukit Tinggi stream (D15) would be **Unlikely**. On the other hand, pond D4 sits on a lower elevation than some of the development sites. Unmanaged pond D4 thus has a **Less Likely** chance of runoff flowing from the construction sites into it, with the minimum controls, such as proper ECM and adequate drainage throughout the construction site, which should keep the runoff contained. Overall, the impact significance on D15 and D4 would be **Negligible** and **Minor** respectively.

As for natural stream D1 and earth drain D14, upstream of its catchment (of minor tributary for D1), would be constructed on. While they would still have **Low** impact intensity and consequence from runoff, it would be more **Likely** to have runoff flowing into these watercourses. Hence, impact on D1 and D14 is **Moderate**. For naturalised stream D7, there would be construction on both upstream and downstream of the stream, including part of the stream being constructed on. Hence, the impact intensity would be **Medium**, and impact consequence would be **Low**. The likelihood of runoff flowing into D7 would be **Certain**, and hence impact on D7 is **Moderate**.

8.7.1.2.2 Chemical Substances

Human Impact

During maintenance of construction vehicles or mechanical equipment, the chemical substances such as fuel and lubricants may accidentally spill and leak to the surrounding streams or drains. Given the relatively small quantities of such potential spills, the impact intensity would be **Medium**. Since the local residents and visitors have been categorised as Priority 1 sensitive receptor, the impact consequence would be **Medium** (refer to the Table 6-5). With the minimum controls, such as proper SOP and storage of chemicals in containers, spillage of chemical substances could happen throughout the construction period with an **Unlikely** likelihood, the impact significance is assessed to be **Negligible** on local residents and visitors.

Ecological Impact

The ecology in the surroundings of the Project Site might be affected by the water quality contamination due to improper management of chemical substances from the construction activities. Many chemicals, especially metals, have lower Aquatic Criteria than NEA Limits (Table 8-1). With the minimum controls, such as proper SOP and storage of chemicals in containers, a small amount of spillage of chemicals therefore have potential to cause a **Medium** impact intensity on these streams (D1, D14, D15) and pond (D4), as they are largely not expected to be within construction sites. Subsequently, impact consequence on Priority 1 watercourses/bodies D1, D4, D14 and D15 are **Medium**. As Bukit Tinggi stream D15 is located on a higher elevation compared to the surrounding Study Area and far away from any construction sites, it is not expected that the potential contamination of water within future construction site would propagate upstream. Therefore, the likelihood of spillage into Bukit Tinggi stream D15 is **Unlikely** and impact significance on Bukit Tinggi stream D15 is **Negligible**. On the other hand, unmanaged pond D4 sits on a lower elevation than some of the development sites. Hence, the likelihood is **Less Likely** and impact significance on pond D4 is **Minor**. For stream D1 and earth drain D14, they will have part of their catchment constructed on, and hence it is **Likely** that some chemicals may spill into the watercourses. Therefore, there would be a **Moderate** impact on them.

For naturalised stream D7, there would be construction on both upstream and downstream of the stream, including part of the stream being constructed on. Hence, more chemicals are expected to come into contact with

watercourse D7, making the impact intensity **High** and impact consequence **Medium**. The likelihood chemicals entering D7 would be **Certain**, as there would be drain diversions constructed on D7. Hence impact significance on D7 is **Major**.

8.7.1.2.3 Domestic Wastes

Human Impact

During construction phase, domestic wastes will be generated from workers. Surface water contamination may occur due to improper storage, handling, transfer and disposal of the domestic wastes. As domestic wastes are high in organics and nutrients, the impact intensity on human would be **Medium**. Therefore, impact consequence was considered to be **Medium** on local residents and visitors (Priority 1). Given the assumptions that the appropriate minimum control measures have been applied, including placing toilet facilities away from watercourses, and regular cleaning of the toilets and septic tanks, the improper discharge of domestic wastes could happen throughout the construction period with an **Unlikely** likelihood, the impact significance is **Negligible** on local residents and visitors.

Ecological Impact

Domestic waste spillage into watercourses would temporarily increase parameters such as TOC and *Enterococcus* due to the streams generally being of flowing water, and thus would be of **Low** impact intensity on watercourses/bodies that are largely expected to be outside the construction sites (i.e. watercourses D1, D14 and D15 and pond D4). Subsequently, impact consequence on Priority 1 watercourses/bodies D1, D4, D14 and D15 are **Low**. As Bukit Tinggi stream D15 is located on a higher elevation compared to the surrounding Study Area, such spillages from the construction site into Bukit Tinggi stream (D15) would be **Unlikely**. On the other hand, pond D4, sits on a lower elevation than some of the development sites but is not within any construction site and hence has a **Less Likely** likelihood of getting contaminated with domestic wastes, with the minimum controls in place, including placing toilet facilities away from watercourses, and regular cleaning of the toilets and septic tanks. Overall, the impact significance on naturalised stream D15 and pond D4 would be **Negligible** and **Minor** respectively. For stream D1 and earth drain D14, they will have part of their upstream catchment constructed on, and hence it is **Possible** that some domestic wastes may spill into the watercourses. Therefore, there would be a **Minor** impact on them.

For naturalised stream D7, there would be construction on both upstream and downstream of the stream, including part of the stream being constructed on, implying it would lie within a construction worksite. Hence, a higher amount of domestic wastes could potentially contaminate watercourse D7, making the impact intensity **Medium** and impact consequence **Low**. The likelihood of domestic wastes contaminating D7 would be **Possible**. Hence impact significance on D7 is **Minor**.

8.7.1.2.4 Construction Wastewater

Human Impact

During construction phase, the liquid effluents generated from the construction activities commonly include extracted groundwater. The elevated suspended solids of liquid effluents will lead to increased turbidity and may cause a **Medium** impact intensity to the watercourses with the minimum controls, such as containment of wastewater in impervious ponds/kerbs and cut-off drains around the worksite. Therefore, impact consequence was considered to be **Medium** on local residents and visitors (Priority 1). The likelihood of construction wastewater spillage affecting local residents and visitors is **Unlikely** with the aforementioned minimum controls, hence the impact significance is assessed to be **Negligible** on the local residents and visitors.

Ecological Impact

As for ecological impacts, impact consequence on watercourses/bodies that are largely expected to be outside the construction sites (i.e. watercourses D1, D14 and D15 and pond D4) would be **Medium**. As Bukit Tinggi is located on a higher elevation compared to the surrounding Study Area, such spillages from the construction site into Bukit Tinggi stream (D15) would be **Unlikely**. On the other hand, pond D4, sits on a lower elevation than some of the development sites but is not within any construction site and hence has a **Less Likely** likelihood of getting contaminated construction wastewater. For stream D1 and earth drain D14, they will have part of their upstream catchment constructed on and turned into the development sites, making it is **Likely** that some construction wastewater may spill into these watercourses. Hence, impact significance on naturalised stream D15, pond D4, natural stream D1 and earth drain D14 would be **Negligible**, **Minor**, **Moderate** and **Moderate** respectively. For

naturalised stream D7, there would be construction on both upstream and downstream of the stream, including part of the stream being constructed on for drain diversions. Hence, more construction wastewater is expected to come into contact with watercourse D7, making the impact intensity **High** and impact consequence **Medium**. The likelihood construction wastewater entering D7 would be **Certain**, as there would be drain diversions constructed on D7. Hence impact significance on D7 is **Major**.

8.7.1.2.5 Solid Wastes

Human Impact

Activities that are planned for the construction phase of the Project (as described in the Section 3.2) could result in generation of various solid wastes which could have significant adverse effects on the water quality of the identified streams and drains. However, quantity of the waste stored on the site (e.g. chemical waste, construction debris, wood waste etc.) is expected to be limited and it would be periodically removed by the licensed waste management contractors. It is expected that, after implementation of the minimum control measures, such as a proper SOP for the handling, transfer, storage and disposal of waste and enclosed bins for disposal, with regular clearing from site, only small amounts of waste may be spilled and hence the impact intensity on local residents and visitors would be **Low**. Hence, impact consequence will be **Low** on local residents and visitors (Priority 1). Given the minimum controls, the expected likelihood of such solid waste spillage is **Unlikely** to affect the humans, hence impact significance is assessed to be **Negligible** on local residents and visitors

Ecological Impact

With the minimum controls, the spillage of solid wastes may have a **Low** impact intensity and consequence on Priority 1 watercourses/bodies D4 and D15, which sit outside of any construction sites. Bukit Tinggi is located on a higher elevation compared to the surrounding Study Area, such spillages from the construction site into Bukit Tinggi stream (D15) would be **Unlikely**. On the other hand, pond D4 sits on a lower elevation than some of the development sites and hence has an **Unlikely** likelihood with the minimum controls such as a proper SOP for the handling, transfer, storage and disposal of waste and enclosed bins for disposal, with regular clearing from site. Overall, the impact significance on naturalised stream D15 and on pond D4 would be **Negligible** and **Minor** respectively.

For stream D1 and earth drain D14, they will have part of their upstream catchment constructed on, and hence there is a higher amount of solid wastes that could potentially contaminate these watercourses, making the impact intensity and consequence of these watercourses **Medium**. It is **Likely** that some solid wastes may spill into the watercourses. Therefore, there would be a **Moderate** impact on D1 and D14.

For naturalised stream D7, there would be construction on both upstream and downstream of the stream, including part of the stream being constructed on, implying it would lie within a construction worksite. Hence, a higher amount of solid wastes could contaminate watercourse D7, making the impact intensity **High** and impact consequence **Medium**. The likelihood of domestic wastes contaminating D7 would be **Certain**, due to the drain diversions being constructed on it. Hence impact significance on D7 is **Major**.

Table 8-12 Summary of impact evaluation during construction phase

Potential Source of Impact	Receptor Sensitivity	Impact Intensity	Consequence	Likelihood	Significance
Stormwater Runoff Generation (Hydrology)	Human Impact				
	Humans – in the vicinity of the Project Site (Priority 2)	Negligible	Imperceptible	Less Likely	Negligible
	Ecological Impact				
	Eng Neo natural stream D1 and Bukit Tinggi naturalised stream D15 (Priority 1)	Negligible	Very Low	Certain	Minor

Potential Source of Impact	Receptor Sensitivity	Impact Intensity	Consequence	Likelihood	Significance
	Unmanaged pond D4 (Priority 1)	High	High	Certain	Major
	Naturalised stream D7 (Priority 2)	High	Medium	Certain	Major
	Bukit Tinggi earth drain D14 (Priority 1)	Low	Low	Certain	Moderate
Stormwater Runoff Generation (Water Quality)	Human Impact				
	Local residents and visitors (Priority 1)	Low	Low	Unlikely	Negligible
	Ecological Impact				
	Eng Neo natural stream D1 and Bukit Tinggi earth drain D14 (Priority 1)	Low	Low	Likely	Moderate
	Unmanaged pond D4 (Priority 1)	Low	Low	Less Likely	Minor
	Naturalised stream D7 (Priority 2)	Medium	Low	Certain	Moderate
	Bukit Tinggi naturalised stream D15 (Priority 1)	Low	Low	Unlikely	Negligible
Chemical Substances (Water Quality)	Human Impact				
	Local residents and visitors (Priority 1)	Medium	Medium	Unlikely	Negligible
	Ecological Impact				
	Eng Neo natural stream D1 and Bukit Tinggi earth drain D14 (Priority 1)	Medium	Medium	Likely	Moderate
	Unmanaged pond D4 (Priority 1)	Medium	Medium	Less Likely	Minor
	Naturalised stream D7 (Priority 2)	High	Medium	Certain	Major
	Bukit Tinggi naturalised stream D15 (Priority 1)	Medium	Medium	Unlikely	Negligible
Domestic Wastes (Water Quality)	Human Impact				
	Local residents and visitors (Priority 1)	Medium	Medium	Unlikely	Negligible
	Ecological Impact				
	Eng Neo natural stream D1 and Bukit Tinggi earth	Low	Low	Possible	Minor

Potential Source of Impact	Receptor Sensitivity	Impact Intensity	Consequence	Likelihood	Significance
	drain D14 (Priority 1)				
	Unmanaged pond D4 (Priority 1)	Low	Low	Less Likely	Minor
	Naturalised stream D7 (Priority 2)	Medium	Low	Possible	Minor
	Bukit Tinggi naturalised stream D15 (Priority 1)	Low	Low	Unlikely	Negligible
Construction Wastewater (Water Quality)	Human Impact				
	Local residents and visitors (Priority 1)	Medium	Medium	Unlikely	Negligible
	Ecological Impact				
	Eng Neo natural stream D1 and Bukit Tinggi earth drain D14 (Priority 1)	Medium	Medium	Likely	Moderate
	Unmanaged pond D4 (Priority 1)	Medium	Medium	Less Likely	Minor
	Naturalised stream D7 (Priority 2)	High	Medium	Certain	Major
	Ecology – Habitat of Bukit Tinggi Stream D15 (Priority 1)	Medium	Medium	Unlikely	Negligible
Solid Wastes (Water Quality)	Human Impact				
	Local residents and visitors (Priority 1)	Low	Low	Unlikely	Negligible
	Ecological Impact				
	Eng Neo natural stream D1 and Bukit Tinggi earth drain D14 (Priority 1)	Medium	Medium	Likely	Moderate
	Unmanaged pond D4 (Priority 1)	Low	Low	Less Likely	Minor
	Naturalised stream D7 (Priority 2)	High	Medium	Certain	Major
	Bukit Tinggi naturalised stream D15 (Priority 1)	Low	Low	Unlikely	Negligible

8.7.2 Operational Phase

As described in Section 8.3, the major sources of impacts on hydrology and surface water quality during operational phase are altered stormwater runoff, stormwater runoff contamination and improper management of liquid and solid wastes. The potential source of altered stormwater runoff will mostly impact the existing hydrological conditions of the site, while the rest of the impact sources will mostly have an impact on surface water quality. The sources of impacts will be assessed qualitatively using the risk matrix method as presented in Section 6.4 and are presented in this section.

8.7.2.1 Hydrology

8.7.2.1.1 Altered Stormwater Runoff

Human Impact

Higher percentage of urbanised areas is known to have an impact on the surface water runoff, both in quantity and quality. Hence, it is expected that the proposed future land use which includes the residential and commercial developments will have an impact on the hydrology during operational phase of the Project, especially during storm events. Increased runoff flow peak is expected in such events which could consequently lead to elevated water depths in drainage system and potentially cause flooding to the surrounding areas. It is assessed that the impact intensity on the human receptors including the residents and visitors within and nearby the proposed development would be **Medium**. Since the human receptors have been categorised as Priority 2 sensitive receptors, the impact consequence would be **Low** (refer to Table 6-5). Since the detention system will be provided as required in PUB's COP on Surface Water Drainage (2023) to capture the stormwater during heavy storm events to reduce the peak runoff and to ensure zero increase in flood peak from the baseline condition, the likelihood of such floods is considered **Less Likely**, and the impact significance would be **Minor** (based on Impact Significance Matrix of Table 6-7).

Ecological Impact

Based on the proposed landuse, majority of Eng Neo Avenue Forest and Bukit Tinggi will be retained. Hence, an estimated 80% or more of the catchment area of natural stream D1 (in Site A) and naturalised stream D15 (in Site C) will be retained during the construction of the Project Site. The remaining developed parts of the Project Site will have runoff directed away from these forests catchments and minimally contribute to its hydrology. As such, the hydrological impacts onto the streams are classified as **Negligible**. Since these ecological receptors are classified as Priority 1 receptors, their impact consequence is **Very Low**. The change in catchment area is **Certain** to occur, and thus the impact significance is **Minor**. For naturalised stream D14 (in Site C), the upstream portion of its catchment, will reduce by less than half, due to the developments nearby. Hence, impact intensity is **Low**. As D14 is a Priority 1 receptor, the impact consequence is **Low**. The catchment area change is **Certain** to occur, and thus impact significance is **Moderate**.

Due to the developments close to the unmanaged pond (D4) and the naturalised stream D7, their catchments will be reduced by more than half. Hence, the impact intensity on the hydrology of these streams' catchments will be **High**. As pond D4 is Priority 1 and naturalised stream D7 is Priority 2, the impact consequences on both watercourses are **High** and **Medium** respectively. The catchment change is **Certain** to occur, making the impact significance on pond D4 and naturalised stream D7 **Major**.

8.7.2.2 Surface Water Quality

8.7.2.2.1 Stormwater Runoff Contamination

Human Impact

The land use of the Project Site will become more urbanised once in operational phase, causing a change in surface runoff water quality. The estimated impact intensity of stormwater runoff contamination on the watercourses would be **Negligible**. Since local residents and visitors have been categorised as Priority 1 sensitive receptors, the impact consequence would be **Very Low** (refer to Table 6-5). With the minimum controls such dedicated procedures for stormwater management, wastewater and solid waste management practice, the likelihood of stormwater contamination within NEA Limits affecting humans is **Unlikely**. Therefore, the impact significance on local residents and visitors will be **Negligible**.

Ecological Impact

Based on the schematic drainage plan, the flow within the developed urbanised areas will be directed away from catchments of natural stream D1 (serving the habitat in Eng Neo Avenue Forest), unmanaged pond D4, and earth drain D14 and naturalised stream D15 (serving Bukit Tinggi). Since these ecological receptors are classified as Priority 1 receptors, their impact consequence is **Low** (as the potential impact intensity remains **Low**). The likelihood of the surface runoff contamination is **Unlikely**, and thus the impact significance is **Negligible**. Naturalised stream D7 is a Priority 2 and hence the impact consequence will be **Very Low**. The runoff from the surrounding will be directed into naturalised stream D7, thus the likelihood is **Likely** and impact significance is **Minor**.

8.7.2.2.2 Improper Management of Liquid and Solid Wastes

Human Impact

During operation phase, the surface water in the Project and surroundings watercourses might easily be contaminated due to inappropriate disposal and storage of liquid and solid wastes. The impact intensity of improper management of liquid and solid wastes on the local residents and visitors would be **Medium**. Since the humans (local residents and visitors) have been categorised as Priority 1 sensitive receptor, the impact consequence would be **Medium** (refer to Table 6-5). By providing inspection on wastes storage system and monitor the proposed watercourses of the operational footprint, **Less Likely** likelihood of the impact would be expected on the local residents and visitors, the impact significance is considered as **Minor**.

Ecological Impact

The Eng Neo Avenue Forest, Bukit Tinggi and forest next to Turf Club Road (within current Site B) area are planned to be retained forests with trails. With minimum controls, there would likely be disposal bins prepared in areas that humans will enter, with adequate signages prohibiting littering. Routine checks on watercourses to ensure it is free of contamination is also expected. Also, as it is retained forests with trails, the amount of humans entering these spaces are considered to be low. With this, the impact intensity of improper management of wastes on these areas may be **Low**, and hence the impact consequence is **Low** (on stream D1, pond D4, and earth drain D14 and naturalised stream D15, all Priority 1) and **Very Low** (on naturalised stream D7, Priority 2). The likelihood of such contamination is **Less Likely** on D1, D4, D14 and D15, which is separated from development sites, while likelihood is **Possible** on D7, which is in between developed sites. Therefore impact significance is **Minor** on ecology.

Table 8-13 Summary of impact evaluation during operational phase

Potential Source of Impact	Receptor Sensitivity	Impact Intensity	Consequence	Likelihood	Significance
Altered Stormwater Runoff (Hydrology)	Human Impact				
	Residents and visitors within the proposed development (Priority 2)	Medium	Low	Less Likely	Minor
	Ecological Impact				
	Eng Neo natural stream D1 and Bukit Tinggi naturalised stream D15 (Priority 1)	Negligible	Very Low	Certain	Minor
	Unmanaged pond D4 (Priority 1)	High	High	Certain	Major
	Naturalised stream D7 (Priority 2)	High	Medium	Certain	Major

Potential Source of Impact	Receptor Sensitivity	Impact Intensity	Consequence	Likelihood	Significance
	Bukit Tinggi earth drain D14 (Priority 1)	Low	Low	Certain	Moderate
Stormwater Runoff Contamination (Surface Water Quality)	Human Impact				
	Local residents and visitors (Priority 1)	Negligible	Very Low	Unlikely	Negligible
	Ecological Impact				
	Eng Neo natural stream D1, unmanaged pond D4, and Bukit Tinggi earth drain D14 and naturalised stream D15 (Priority 1)	Low	Low	Unlikely	Negligible
	Naturalised stream D7 (Priority 2)	Low	Very Low	Likely	Minor
Improper Management of Liquid and Solid Wastes (Surface Water Quality)	Human Impact				
	Local residents and visitors (Priority 1)	Medium	Medium	Less Likely	Minor
	Ecological Impact				
	Eng Neo natural stream D1, unmanaged pond D4, and Bukit Tinggi earth drain D14 and naturalised stream D15 (Priority 1)	Low	Low	Less Likely	Minor
	Naturalised stream D7 (Priority 2)	Low	Very Low	Possible	Minor

8.8 Recommended Mitigation Measures

In this section, mitigation measures were proposed to further minimise the adverse impacts on the environment where impact significance were assessed to be Moderate or Major during both construction and operational phases.

8.8.1 Construction Phase

From previous sections, it was expected that there would be major impact on hydrology of unmanaged pond D4 and naturalised stream D7, while moderate impact on Bukit Tinggi earth drain D14 during construction phase. Hydrological conditions of the streams are expected to change with catchment modification and may affect the ecology surrounding. Hence, it is recommended to redirect clean water from elsewhere that have similar water quality (e.g. other forested runoff) or do not exceed the Aquatic Criteria into these affected watercourses/bodies to match the existing base flow discharge to each waterbody. The streams and pond should be also monitored during construction phase to ensure that there are as minimal changes as possible in the hydrology (i.e. the discharge within the stream during dry weather) or water quality of the waterbodies.

For water quality, it was expected that moderate to major impacts on Eng Neo natural stream D1, naturalised stream D7, and Bukit Tinggi earth drain D14. Due to the construction expected on the naturalised stream D7, natural stream D1 and earth drain D14, mitigation measures are required. For natural stream D1 and earth drain D14, a cut-off berm structure or equivalent should be provided to block its upstream of tributary to minimise water quality contamination from the worksite to its downstream. For naturalised stream D7, the drain diversions should be completed prior to connection. Silt curtains or equivalent should be provided during the connection to prevent contamination to the upstream.

In addition, due to the ecological sensitive waterbodies in the Study Area, it is not recommended to allow the waters or discharges from construction sites to flow into the ecologically sensitive watercourses/bodies that are planned to be retained (i.e. unmanaged pond D4, and naturalised streams D7, earth drain D14 and natural stream D1). Discharges from the site should be directed into less ecologically sensitive watercourses (such as roadside drains).

It is also to note that ECM implementation of bare soil/stockpile coverage during heavy rainfall are sometimes not sufficiently quick, leading to high TSS concentrations in watercourses. Hence, it is recommended that coverage of all bare/erodible surfaces are to be done as soon as possible when works are complete or at the start of heavy rain and cessation of works are necessary, implying that tarp or other coverage material should always be on standby next to bare soil.

8.8.2 Operational Phase

Moderate and major impact significance is expected on hydrology (i.e. stormwater runoff quantity) for retained ecologically sensitive waterbodies D4, D7, and D14. Avoiding this source of impact would reduce the land available for residential development and may not be feasible. To remedy some of the hydrological changes, especially on waterbodies with major impact, some of the runoff from the developed locations can potentially be directed towards the retained waterbodies. If possible, this redirected runoff could be cleansed first through Active, Beautiful, Clean (ABC) Waters Design approach [P-50]. This includes adding features such as bioretention swales, rain gardens, constructed wetlands and green roofs prior to flowing into these retained watercourses/bodies. These features can reduce the peak-flow (due to a change in land use), and provide runoff treatment through sedimentation, filtration, and biological uptake. ABC Waters Design can also be adopted along other areas of the development, which can treat the runoff from the Project Site before flowing into the reservoir. Such design will introduce more greenery in the proposed development and enhance biodiversity value of the project.

8.9 Residual Impacts

A residual impact assessment has been undertaken assuming the mitigation measures recommended in the previous section have been implemented.

For surface water quality impacts (stormwater runoff generation – water quality) during construction phase, with the implementation of the recommended mitigation measures in conjunction with the identified minimum controls, the residual likelihood can be reduced to **Less Likely** (natural stream D1 and earth drain D14), and residual impact significance can be reduced to **Minor** for D1 and D14. For naturalised stream D7 with the immediate presence of

segment adjacent to the construction site, likelihood of stormwater runoff contamination remains as certain, and thus the impact significance remains as **Moderate**.

For surface water quality impacts (chemical substances, construction wastewater and solid wastes) during construction phase, with the implementation of the recommended mitigation measures in conjunction with the identified minimum controls, the residual likelihood can be reduced to **Less Likely** (natural stream D1 and earth drain D14), and residual impact significance can be reduced to **Minor** for D1 and D14. For naturalised stream D7 with the immediate presence of segment adjacent to the construction site, likelihood of these sources of impacts are reduced to **Likely**, while the impact residual intensity can be reduced to **Medium** (making impact consequence **Low**). Thus, the impact significance on D7 reduces to **Moderate**.

For hydrological impacts (catchment reduction) during both construction and operational phase, with the implementation of the recommended mitigation measures in conjunction with the identified minimum controls, the residual impact intensity on ecology (natural stream D1, pond D4, naturalised stream D7 and earth drain D14) can be reduced to **Negligible**, making the residual impact significance **Minor**.

8.10 Cumulative Impacts

There is no information on any future developments within or surrounding the surrounding Project Site, except for Turf City MRT station, which has been assessed in a separate study. For hydrology and water quality, the impacts from the Turf City MRT works are not expected to exacerbate the impacts of the Project as the works on the same site are expected to occur at different times, and thus not affecting the same waterbody concurrently. Hence, there is no need to assess cumulative impacts.

8.11 Summary of Key Findings

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, topographic data, and secondary data such as catchment and drainage map.

Twenty-seven (27) water catchment areas were delineated from the Study Area and its vicinity. There are a total of sixteen (16) watercourses identified for hydrology and water quality analysis within the Study Area. Four (4) watercourses are in Site A, which includes a man-made ephemeral earth drain, an ephemeral concrete drain, an Unmanaged pond and a natural stream. In Site B, there are two (2) perennial naturalised drains, with the northeastern one connecting to an ephemeral concrete drain at its upstream. Site C has a man-made earth drain cum concrete drain which merge with a naturalised stream. A perennial man-made earth drain is located in Site D. Site E has eight watercourses, including two man-made managed ponds, one naturalised stream with two tributaries, one roadside drain, and two concrete drains. One main canal exists in Site F.

Stream mapping was conducted for the main streams in Sites A, B, C and E. The natural stream in Site A has natural earth banks throughout the entire length of the stream. However, the bank conditions, such as the bank slope gradient and stream width, are varied from its upstream to downstream. It was found that the pond area at upstream of the natural stream in Site A discharges flow downstream. Generally, the upstream of this natural stream is relatively wide and has earth banks with milder slopes. The midstream has a narrower width, steeper slopes and there were many medium to large rocks present along the stream bed. The natural stream gradually widened again downstream, had milder/ almost flat bank slopes and the bed substrate was a mixture of sand and numerous small rocks.

The naturalised stream in Site B is a concrete pond upstream that overflows into a shallow flooded grassland area that later becomes a stream with sandy bed with root banks. The water then discharges into a concrete drain with naturalised banks midstream, which varies with width throughout the course, before disappearing into a series of culverts and re-emerging in a stagnant stream with soft clay-like banks covered in leaf litter. This natural portion only lasts a small section, as it becomes a concrete drain downstream. Generally, the water flow in this stream is very low, except in shallower or narrower portions.

As for the main naturalised stream in Site C, the watercourse has alternating stretches of natural bed substrate with earth banks, naturalised concrete drain and concrete drains. Its upstream consisted of naturalised concrete

drains with mild sloping/ flat banks. Its midstream consists of earth banks with varying slope gradients and varying stream width and depths. The downstream of Site C consists of concrete drains and naturalised concrete drains, which joins with the concrete drain along the western portion of Site C at the confluence point, from which water flows out of the site.

In Site E, the naturalised stream D12-A starts off as an almost stagnant concrete ponds which narrows down into a smaller stream with faster flow downstream, before widening again further downstream. D12-A has fairly consistent sandy-clay banks and sandy beds. However, bricks were observed in the streams at a couple of locations. Similarly, the naturalised stream D12-B starts off with as a stagnant body of water which narrows down into a smaller stream before widening again further downstream. However, flow in D12-B is overall slower than that of D12-A. D12-B has alternating stretches of vegetated earth banks and concrete banks and also receives flow from D7 midstream. Eventually, D12-A and D12-B merge in a Y-shape at a location with sandy bed and vegetated banks to become naturalised stream D12, which downstream becomes concretised and eventually flows out of the Study Area as a concrete drain along Eng Neo Avenue.

Thirty-five (35) water quality sampling locations have been identified based on hydrological findings, including nine sampling points in Site A (i.e. WQA1 – WQA9), six in Site B (i.e. WQB1 – WQB6), four in Site C (i.e. WQC1 – WQC4), two in Site D (i.e. WQD1, WQD2), thirteen in Site E (i.e. WQE1 – WQE13) and one in Site F (i.e. WQF1).

Water samples were tested for the parameters temperature, pH, conductivity, turbidity,, total dissolved solids (TDS), dissolved oxygen (DO), total nitrogen (TN), total phosphorus (TP), nitrates (NO₃-N), total ammonia nitrogen (TAN) (NH₄-N and NH₃-N), orthophosphates (PO₄-P), total suspended solids (TSS), total organic carbon (TOC), aluminium, antimony, arsenic, barium, beryllium, boron, cadmium, chromium, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, tin, zinc, cyanide, sulphide and *Enterococcus*.

Water samples in Site A were generally of good quality, although phosphorus, aluminium and iron typically exceeded guidelines but are likely due to natural sources. Only some locations had low DO, likely due to the low flow rates observed at the sites.

The water in Site B was poorer in naturalised stream D7, compared to roadside drain D6, with high turbidity at some locations due to the presence of visible bacteria films. DO was consistently low in naturalised stream D7 in dry weather due to low flow. Arsenic also exceeded guidelines at the upstream location in dry weather.

In Site C, water quality was better in dry weather, although pH could be slightly acidic, and phosphate was high. During wet weather Aquatic Criteria exceedances of copper, lead and nickel were detected. DO is also low in the earth drain in dry weather, due to the low flow.

Site D waters are generally good quality albeit high phosphate content. However, in wet weather, TSS can spike to high concentrations, likely due to sediment in runoff from the steep ravine slopes.

Many watercourses/bodies exist in Site E with varying water quality. The golf course ponds generally have lower DO content especially in dry weather but are overall good water quality. Only iron consistently exceeds guidelines in the golf ponds but is a naturally occurring mineral in soils. The concrete drains along Turf Club Road (D10) and along Swiss Club residential (D13) had no exceedance except aluminium, which is a typical exceedance due to its naturally high content in soils. The naturalised stream D16 along Merlion Sports field is also of good quality, albeit the consistently low DO. This could be due to the high amount of decomposing leaf litter in the base of the stream. The largest stream in Site E is D12, which receives inflow from tributaries D12-A, D12-B and D7. D12-B and D7 are largely stagnant watercourses in dry weather, and hence have low DO. There are no metal exceedances in naturalised stream D12 or its tributaries, except for iron and aluminium, which are naturally occurring minerals in soil. Generally, D12 and its tributaries have high phosphate content, especially in wet weather, due to the high nutrient content of surrounding forests.

The water in Site F had exceedance of arsenic in all weathers and may be due to the traffic pollution along Eng Neo Avenue. There was also phosphate, aluminium and iron exceedance, and could come from upstream (natural stream D1).

The proposed construction activities with minimum control measures result in hydrological and water quality impact significances that were **Negligible** on humans and **Negligible to Major** on ecological receptors. For ecological impacts, moderate to major impacts are expected from hydrological changes of retained pond D4, naturalised stream D7 and earth drain D14, as their catchment sizes would change by 40% or more. Avoiding such catchment changes will mean to reduce the land available for development, and may not be feasible. Hence, cleaner waters from elsewhere can instead be diverted into the watercourses/bodies to ensure minimal hydrological changes. It is

however not advisable to discharge runoff from construction sites into the ecologically sensitive watercourses/bodies as it may contaminate the watercourses/bodies. With this, hydrological impacts on ecology will reduce to **Minor** during construction phase. Water quality impacts on ecology are generally **Negligible to Major**, with moderate to major impacts arising from the construction on partially retained watercourses D1, D7 and D14. These impacts can be reduced to **Minor to Moderate** respectively, by having mitigating measures to prevent contamination flowing into the rest of the retained portion of the streams during construction. It should be noted that the impact cannot be reduced further mainly due to the immediate presence of naturalised stream segment in Site B (D7) adjacent to the construction site.

The operational phase impact significance of hydrology and water quality are **Negligible to Minor** on humans, and **Negligible to Major** on ecology. Changes in catchment area will cause moderate to major impacts on the retained ecologically sensitive watercourses/bodies. It is proposed that some of the runoff from the developments can be channelled to the affected watercourses/bodies, but the runoff is recommended to be cleansed first through features such as ABC Waters Design, where possible. Diversion of water into these affected catchments could reduce to ecological hydrological impacts to **Minor**.

Table 8-14 Summary of hydrology and water quality impact assessment

Potential Source of Impact	Impact Significance with Minimum Control	Key Mitigation Measures (if any)	Residual Impact Significance with Mitigation Measures (if required)
Construction Phase			
Stormwater Runoff Generation (Hydrology)	- Human: Negligible - Ecology: Minor to Major	Redirect clean water into retained ecologically sensitive watercourses/bodies with significant catchment loss (i.e. pond D4, naturalised stream D7 and earth drain D14)	- Human: N.A. - Ecology: Minor
Stormwater Runoff Generation (Water Quality)	- Human: Negligible - Ecology: Negligible to Moderate	- Prohibit any discharges from construction site into retained ecologically sensitive watercourses/bodies (i.e. D1, D4, D7, D14 and D15) - Build a berm structure or equivalent at the upstream of tributary of natural stream D1 and earth drain D14 prior to construction works (e.g. backfilling) - Complete drain diversion construction prior to connection with naturalised stream D7 - Provide silt curtains or equivalent when connecting naturalised stream D7 to the drain diversion - Coverage of all bare/erodible surfaces are to be done as soon as possible when works are complete or at the start of heavy rain and cessation of works are necessary, implying that tarp or other coverage material should always be on standby next to bare soil	- Human: N.A. - Ecology: Negligible to Moderate
Chemical Substances (Water Quality)	- Human: Negligible - Ecology: Negligible to Major		- Human: N.A. - Ecology: Negligible to Moderate
Domestic Wastes (Water Quality)	- Human: Negligible - Ecology: Negligible to Minor		N.A.
Construction Wastewater (Water Quality)	- Human: Negligible - Ecology: Negligible to Major		- Human: N.A. - Ecology: Negligible to Moderate
Solid Wastes (Water Quality)	- Human: Negligible - Ecology: Negligible to Major		- Human: N.A. - Ecology: Negligible to Moderate
Operational Phase			
Altered Stormwater Runoff (Hydrology)	- Human: Minor - Ecology: Minor to Major	Redirect clean water into retained ecologically sensitive watercourses/bodies with significant catchment loss (i.e. pond D4, naturalised stream D7, earth drain D14) to increase the flow into these watercourses/bodies. If possible, the water can be from ABC Waters Design features	- Human: N.A. - Ecology: Minor

Potential Source of Impact	Impact Significance with Minimum Control	Key Mitigation Measures (if any)	Residual Impact Significance with Mitigation Measures (if required)
Stormwater Runoff Contamination (Water Quality)	- Human: Negligible - Ecology: Negligible to Minor	-	N.A.
Improper Management of Liquid and Solid Wastes (Water Quality)	- Human: Minor - Ecology: Minor		N.A.

9 Soil and Groundwater

9.1 Introduction

Activities during construction and operational phase of the Project, if not managed properly, could potentially lead to contamination of soil and groundwater. In addition to that, during the pre-construction and construction activities such as land preparation and excavation for construction works there is also a potential to encounter historically contaminated soils and groundwater. This section presents the assessment undertaken to define the nature and scale of potential impacts that soil and groundwater can have on identified sensitive receptors associated with the Project's construction and operational phase. This section also outlines appropriate controls and best management practices.

9.2 Methodology and Assumptions

This section outlines the methodology adopted for the soil and groundwater baseline studies as well for impact assessment for both construction and operational phases of the Project.

9.2.1 Soil and Groundwater Baseline Study

The purpose of soil and groundwater baseline study was to determine the soil profile of the Study Area, hydrogeological conditions of the aquifer and soil and groundwater chemistry which may potentially have adverse impacts on the surrounding vegetation and downstream waterbodies, and eventually impacting humans, habitats and biodiversity (e.g. current and future users of the area, groundwater-dependent habitats and flora and fauna species). Furthermore, this baseline study will assess the presence of possible pollutants in the underlying soil and groundwater that may impact the local biodiversity and humans.

Soil baseline conditions of the Study Area were determined from the primary data (collected during field surveys) and secondary data (obtained from desktop research). Field surveys included array of activities such as site reconnaissance, drilling of boreholes and soil sampling. Desktop research included review and analysis of relevant publicly available secondary data as well as review and analysis of the data provided by the Client and other Agencies. Following sub-sections detail the methodologies used for data collection and analysis of the collected baseline data.

Groundwater baseline conditions of the Study Area were obtained from the previous EIA study at the Site commissioned by LTA [R-92]. The groundwater data is supplemented by updated gauging records of the stabilised water level (SWL) or water first noticed during borehole drilling.

9.2.1.1 Baseline Data Collection Methodology

9.2.1.1.1 Desktop Research

As a part of desktop research, AECOM reviewed available site-specific public utility drawings (i.e. drainage, water services, sewer, telecommunication and electrical lines) to assess the presence of utilities at the proposed borehole locations. The historical use of land was analysed (refer to Section 4.1 of this Report) in order to assess possibility of historical contamination of underlying soil. Furthermore, geological conditions of the Study Area have been determined based on geological maps of Singapore [M-5] in order to better understand soil and hydrogeological conditions of the area (refer to the Section 4.3 of this Report).

Information from past environmental site investigation / environmental site assessment / environmental baseline study report(s) and observations from a site reconnaissance were considered to better refine the positioning of the borehole locations. AECOM reviewed information from the CRL2 EIA report [R-92], as approved by URA and LTA, particularly for information on the groundwater quality. The groundwater quality is summarised in Section 9.4.2.3.

9.2.1.1.2 Soil and Groundwater Field Investigations

Soil and groundwater field investigations included the following tasks:

- Site reconnaissance and underground utilities detection;
- Drilling of three (3) boreholes at the Study Area and collection of nine (9) soil samples as per PUB's requirement via URA on 1 November 2022;

- Gauging of groundwater (first noticed or the SWL) during drilling of boreholes;
- In-situ measurements and laboratory analysis of collected soil.

9.2.1.1.2.1 Site Reconnaissance and Underground Utilities Detection

Site reconnaissance was carried out in order to do visual inspection of the Study Area and obtain preliminary information regarding Study Area's topography, geology, soil conditions, watercourses as well as flora and fauna presence. Information gathered during the site reconnaissance was also used when finalizing the locations of boreholes as a part of this study.

Justifications for the borehole locations are shown in the Table 9-1. The locations of the boreholes are shown in Figure 9-2.

Table 9-1 Rationale for the selection of boreholes and monitoring wells' locations with photos

Borehole/ Monitoring Well ID	Monitoring Location	Justification	Photo of Installed Monitoring Well
TC-BH01	Located within Site E, within the vicinity of Turf City, on a greenfield along an access road.	• To determine the soil profile and groundwater level of the Study Area i.e. at within Turf City, Champion Golf course and a PUB site (Site A). • To assess the presence of possible pollutants in the underlying soil and groundwater that may impact the local vegetation and surrounding waterbodies.	
TC-BH02	Located within Site E, within the premises of the Champion Golf Course, adjacent to the maintenance area.		
TC-BH03	Located in Site A, within PUB land. Adjacent to a one-way road, approximately 500 m from the entrance gate.		

Before the commencement of intrusive works (i.e. borehole advancement), a site utility survey was conducted to assess presence of underground services in the vicinity of the proposed borehole locations.

9.2.1.1.2.2 *Soil Boring and Soil Sampling*

A total of three (3) boreholes, designated as TC-BH01 through TC-BH03 were advanced within the Study Area (refer to the Figure 9-2).

To avoid disruptions to activities within the Study Area (i.e. activities conducted within the and around the Turf City and Champion Golf Course area) all boreholes were advanced by using a hand auger. All boreholes were advanced to depths of between 4.0 m to 6.0 m below ground surface at the borehole location during drilling events.

Soil samples were collected from each borehole at intervals of approximately 0.5 m for soil identification purposes, including assessment of physical properties of soil such as colour, moisture, firmness, plasticity, odour and staining (if any). Furthermore, in-situ measurements of volatile organic compounds (VOCs) by using a photoionization detector (PID) were carried out for each of the collected soil samples. Three (3) soil samples were selected from each of the boreholes and sent for laboratory analysis – one (1) sample from surface layer (i.e. 0.3 m below ground surface [m bgs] to 0.5 m bgs), one (1) soil sample approximately at the observed groundwater level and one (1) sample at the termination depth of the borehole. Detailed soil laboratory analysis programme is described in the Section 9.2.1.1.2.3.



Figure 9-1 Soil boring (TC-BH02)

9.2.1.1.2.3 Soil Laboratory Analysis Programme

The collected soil samples were analysed by a Singapore Accreditation Council (SAC) certified laboratory under the Singapore Laboratory Accreditation Scheme (SINGLAS). The soil parameters that were analysed included the suite of chemicals listed in the Dutch Remediation Circular 2013, as well as sulphide, as advised by PUB through URA. A summary of the soil parameters and their corresponding test methods are presented in the following table.

Table 9-2 Soil parameters analysed and the corresponding test methods

Test Parameter	Test Method
	Soil (mg/kg)
Metals⁷	USEPA 3051A / APHA 3120B / USEPA 245.1 / APHA 3125B
Total Cyanide	APHA 4500-CN(N)
Volatile Organic Compounds (VOCs)	USEPA 5021A / 8260D
Semi-Volatile Organic Compounds (SVOCs), including pesticides⁸	USEPA 3545A / 8270E
Total Petroleum Hydrocarbon (TPH)	USEPA 8015C
Sulphide	USEPA 9030/9031 or similar methods
Moisture (% w/w) and organic matter (%)	BS1377: Pt 2&3: 1990

In-situ measurements of soil parameters including VOCs were carried out using a photoionization detector (PID).

AECOM notes that the soil assessment objective is to collect data to assess the environmental impacts and not for the Building Construction Authority (BCA) or building plan submission purpose (Soil Investigation Report), hence drilling through bedrock was not required.

9.2.1.1.2.4 Groundwater Gauging

As part of baseline study, the stabilised water level was measured during drilling of the boreholes. The groundwater level was gauged using a water level meter, with the reference taken from the ground level. No groundwater sample was collected for laboratory analysis or measurement of groundwater quality parameters.

9.2.1.2 Baseline Data Analysis and Assessment Methodology

The Dutch Intervention Values (DIV) in the Dutch Environmental Guidelines Soil Remediation Circular [R-24] are adopted in this study for screening of the 12 priority pollutant metals, inorganic compounds, aromatic compounds, polycyclic aromatic hydrocarbons (PAHs), chlorinated hydrocarbons, pesticides and other pollutants in soil. The DIV is referenced in the latest Code of Practice for Pollution Control, 2013 (COPCC) by the NEA.

The DIVs are related to spatial parameters and define soil as being seriously contaminated if the mean soil/sediment concentration of at least one substance is at least 25 cubic meters (m³) of soil-volume exceeds the DIV.

It is recognised that the Dutch Guidelines were developed to assess the acceptability of impacted soil at housing estates in the Netherlands and is based on local Dutch ecotoxicology and soil condition (that is, soil made of 10% organic clay or 25% clay), without reference to commercial or industrial general, or similar land uses in Singapore. On that basis, exceedances of the DIVs should not necessarily be interpreted as conclusive regarding the need for remediation. Conversely, if the concentrations of Chemicals of Potential Concern (COPC) were below these criteria, it would be reasonable to conclude that the concentrations are not of concern.

⁷ Metals analysis to include arsenic, antimony, barium, cadmium, chromium, cobalt, copper, mercury, lead, molybdenum, nickel and zinc

⁸ Pesticides analysis to include DDT, DDE, DDD, Aldrin, Dieldrin, Endrin, a-HCH, b-HCH, g-HCH, d-HCH, Atrazine, Carbaryl, Carbofuran, Chlordane, Endosulfan, Heptachlor and Heptachlor Epoxide

9.2.2 Prediction and Evaluation of Impact Assessment

The soil and groundwater impact assessment will include evaluation of potential impacts on identified human and ecological receptors due to soil and groundwater changes as a result of the proposed pre-construction, construction and operational activities.

9.3 Potential Sources of Soil and Groundwater Impact

Activities during both construction and operational phase of the Project may cause contamination of soil and groundwater. Furthermore, during the pre-construction and construction activities such as land preparation and excavation for construction works there is also a potential to encounter historically contaminated soils which could further lead to surface contamination (e.g., via runoff).

9.3.1 Construction Phase

Soil and groundwater can be potentially exposed to contaminants due to the activities during the construction phase of the Project, especially within and around the cut and cover areas. The activities which could affect soil and groundwater qualities during the construction phase and their associated impacts are listed in the Table 9-3.

Table 9-3 Potential sources of soil and groundwater impacts during the construction phase

Activity	Potential Sources of Impacts	Potentially Affected Environmental Parameter	Potential Associated Impacts
- Site clearance - Groundwater extraction for the purpose of soil dewatering - Earthworks (e.g. excavation of cut and cover areas, civil engineering earthworks) - Stockpiling of excavated soil from cut and cover areas - Storing, handling, transportation and disposal of soil and groundwater	- Seepage of contaminants from excavated contaminated soil (if encountered) into the underlying soil and groundwater - Soil erosion of exposed soil from excavations and stockpiles - Seepage of contaminants from extracted contaminated groundwater (if encountered) into the underlying soil and groundwater	Soil and groundwater quality	- Some contaminants such as metals can accumulate in the root zone, affecting vegetation growth and long-term viability - Contaminated soil and groundwater can directly or indirectly affect fauna, possibly leading to reduction in size of species' population and long-term viability - Adverse impact on human health due to direct or indirect exposure to contaminated soil and groundwater - It is understood that currently in Singapore groundwater is not used for any beneficial purposes (i.e. drinking or industrial purposes, irrigation) - Groundwater contamination can lead to soil contamination and degradation of land quality. Furthermore, contaminated groundwater may affect the quality of downgradient surface watercourses in their vicinity - Contamination can spread beyond the Study Area boundaries via groundwater
- Site clearance - Handling, transfer and storage of toxic chemical waste - Handling, transfer, refuelling and storage of chemicals (e.g. diesel, bentonite, lubricants, oils, grease, paints solvents, waste treatment chemicals, etc.) - Maintenance of vehicles,	- Discharge and leakage of toxic chemical waste - Discharge or leakage of chemicals used for refuelling and maintenance of vehicles, machinery and equipment		

Activity	Potential Sources of Impacts	Potentially Affected Environmental Parameter	Potential Associated Impacts
machinery and equipment			

The proposed minimum controls or stand practices commonly implemented in Singapore are discussed in Section 9.6.

9.3.2 Operational Phase

It is anticipated that there will be limited sources of impacts to soil and groundwater quality during the operational phase as use of chemicals and generation of toxic chemical waste are expected to be of limited quantities. However, the permanent land use change (i.e. increase of impervious surfaces) due to the proposed developments may lead to decrease in infiltration of surface water and stormwater into the soil. The activities which could affect soil and groundwater qualities during operational phase and their associated impacts are listed in the Table 9-4.

Table 9-4 Potential sources of soil and groundwater impacts (Operational Phase)

Activity	Potential Sources of Impacts	Potentially Affected Environmental Parameter	Potential Associated Impacts
Permanent Land Use Change	Heavy rain and stormwater wash-off pollutants built-up in the new development area and discharge to surrounding soil and groundwater	• Soil and groundwater quality	• Some contaminants such as metals can accumulate in the root zone, affecting vegetation growth and long-term viability • Contaminated soil and groundwater can directly or indirectly affect fauna, possibly leading to reduction in size of species' population and long-term viability • Adverse impact on human health due to direct or indirect exposure to contaminated soil and groundwater • It is understood that currently in Singapore groundwater is not used for any beneficial purposes (i.e. drinking or industrial purposes, irrigation)
Maintenance and landscaping works	Discharge or leakage of waste and chemicals into the soil	• Soil and groundwater quality	• Some contaminants such as metals can accumulate in the root zone, affecting vegetation growth and long-term viability • Contaminated soil and groundwater can directly or indirectly affect fauna, possibly leading to reduction in size of species' population and long-term viability • Contaminated soil and groundwater can have adverse effects on human health • It is understood that currently in Singapore groundwater is not used for any beneficial purposes (i.e. drinking or industrial purposes, irrigation)

Activity	Potential Sources of Impacts	Potentially Affected Environmental Parameter	Potential Associated Impacts
			Groundwater contamination can lead to soil contamination, degradation of land quality and it can be transported to surface water bodies, leading to their deterioration

The proposed minimum controls or stand practices commonly implemented in Singapore are discussed in Section 9.6.

9.4 Soil and Groundwater Baseline Study

A soil baseline study was carried out as a part of this EIA to determine the soil profile of the Study Area, and also to ascertain the presence of possible pollutants in the underlying soil that may impact the local vegetation, humans and downgradient watercourses.

The groundwater baseline aims to determine the groundwater quality and to ascertain the presence of possible pollutants in the underlying groundwater. It should be noted that the information used for the groundwater baseline study is primarily taken from the CR2005 EIA report performed by AECOM for LTA in 2022 [R-92].

The following sub-sections describe the results of the baseline assessment.

9.4.1 Baseline Monitoring Personnel

The assessment and site surveys were conducted by the following personnel:

- Mr. Neo Zhan Yuan Samuel, AECOM Singapore Pte Ltd (Soil and Groundwater Specialist);
- Mr. Jaypee Bautista, AECOM Singapore Pte Ltd (Soil and Groundwater Specialist);
- Specialist Testing and Technical Services (STATS) Asia Pacific Pte Ltd (Drilling Specialists)

9.4.2 Baseline Findings

9.4.2.1 Soil Profile

The boreholes within the Study Area were drilled between September 11 and 13, 2023. Termination depths of all the boreholes ranged from 4.0 m (TC-BH03) to 6.0 m (at TC-BH01) bgs. All the boreholes were advanced using a hand auger. At each borehole, the encountered lithology was logged by AECOM field personnel in accordance with the Unified Soil Classification System (USCS). The PID detector screening and visual/olfactory observations were also recorded.

Based on the information obtained during the soil investigation study, the encountered soil profile varies within the Study Area. The study area generally consisted of clayey silt. Silt was observed at TC-BH01 from 0.0 to 1.0 m bgs, TC-BH02 from 0.5 to 3.5 m bgs and 3.8 to 4.4 m bgs and silty sand was observed at TC-BH02 from 3.5 to 3.8 m bgs and in TC-BH03 from 0.0 to 3.2 m bgs.

During the borehole drilling and soil sampling no staining was observed in soil samples. A mild sweet chemical odour was observed at TC-BH02 from 3.5 m bgs to 3.8 m bgs. However, it should be noted that no exceedances of DIVs were reported in soil samples taken from this TC-BH02.

9.4.2.2 Soil Baseline Results

Nine (9) soil samples were collected from the boreholes designated TC-BH01 through TC-BH03. Three (3) soil samples were collected from each borehole. Soil samples were collected from the subsurface level (0.5 m bgs), above the groundwater table (1.3 to 3.0 m bgs) and the termination depth (4.0 to 6.0 m bgs). A mild sweet chemical odour was observed at TC-BH02 from 3.5 m to 3.8 m bgs. No signs of other visual or olfactory contamination were observed during field activities. The PID readings recorded for all soil samples were between 0.0 parts per million (ppm) and 45.1 ppm, indicating negligible concentration of VOCs.

A summary of the reported constituents in soil and a comparison of the soil analytical results with the DIVs for soil is shown in Table 9-5. A copy of the laboratory report for the soil samples is included in **Appendix X**.

Table 9-5 Summary of soil analytical results

Test Parameters	Unit	DIV (2013)	TC-BH01			BH2			BH3		
			0.5 m bgs	2.0 m bgs	6.0 m bgs	0.5 m bgs	3.0 m bgs	6.0 m bgs	0.5 m bgs	1.3 m bgs	4.0 m bgs
Metals											
Arsenic	mg/kg	76.00	9.7	15.52	4.31	28.03	22.94	30.78	30.08	35.5	12.48
Barium	mg/kg	..a	3.33	3.29	2.05	37.27	38.55	34.74	68.94	283.59	81
Cadmium	mg/kg	13	1.2	0.4	<0.5	0.5	0.5	0.5	0.8	0.5	1.0
Chromium	mg/kg	180 / 78 ^b	152.77	101.61	10.17	20.98	24.93	15.26	24.46	19.91	27.61
Cobalt	mg/kg	190	0.29	0.1	<0.5	1.57	1.49	1.2	3.68	2.24	1.34
Copper	mg/kg	190	14.04	14.41	5.25	20.79	16.33	13.29	93.23	48.57	111.83
Mercury	mg/kg	36 / 4 ^c	0.38	0.16	<0.01	0.17	0.16	0.25	0.31	0.17	0.19
Lead	mg/kg	530	6.56	5.47	4.5	22.13	19.22	17.07	50.98	35.82	29.93
Molybdenum	mg/kg	190	0.29	0.43	0.45	1.54	1.56	2.88	7.15	3.87	5.99
Nickel	mg/kg	100	6.38	2.01	<0.5	4.82	4.93	4.24	9.65	8.18	10.4
Zinc	mg/kg	720	18.17	6.98	1.03	59.29	71.78	47.89	209.18	118.4	181.69
Antimony	mg/kg	22.00	5.63	3.19	0.2	1.4	1.99	1.6	3.71	2.48	3.92
Inorganic Compounds											
Cyanide	mg/kg	20	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Total Petroleum Hydrocarbons											
C6 – C9	mg/kg	-	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
C10 – C14	mg/kg	-	26.60	21.3	18.3	20.6	14	20.6	21.4	21.4	26.6
C15 – C28	mg/kg	-	32.6	21.2	18.3	105.6	115.6	81.1	146.7	227.7	180.7
C29 – C36	mg/kg	-	10.70	<10	<10	91.7	97.2	77.2	309.5	311.9	125.6
C6 – C36 (Total)	mg/kg	5,000	69.8	42.5	36.7	217.9	226.9	178.9	477.7	561	333
Aromatic Compounds											
10 Compounds	mg/kg	Various	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs
Polynuclear Aromatic Hydrocarbons											

Test Parameters	Unit	DIV (2013)	TC-BH01			BH2			BH3		
			0.5 m bgs	2.0 m bgs	6.0 m bgs	0.5 m bgs	3.0 m bgs	6.0 m bgs	0.5 m bgs	1.3 m bgs	4.0 m bgs
Fluoranthene	mg/kg	-	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Sum of PAHs	mg/kg	40	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
9 Compounds	mg/kg	Various	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs
Chlorinated Hydrocarbons											
29 Compounds	mg/kg	Various	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs
Pesticides											
20 Compounds	mg/kg	Various	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs
Other Pollutants											
Dibutylphthalate (DBP)	mg/kg	36	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.6	0.3	<0.2
Di(2-ethylhexyl)phthalate (DEHP)	mg/kg	60	<0.2	<0.2	<0.2	0.3	0.4	0.4	0.8	3.8	2.7
Phthalates (total)	mg/kg	-	<0.2	<0.2	<0.2	0.3	0.4	0.4	1.4	4.1	2.7
10 Compounds	mg/kg	Various	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs
Conventional Parameters											
Moisture Content	%	-	41.51	50.14	40.4	18.54	24.71	23.72	17.52	25.79	30.63
Organic Matter	%	-	2.73	1.6	0.54	2.08	2.18	2.65	3.46	1.62	2.14
Sulphide as Acid Soluble											
Sulphide	mg/kg	1.00	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Notes: Not Available – value not specified in standard LOR – Limit of reporting (LOR) a – The barium standard has been repealed because the intervention value for barium proved to be lower than the concentration naturally occurring in the soil. b – Intervention value for Chromium (III) = 180 mg/kg; Chromium (IV) = 78 mg/kg c – Intervention value for Inorganic Mercury = 36 mg/kg; Organic Mercury = 4 mg/kg d - Intervention value for free cyanide = 20 mg/kg; complex cyanide = 50 mg/kg e – Intervention value for mineral oil; This applies to contamination due to mixtures (e.g. gasoline or domestic heating oil), then not only the alkane content but also the content of aromatic and/or polycyclic aromatic hydrocarbons must be determined. This aggregate parameter has been adopted for practical reasons. Further toxicological and chemical disaggregation is under study.											

All metals including were reported in most soil samples at concentrations above their respective levels of reporting (LOR). All of the detections were below their respective DIVs.

Polynuclear Aromatic Hydrocarbons (PAHs) were reported at TC-BH03 at depth 4.0 m bgs (i.e. Fluoranthene). Other pollutants were reported at TC-BH03 at depth 0.5 to 1.3 m bgs (i.e. Dibutylphthalate (DBP), Di(2-ethylhexyl)phthalate (DEHP) and Phthalates (total)), at TC-BH02 at 0.5 to 4.2 m bgs and at TC-BH03 at 0.5 to 4.0 m bgs (i.e. Di(2-ethylhexyl)phthalate (DEHP) and Phthalates (total)).

Total Petroleum Hydrocarbons (TPH) (i.e. C10 – C36) were reported in soil samples collected from TC-BH01 (0.5 m to 6.0 m bgs, except TC-BH01 2.0 and 6.0 m bgs for C29 – C36), TC-BH02 (0.5 m bgs to 4.2 m bgs), and TC-BH03 (0.5 m bgs to 4.0 m bgs), BH6 (0.3 m bgs, 0.5 m bgs and 1.5 m bgs).

All of the detections were below their respective DIVs.

The remaining parameters analysed for soil samples were below their LORs.

The source(s) of parameters reported above their respective LOR in collected soil samples could not be conclusively ascertained. As detailed in Section 4.1 of this Report, in the early 20th century, most parts of Singapore became rubber plantations, with the exception of the Swiss Rifle Club area (Site C), that has been left relatively untouched since the extensive deforestation that occurred during the colonial period in the 19th century. Rubber processing factories that complemented the rubber plantations also operated in the area, particularly west of Singapore Turf Club, taking advantage of the proximity to the railway in Bukit Timah that facilitated the transport of goods and materials. The northern part of Eng Neo Avenue Forest also became a part of the Municipal Water Catchment (later gazetted as Central Catchment Nature Reserve). Given the fact that the presence of PAHs, other pollutants and TPHs is a common and well-documented occurrence in urban soils that are exposed to anthropogenic activities, it is possible that the historical use of land has potentially caused the changes in chemical composition of soil, as reported in this Study. However, it should be noted that some of the reported parameters, such as metals, are also naturally occurring elements in the environment and their presence in soil might be due to soil weathering process. However, abovementioned claims cannot be confirmed nor disproved as currently there are no comprehensive studies that provide the information on the background concentrations of these parameters in soils in Singapore.

9.4.2.3 Groundwater Baseline Results

AECOM reviewed the groundwater analytical results from 17 monitoring wells installed and sampled as part of the EIA for the Study Area under the LTA CRL2 project [R-92]. The groundwater quality data is summarised in Table 9-6.

Table 9-6 Summary of groundwater analytical results

Test Parameters	Unit	DIV (2013)	Well ID											
			RC/30918	RC/30199	RC/30200	RC/30201	RC/30202	RC/30203	RC/30204	RC/30205	RC/30206	RC/30207	RC/30208	
Metals														
Arsenic	µg/L	60	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
Barium	µg/L	625	4.7	4.2	10.4	2.8	27.9	59.4	9.1	7.4	4.1	4.9	29.4	
Cadmium	µg/L	6	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	
Chromium	µg/L	30	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.2	0.2	0.2	
Cobalt	µg/L	100	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
Copper	µg/L	75	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	
Mercury	µg/L	0.3	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	
Lead	µg/L	75	14.1	9.5	10.4	2.5	27.2	6.0	75.2	95.4	33.6	8.0	<1.5	
Molybdenum	µg/L	300	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.3	
Nickel	µg/L	75	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	
Zinc	µg/L	800	5.6	4.5	25.6	8.1	10.5	5.5	2.5	2.7	28.7	2.4	2.6	
Antimony	µg/L	20	1.5	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	
Inorganic Compounds														
Cyanide	µg/L	1,500	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	
Total Petroleum Hydrocarbons														
C6 – C9	µg/L	NA	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	
C10 – C14	µg/L	NA	<100	<100	<100	<100	<100	<100	103	<100	109	127	<100	
C15 – C28	µg/L	NA	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	
C29 – C36	µg/L	NA	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	
C6 – C36 (Total)	µg/L	600	<100	<100	<100	<100	<100	<100	103	<100	109	127	<100	
Aromatic Compounds														
10 Compounds	µg/L	Various	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	
Polynuclear Aromatic Hydrocarbons														

Test Parameters	Unit	DIV (2013)	Well ID										
			RC/30918	RC/30199	RC/30200	RC/30201	RC/30202	RC/30203	RC/30204	RC/30205	RC/30206	RC/30207	RC/30208
10 Compounds	µg/L	Various	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs
Sum of PAHs	µg/L	NA	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Chlorinated Hydrocarbons													
29 Compounds	µg/L	Various	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs
Pesticides													
20 Compounds	µg/L	Various	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs
Other Pollutants													
10 Compounds	µg/L	Various	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs
Notes: Not Available – value not specified in standard LOR – Limit of reporting (LOR) Bold in Red Text – value exceeds the DIV													

Test Parameters	Unit	DIV (2013)	Well ID					
			RC/40166	RC/40167	RC/40168	RC/40169	RC/40170	RC/40171
Metals								
Arsenic	µg/L	60	<1.0	<1.0	2.0	14.3	2.4	<1.0
Barium	µg/L	625	4.9	10.9	38.3	100.5	37.3	5.3
Cadmium	µg/L	6	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Chromium	µg/L	30	<0.1	0.3	0.1	0.3	1.2	0.2
Cobalt	µg/L	100	<1.0	2.0	<1.0	<1.0	2.2	<1.0
Copper	µg/L	75	<1.5	<1.5	<1.5	3.4	<1.5	<1.5
Mercury	µg/L	0.3	<0.02	<0.02	0.04	0.07	0.11	<0.02
Lead	µg/L	75	<1.5	<1.5	<1.5	2.2	<1.5	<1.5
Molybdenum	µg/L	300	<0.5	2.8	3.5	32.7	3.0	<0.5
Nickel	µg/L	75	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5

Test Parameters	Unit	DIV (2013)	Well ID					
			RC/40166	RC/40167	RC/40168	RC/40169	RC/40170	RC/40171
Zinc	µg/L	800	<1.0	1.4	10	7.6	4.1	12.3
Antimony	µg/L	20	<1.0	2.3	1.6	1.9	1.0	<1.0
Inorganic Compounds								
Cyanide	µg/L	1,500	<20	<20	<20	<20	<20	<20
Total Petroleum Hydrocarbons								
C6 – C9	µg/L	NA	<20	<20	<20	<20	<20	<20
C10 – C14	µg/L	NA	<100	<100	<100	<100	<100	<100
C15 – C28	µg/L	NA	<100	430	147	303	174	<100
C29 – C36	µg/L	NA	<100	<100	<100	<100	<100	<100
C6 – C36 (Total)	µg/L	600	<100	430	147	303	174	<100
Aromatic Compounds								
10 Compounds	µg/L	Various	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs
Polynuclear Aromatic Hydrocarbons								
10 Compounds	µg/L	Various	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs
Sum of PAHs	µg/L	NA	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Chlorinated Hydrocarbons								
29 Compounds	µg/L	Various	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs
Pesticides								
20 Compounds	µg/L	Various	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs
Other Pollutants								
10 Compounds	µg/L	Various	<LORs	<LORs	<LORs	<LORs	<LORs	<LORs
Notes: Not Available – value not specified in standard LOR – Limit of reporting (LOR) Bold in Red Text – value exceeds the DIV								

Metals were reported above the LOR in the groundwater samples with two samples exceeding the DIV for lead.

TPH (C₁₀-C₁₄ and C₁₅-C₂₈) were reported above the LOR in some groundwater samples. None of the detections exceeded the DIV.

The remaining parameters analysed for groundwater samples were below their LORs.

The sources of the compounds detected in the groundwater samples cannot be ascertained, as the current land use of the Site is considered non-pollutive. It is possible that the TPH detections are from historical activities, as TPH is a common and well-documented occurrence in areas exposed to anthropogenic activities. It should also be noted that the reported metals are also naturally occurring elements in the environment. However, abovementioned claims cannot be confirmed nor disproved as currently there are no comprehensive studies that provide the information on the background concentrations of these parameters in soils in Singapore.

9.5 Identification of Soil and Groundwater Sensitive Receptors

The receptor screening for soil and groundwater was conducted within the Study Area (as defined in Section 6.2.2) and classified based on the methodology outlined in Table 6-2.

9.5.1 Construction Phase

As detailed in Section 3.2, the activities planned for the construction phase of the Project may cause soil and groundwater contamination which can subsequently have adverse effects on human and ecological receptors. Furthermore, during pre-construction activities such as soil excavation there is also a potential of encountering historically contaminated soil. The following table identifies potential soil and groundwater sensitive receptors and summarises sensitivity of each of the receptors.

Table 9-7 Classification of soil and groundwater sensitive receptors for construction phase

Sensitive Receptor	Receptor Description	Receptor Classification
Human Receptors		
Onsite construction workers during site redevelopment with frequent direct contact with soil and/or groundwater (e.g. excavation workers)	Humans within and in the vicinity of the Project Site who may come into frequent direct contact with potentially contaminated soil (or groundwater), for short or prolonged durations, potentially causing harm to their health. Receptors of particular concern include on-site outdoor construction workers during site redevelopment and future on-site intrusive workers undertaking excavations.	Priority 1
Onsite construction workers with infrequent direct contact with soil and/or groundwater (e.g., helpers, waste collectors)	Humans within and in the vicinity of the Project Site who may come into infrequent direct contact with potentially contaminated soil (or groundwater), potentially causing harm to their health.	Priority 2
Onsite visitors of the Study Area	Humans within and in the vicinity of the Project Site who comes into minimal to no direct contact with soil, thus not developing any health issues as a result of soil and/or groundwater conditions	Priority 3
Ecological Receptors		
High ecological value, low tolerance flora	Flora species and its biocenosis of high ecological value with low tolerance to changes in soil and groundwater quality.	Priority 1
Medium ecological value, moderate to high tolerance flora	Flora species and its biocenosis of medium ecological value with moderate to high tolerance to changes in soil and groundwater quality.	Priority 2
Low ecological value, high tolerance flora	Flora species and its biocenosis of low ecological value with high tolerance to changes in soil and groundwater quality.	Priority 3

9.5.2 Operational Phase

As the proposed development area becomes operational, it is expected that the human activities will increase within the Study Area. Activities planned for the operational phase of the project, such as landscaping and maintenance activities may potentially cause soil and groundwater pollution and subsequently have adverse impact on human and ecological receptors. The following table identifies potential soil and groundwater sensitive receptors during operational phase and summarises sensitivity of each of the receptors.

Table 9-8 Classification of soil and groundwater sensitive receptors during operational phase

Sensitive Receptor	Receptor Description	Receptor Classification
Human Receptors		
Maintenance workers	Humans within and in the vicinity of the future development who may come into frequent direct contact with potentially contaminated soil (or groundwater), for short or prolonged durations, potentially causing harm to their health.	Priority 1
Future residents	Humans within and in the vicinity of the Project Site who may come into infrequent direct contact with potentially contaminated soil (or groundwater), potentially causing harm to their health.	Priority 2
Visitors of future development	Humans within and in the vicinity of the Project Site who comes into minimal to no direct contact with soil, thus not developing any health issues as a result of soil and/or groundwater conditions.	Priority 3
Socio-Economic Receptors		
Community farms, gardens and similar developments where crops are ingested	- Developments within and in the vicinity of the Project Site that uses surface soil (0 to 1 m depth) for beneficial purposes such as community gardens, where homegrown fruits/vegetables are ingested. - Community farm assumed to use irrigated reticulated water supply. Unlined ponds utilising groundwater for irrigation will not be present.	Priority 1
Community farms, gardens and similar developments where crops are <u>not</u> ingested	Developments within and in the vicinity of the Project Site that uses surface soil (0 to 1 m depth) for beneficial purposes such as community gardens, where homegrown fruits/vegetables are not ingested.	Priority 2
Developments not using surface soil	Developments within and in the vicinity of the Project Site that do not use surface soil (0 to 1 m depth) for beneficial purposes.	Priority 3
Ecological Receptors		
High ecological value, low tolerance flora	Flora species and its biocenosis of high ecological value with low tolerance to changes in soil and groundwater quality.	Priority 1
Medium ecological value, moderate to high tolerance flora	Flora species and its biocenosis of medium ecological value with moderate to high tolerance to changes in soil and groundwater quality.	Priority 2
Low ecological value, high tolerance flora	Flora species and its biocenosis of low ecological value with high tolerance to changes in soil and groundwater quality.	Priority 3

9.6 Minimum Control Measures

This section proposed minimum controls or standard practices commonly implemented in Singapore for similar developments that have been assumed to be implemented for the purposes of impact assessment during both construction and operational phases of the Project.

9.6.1 Construction Phase

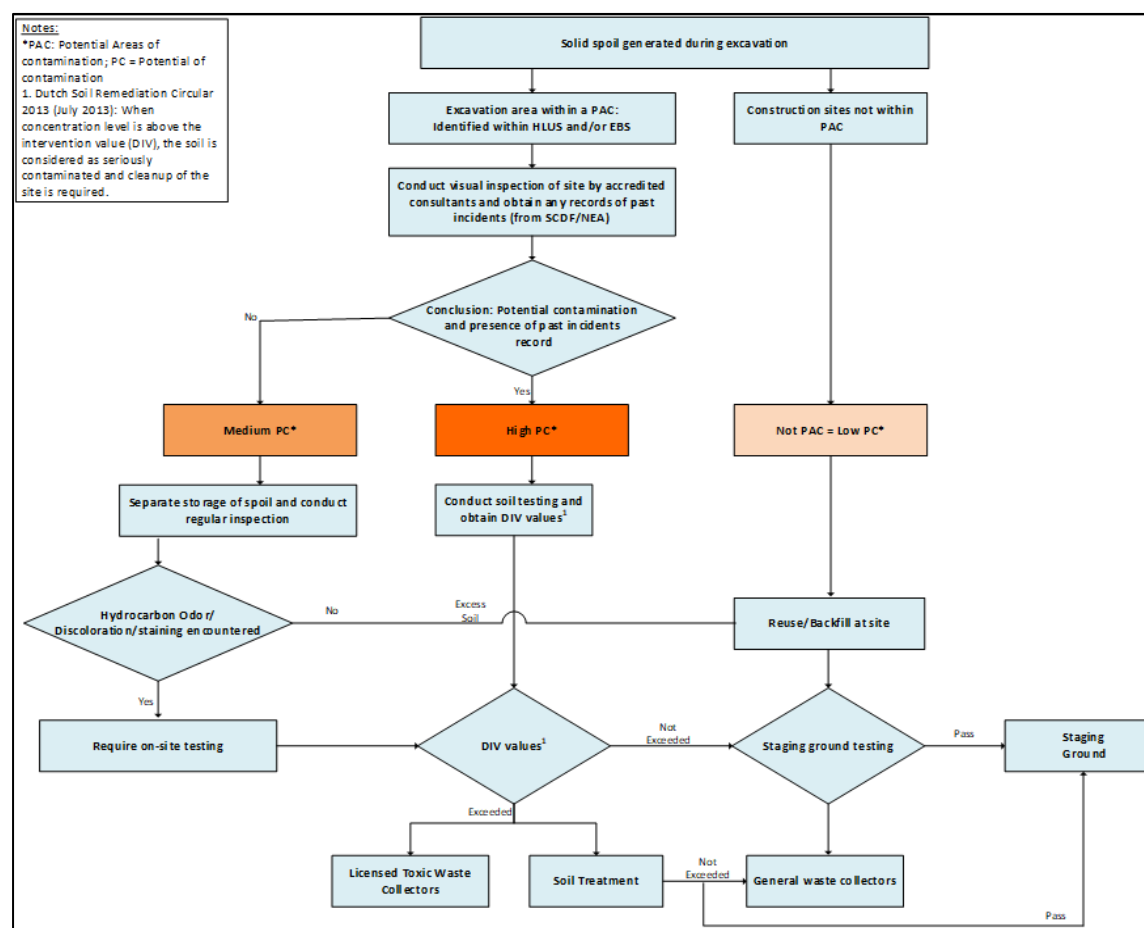
Table 9-9 sets out the minimum controls that have been identified for the Project during construction phase. Regular inspections and workers' training must be conducted to ensure these measures are inculcated in the behaviour and practice of all the staff at the site.

Table 9-9 Minimum controls during construction phase (soil and groundwater)

Potentially Affected Environmental Parameter	Potential Sources of Impacts	Minimum Control Measures
• Soil quality • Groundwater quality	• Improper management and disposal of excavated soils and/or groundwater during excavations activities. Contaminated excavated soils or groundwater (if encountered), if not stored, handled, transported and disposed properly, can lead to direct or indirect contamination to soil and/or groundwater.	• Identify all types of solid waste and implement comprehensive waste management system at the site in order to ensure proper disposal and prevent pollution to the environment. This contractor should conduct a construction risk assessment and prepare a comprehensive construction health, safety and environment plan. If health impacts to workers are foreseen due to the handling of such waste, necessary precautionary measures as per the safety data sheets (SDS) including personal protective equipment should be implemented on site. • Use approved materials, of the same or better quality as the surrounding area, for backfilling works. All backfilled material shall be free of debris, and of good material soil. • Handle and dispose excavated soil following the procedure shown in Figure 9-3. This flow chart explains how to handle excavated soils, and identify potential areas of contamination (PAC) in excavated soils. Should an area be identified as a PAC, soils are to be tested for exceedance in DIVs. If the soils are tested for exceedance in DIVs, the soils can be disposed of toxic waste collectors or undergo soil treatment. If contaminated soils were sent for treatment to an acceptable standard such as the DIV, the treated soil can be disposed in the staging ground or through a general waste collector, depending on the level of the contaminants during the staging ground testing. • Upon receipt of results on the tested parameters (chemicals, heavy metals) exceeding the regulatory limits, the construction contractor should further assess the potential inhalation and dermal contact impacts of the exceeded parameters to the site workers exposed to areas where soil and/or groundwater contamination is identified. The risk assessment should be conducted before the commencement of construction activities and the findings incorporated into the contractors' construction risk assessment and health, safety and environment plan. If health impacts to workers are foreseen, necessary precautionary measures, as per the respective chemical SDS, should be implemented on site. • A site management plan should include plans of safe handling, transfer and storage of excavated soils following the procedure in Figure 9-3. • Discharge of extracted groundwater shall be to an area approved for such disposal by the NEA and the proposed location as identified in Figure 9-3 and following the process set out in Figure 9-4. Based on the results of the soil and groundwater baseline study, the detected concentrations in groundwater do not exceed the DIVs. However, it is recommended that the construction contractor to be vigilant of site conditions and extracted groundwater to be tested at regular intervals, especially for extracted groundwater with oily sheens or noticeable odour. If a contaminant concentration in

Potentially Affected Environmental Parameter	Potential Sources of Impacts	Minimum Control Measures
		excess of the DIV is detected, the contractor shall assess the potential inhalation and dermal impacts of the chemical identified and assess potential health and safety considerations for exposure to groundwater before commencement of construction activities. Such contaminated wastewater may need to be disposed of to a licenced toxic waste collector.
	• Improper handling, transfer and storage of toxic chemical waste (liquid effluents / wastewater). This could potentially lead to discharge of toxic chemical waste due to spillage or leakage during storage, handling, and transfer. • Improper handling, transfer, refuelling and storage of chemicals (e.g. diesel, bentonite, lubricants, oils, grease, paints, solvents, waste treatment chemicals, etc.) generated during construction activities. These activities could lead to incidental discharge of chemical due to spillage or leakage during storage, handling, transfer and refuelling (oil, grease or other chemical substance release). • Improper discharge of the domestic sewage and poor maintenance of the portable chemical toilet (e.g. overflow or overload). This could potentially lead to discharge of sewerage waste due to spillage or leakage during storage, handling and transfer.	• Identify all types of toxic chemical waste and implement comprehensive waste management system at the site in order to ensure proper disposal and prevent pollution to the environment. This contractor should conduct a construction risk assessment and prepare a comprehensive construction health, safety and environment plan. If health impacts to workers are foreseen due to the handling of such waste, necessary precautionary measures as per the safety data sheets (SDS) including personal protective equipment should be implemented on site. • Inspect all equipment prior to entering the site for fuel/hydraulic lines, leaking tanks, and other potential faulty parts that could potentially cause contamination to soil or groundwater. • Dispose all construction debris (under category C&D) at the gazetted Government dumping grounds or at such other sites or locations as directed by NEA. • Store generated toxic chemical waste under shelter within concrete bund walls or in storage containers with good ventilation. Spill trays shall be provided for all waste containers. Spill trays shall be regularly maintained to prevent rain from washing out the pollutive substances. • Note that the Earth Control Measures (ECM) is for the containment and treatment of silty discharge due to the impact of rainwater. ECM is not meant for the treatment of wastewater due to construction activities (such as pipe-jacking and bore-piling works) which shall be treated to comply with the requirements under prevailing legislation. • The wastewater from construction activities should be stored and removed for treatment and disposal off-site by an approved Waste Management Contractor. • Remove any hazardous substance or chemical if there are safer alternatives. • Ensure all hazardous substance and chemical containers are labelled its movement is recorded and returned to the designated storage areas when not in use. • Assess the SDS of all the hazardous substances and chemicals prior to its entry to site for its suitability in terms of SHE hazards and consider safer alternatives. • Ensure no trade effluent other than that of a nature or type approved by NEA Director-General shall be discharged into any watercourse or land. • Ensure all activities involving repair, servicing, engine overhaul works, etc. shall be carried out on an area which is appropriately contained (e.g.

Potentially Affected Environmental Parameter	Potential Sources of Impacts	Minimum Control Measures
		concreted area and with proper containment/sumps) and all wastes are channelled for appropriate treatment or disposal to meet the regulations. - Store chemicals stored under shelter within concrete bund walls or in storage containers with good ventilation. Spill trays shall be provided for all drums, plants and machinery and potential pollutive substances used on site. Spill trays shall be regularly maintained to prevent rain from washing out the pollutive substances. - Provide emergency spill kits on site in the event of any chemical spillages. The emergency response team shall also be competent in the use of these spill kits.



Notes:

- DIV standards were developed to assess the acceptability of impacted sites in the Netherlands in support of the Dutch Soil Protection Act. Therefore, it is based on local Dutch ecotoxicology, soil (consisting of 10% organic clay or 25% clay) and climate conditions for residential usage which may not be applicable to conditions in Singapore.
- HLUS stands for historical land use study.

Figure 9-3 Screening and disposal of excavated soils

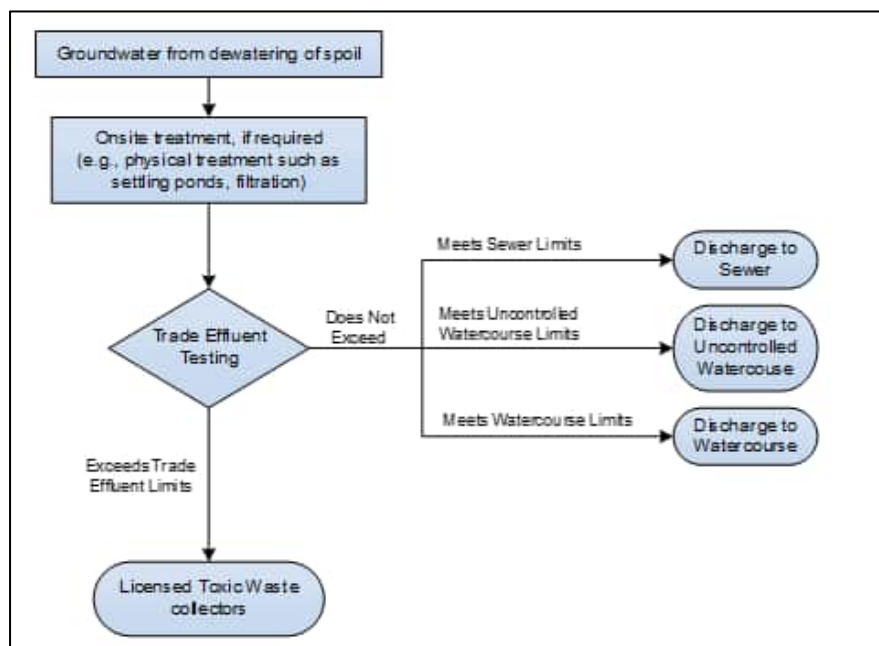


Figure 9-4 Disposal of the groundwater generated through dewatering or inflow into excavations

9.6.2 Operational Phase

Table 9-10 sets out the minimum controls that have been identified for the Project during operational phase.

Table 9-10 Minimum controls during operational phase (soil and groundwater)

Potentially Affected Environmental Parameter	Potential Sources of Impacts	Minimum Control Measures
- Soil quality - Groundwater quality	Heavy rain and stormwater wash-off pollutants built-up in the new development area and discharge to surrounding soil and groundwater	Ensure no trade effluent other than that of a nature or type approved by NEA Director-General shall be discharged into any watercourse or land.
	Discharge or leakage of waste and chemicals into the soil	- Conduct regular inspections on waste storage system within the Project to prevent system's clogging and leachate entering the underlying soil - Store all toxic waste and hazardous substances/chemicals (if any) at designated sheltered area provided with access-controlled entrance and concrete bund walls or in storage of containers with good ventilation. Spill trays shall be provided for all chemical drums and potentially pollutive substances. Spill trays shall be regularly maintained to prevent the rain from washing out the pollutive substances - Dispose all toxic waste chemicals (if any) to licensed Toxic Industrial Waste (TIW) collectors for treatment - Ensure all hazardous chemicals/substances (if stored on site) are labelled, its movement is recorded and returned to the designated storage areas when not in use - Ensure all activities involving the use of hazardous chemicals/substances are carried out on an area which is appropriately contained (e.g. concreted area and with proper containment/sumps).

Potentially Affected Environmental Parameter	Potential Sources of Impacts	Minimum Control Measures
		Provide emergency spill kits on site in the event of any chemical spillages. The emergency response team shall also be competent in the use of these spill kits

9.7 Prediction and Evaluation of Soil and Groundwater Impacts

This section details prediction and evaluation of soil and groundwater impacts identified to arise from construction and operational phase of the Project.

9.7.1 Construction Phase

Land preparation activities will be carried out in three stages (as described in Section 3.3.1), with the goal being to prepare land parcels so that they are ready for future development and building construction. During the site clearance, existing buildings, facilities and infrastructure within the Study Area that are not intended to be preserved will be demolished and resulting debris will be removed. Some removal of trees, shrubs and other vegetation from the site is also planned to be carried out to facilitate redevelopment works within the Project Site. Following the land preparation activities, earthworks including soil excavation, utility diversion and ground levelling will be carried out.

Beforementioned activities could potentially impact soil quality as well as groundwater. Subsequently, this might have adverse effects on identified sensitive receptors. The following sub-sections provide qualitative assessment and evaluation of soil and groundwater impacts during the construction phase of the Project.

9.7.1.1 Impacts due to Soil and Groundwater Contamination

Based on available historical land use data (refer to Section 4.1), the potential contamination severity from past uses of the current site area (i.e. rubber plantation, horse racing facilities etc.) is likely to be low. Whilst there is exceedance of DIV for lead in groundwater in two locations, overall, the groundwater quality does not suggest an extensively contaminated area. Furthermore, soil baseline analytical results did not show signs of contamination within the site.

The quantity of solid waste stored on site (e.g. excavated soil, debris resulting from demolition activities, construction debris, etc.) is expected to be limited, given the periodical disposal by licenced general and toxic waste contractors as part of minimal controls (as shown in Section 9.6). There may be significant amount of extracted groundwater generated from dewatering activities but as with soil, periodic disposal by waste collectors is expected to be part of the construction activities. The potential exposure pathways and mechanisms for onsite workers include direct contact of soil and groundwater when handling and storing/staging excavated soils and groundwater. In the event that contaminated (based on visual or olfactory observations) soil or groundwater is encountered during excavations or dewatering, implementation of the mitigation measures detailed in Figure 9-3 and Figure 9-4 is crucial in management and disposal of such contaminated media.

Besides historical contamination, another potential mechanism to soil and groundwater contamination is through leakage and seepage of contaminants originating from toxic waste that is stored on site as well as from chemicals used and stored onsite. The quantity of toxic waste stored onsite is expected to be limited, with the assumption that generated waste will be periodically removed and disposed off-site by licensed Toxic Industrial Waste (TIW) contractors during the construction phase. Chemicals used during the construction phase will be stored at designated sheltered area with access-controlled entrance and concrete bund walls or in storage containers with good ventilation or on spill pallets. In the event of chemical spillage, spill kits will be available on site to be operated by an emergency response team competent in their use.

The overall sensitivity of identified human receptors in the Study Area is considered as **Priority 1** based on the highest priority human receptor present during the construction phase (i.e., construction workers doing

excavations). Ecological receptors have been categorised as **Priority 1**, based on their ecological significance and tolerance to soil/groundwater.

Given the historical land use and assuming that proposed minimum controls are successfully implemented (and approved by the relevant Agencies, where applicable) it is unlikely that discharge, spillage and/or leakage from spoil, toxic waste and chemicals will be in quantity that may adversely impact the environment (i.e. soil and groundwater). Furthermore, if the potential contamination occurs, it will most likely cause localised impacts to soil and groundwater quality which are unlikely to extend beyond the Study Area and which will be possible to remediate. Therefore, the impact intensity is considered to be **Low**. The impact consequence for human sensitive receptors is assessed to be **Very Low to Low**, while the impact consequence for ecological sensitive receptors is assessed to be from **Medium to Low**. With the assumption that the proposed minimum control measures have been implemented, proper mandatory training for workers regarding environmental management and spill management has been conducted and regular site inspections are carried out, the likelihood of occurrence during the construction phase is expected to be **Rare to Occasional**.

Overall, based upon the assessment of the likelihood and consequences, and considering the routine, standard industry practices implemented during the construction phase of the Project, the potential impacts on human sensitive receptors due to soil and groundwater contamination are assessed to be **Negligible to Minor**. The overall impact on ecological receptors is assessed to be **Minor**. Therefore, no further mitigation measures were required.

The summary of assessment of impacts due to soil and groundwater contamination during the construction phase of the Project is shown in Table 9-11.

Table 9-11 Summary of soil impact assessment for the construction phase of the Project

Impact	Source of Impact	Environmental Parameter Affected	Sensitive Receptor Affected	Receptor Sensitivity	Impact Intensity	Impact Consequence	Impact Likelihood	Impact Significance
Human Receptors								
Adverse impact on human health due to direct or indirect exposure to contaminated soil and groundwater	- Seepage of contaminants (if encountered) from excavated soil, erosion of exposed soil, and extracted groundwater - Discharge of toxic chemical waste and/or leakage of chemicals used for refuelling and maintenance of vehicles, machinery and equipment	- Soil Quality - Groundwater Quality	Maintenance workers	Priority 1	Low	Low	Possible/Occasional	Minor
			Future residents	Priority 2	Low	Low	Less Likely/Rare	Minor
			Off-site visitors	Priority 3	Low	Very Low	Less Likely/Rare	Negligible
Ecological Receptors								
Flora	- Seepage of contaminants (if encountered) from excavated soil and extracted groundwater, soil erosion of exposed soil - Discharge of toxic chemical waste and/or leakage of chemicals used for refuelling and maintenance of vehicles, machinery and equipment	- Soil Quality - Groundwater Quality	High ecological value, low tolerance flora	Priority 1	Low	Low	Possible/Occasional	Minor
			Medium ecological value, moderate to high tolerance flora	Priority 2	Low	Low	Possible/Occasional	Minor
			Low ecological value, high tolerance flora	Priority 3	Low	Very Low	Possible/Occasional	Minor

9.7.2 Operational Phase

After the construction phase has been completed, it is expected that human activity will increase within the Study Area. As described in the Section 9.3.2 of this Report, permanent land use change (i.e. increase in impervious surfaces) might cause decreased infiltration of runoff water or chemicals into the ground. Furthermore, chemicals used during the maintenance and landscaping activities might accidentally leak into the ground, affecting underlying soil and groundwater quality. The detailed impact assessment for the operational phase of the Project is given in the following sub-sections.

9.7.2.1 Impacts due to Soil and Groundwater Contamination

As the area becomes operational, increased human activity (both from permanent future residents and visitors) will possibly lead to higher generation of solid and liquid waste. Furthermore, the maintenance of proposed green areas, open spaces and parks might require the usage of certain chemicals (e.g. pesticides) which may or may not be stored on the site. If not managed properly, leachate from waste generated and collected on the site and accidental leakage of chemicals stored and used on site may infiltrate the ground, potentially affecting soil and groundwater quality. However, it is expected that during the operational phase, the Study Area will have little use of hazardous substances and chemicals. Furthermore, small, localised contamination that may happen in certain areas as a result of accidental spillages and leakages will most likely cause limited impacts to soil and groundwater quality and are unlikely to extend beyond the Study Area. Therefore, the impact intensity is considered to be **Low**.

For human receptors, maintenance workers at the Study Area may come in contact with the potentially contaminated soil and groundwater during maintenance activities. Future residents and future visitors are less likely to come in contact. Given that the human receptors are categorised as **Priority 1 to Priority 3** (refer to the Section 9.5.2) and that the impact intensity is **Low**, the impact consequence is assessed to be **Low**. As accidental spills and leaks are expected to occur **Rarely**, the overall impact significance of potential soil and groundwater contamination on human sensitive receptors is assessed to be **Minor**.

Similar to human receptors, the socio-economic receptors such as community gardens, farms and similar developments that utilise soil have impact intensity and consequence that are considered **Low** (for Priority 3 community gardens, impact consequence is Very Low). Overall, the impact significance is **Minor**.

Ecological receptors have been categorised as **Priority 1 to Priority 3**, based on their ecological significance and tolerance to soil and groundwater quality. As the impact intensity is assessed to be **Low**, the impact consequence will be **Low to Very Low** (based on the impact consequence matrix [refer to the Table 6-5]). The potential accidental spills and leaks of chemicals are expected to occur **Rarely** on the site. Based on the assessed impact consequences and their likelihoods, the overall impact significance of potential soil and groundwater contamination during the operational phase of the project on ecological sensitive receptors is assessed to be **Negligible to Minor**.

The summary of assessment of impacts due to groundwater level decrease during the operational phase of the Project is shown in Table 9-12.

Table 9-12 Summary of soil and groundwater impact assessment for the operational phase of the Project

Impact	Source of Impact	Environmental Parameter Affected	Sensitive Receptor Affected	Receptor Sensitivity	Impact Intensity	Impact Consequence	Impact Likelihood	Impact Significance
Human Receptors								
Adverse impact on human health due to direct or indirect exposure to contaminated soil and groundwater	- Runoff and stormwater wash-off pollutants built-up in the new development area and discharge to surrounding soil and eventually, the groundwater. - Leakage of solid waste leachate into the underlying soil and eventually, the groundwater - Discharge or leakage of waste and chemicals into the soil and eventually, the groundwater	- Soil Quality - Groundwater Quality	Maintenance workers	Priority 1	Low	Low	Possible/ Occasional	Minor
			Future residents	Priority 2	Low	Low	Less Likely/ Rare	Minor
			Visitors of future development	Priority 3	Low	Low	Less Likely/ Rare	Minor
Socio-Economic Receptors								
Future developments using surface soil (e.g. community farms and gardens)	Runoff and stormwater wash-off pollutants built-up in the new development area and discharge to surrounding soil and eventually, the groundwater.	- Soil Quality - Groundwater Quality	Community farms, gardens and similar developments where crops are ingested	Priority 1	Low	Low	Possible/ Occasional	Minor
			Community farms, gardens and similar developments where crops are <u>not</u> ingested	Priority 2	Low	Low	Possible/ Occasional	Minor

Impact	Source of Impact	Environmental Parameter Affected	Sensitive Receptor Affected	Receptor Sensitivity	Impact Intensity	Impact Consequence	Impact Likelihood	Impact Significance
	- Leakage of solid waste leachate into the underlying soil and eventually, the groundwater - Discharge or leakage of waste and chemicals into the soil and eventually, the groundwater		Developments not using surface soil	Priority 3	Low	Very Low	Possible/ Occasional	Minor
Ecological Receptors								
Flora	- Runoff and stormwater wash-off pollutants built-up in the new development area and discharge to surrounding soil and eventually, the groundwater - Leakage of solid waste leachate into the underlying soil and eventually, the groundwater	- Soil Quality - Groundwater Quality	High ecological value, low tolerance flora	Priority 1	Low	Low	Possible/ Occasional	Minor
			Medium ecological value, moderate to high tolerance flora	Priority 2	Low	Low	Possible/ Occasional	Minor
			Low ecological value, high tolerance flora	Priority 3	Low	Very Low	Possible/ Occasional	Negligible
	Discharge of toxic chemical waste and/or leakage of chemicals used for refuelling and maintenance of vehicles, machinery and equipment							

9.8 Recommended Mitigation Measures

In this section, no mitigation measures are proposed to further minimise the adverse impacts on the environment as none of the impacts on the sensitive receptors have been assessed to be Moderate or Major.

9.9 Residual Impacts

No residual impact assessment has been undertaken as no Moderate or Major impact significance on sensitive receptors were identified.

9.10 Cumulative Impacts

Cumulative impacts from both the site development activities and construction of an MRT station are deemed to be not significantly different from the construction impacts discussed in Section 9.7 in terms of soil and groundwater. The recommended minimum controls detailed in Section 9.6 are considered to be adequate in addressing cumulative impacts to soil and groundwater.

9.11 Summary of Key Findings

A soil and groundwater baseline study was carried out as part of the EIA to determine the soil profile and hydrogeological conditions of the Study Area, and also to know the presence of possible pollutants in the underlying soil and groundwater that may impact human and ecological receptors.

Based on the information obtained during the soil and groundwater study, the soil profile encountered at the Study Area generally consisted of clayey silt. Furthermore, layers of silt and silty sand were also encountered within the Study Area.

Soil samples collected from the Study Area reported detections of metals (i.e. arsenic, barium, cadmium, chromium, cobalt, copper, mercury, lead, molybdenum, nickel, zinc and antimony), PAHs (i.e. fluoranthene), other pollutants (i.e. dibutylphthalate (DBP) and di(2-ethylhexyl)phthalate (DEHP) and TPHs (i.e. C10 – C36, mineral oils). These detections were all below the DIV.

Based on information collected from a previous report, the groundwater underneath the Study Area reported detections of metals and TPH (C10 – C28). Lead concentration in two monitoring well locations reported exceedance of the DIV. The rest of the detected concentrations were below the DIV.

The soil analytical results showed that the soil does not pose potentially unacceptable risks to future construction workers and residents of the proposed developments as all of the parameters reported were below their respective DIVs. Overall, the groundwater analytical results do not indicate gross contamination that would require remedial actions. Furthermore, groundwater is not extracted for any beneficial use in Singapore. The exceedances do not automatically indicate presence of unacceptable risk to humans (and ecology) and are likely background levels. Therefore, human receptors were classified as Priority 2 with regard to potential soil and groundwater quality changes during construction and operation phase of the Project and as Priority 3 for visitors of future development and permanent residents in the vicinity of the proposed development.

Based on the assessment of the ecological value of the habitats and biocenosis of the Study Area as well as on their dependency of the groundwater, identified ecological receptors were classified as Priority 2 receptors. Given the high ecological value of Eng Neo Avenue Forest, Bukit Tinggi and the forest adjacent to Turf Club Road, these receptors were classified as Priority 2.

The potential impacts on soil resources associated with the activities conducted during the construction phase of the Project include intrusive activities such as excavation as well as potential use of imported backfill soil. Soil and groundwater quality could also be affected due to seepage of contaminants from excavated contaminated soil (if encountered) or extracted groundwater, soil erosion, surface runoff as well as leakage of toxic chemical waste and chemicals.

During the operational phase of the Project, it is anticipated that the impact on soil quality will be limited as use of chemicals and generation of toxic chemical waste is expected to be of limited quantities. Increase of impervious surfaces within the Study Area are expected to reduce potential for contamination of underlying soil and groundwater from aboveground sources.

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 minimise the adverse effects on the environment.

Table 9-13 Summary of soil impact assessment

Potential Source of Impact	Impact Significance with Minimum Control	Residual Impact Significance with Mitigation Measures (if required)
Construction Phase		
Soil and groundwater contamination due to seepage of contaminants originating from excavated soil, extracted groundwater, chemicals and waste stored on the site	Negligible to Minor	N.A.
Operational Phase		
Soil contamination due to seepage and leakage of contaminants originating from generated waste and chemicals stored and/or used on the site	Negligible to Minor	N.A.
Note: NA – Not Applicable; no Moderate or Major Impacts have been identified		

10 Air Quality

10.1 Introduction

This section presents the air quality impact assessment for the construction and operational phases of the Project following the general EIA methodology described in Section 6. Air quality impact tends to impact sensitive receptors such as schools, medical institutions, residential area in the vicinity of the Study Area, therefore the Assessment Area for air quality is well beyond the Study Area and focused largely on the sensitive receptors (see Section 6.2.1). In line with the applicable legislation detailed in Section 5, the key steps for conducting the air quality impact assessment are as follows:

- Review existing baseline monitoring data and to conduct and evaluate existing air quality in the Assessment Area;
- Identify and classify sensitivity of the area around the construction worksite or project footprint;
- Understand the proposed activities during construction and operational phases;
- Conduct an impact assessment to qualitatively assess air quality impacts during construction and operation of the Project;
- Evaluate qualitative air quality impacts against nominated assessment criteria;
- Specify mitigation measures to be implemented;
- Determine the overall significance of the residual air quality impacts after implementation of mitigation measures; and
- Recommend a suitable monitoring and management plan.

10.2 Methodology and Assumptions

The sections below outline the methodology used in the air quality impact assessment for both construction and operational phases, including the determination of Assessment Area and baseline collection methodology.

10.2.1 Assessment Area and Screening of Air Sensitive Receptors

The Assessment Area for air quality impact assessment is recommended as 350 m and 50 m from the construction worksite areas for human and ecological receptors respectively during construction phase in accordance with UK IAQM guidance [R-26] and 250 m around the project footprint for operational phase. During the scoping phase for this EIA, an initial screening of receptors in the Assessment Area was conducted as per Section 6.2.2 and detailed in Section 10.4, in order to determine the areas which are sensitive to potential construction impacts detailed in Section 10.3.

10.2.2 Air Quality Baseline Study

Baseline air quality monitoring includes primary data collection in the form of baseline ambient air quality monitoring in the Assessment Area. Of the criteria pollutants generally measured as part of ambient air monitoring, such as CO, NO₂, SO₂, PM₁₀ and PM_{2.5}, this baseline monitoring only focuses on dust levels i.e. PM₁₀ and PM_{2.5}, since these are the major pollutants that are likely to have the biggest impact on the ambient air quality as a result of the Project. The purpose of the baseline monitoring is to understand what the natural conditions of these air quality parameters are, so that in the event that a repeat monitoring event is to be conducted during the construction and/or operational phases of the Project, this monitoring data can be used as a reference of the existing baseline prior to any disturbance in the Assessment Area.

Air quality has both short-term and long-term targets which vary from a 1-hr target to an annual target. Owing to the timeframe of the Project, annual monitoring cannot be accommodated in this study; however, a short-term monitoring baseline will be established. With varying seasonal fluctuations, it is understandable that wind flow and direction will vary throughout the year, and hence short-term baselines shall also fluctuate. However, a correlation, be it direct or indicative between the site baseline and NEA's central area monitoring data, will be useful for future

monitoring as it provides a reliable context for any future comparisons based on the relation between the two datasets. Hence, secondary data, such as NEA's long-term air quality data, hourly Pollution Standard Index (PSI), and meteorological data observed in the vicinity of the Assessment Area have been collected from publicly available sources.

10.2.2.1 Secondary Data Collection (Review of Background Data)

Desktop research consists of a review of secondary data (including existing land use and development activities, satellite images, etc.) which aids in determining the baseline air monitoring location. The information retrieved during the desktop research comprised of publicly available data from government and technical agencies, existing available data, relevant articles, and other online sources.

10.2.2.1.1 NEA Long Term Ambient Air Quality

NEA carries out routine monitoring of ambient air quality through the Telemetric Air Quality Monitoring and Management System (TAQMMS). This system comprises 22 monitoring stations (refer to Figure 10-1) which are located around Singapore and linked into a Central Control System (CCS). The air quality monitoring stations are distributed amongst urban, industrial, suburban, coastal, and roadside locations. General NEA ambient air monitoring results for Singapore over the period 2018 – 2022 have been presented and compared with Singapore Long Term Ambient Air Quality Targets in Section 10.5.2.1.1. Air pollution control in Singapore is governed by legislation listed in Section 5.

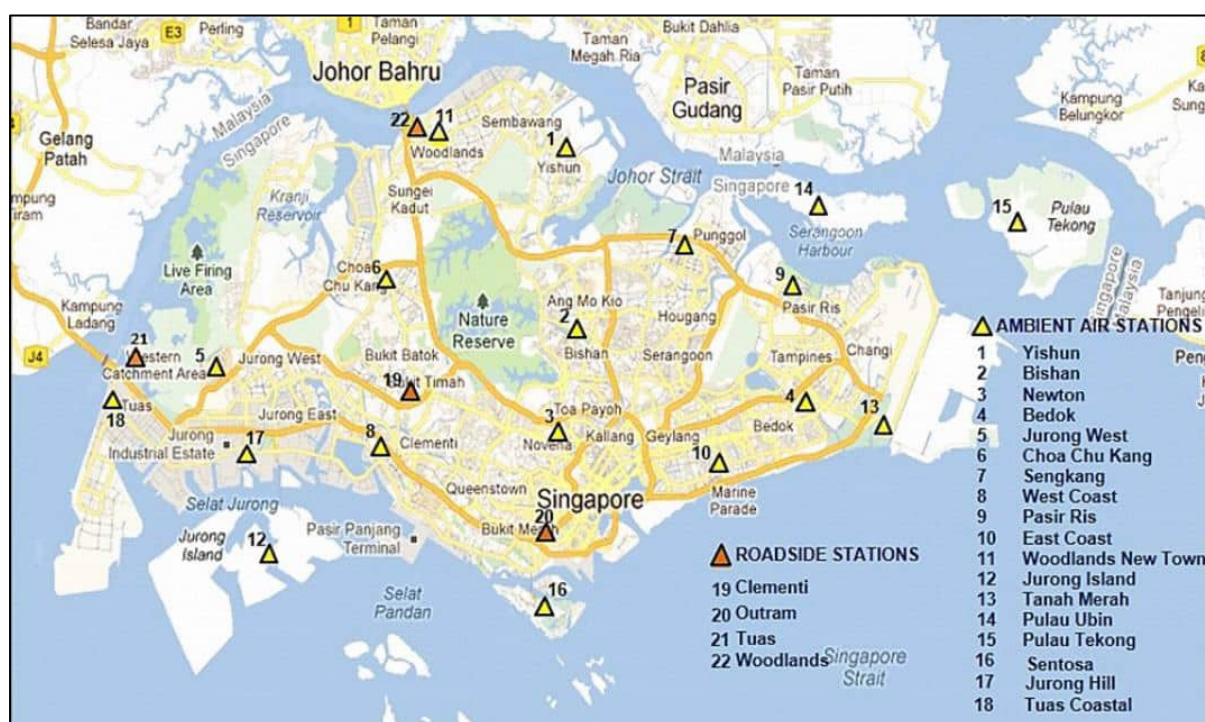


Figure 10-1 NEA ambient air quality monitoring stations in Singapore [R-36]

10.2.2.1.2 Hourly 24-hour PM₁₀ and PM_{2.5} Concentrations

Hourly 24-hr PM_{2.5} and PM₁₀ readings were available on data.gov.sg for the Central Region of Singapore. These data were collected during the same period of primary data collection period and discussed in Section 10.5.2.1.2.

10.2.2.1.3 Other Parameters (Rainfall, Temperature, Wind Speed)

Rainfall, temperature, and wind speed can significantly affect the distribution of pollutants. Upper Thomson is the nearest monitoring station to the Study Area, located approximately 1 km from the Study Area. However, this monitoring location only recorded rainfall data and has stopped operation since December 2020. Hence, only rainfall data up to December 2020 was presented for Upper Thomson. Collection of rainfall, temperature and wind speed was conducted for the next nearest weather monitoring location, Clementi, located approximately 4 km from the Study Area. The weather monitoring station recorded rainfall, temperature and wind speed data for the past 5 years have been collected and the results are discussed in Section 10.5.2.1.3.



Figure 10-2 NEA weather monitoring stations in Singapore [W-4]

10.2.2.2 Secondary Data from Previous Study

Air quality monitoring was conducted by AECOM Singapore Pte Ltd with the assistance from ALS Technichem (S) Pte Ltd for previous EIS study for LTA [R-4]. A total of one (1) air monitoring location was conducted for one (1) week to collect air quality samples for the following air quality parameters:

- Particulate matter smaller than 2.5µm, PM_{2.5}; and
- Particulate matter smaller than 10 µm, PM₁₀.

Air quality monitoring for LA01 was conducted for one week from 26 March – 2 April 2020. The air monitoring locations from the previous studies are presented in Table 10-1 and Figure 10-3. The results for the previous studies are summarised in Section 10.5.2.2 of this report.

TSI Environmental DustTrak Monitoring System was used for the purpose of PM₁₀ and PM_{2.5} monitoring. Concentrations of PM₁₀ and PM_{2.5} are measured by the light scattering laser photometer principle using an Environmental DustTrak Monitoring System coupled with a heated inlet for 5-minute interval data logging over a 7-day continuous sampling period. The photometer uses an ellipsoidal reflector and simple optical components to collect the laser-scattered light and to focus it onto a photodiode array. The mass and particle size are determined by detecting how the particles scatter light.

Table 10-1 Air quality monitoring locations from Previous Studies

Monitoring ID in the Previous / EBS Study	Site	Monitoring Location	Photo of Monitoring Location
LA03	Site A	Eng Neo Avenue Forest	

10.2.2.3 Primary Data Collection (Survey & Sampling)

Air quality monitoring services were provided by ALS Technichem (S) Pte. Ltd. (ALS). Air monitoring locations were proposed (at the Inception stage), based on the following considerations:

- Identification of ASRs (hospitals, schools, childcare facilities, old age homes, residences, flora and habitats of high ecological value) nearest to the construction worksite areas / project footprint boundary;
- Other ASRs away from the assessment area were eliminated;
- ASRs with areas having ongoing construction were avoided; and
- The closest ASR to the assessment area was selected.

Air quality monitoring was conducted at the monitoring locations for one week, to collect air quality samples for the following air quality parameters:

- Particulate matter smaller than 2.5µm, PM_{2.5}; and
- Particulate matter smaller than 10 µm, PM₁₀.

Air quality monitoring was conducted for 1 week within the Study Area in order to establish a baseline for existing air quality levels. The air monitoring for EA01, EA02 and EA03 was conducted for one (1) week to represent Site A – D, from 23 – 30 September 2021 and 1 – 8 December 2021. Furthermore, following the site survey conducted on 29 March 2023 and 16 May 2023, eight (8) monitoring locations were identified to represent Sites E and F. This has been proposed and accepted in the inception report. The air monitoring for AQ01 – AQ08 was conducted for a duration of one (1) week at each location from between 14 August 2024 and 14 September 2024. The monitoring location was chosen so that the equipment was more than 1 metre from any buildings or structures, and not shaded by structures or trees. This is necessary to ensure adequate airflow. The indicative air quality monitor was installed at 1.8 m from ground level in the breathing zone. Baseline air monitoring locations are provided in Table 10-2 and Figure 10-3.

TSI Environmental DustTrak Monitoring System was used for the purpose of PM₁₀ and PM_{2.5} monitoring. Concentrations of PM₁₀ and PM_{2.5} are measured by the light scattering laser photometer principle using an Environmental DustTrak Monitoring System coupled with a heated inlet for 5-minute interval data logging over a 7-day continuous sampling period. The photometer uses an ellipsoidal reflector and simple optical components to collect the laser-scattered light and to focus it onto a photodiode array. The mass and particle size are determined by detecting how the particles scatter light. For further details of the Air Quality Monitoring, please refer to Appendix Q.

Table 10-2 Rationale for the air quality monitoring locations with photos

S/N	Site	Monitoring Location	Justification	Photo of Monitoring Location
EA01	Site A	Southern portion of Eng Neo Avenue Forest	EA01 is representative of the ambient air quality in the southern part of Eng Neo Avenue Forest affected by traffic along the PIE and Eng Neo Avenue.	
EA02	Site B	Within 53 Fairways Drive	EA02 is representative of the ambient air quality within 53 Fairways Drive in an empty lot within Site B of this Project. Due to the short distance from AQ2 to Site D (~250 m), it can also be argued that this monitoring location may also be representative of south of Site D.	
EA03	Site C	Forested area along Turf Club Road	EA03 is representative of ambient air quality within Forested area along Turf Club Road within Site C of this Project, that is affected by traffic along Turf Club Road and the PIE. Due to the short distance from AQ3 to Site D (~150 m), it can also be argued that this monitoring location may also be located within the same airshed as Site D and representative of north of Site D.	
AQ01	Site E	Northern portion of Champions Golf near PIE	AQ01 is representative of the ambient air quality at the open area at the Northern portion of Champions Golf near PIE, that is affected by traffic along PIE and nearby recreational activities at Champions Golf.	

S/N	Site	Monitoring Location	Justification	Photo of Monitoring Location
AQ02	Site E	Southern portion of Champions Golf near Turf Club Road	AQ02 is representative of the ambient air quality at the open area at the Southern portion of Champions Golf near Turf Club Road, that is affected by traffic along Turf Club Road and nearby recreational activities at Champions Golf.	
AQ03	Site E	Near Grandstand	AQ03 is representative of the ambient air quality at the open area near Grandstand, along Turf Club Road, that is affected by traffic along Turf Club Road and nearby commercial/recreational activities at Grandstand.	
AQ04	Site E	Near Blue House International Pre-School	AQ04 is representative of the ambient air quality near Blue House International Pre-School along Turf Club Road, that is affected by traffic along Turf Club Road.	
AQ05	Site E	Near Chiltern House Turf Club Road	AQ05 is representative of the ambient air quality the open area near Dayspring Residential Treatment Centre along Turf Club Road, that is affected by traffic along Turf Club Road.	
AQ06	Site C	Near residential properties along Swiss View	AQ06 is representative of the ambient air quality the open area near residential properties along Swiss View, that is affected by traffic along Swiss View.	

S/N	Site	Monitoring Location	Justification	Photo of Monitoring Location
AQ07	Site F	Green area near PIE	AQ07 is located at an open area near PIE, representative of the ambient air quality in the vicinity of AQ07 that is affected by traffic along PIE.	
AQ08	Site F	Near Eng Neo Avenue and Linden Drive	AQ08 is representative of the ambient air quality at the open area near Eng Neo Avenue, that is affected by traffic along Eng Neo Avenue and Linden Drive.	

10.2.3 Prediction and Evaluation of Impact Assessment

The air quality impact assessment includes evaluation of air quality impacts from construction and operational activities.

10.2.3.1 Construction Phase

Air quality impacts are assessed using the methodology outlined in the document entitled “Guidance on the Assessment of Dust from Demolition and Construction” which was published by the UK IAQM in 2014 for impacts during construction phase. This methodology has been adapted to the general methodology outlined in this EIA.

10.2.3.1.1 Identification of Potential Sources of Air Quality Impacts

It is important to identify potential sources of air quality impact in the vicinity of the Assessment Area. While conducting the assessment, a typical construction machinery is assumed to be used during the construction equipment and activities. These have been detailed in Section 10.3.1.

10.2.3.1.2 Identification of Sensitive Receptors

Identification of Air Sensitive Receptors (ASRs) in the Assessment Area was subsequently undertaken. IAQM identifies an entire area around one continuous stretch of construction footprint as a category or sensitive receptor. It does not distinguish between each unit, household or block present in the area as a separate ASR but designates the whole area as same category of sensitivity based on an overall location, number, proximity and scale to the construction activity. This approach thereby adopts a conservative principle to air quality. A further discussion on Receptor Sensitivity is presented in Section 10.4.1.

Sensitive areas identified as Priority 1, Priority 2, and Priority 3 for air quality during the screening process have been examined in the Impact Assessment in this EIA in order to provide a more refined classification for Receptor Sensitivity. Sensitivity of the area has been determined based on the usage, number of receptors, distance from the construction footprint, and the current context of sensitive buildings in Singapore.

10.2.3.1.3 Understanding of Baseline Air Quality

Primary and secondary data were collected to understand the baseline air quality of the Assessment Area. NEA's PSI data available from the nearest monitoring station was also reviewed for the Assessment Area. In addition, baseline air quality data was collected for representative location near the construction footprint. The baseline air quality review and data measured is discussed in Section 10.5.2.

10.2.3.1.4 Impact Intensity Definition

The impact intensity was determined by reviewing the scale of construction activities and classifying them as Low, Medium or High. The IAQM Guidance document provides example definitions for determining impact intensity for earthworks (based on construction footprint, heavy duty vehicles movement, formation of bunds, and material moved), for construction (based on total building volume, on-site concrete batching), for trackout (based on heavy duty vehicle outward movement, surface material, and unpaved road lengths), and for demolition (based on total demolition volume, construction material, on-site crushing of material, and height of demolition activity). The definition of parameters is defined in Table 6-4 in Section 6.4.2. It should be noted that in each case, not all criteria need to be met and that determination of magnitude is also based on the professional judgment of the air quality consultant. If the areas around the construction footprint are rated as High for one activity and Medium or Low for the other activities, the overall impact intensity result is classified as High for that site as those multiple activities may be occurring concurrently.

10.2.3.1.5 Classification of Overall Consequence

The dust impact assessment therefore evaluates the overall consequence prior to the implementation of mitigation. The work site has been assessed by considering both the impact intensity and the Receptor Sensitivity to obtain an overall consequence rating. Since the definition of impact intensity is different for each activity, the overall consequence for each activity is explained in matrices shown in Table 10-3 to Table 10-6. Each activity for the work site has been rated as being High, Medium, Low, or Imperceptible in terms of overall consequence based upon pre-mitigation measures.

Table 10-3 Overall consequence of the air impact analysis (Earthworks)

Receptor Sensitivity \ Impact Intensity	Priority 3	Priority 2	Priority 1
Negligible	-	-	-
Low	Imperceptible	Low	Low
Medium	Low	Medium	Medium
High	Low	Medium	High

Table 10-4 Overall consequence of the air impact analysis (Construction)

Receptor Sensitivity \ Impact Intensity	Priority 3	Priority 2	Priority 1
Negligible	-	-	-
Low	Imperceptible	Low	Low
Medium	Low	Medium	Medium
High	Low	Medium	High

Table 10-5 Overall consequence of the air impact analysis (Trackout)

Receptor Sensitivity \ Impact Intensity	Priority 3	Priority 2	Priority 1
Negligible	-	-	-
Low	Imperceptible	Imperceptible	Low
Medium	Low	Low	Medium
High	Low	Medium	High

Table 10-6 Overall consequence of the air impact analysis (Demolition)

Receptor Sensitivity \ Impact Intensity	Priority 3	Priority 2	Priority 1
Negligible	-	-	-
Low	Imperceptible	Low	Medium
Medium	Low	Medium	Medium
High	Medium	High	High

10.2.3.1.6 Establishing Impact Significance

Impact Significance is evaluated by considering both the overall Consequence and the Likelihood of occurrence of significant adverse impacts. The Likelihood of occurrence may be defined as remote, rare, occasional, regular, and continuous as per criteria listed in Table 6-6. Impact Significance has been evaluated in accordance with the matrix presented below in Table 10-7. The IAQM methodology does not differentiate between imperceptible and very low Consequences, due to the nature of air impacts as perceived by humans. In order to align the IAQM methodology with the methodology of this report, imperceptible and very low Consequences were consolidated.

Table 10-7 Impact significance matrix for air quality

Consequence Likelihood	Imperceptible / Very Low	Low	Medium	High
Remote	Negligible	Negligible	Negligible	Negligible
Rare	Negligible	Minor	Minor	Minor
Occasional	Minor	Minor	Moderate	Moderate
Regular	Minor	Moderate	Moderate	Major
Continuous	Minor	Moderate	Major	Major

10.2.3.1.7 Mitigation Measures Recommendations

Mitigation measures have been proposed for implementation when the Impact Significance is predicted to be Moderate or Major. Where mitigation measures are required, specific mitigation measures have been proposed based on the level of overall Consequence (High, Medium, and Low) as per the IAQM guidance. This is the most efficient way of prescribing dust mitigation measures so that high Consequence areas have the most comprehensive mitigation measures implemented whilst avoiding unnecessary implementation of complex mitigation measures in low Consequence areas.

10.2.3.1.8 Establishing Residual Impact Significance

Following implementation of mitigation measures prescribed in the EIA at the proposed construction footprint, the residual Impact Significance is evaluated using the matrix outlined in Table 10-7. Ideally, the mitigation measures required should be specified within the conditions given for planning permission and should be stipulated in construction contracts.

10.2.3.2 Operational Phase

This methodology below has been used to assess the air quality impact during operational phase of the Project.

10.2.3.2.1 Identification of Potential Sources of Air Quality Impacts

It is important to identify potential sources of air quality impact in the vicinity of the Assessment Area. While conducting the assessment, an increase in traffic volume in the vicinity of the Project during operational phase is assumed. These have been detailed in Section 10.3.2.

10.2.3.2.2 Identification of Sensitive Receptors

Identification of Air Sensitive Receptors (ASRs) in the Assessment Area within 250 m around the Project Footprint was subsequently undertaken. A further discussion on Receptor Sensitivity is presented in Section 10.4.2.

Sensitive areas identified as Priority 1, Priority 2, and Priority 3 for air quality during the screening process have been examined in the Impact Assessment in this EIA in order to provide a more refined classification for Receptor Sensitivity. Sensitivity of the area has been determined based on the usage and the current context of sensitive buildings in Singapore.

10.2.3.2.3 Understanding of Baseline Air Quality

Primary and secondary data were collected to understand the baseline air quality of the Assessment Area. NEA's PSI data available from the nearest monitoring station was also reviewed for the Assessment Area. In addition, baseline air quality data was collected for representative location near the Project Footprint. The baseline air quality review and data measured is discussed in Section 10.5.2.

10.2.3.2.4 Impact Intensity Definition

The impact intensity was determined by reviewing the scale of increase in air quality pollutant levels due to traffic volume increase in the vicinity of the Project Footprint by comparing the baseline and predicted traffic volume. The impact intensity is then classified as Low, Medium or High.

10.2.3.2.5 Classification of Overall Consequence

The air quality impact assessment therefore evaluates the overall consequence prior to the implementation of mitigation. The work site has been assessed by considering both the impact intensity and the Receptor Sensitivity to obtain an overall consequence rating. The overall consequence has been rated as being High, Medium, Low, or Imperceptible in terms of overall consequence based upon pre-mitigation measures.

10.2.3.2.6 Establishing Impact Significance

Impact Significance is evaluated by considering both the overall Consequence and the Likelihood of occurrence of significant adverse impacts. The Likelihood of occurrence may be defined as unlikely, rare, occasional, regular, and continuous as per criteria listed in Table 6-6. Impact Significance has been evaluated in accordance with the matrix presented in Table 10-7.

10.2.3.2.7 Mitigation Measures Recommendations

Mitigation measures have been proposed for implementation when the Impact Significance is predicted to be Moderate or Major.

10.2.3.2.8 Establishing Residual Impact Significance

Following implementation of mitigation measures prescribed in the EIA at the proposed Project Footprint, the residual Impact Significance is evaluated using the matrix outlined in Table 10-7. Ideally, the mitigation measures required should be specified within the conditions given for planning permission and should be stipulated in construction contracts.

10.3 Potential Sources of Air Quality Impact

Fugitive particulate emissions from construction and operational activities have the potential to result in adverse impacts on air quality and therefore, public and ecosystem health. Particulate emissions may also generate significant nuisance to receptors near the heavy use construction footprint.

10.3.1 Construction Phase

For human receptors, dust emissions could potentially result in adverse impacts on air quality and public health causing respiratory problems on human. For ecological receptors, 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, which may then have indirect effects on the quality of the affected habitats and associated fauna. Table 10-8 listed potential sources of air quality impact during construction phase of the project.

Table 10-8 Potential air quality impacts during the construction stage

Potential Source of Impacts	Potential Associated Impacts
Dust emissions generated by earthworks processes, including land clearance, soil-stripping, ground levelling, excavation, stockpiling of spoil and landscaping.	Dust emissions could potentially result in adverse impacts on air quality and public health and may also generate significant nuisance at receptors, including the biodiversity, located nearby heavy construction worksite areas.
Dust emissions generated by the construction of new structures, including holding areas and site offices.	Dust emissions could potentially result in adverse impacts on air quality and public health and may also generate significant nuisance at receptors, including the biodiversity, located nearby heavy construction worksite areas.
Dust emissions generated from potential demolition works.	Dust emissions could potentially result in adverse impacts on air quality and public health and may also generate significant nuisance at receptors, including the biodiversity, located nearby heavy construction worksite areas.

Potential Source of Impacts	Potential Associated Impacts
Dust emissions from transport of dust and dirt by dumper trucks for transporting spoil within the site and from the site onto public road network, where it may be deposited and resuspended by vehicles using the network.	Dust emissions could potentially result in adverse impacts on air quality and public health and may also generate significant nuisance at receptors nearby haulage routes.
Gaseous emissions from vehicle exhaust due to movement of construction vehicles and equipment, including spoil disposal	Exhaust emissions (NO ₂ , SO ₂ , CO, PM ₁₀ and PM _{2.5}) could potentially impact the air quality in the vicinity of construction worksites.
Gaseous emissions from off-road diesel engines on-site such as generators, if any	Exhaust emissions (NO ₂ , SO ₂ , CO, PM ₁₀ and PM _{2.5}) could potentially impact the air quality in the vicinity of construction worksites.

Assessment of the air quality impacts were based on the development phases detailed in Section 3.3. Key activities resulting in air pollution during construction typically includes earthworks, construction and trackout phases (Figure 10-6 to Figure 10-10).

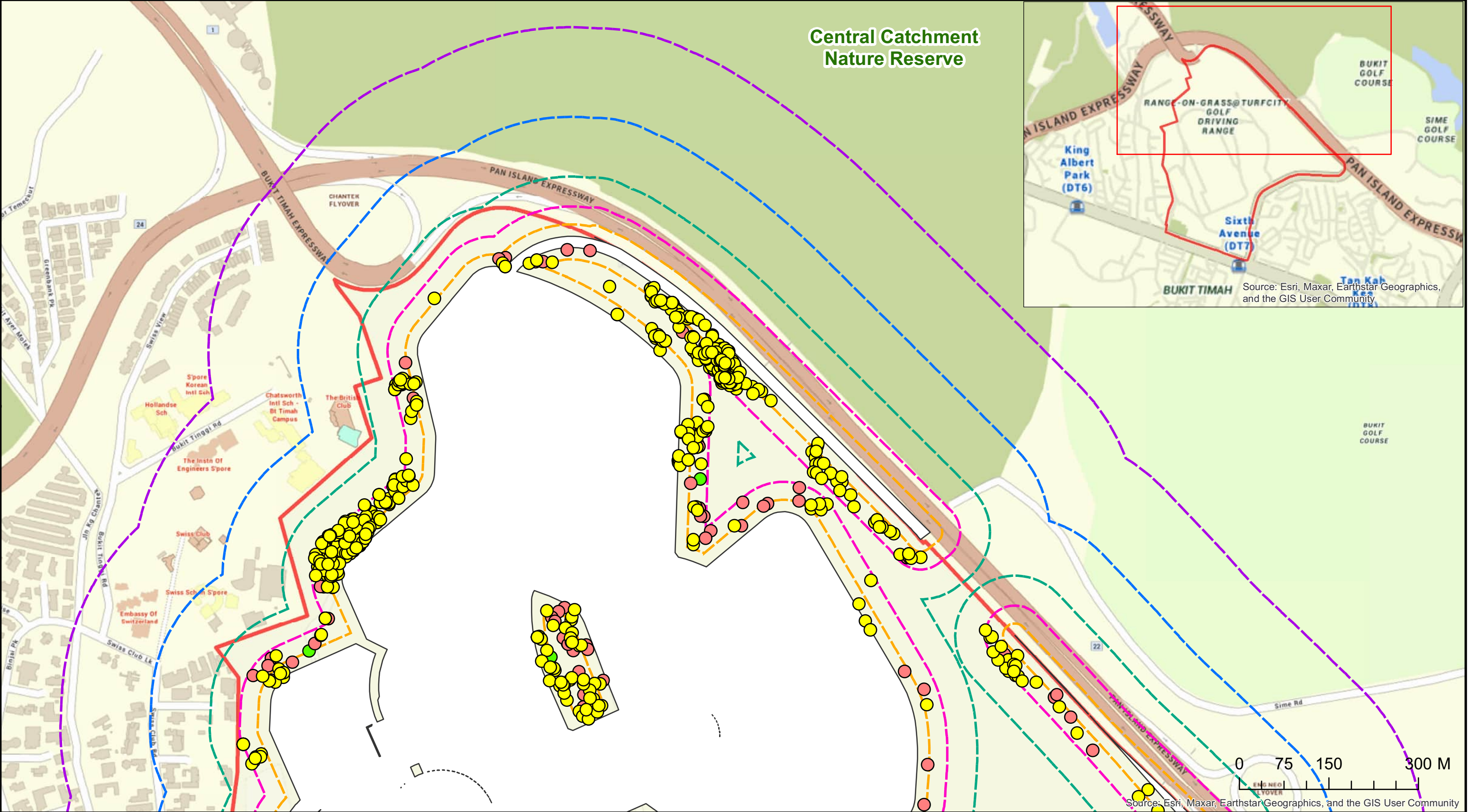
The Project will require complete demolition and partial demolition of certain permanent structures/ buildings within the Project Site. With the approximate demolition area and height of the buildings, it is estimated to be generating 100,000 – 500,000 m³ of concrete.

At this early stage, no detailed plan regarding the footprint and exact location of the proposed buildings is available, however proposed preliminary land use plan is available (refer to Figure 3-2). Therefore, the worst-case emission source for earthworks comprises the whole area planned for development, including roads, parks, and canals. This area has been referred as earthworks footprint for the purpose of air quality impact assessment (refer to Figure 10-6 and Figure 10-7). The earthworks activity includes some extent of soil-cutting, excavation, piling and excavation works, while the construction activity includes the construction of the proposed buildings. Given the area of the earthworks footprint, the spoil amount will be greater than 100,000 tonnes in total based on at least 0.1 m depth excavation works across the earthworks footprints of 500,000 – 1,000,000 m² for Phase 1 and Phase 2, and assumption of typical soil density of 2650 kg/m³.

Extensive construction works (refer to Figure 10-8 and Figure 10-9) will potentially generate extensive air pollution in terms of dust (PM₁₀ and PM_{2.5}). Estimated volume of concrete for Phase 1 and 2 was calculated based on an assumption of at least 10 m height of the development given the aim is to establish high rise establishments.

It is also assumed that a minimum of one (1) concrete batching plant to be located within the construction footprint of each phase due to the large construction footprint.

The trucks carrying spoil to and from the construction footprint on access roads are also a key source of emission (referred to as trackout activity) as shown in Figure 10-10. Based on the existing road tracks leading to the Project Site, site entrances are assumed to be present at certain locations. Trackout are drawn up to 500 m from the assumed entrances of the Project Site. The number of outward trucks movement for a scale of development as this is estimated to be much greater than 50 HDVs per day. The length of unpaved roads has been assumed to be >100 m based on the internal road development that will be ongoing during construction phase as well as the extent of the project area. In addition, the road construction works may not be completed and paved before the construction of other development commences. Impact prediction and evaluation were detailed in Section 10.7.1.



Legend							Qualified Person Endorsement : NA		Consultant : AECOM		Client: URB URBAN REDEVELOPMENT AUTHORITY	
									Project Title : CONTRACT URA/T/22/031 ENVIRONMENTAL IMPACT ASSESSMENT (EIA) FOR FORMER TURF CLUB AT BUKIT TIMAH		Figure Title : Emission Sources and Sensitive Receptors Construction (Part 1 of 2)	
							URA Endorsement : NA		Designed HBS		Figure No. : 10-8	
									Checked LAL		Rev. -	
									Approved JAG		Sheet 1 of 1	
									Date MAY 2024		CAD File Name : NA	
											A3	
							Rev.	Date	By	Description	Chk'd	App'd
							-	MAY 2024	LLG	Turf Club EIA	LAL	JAG

10.3.2 Operational Phase

Key contributor of air quality impact in the area during operational phase of the Project is likely to be vehicular emissions due to increased traffic in the vicinity of the Project. Gaseous and particulate emissions could potentially result in respiratory problems as a key concern on public health. Air pollutants such as nitrogen oxides (NO_x), sulphur dioxide (SO₂) and ammonia (NH₃) [R-37] also impact vegetation and ecosystems. In the context of this project, the air pollutant of concern will be Nox which are produced from road traffic emission. SO₂ is not relevant for this project as low sulphur content fuel will be used by vehicles in Singapore. NH₃ is mainly produced from agricultural activities and therefore, not relevant for the purpose of this project. There is no published evidence for any direct toxic effect of Nox on animals and therefore effects on animals are not included in ecological impact assessment [R-37].

As per the NEA website, since 1 September 2017, all new petrol vehicles have had to meet the Euro 6 emission standard, and since 1 January 2018, all new diesel vehicles have had to meet the Euro 6 emission standard. The new standards will tighten fine particulate emissions from direct-injection petrol engines in addition to the other pollutants. Since 1 January 2018, the emission standard for all three-wheeled (Cat L5e) and large motorcycles with an engine capacity more than 200cc have been tightened to Euro 4 standard, while smaller motorcycles with an engine capacity of 200cc and below will see the Euro 4 emission standard implemented from 1 January 2020. Compared to the Euro 3 emission standard, the tighter Euro 4 emission standard will help reduce emissions of hydrocarbons and nitrogen oxides (Nox), which are precursors to ozone. The emission standards for various vehicle classes have been summarised in Table 10-10.

Table 10-9 Potential air quality impacts during the operational stage

Potential Source of Impacts	Potential Associated Impacts
Gaseous and particulate emissions from vehicle exhaust due to the increased traffic in vicinity of the project due to project operation.	Exhaust emissions (NO ₂ , SO ₂ , CO, PM ₁₀ and PM _{2.5}) could potentially impact the air quality in the vicinity of the project.

Table 10-10 Emission standard of various vehicle classes

No	Implementation Date	Vehicle Classes	Emission Standard
1	1 September 2017	New petrol vehicles	Euro 6
2	1 January 2018	New diesel vehicles	Euro 6
3	1 January 2018	Three-wheeled (Cat L5e) and large motorcycles with engine capacity more than 200cc	Euro 4
4	1 January 2020	Smaller motorcycles with engine capacity of 200cc and below	Euro 4

10.4 Identification of Air Quality Sensitive Receptors

10.4.1 Construction Phase

Figure 10-4 to Figure 10-10 present the buffer zones for demolition, earthworks, construction and trackout. The buffer zones are determined based on the IAQM Guidance. The IAQM Guidance takes into consideration the distance of the receptor from the source and categorised into <20 m, <50 m, <100 m, <200 m and <350 m for human receptors and categorised into <20 m and <50 m for ecological receptors. The number of receptors within each distance category are identified to determine the receptor sensitivity. This is further detailed below for ecological and human receptors receptively.

Ecological Receptors

The construction activities at the construction worksite pose a potential risk of dust emissions that may impact upon target habitat areas lying within the zone of influence of the construction site. In line with the IAQM Guidance, an Assessment Area of 50 m was considered for ecological impacts during construction phase. Table 10-11 below summarises the sensitivity of each construction phase for earthworks, construction, and trackout. Earthworks footprint, construction footprint and access roads are located within or in close proximity to ecologically sensitive receptors. Based on the distances of emission sources to the identified receptors presented in Figure 10-4 to Figure 10-10, the Sensitivity of the Area was determined to range from Priority 1. In line with the IAQM Guidance, Priority 1 refers to emission source located <20 m to the nearest ecologically sensitive receptors, while Priority 2 refers to construction worksites with emission source located within 20-50m from the nearest ecologically sensitive receptors. Flora species of high value identified within the air quality assessment area are presented in Table 10-12.

Table 10-11 Receptor sensitivity for air quality impact assessment – construction phase (ecological receptor)

Distance	Identified Receptors	Sensitivity of the Area
For Demolition:		
Within 20 m	Vegetated area within Project Site 6 Conservation Significant Species 10 Large Specimen 1 Other Species of Value	Priority 1
Between 20 m to 50 m	Vegetated area within Project Site 35 Conservation Significant Species 9 Large Specimen	
For Earthworks:		
Within 20 m	Vegetated area, 20m from Earthworks Emission Sources 222 Conservation Significant Species 43 Large Specimen 12 Other Species of Value	Priority 1
Between 20 m to 50 m	Vegetated area, 50m from Eartworks Emission Sources 571 Conservation Significant Species 66 Large Specimen	
For Construction:		
Within 20 m	Vegetated area, 20m from Construction Emission Sources 222 Conservation Significant Species 43 Large Specimen 12 Other Species of Value	Priority 1
Between 20 m to 50 m	Vegetated area, 50m from Construction Emission Sources 571 Conservation Significant Species 66 Large Specimen	
For Trackout:		
Within 20 m	Vegetated area, 20m from Trackout Emission Sources 13 Conservation Significant Species 1 Large Specimen 5 Other Species of Value	Priority 1
Between 20 m to 50 m	Vegetated area, 50m from Trackout Emission Sources 111 Conservation Significant Species 3 Large Specimen	

Table 10-12 Flora Species of High Value Identified within the Air Quality Assessment Area

Distance	Site	Identified Species	Status	Number of Species Identified
Conservation Species				
Within 20 m	Site A	Aporosa lucida var. lucida	Vulnerable	1
		Archidendron jiringa	Vulnerable	4
		Artocarpus dadah	Endangered	1
		Aspidopterys concava	Endangered	9
		Baccaurea pyriformis	Critically Endangered	1
		Calophyllum tetrapterum var. tetrapterum	Vulnerable	12
		Cratoxylum maingayi	Critically Endangered	1
		Daphniphyllum griffithianum	Critically Endangered	1
		Ficus vasculosa	Vulnerable	1
		Garcinia celebica	Endangered	1
		Glochidion zeylanicum var. zeylanicum	Vulnerable	1
		Gymnacranthera farquhariana var. farquhariana	Endangered	2
		Horsfieldia polyspherula var. polyspherula	Vulnerable	24
		Hypserpa nitida	Endangered	3
		Litsea umbellata	Vulnerable	21
		Lophopetalum wightianum	Endangered	8
		Macaranga griffithiana	Vulnerable	2
		Memecylon edule var. edule	Endangered	1
		Palaquium obovatum	Vulnerable	1
		Strophanthus caudatus	Endangered	1
		Symplocos fasciculata	Vulnerable	1
	Site B	Actinodaphne maingayi	Critically Endangered	1
		Angiopteris evecta	Vulnerable	1
		Aporosa lucida var. lucida	Vulnerable	1
		Archidendron jiringa	Vulnerable	1
		Dacryodes cf. rostrata	-	1
		Ficus glandulifera	Endangered	1
		Gymnacranthera farquhariana var. farquhariana	Endangered	1
		Horsfieldia polyspherula var. polyspherula	Vulnerable	1
		Litsea umbellata	Vulnerable	15
		Macaranga griffithiana	Vulnerable	1
		Palaquium obovatum	Vulnerable	1
		Pellacalyx axillaris	Vulnerable	1
		Pternandra coerulescens	Vulnerable	2
		Sterculia parviflora	Critically Endangered	1
		Symplocos fasciculata	Vulnerable	1
		Uncaria longiflora var. pteropoda	Endangered	2
		Xanthophyllum euryhynchum	Vulnerable	2
	Site C	Ampelocissus elegans	Vulnerable	1
		Aporosa benthamiana	Vulnerable	1
		Aspidopterys concava	Endangered	1
		Calophyllum tetrapterum var. tetrapterum	Vulnerable	13
		Daphniphyllum griffithianum	Critically Endangered	3
		Elaeocarpus griffithii	Critically Endangered	10
		Elaeocarpus nitidus	Vulnerable	1
		Endospermum peltatum	Vulnerable	1
		Ficus glandulifera	Endangered	1
		Ficus vasculosa	Vulnerable	8
		Gironniera subaequalis	Endangered	1
		Horsfieldia polyspherula var. polyspherula	Vulnerable	2
		Litsea umbellata	Vulnerable	25

Distance	Site	Identified Species	Status	Number of Species Identified
Between 20 m to 50 m		Phytocrene bracteata	Vulnerable	2
		Psychotria maingayi	Endangered	1
		Psychotria ovoidea	Endangered	6
		Strophanthus caudatus	Endangered	3
		Uncaria cordata	Endangered	1
	Site D	-	-	-
	Site E	Bulbophyllum vaginatum	Vulnerable	1
		Calophyllum tetrapterum var. tetrapterum	Vulnerable	2
		Ficus vasculosa	Vulnerable	1
		Ficus virens	Endangered	2
		Litsea umbellata	Vulnerable	2
		Piper cf. ramipilum	-	1
	Site F	Phlegmariurus phlegmaria	Endangered	1
Between 20 m to 50 m	Site A	Aporosa benthamiana	Vulnerable	1
		Archidendron jiringa	Vulnerable	10
		Aspidopterys concava	Endangered	2
		Baccaurea pyriformis	Critically Endangered	1
		Calophyllum tetrapterum var. tetrapterum	Vulnerable	37
		Carallia brachiata	Vulnerable	2
		Curculigo latifolia	Vulnerable	1
		Diospyros styraciformis	Critically Endangered	1
		Epicharis cuneata	Vulnerable	1
		Ficus glandulifera	Endangered	1
		Ficus villosa	Endangered	6
		Flacourtia rukam	Vulnerable	2
		Garcinia brevirostris	Vulnerable	1
		Garcinia celebica	Endangered	2
		Garcinia griffithii	Endangered	2
		Glochidion zeylanicum var. zeylanicum	Vulnerable	1
		Gnetum sp.	-	3
		Goniophlebium percussum	Vulnerable	1
		Gymnacranthera farquhariana var. farquhariana	Endangered	2
		Hornstedtia scyphifera var. scyphifera	Vulnerable	1
		Horsfieldia polyspherula var. polyspherula	Vulnerable	35
		Hoya diversifolia	Vulnerable	1
		Hypserpa nitida	Endangered	3
		Koompassia malaccensis	Endangered	5
		Litsea grandis	Endangered	1
		Litsea umbellata	Vulnerable	34
		Lophopetalum wightianum	Endangered	13
		Macaranga griffithiana	Vulnerable	6
		Memecylon excelsum	Critically Endangered	1
		Memecylon floridum	Critically Endangered	3
		Oncosperma sp.	-	3
		Ormosia cf. bancana	-	1
		Phytocrene bracteata	Vulnerable	1
		Piper baccatum	Critically Endangered	14
		Porterandia anisophylla	Vulnerable	1
		Prunus arborea var. stipulacea	Critically Endangered	4
		Psychotria maingayi	Endangered	3
		Santiria laevigata	Vulnerable	4
		Sterculia rubiginosa	Vulnerable	1
		Strombosia javanica	Vulnerable	1
		Strophanthus caudatus	Endangered	2

Distance	Site	Identified Species	Status	Number of Species Identified
		Symplocos fasciculata	Vulnerable	8
		Syzygium subcrenatum	Endangered	4
		Uncaria cordata	Endangered	4
		Xanthophyllum ellipticum	Critically Endangered	12
	Site B	Actinodaphne maingayi	Critically Endangered	1
		Aporosa benthamiana	Vulnerable	2
		Aporosa lucida var. lucida	Vulnerable	1
		Aporosa nigricans	Critically Endangered	1
		Aspidopterys concava	Endangered	1
		Baccaurea pyriformis	Critically Endangered	2
		Carallia brachiata	Vulnerable	2
		cf. Dibridsonia conferta	-	1
		Horsfieldia polyspherula var. polyspherula	Vulnerable	1
		Litsea umbellata	Vulnerable	24
		Psychotria maingayi	Endangered	1
		Strophanthus caudatus	Endangered	1
	Site C	Archidendron jiringa	Vulnerable	3
		Aspidopterys concava	Endangered	5
		Calophyllum tetrapterum var. tetrapterum	Vulnerable	39
		Carallia brachiata	Vulnerable	1
		Chassalia curviflora	Vulnerable	1
		Cratogeomys formosum	Endangered	10
		Curculigo latifolia	Vulnerable	1
		Dalbergia velutina var. maingayi	Endangered	1
		Daphniphyllum griffithianum	Critically Endangered	2
		Dasymaschalon dasymaschalum	Endangered	1
		Diospyros styraciformis	Critically Endangered	6
		Elaeocarpus griffithii	Critically Endangered	10
		Elaeocarpus nitidus	Vulnerable	1
		Embelia canescens	Endangered	1
		Enkleia malaccensis	Critically Endangered	1
		Erythralium scandens	Vulnerable	1
		Ficus vasculosa	Vulnerable	7
		Horsfieldia polyspherula var. polyspherula	Vulnerable	4
		Litsea castanea	Endangered	1
		Litsea umbellata	Vulnerable	24
		Lophopetalum wightianum	Endangered	1
		Palaquium obovatum	Vulnerable	2
		Phytocrene bracteata	Vulnerable	6
		Porterandia anisophylla	Vulnerable	1
		Psychotria maingayi	Endangered	1
		Psychotria ovoidea	Endangered	6
		Strophanthus caudatus	Endangered	6
		Tacca cristata	Vulnerable	2
		Tetracera fagifolia	Critically Endangered	1
		Xanthophyllum ellipticum	Critically Endangered	1
		Xanthophyllum flavescens	Endangered	1
	Site D	-	-	-
	Site E	Calophyllum tetrapterum var. tetrapterum	Vulnerable	1
		Cyclea laxiflora	Critically Endangered	13
		Ficus kerkhovenii	Endangered	2
		Ficus vasculosa	Vulnerable	3
		Ficus virens	Endangered	5
		Horsfieldia polyspherula var. polyspherula	Vulnerable	2
		Litsea umbellata	Vulnerable	2
		Pterospermum cf. diversifolium	-	1

Distance	Site	Identified Species	Status	Number of Species Identified
		Trema tomentosum	Vulnerable	1
		Xanthophyllum ellipticum	Critically Endangered	2
	Site F	Aporosa benthamiana	Vulnerable	1
		Calophyllum rubiginosum	Endangered	1
		Calophyllum tetrapterum var. tetrapterum	Vulnerable	7
		Diospyros styraciformis	Critically Endangered	1
		Elaeocarpus ferrugineus	Vulnerable	2
		Epicharis cuneata	Vulnerable	1
		Garcinia cf. brevirostris	-	1
		Horsfieldia polyspherula var. polyspherula	Vulnerable	29
		Horsfieldia sp.	-	1
		Knema conferta	Endangered	2
		Litsea umbellata	Vulnerable	14
		Macaranga griffithiana	Vulnerable	4
		Piper baccatum	Critically Endangered	12
		Psychotria ovoidea	Endangered	4
		Sterculia cf. parviflora	-	2
		Sterculia parviflora	Critically Endangered	4
		Sterculia rubiginosa	Vulnerable	8
		Strophanthus caudatus	Endangered	2
		Symplocos fasciculata	Vulnerable	4
		Uncaria longiflora var. pteropoda	Endangered	2
		Xanthophyllum ellipticum	Critically Endangered	8
Large Specimens				
Within 20 m	Site A	Bambusa vulgaris	Casual	1
		Cyrtophyllum fragrans	Least Concern	3
		Elaeis guineensis	Casual	2
		Falcataria falcata	Naturalised	11
		Ficus microcarpa	Least Concern	1
	Site B	Cyrtophyllum fragrans	Least Concern	5
		Ficus benjamina	-	3
		Ficus microcarpa	Least Concern	2
		Peltophorum pterocarpum	Critically Endangered	1
		Spathodea campanulata	Naturalised	1
		Syzygium grande	Least Concern	1
		Thyrsostachys siamensis	Casual	1
	Site C	Ficus microcarpa	Least Concern	1
		Spathodea campanulata	Naturalised	1
	Site D	-	-	-
	Site E	Cyrtophyllum fragrans	Least Concern	3
		Ficus microcarpa	Least Concern	4
		Samanea saman	Casual	2
	Site F	-	-	-
Between 20 m to 50 m	Site A	Alstonia angustiloba	Least Concern	1
		Bambusa vulgaris	Casual	4
		Cyrtophyllum fragrans	Least Concern	2
		Elaeis guineensis	Casual	1
		Falcataria falcata	Naturalised	10
		Ficus benjamina	-	1
		Ficus variegata	Least Concern	1
	Site B	Cyrtophyllum fragrans	Least Concern	6
		Erythrophleum suaveolens	Cultivated Only	5
		Ficus benjamina	-	3
		Ficus microcarpa	Least Concern	2

Distance	Site	Identified Species	Status	Number of Species Identified
		Samanea saman	Casual	2
	Site C	Cyrtophyllum fragrans	Least Concern	2
		Ficus microcarpa	Least Concern	1
		Ficus variegata	Least Concern	2
		Pterocarpus indicus	Casual	2
		Syzygium grande	Least Concern	1
	Site E	Bambusa vulgaris	Casual	5
		Casuarina equisetifolia	Least Concern	1
		Cinnamomum iners	Least Concern	1
		Cyrtophyllum fragrans	Least Concern	1
		Falcataria falcata	Naturalised	1
		Ficus benamina	-	3
		Ficus kerkhovenii	Endangered	1
		Ficus microcarpa	Least Concern	3
		Ficus virens	Endangered	1
		Spathodea campanulata	Naturalised	1
	Site F	Bambusa vulgaris	Casual	2
Other Specimens of Value				
Within 20 m	Site A	Bambusa vulgaris	Casual	5
		Falcataria falcata	Naturalised	1
	Site B	Syzygium polyanthum	Least Concern	1
Between 20 m to 50 m	Site A	Bambusa vulgaris	Casual	2
		Falcataria falcata	Naturalised	1
	Site B	Unknown 1	-	1
	Site C	Falcataria falcata	Naturalised	1

Human Receptors

Assessment Area of 350 m was considered for human health impacts during construction phase. Based on Table 6-2, in line with the IAQM Guidance, Priority 1 is defined as having sensitive receptors (i.e. residentials, hospitals, schools) within 20 m of construction worksite or >100 sensitive receptors within 50 m of construction worksite. While Priority 2 is defined as having commercial receptors within 20 m of construction worksite, having 1-100 sensitive receptors between 20-50 m of construction worksite or having >100 sensitive receptors between 50-100 m of construction worksite. All other buildings within the 350 m Assessment Area will be considered as Priority 3.

Therefore, based on the distances of emission sources to the identified receptors presented in Figure 10-4 to Figure 10-10, the Sensitivity of the Area for each construction worksite was determined to be ranging from Priority 1 to Priority 2 as summarised in Table 10-13 for demolition, earthworks, construction, and trackout. Due to the extensive list of the identified sensitive receptors for construction phase, this is elaborated and presented in Appendix R.

Table 10-13 Receptor sensitivity for air quality impact assessment – construction phase (human receptors)

Activities	Sensitivity of the Area
Demolition	Priority 1
Trackout – Earthworks	Priority 1
<u>Phase 1</u>	
Earthworks	Priority 1
Construction	Priority 1
Trackout – Construction	Priority 1
<u>Phase 2</u>	

Activities	Sensitivity of the Area
Earthworks	Priority 2
Construction	Priority 2
Trackout – Construction	Priority 1

10.4.2 Operational Phase

Potential air quality impact during operational phase of the Project would be vehicular emissions due to increased traffic to the proposed development. Potential human and ecological sensitive receptors which might be impacted by the increased traffic (within 250 m assessment area) are presented in Table 10-14 below.

Table 10-14 Receptor sensitivity for air quality impact assessment – operational phase

No	Receptor Name	Receptor Type	Sensitivity Classification
1	Chiltern House Turf Club Road	Educational Institute	Priority 1
2	Chatsworth International School	Educational Institute	Priority 1
3	Swiss School in Singapore	Educational Institute	Priority 1
4	EtonHouse Pre-school Vanda Road	Educational Institute	Priority 1
5	Fourth Avenue Residence	Residential	Priority 1
6	Royal Green Condominium	Residential	Priority 1
7	4, 6, 8 Ascot Rise	Residential	Priority 1
8	64B, 66B Binjai Park	Residential	Priority 1
9	70, 72, 74, 76, 78, 80, 82, 84, 86, 88, 90, 96, 98, 100, 100A, 100B, 102, 102A, 104, 106, 108, 110, 112, 114, 116, 120, 122, 124, 126, 128 Eng Neo Avenue	Residential	Priority 1
10	17, 23, 25, 27A, 27, 28, 37, 39, 41, 42, 44, 45, 46, 47, 48A, 48B, 50, 52, 54 Jalan Kampong Chantek	Residential	Priority 1
11	4, 6, 8, 17 Jalan Senandong	Residential	Priority 1
12	4, 6 Jalan Naga Sari	Residential	Priority 1
13	80, 85, 89 Linden Drive	Residential	Priority 1
14	1, 2, 2A, 2B, 2C, 2D, 2E, 2F, 2G, 3, 4, 5, 6, 6A, 6, 7, 9, 9A, 10, 11, 11A, 11B, 11C, 11D, 12, 14, 14A, 14B, 16, 20, 22A, 24, 27A, 28, 29, 30A, 30B, 30C, 30D, 30E, 30F, 31, 32, 32A, 33, 33A, 24, 25 Swiss Club Road	Residential	Priority 1
15	8 Swiss Club Lane	Residential	Priority 1
16	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 Swiss Club Avenue	Residential	Priority 1
17	1, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 17, 19 Vanda Crescent	Residential	Priority 1
18	21, 23, 25, 25A, 27A, 27B, 27C, 29, 31 Vanda Avenue	Residential	Priority 1
19	2, 4, 10, 12, 14, 16, 18, 20, 22, 24, 27, 29 Vanda Drive	Residential	Priority 1
20	2, 4, 18, 18A, 20, 22, 23, 29, 31, 33, 35, 39, 43 Vanda Road	Residential	Priority 1
21	779, 781, 783, 785, 787, 789, 791, 793, 795, 827 Bukit Timah Road	Commercial	Priority 3

No	Receptor Name	Receptor Type	Sensitivity Classification
22	10, 10E Sixth Avenue	Commercial	Priority 3
23	The British Club	Commercial	Priority 3
24	Gunthrie House	Commercial	Priority 3
25	Orchid Village	Commercial	Priority 3
26	Sixth Avenue MRT Station	Transport Facility	Priority 3

10.5 Baseline Air Quality

10.5.1 Baseline Monitoring Personnel

The assessment and site surveys were conducted by the following personnel:

- Ms. Jagriti Dawra, AECOM (EIA Specialist)
- Mr. Hanzel Lalitan, AECOM (Air Quality Consultant)
- Ms Tiffany Tan, AECOM (Air Quality Consultant)
- Ms Leela Guvvala, AECOM (Air Quality Consultant)
- Mr. Edmundo Il Casapao, ALS Technichem (S) Pte Ltd

Site reconnaissance was conducted on 29 March 2023 and 16 May 2023. Subsequently, the primary baseline air quality data collection has been conducted between 14 August 2023 and 14 September 2023.

10.5.2 Baseline Findings

10.5.2.1 Secondary Data Collection (Review of Background Data)

10.5.2.1.1 NEA Long Term Ambient Air Quality

Table 10-15 provides the general NEA ambient air monitoring results for Singapore over the period 2018 – 2022 and compares them with the Singapore Long Term Ambient Air Quality Targets. The Singapore Long Term Air Quality Targets have been adopted in this report and are generally more stringent than the USEPA National Ambient Air Quality Standards (NAAQS).

It can be observed from Table 10-15 that the NEA monitoring results for background particulate matter less than 10 μm (PM_{10}), particulate matter less than 2.5 μm ($\text{PM}_{2.5}$), sulfur dioxide (SO_2) and ozone (O_3) have consistently exceeded the Singapore Long Term Air Quality Targets over the period 2018 – 2022. Carbon monoxide (CO) and nitrogen dioxide (NO_2) were below the Singapore Long Term Air Quality Target between 2018 and 2022. The elevated PM_{10} , $\text{PM}_{2.5}$, SO_2 and O_3 concentrations in Singapore are partly attributable to the intermittent haze periods resulting from forest fires in neighbouring countries although other significant contributors to the background levels may also be domestic emissions from industries, shipping and motor vehicles.

Table 10-15 NEA long term ambient air quality monitoring [R-38]

Pollutants	Averaging Period	2018 results ($\mu\text{g}/\text{m}^3$)	2019 results ($\mu\text{g}/\text{m}^3$)	2020 results ($\mu\text{g}/\text{m}^3$)	2021 results ($\mu\text{g}/\text{m}^3$)	2022 results ($\mu\text{g}/\text{m}^3$)	Average results 2018 – 2022 ($\mu\text{g}/\text{m}^3$)	Singapore Ambient Air Quality Long Term Targets ($\mu\text{g}/\text{m}^3$)
PM_{10}	99 th %ile of 24-Hour Averages	59	90	43	51	51	59	50
	Annual Mean	29	30	25	28	24	27	20

Pollutants	Averaging Period	2018 results ($\mu\text{g}/\text{m}^3$)	2019 results ($\mu\text{g}/\text{m}^3$)	2020 results ($\mu\text{g}/\text{m}^3$)	2021 results ($\mu\text{g}/\text{m}^3$)	2022 results ($\mu\text{g}/\text{m}^3$)	Average results 2018 – 2022 ($\mu\text{g}/\text{m}^3$)	Singapore Ambient Air Quality Long Term Targets ($\mu\text{g}/\text{m}^3$)
PM_{2.5}	99 th %ile of 24-Hour Averages	32	62	24	28	26	34	25
	Annual Mean	15	16	11	12	11	13	10
CO	Maximum 1-Hour Average	2,500	2,300	1,600	1,300	2,100	1,960	30,000
	Maximum 8-Hour Average	2,000	1,700	1,200	1,200	1,700	1,560	10,000
NO₂	Maximum 1-Hour Average	147	156	118	123	128	134	200
	Annual Mean	26	23	20	25	25	24	40
SO₂	24-Hour Average	65	57	30	89	37	56	50
O₃	8-Hour Average	150	125	145	176	124	144	100
Note: Values in Bold exceed the Singapore Ambient Air Quality Long Term Targets								

10.5.2.1.2 Hourly Pollution Standard Index (PSI) and 24-hour PM₁₀ and PM_{2.5} Concentrations Readings

24-hr PM₁₀ and PM_{2.5} readings available on data.gov.sg for Western and Central Region of Singapore were collected during the same period as primary data collection period for comparison against primary baseline monitoring results.

A review was also conducted for 24-hr PM_{2.5} and PM₁₀ readings available on data.gov.sg for Western and Central Singapore during the monitoring period (14 August – 14 September 2023). Figure 10-11 and Figure 10-12 show the variation of PM₁₀ and PM_{2.5} concentrations recorded by the NEA during the primary baseline data collection period.

A review was also conducted for 24-hr PM_{2.5} and PM₁₀ readings available on data.gov.sg for South Singapore during the monitoring period (22 – 29 March 2021). Figure 10-11 and Figure 10-12 show the variation of PM₁₀ and PM_{2.5} concentrations recorded by the NEA during the primary baseline data collection period.

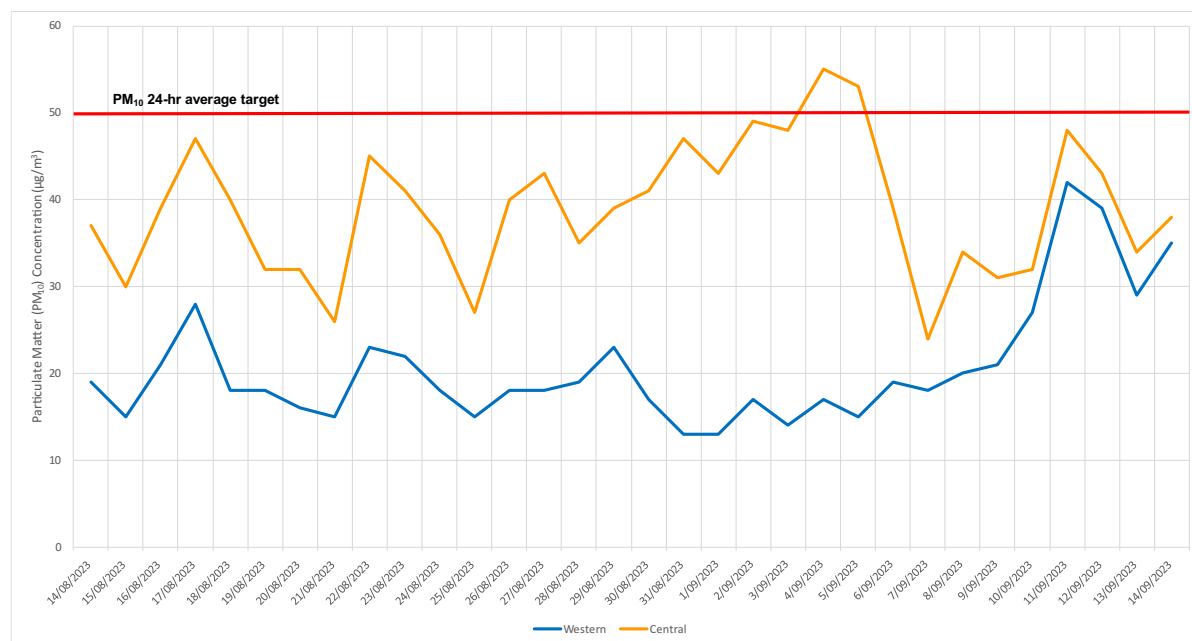


Figure 10-11 24-hr PM₁₀ concentrations reading of Western and Central Singapore (14 August – 14 September 2023) [W-8]

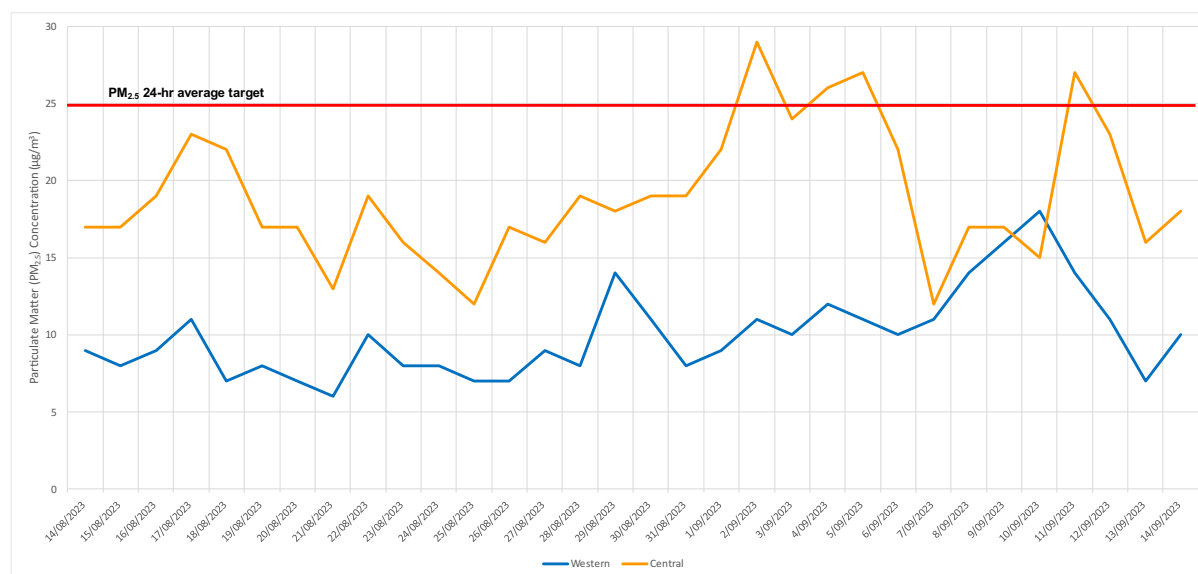


Figure 10-12 24-hr PM_{2.5} Concentrations Reading of Western and Central Singapore (14 August – 14 September 2023) [W-8]

10.5.2.1.3 Other Parameters (Rainfall, Temperature, Wind Speed)

Figure 10-13, Figure 10-14, and Figure 10-15 below present the trend of daily total rainfall, mean temperature and mean wind speed observed at Clementi and Upper Thomson weather monitoring stations, from January 2018 to September 2023.

From Figure 10-13, an average of approximately 6.89 mm and 6.09 mm of daily rain was observed from Clementi and Upper Thomson monitoring stations, respectively. This calculates to approximately 2,500 mm and 2,200 mm of rain annually for Clementi and Upper Thomson respectively. With regards to mean temperature and mean wind speed, the temperature and wind speed recorded at Clementi station is relatively constant with average 27.7°C mean temperature and 9.7 km/h mean wind speed. It should be noted that Upper Thomson station only recorded rainfall data up to December 2020 and is no longer in operation since then.

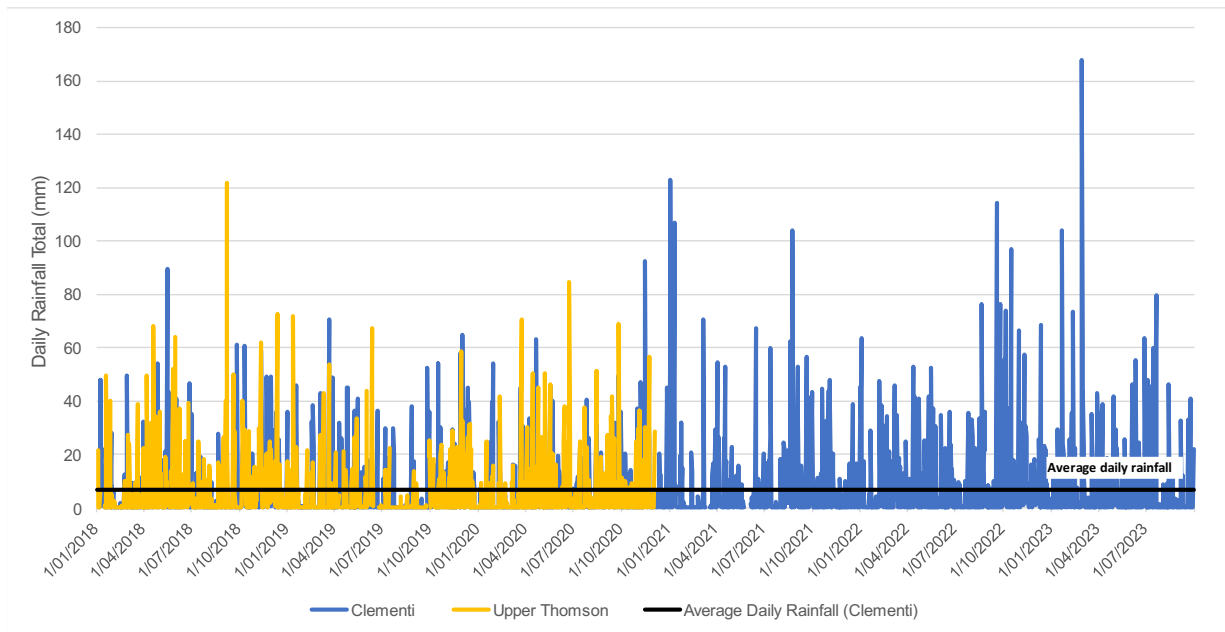


Figure 10-13 Daily rainfall monitored at Clementi and Upper Thomson monitoring stations [W-9]

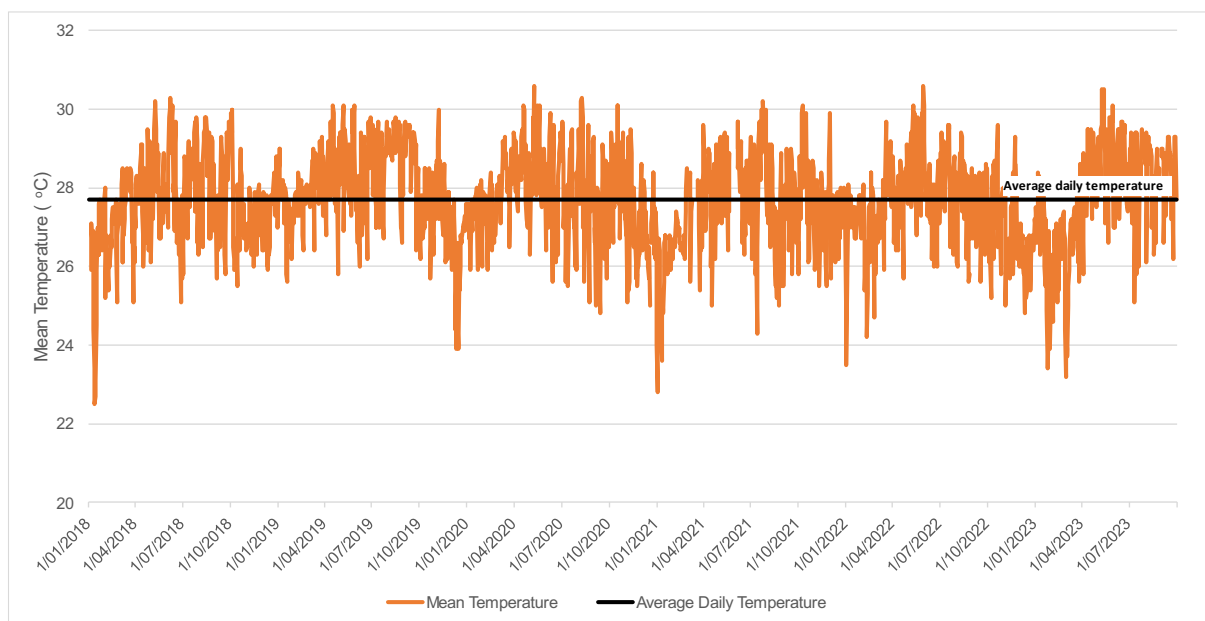


Figure 10-14 Mean temperature monitored at Clementi monitoring station [W-9]

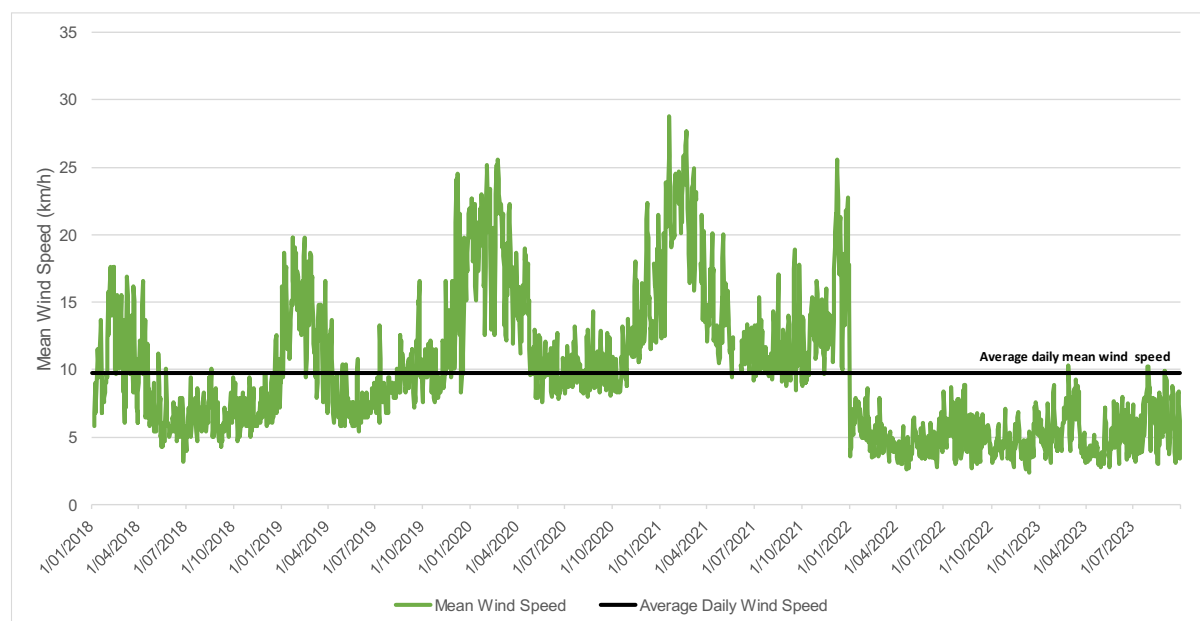


Figure 10-15 Mean wind speed monitored at Clementi monitoring station [W-9]

10.5.2.2 Secondary Air Quality Monitoring Data from Previous Studies

Seven (7) days of continuous ambient air quality monitoring was conducted at the locations mentioned in Section 10.2.2.2 to determine the pollutant concentrations from existing background pollutant sources. The monitoring results for each pollutant at all monitoring locations are summarised in Table 10-16 below and compared with the Singapore Ambient Air Quality Long Term Targets.

Table 10-16 Air quality monitoring results from Previous Studies [R-4]

Monitoring Location	Monitoring Date	Daily PM ₁₀ Concentration, $\mu\text{g}/\text{m}^3$			Daily PM _{2.5} Concentration, $\mu\text{g}/\text{m}^3$		
		Min	Max	Average	Min	Max	Average
LA01 – Eng Neo Avenue Forest	26 March – 2 April 2020	14.6	25.5	19.0	10.0	16.9	13.4
Singapore Ambient Air Quality Long Term Targets		50			25		
Notes: Air quality monitoring was conducted during COVID-19 pandemic. Ambient air quality in this area might be higher during normal condition.							

It can be observed from Table 10-17 that all pollutant concentrations are within the Singapore Ambient Air Quality Long Term Targets at the monitoring locations.

10.5.2.3 Primary Data Collection (Survey & Sampling)

Seven (7) days of continuous ambient air quality monitoring was conducted at the locations mentioned in Section 10.2.2.3. The monitoring results are summarised in Table 10-17 below and compared with the Singapore Ambient Air Quality Long Term Targets. Baseline monitoring results are presented graphically in Figure 10-16 and Figure 10-17. Detailed baseline monitoring report is presented in Appendix Q.

It can be observed from Table 10-17, Figure 10-16 and Figure 10-17 that the results of 24-hours average PM₁₀ at all locations were well below the Singapore Ambient Air Quality Long Term Targets. However, the maximum concentration of 24-hour average PM_{2.5} at AQ01, AQ04, AQ05 and AQ07 exceeded the Singapore Ambient Air

Quality Long Term Targets. The monitoring results trend is similar with the trend of secondary data presented in Section 10.5.2.1.

Table 10-17 Baseline air quality monitoring results

Monitoring Location	Site	Monitoring Date	24-hour Average PM ₁₀ Concentration (7-day Period), µg/m ³			24-hour Average PM _{2.5} Concentration (7-day Period), µg/m ³		
			Min	Max	Average	Min	Max	Average
EA01 – Southern portion of Eng Neo Avenue Forest (Site A)	Site A	23 – 30 September 2021	14.5	24.2	20.1	8.0	16.8	12.4
EA02 – Within 52 Fairways Drive (Site B)	Site B	23 – 30 September 2021	14.0	24.9	20.6	7.9	16.4	12.0
EA03 – Forested area along Turf Club Road (Site C) *	Site C	1 – 8 December 2021	12.0	17.0	14.6	7.7	10.5	8.9
AQ01 – Northern Portion of Champions Golf near PIE	Site E	7 – 14 September 2023	14.6	30.9	20.09	10.3	25.5	15.13
AQ02 – Southern Portion of Champions Golf near Turf Club Road	Site E	7 – 14 September 2023	15.7	30.3	20.36	10.9	24.8	15.53
AQ03 – Near The Grandstand	Site E	21 – 28 August 2023	16.6	30.0	22.16	10.8	20.4	14.40
AQ04 – Near Blue House International Pre-School	Site E	14 – 21 August 2023	23.9	44.4	30.20	13.8	25.9	17.73
AQ05 – Near Chiltern House Turf Club Road	Site E	14 – 21 August 2023	17.5	32.8	22.67	13.3	25.3	16.71
AQ06 – Near residential properties along Swiss View	Site C	30 August – 6 September 2023	16.1	26.9	21.67	13.3	24.3	18.76
AQ07 – Green area near PIE, along Hillcrest Road	Site F	30 August – 6 September 2023	20.5	31.4	25.83	14.1	25.8	19.77

Monitoring Location	Site	Monitoring Date	24-hour Average PM ₁₀ Concentration (7-day Period), µg/m ³			24-hour Average PM _{2.5} Concentration (7-day Period), µg/m ³		
			Min	Max	Average	Min	Max	Average
AQ08 – Near Eng Neo Avenue and Linden Drive	Site F	21 – 28 August 2023	12.7	28.3	18.17	9.0	18.6	13.04
Singapore Ambient Air Quality Long Term Targets			50			25		

Note: **Bold font denotes exceedance of SAAQT**

* Due to the short distance from EA03 to Site D (~150 m), it can also be argued that AQ03 may also be located within the same airshed as Site D and representative of Site D.

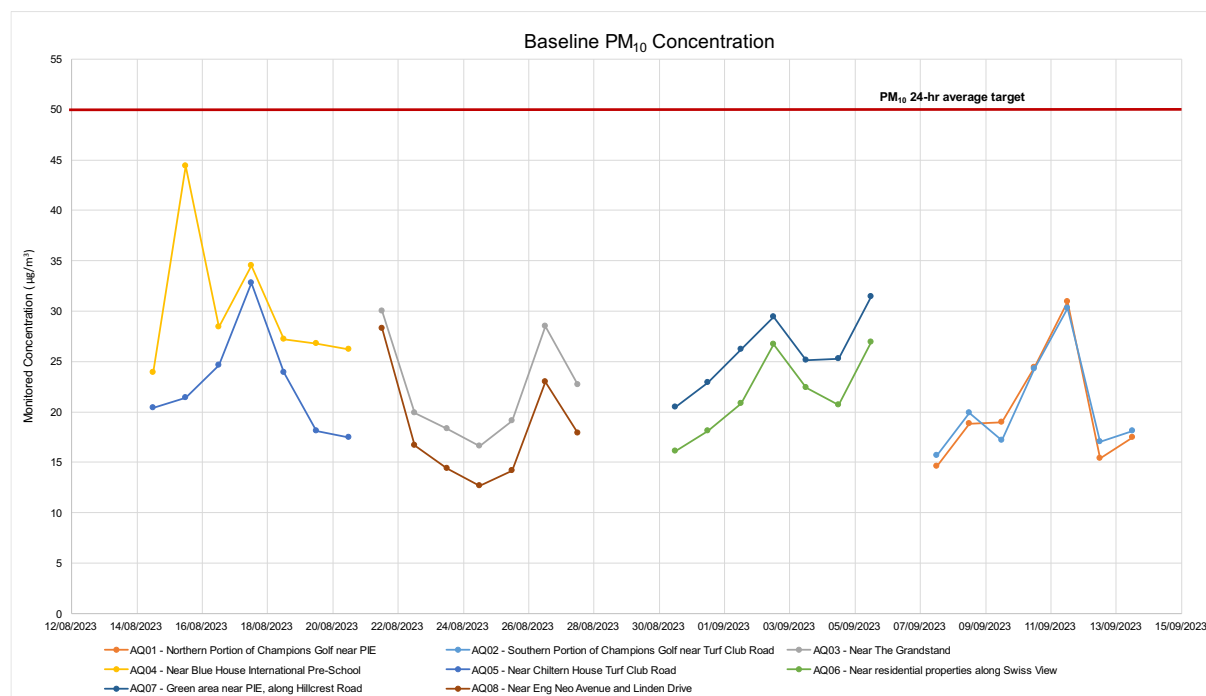


Figure 10-16 Baseline PM₁₀ Monitoring Results

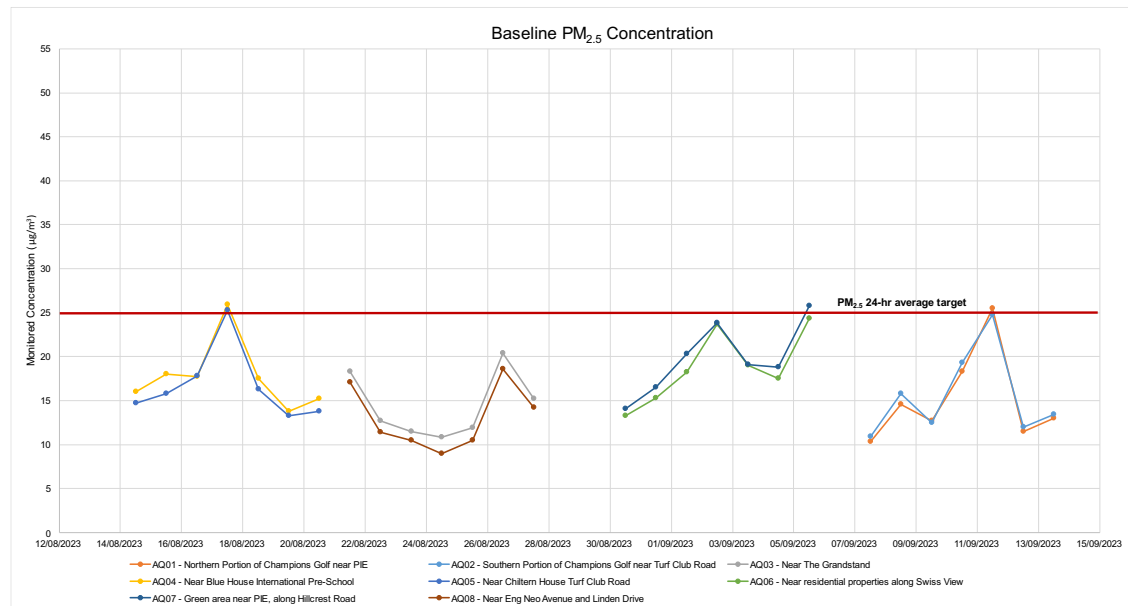


Figure 10-17 Baseline PM_{2.5} Monitoring Results

The findings from the secondary air quality monitoring data and primary data collection are summarised and represented in Figure 10-18.

Overall, generally, the baseline air quality within the Sites A, B, C and D is of good quality as there is no major air pollution sources within the Sites A, B, C and D. Sites A, B, C and D were quite uniform in its use during the time period when the monitoring was conducted, consisting largely of forested land, sparsely inhabited, with little human activity and mainly vegetation. The green areas and canopy cover within Sites A, B, C and D also help in terms of providing cleaner air. It should be noted that certain areas within the Sites A and B bordering major roads (i.e. PIE, Eng Neo Avenue, etc.) may have higher existing ambient air quality levels due to contribution from traffic emissions. However, the majority of the Sites A, B, C and D is located further away from the roads and hence, pollutants recorded at all monitoring locations are generally low and less affected by traffic.

The baseline air quality within Sites E and F is of relatively good quality, with some exceptions of exceedance on some monitoring days at AQ01, AQ04, AQ05 and AQ07. It is to be noted that during the time period there was existing source of air pollution, the construction site within Site B, extending into Site E. Heavy duty vehicles were observed along Fairway Drive and Turf Club Road, near Blue House International Pre-School during the monitoring period of AQ04. Certain areas within the Sites E and F bordering major roads (i.e. PIE, etc.) may have higher existing ambient air quality levels due to contribution from traffic emissions. However, it should be noted that the monitoring results at AQ01 and AQ07 are in trend with the other monitoring location conducted during the same time period, AQ02 and AQ06, respectively. Moreover, the overall monitoring results are similar with the trend of secondary data presented in Section 10.5.2.1.

10.6 Minimum Control Measures

This section proposes minimum controls or standard practices commonly implemented that have been assumed to be implemented for the purposes of impact assessment.

10.6.1 Construction Phase

The following control measures should be observed during the construction stage:

- The construction footprint shall be hoarded on all sides; and
- Access road construction or expansion is recommended to be completed first and paved before the construction of other development commences.

10.6.2 Operational Phase

No minimum control has been assumed for the purpose of air quality impact assessment during operational phase.

10.7 Prediction and Evaluation of Air Quality Impacts

10.7.1 Construction Phase

Throughout the study a conservative but credible approach was adopted to assess potential dust impacts. This may lead to an over-estimation of the levels of pollutants that will arise in practice, but this is considered to be appropriate for planning purposes at this stage of the project and is consistent with precautionary principles.

The assessment is conducted using the site area, hours of operation, timescale of construction, construction material, excavation quantities, surface material and number of vehicles on site as discussed in Section 10.3.1.

Ecological Receptors

Dust from construction sites deposited on vegetation may create ecological stress within the local plant community. During dry periods dust can coat plant foliage adversely affecting photosynthesis and other biological functions. Rainfall removes the deposited dust from foliage and can rapidly leach chemicals into the soil. Large scale construction sites may give rise to dust deposition over an extended period of time and adversely affect vascular plants. Deposition of concrete dust has the potential to increase the surface alkalinity, which in turn can hydrolyse lipid and wax components, penetrate the cuticle, and denature proteins, finally causing the leaf to wilt [P-27]. Dust may affect photosynthesis, respiration, transpiration and allow the penetration of phytotoxic gaseous pollutants [P-28].

The ecological receptors are mainly located at the northern and eastern parts of the Project Site, within Sites A, B, C, E and F. Ecological receptors within 50 m from construction activities within these areas are likely to be affected by dust deposition.

In line with the IAQM Guidance, the Impact Intensity was determined by reviewing the scale of construction activities and classifying them as low, medium or high for each activity type (earthworks, construction, and trackout). The amount of dust deposited, and its effects are also dependent upon weather conditions, during wet weather less dust will be generated and that which has been deposited upon foliage is more likely to be washed off. As presented in Section 10.5.2.1.3, the project is expected to receive relatively high rainfall. Hence, this is expected to help to lessen the intensity of dust generated and deposited upon plant foliage. However, the IAQM methodology does not take into account the rainfall intensity in the assessment area. Therefore, the air quality assessment is expected to be conservative for the purpose of the project.

The overall Consequence for each activity was classified by considering Impact Intensity with the Receptor Sensitivity. Without any mitigation measures in place, the Likelihood of occurrence of impacts from construction of the project is classified as **Regular** as the activity would occur on a regular basis during construction. The Impact Intensity, overall Consequence and Impact Significance are outlined in Table 10-18.

Based on the assessment, the highest Impact Significance is predicted to be **Major** for ecological impact. Hence, based on the assessment methodology in Section 10.2.3.1.7, Impact Significance evaluated as Major requires the adoption of management or mitigation measures.

Human Receptors

In line with the IAQM Guidance, the Impact Intensity was determined by reviewing the scale of construction activities and classifying them as low, medium or high for each activity type (earthworks, construction, and trackout). The project was expected to receive relatively higher rainfall in the long term compared to the other parts of Singapore. Hence, this was expected to help to lessen the intensity of dust generated and deposited. However, the IAQM methodology does not take into account the rainfall intensity in the assessment area. Therefore, the air quality assessment was expected to be conservative for the purpose of the project.

Human receptors are mainly located at the south, east (along Eng Neo Avenue) and west (along Swiss Club Road) of the Project Site. During the initial phase of the project development, the human receptors towards the western and south-western part of the Project Site are largely affected by the construction activities. As the phases progress, the human receptors towards the south-eastern part of the Project Site are largely affected by the construction activities. Overall, construction activities within Site B and E, in proximity to the south boundary of the Project Site, are likely to affect the human receptors.

It should also be noted that as the development phases progress, the completed developments from the initial phases will be the new human receptors, likely to be largely affected by the construction activities during the progressive phases. This is likely to reduce the impacts on the identified human receptors within the earthworks and construction study areas.

The overall Consequence for each activity was classified by considering Impact Intensity with the Receptor Sensitivity. Without any mitigation measures in place, the Likelihood of occurrence of impacts from construction of the project was classified as **Regular** as the activity (i.e. demolition of buildings, earthworks or construction of buildings) would occur on a regular basis during demolition, earthworks and construction works. The Impact Intensity, overall Consequence and Impact Significance are outlined in Table 10-18 to Table 10-21.

Based on the assessment, the Impact Significance was predicted to be **Moderate – Major** for human health impact. Hence, based on the assessment methodology in Section 10.2.3.1.7, Impact Significance evaluated as Major and Moderate requires the adoption of management or mitigation measures.

Table 10-18 Impacts of dust risk assessment – Demolition (before mitigation)

Key Parameter – Demolition			Impact Assessment							
Total Building Volume (m ³)	Construction Material	Height of Demolition Activities	Impact Intensity	Sensitivity of the Area		Overall Consequence / Dust Risk		Likelihood	Impact Significance	
				Ecological Receptor	Human Receptor	Ecological Receptor	Human Receptor		Ecological Receptor	Human Receptor
100,000 – 500,000	Potentially dusty construction material	10-20	High	Priority 1	Priority 1	High	High	Regular	Major	Major

Table 10-19 Impacts of dust risk assessment – Earthworks (before mitigation)

Key Parameter – Earthworks				Impact Assessment						
Total Earthworks Footprint (m²)	Earthwork Material	No. of heavy machineries during foundation work	Impact Intensity	Sensitivity of the Area		Overall Consequence / Dust Risk		Likelihood	Impact Significance	
				Ecological Receptor	Human Receptor	Ecological Receptor	Human Receptor		Ecological Receptor	Human Receptor
Phase 1										
500,000 – 1,000,000	Moderately dusty soil type	>10	High	Priority 1	Priority 1	High	High	Regular	Major	Major
Phase 2										
500,000 – 1,000,000	Moderately dusty soil type	>10	High	Priority 1	Priority 2	High	Medium	Regular	Major	Moderate

Table 10-20 Impacts of dust risk assessment – Construction (before mitigation)

Key Parameter – Construction			Impact Assessment							
Total Building Volume (m³)	Construction Material	No. of concrete batching plant	Impact Intensity	Sensitivity of the Area		Overall Consequence / Dust Risk		Likelihood	Impact Significance	
				Ecological Receptor	Human Receptor	Ecological Receptor	Human Receptor		Ecological Receptor	Human Receptor
Phase 1										
5,000,000 – 10,000,000	Potentially dusty (e.g. concrete)	1	High	Priority 1	Priority 1	High	High	Regular	Major	Major
Phase 2										
5,000,000 – 10,000,000	Potentially dusty (e.g. concrete)	1	High	Priority 1	Priority 2	High	Medium	Regular	Major	Moderate

Table 10-21 Impacts of dust risk assessment – Trackout (before mitigation)

Key Parameter – Trackout			Impact Assessment							
No. of outward trucks movement per day	Road surface material	Unpaved Road Length (m)	Impact Intensity	Sensitivity of the Area		Overall Consequence / Dust Risk		Likelihood	Impact Significance	
				Ecological Receptor	Human Receptor	Ecological Receptor	Human Receptor		Ecological Receptor	Human Receptor
Earthworks										
>50	Moderately dusty	5-100	High	Priority 1	Priority 1	High	High	Regular	Major	Major
Construction Phase 1										
>50	Moderately dusty	5-100	High	Priority 1	Priority 1	High	High	Regular	Major	Major
Construction Phase 2										
>50	Moderately dusty	5-100	High	Priority 1	Priority 1	High	High	Regular	Major	Major

10.7.2 Operational Phase

As discussed in Section 10.3.2, emissions from vehicle exhaust due to increased traffic to the proposed project is expected. It is assumed that all new petrol and diesel vehicles will meet Euro 6 emission standard, while all motorcycles will meet Euro 4 standard going forward and slowly completely convert to these or better standards as they get phased out in 10 years from their onset. It can be observed from Table 10-22, Nox reduction from the last three Euro emission standard tier is 55.6% and 25% for diesel and gasoline passenger cars respectively. Similarly, as observed in Table 10-23, Nox reduction from the last three Euro emission standard tier is approximately 55% and 25% for diesel and gasoline commercial good vehicles respectively across all vehicle category.

Table 10-22 Euro emission standard for passenger cars [W-10]

Tier	Approval Date	Emission standard for passenger cars, g/km				
		CO	HC	Nox	HC+Nox	PM
<u>Compression Ignition (Diesel)</u>						
Euro 5a	September 2009	0.50	-	0.18	0.23	0.005
Euro 5b	September 2011	0.50	-	0.18	0.23	0.005
Euro 6	September 2014	0.50	-	0.08	0.17	0.005
<u>Positive Ignition (Gasoline)</u>						
Euro 4	January 2005	1.00	0.10	0.08	-	-
Euro 5	September 2009	1.00	0.10	0.06	-	0.005
Euro 6	September 2014	1.00	0.10	0.06	-	0.005

Table 10-23 Euro emission standard for commercial good vehicles [W-10]

Category	Tier	Approval Date	Emission standard for commercial good vehicles, g/km				
			CO	HC	Nox	HC+NO x	PM
<u>Compression Ignition (Diesel)</u>							
N1, Class I ≤ 1305 kg	Euro 5a	September 2009	0.50	-	0.18	0.23	0.005
	Euro 5b	September 2011	0.50	-	0.18	0.23	0.005
	Euro 6	September 2014	0.50	-	0.08	0.17	0.005
N1, Class II 1305 – 1760 kg	Euro 5a	September 2009	0.63	-	0.235	0.295	0.005
	Euro 5b	September 2011	0.63	-	0.235	0.295	0.005
	Euro 6	September 2014	0.63	-	0.105	0.195	0.005
N1, Class III 1760- 3500 kg	Euro 5a	September 2009	0.74	-	0.28	0.35	0.005
	Euro 5b	September 2011	0.74	-	0.28	0.35	0.005
	Euro 6	September 2014	0.74	-	0.125	0.215	0.005
N2, 3500 – 12000 kg	Euro 5a	September 2009	0.74	-	0.28	0.35	0.005
	Euro 5b	September 2011	0.74	-	0.28	0.35	0.005
	Euro 6	September 2014	0.74	-	0.125	0.215	0.005
<u>Positive Ignition (Gasoline)</u>							
N1, Class I ≤ 1305 kg	Euro 4	January 2005	1.00	0.10	0.08	-	-
	Euro 5	September 2009	1.00	0.10	0.06	-	0.005
	Euro 6	September 2014	1.00	0.10	0.06	-	0.005

Category	Tier	Approval Date	Emission standard for commercial good vehicles, g/km				
			CO	HC	Nox	HC+NO x	PM
N1, Class II 1305 – 1760 kg	Euro 4	January 2005	1.81	0.13	0.10	-	-
	Euro 5	September 2009	1.81	0.13	0.075	-	0.005
	Euro 6	September 2014	1.81	0.13	0.075	-	0.005
N1, Class III 1760- 3500 kg	Euro 4	January 2005	2.27	0.16	0.11	-	-
	Euro 5	September 2009	2.27	0.16	0.082	-	0.005
	Euro 6	September 2014	2.27	0.16	0.082	-	0.005
N2, 3500 – 12000 kg	Euro 5	September 2009	2.27	0.16	0.082	-	0.005
	Euro 6	September 2014	2.27	0.16	0.082	-	0.005

Additionally, the introduction of the Commercial Vehicle Emissions Scheme (CVES) in April 2021 to encourage the adoption of cleaner light commercial vehicles (LCVs) which have lower emissions, including Light Goods Vehicles, Goods-Cum-Passenger Vehicles, and small buses, with maximum laden weight not exceeding 3,500kg could also help to reduce the emission of CO₂, HC, CO, NO_x and PM.

Furthermore, land transport emissions are aimed to be reduced with the switch from internal combustion engine (ICE) vehicles to electric vehicles (EVs). Usage of EVs is more sustainable as EV emits half the amount of CO₂ as compared to a similar ICE vehicle. [W-39] The EV Early Adoptive Incentive (EEAI) scheme and CVES work in tandem to make cleaner energy cars (including electric and hybrid cars) more affordable by reducing the price disparity between cleaner energy vehicles and ICE vehicles. Since 2021, more than 8,000 electric cars and taxis have received the VES rebates and/or EEA. [W-40]

Singapore targets to deploy 60,000 EV charging points by 2030 in tandem with adoption, inclusive of 40,000 charging points in public carparks and 20,000 charging points in private premises. Land Transport Authority (LTA) will electrify half of the bus fleet by 2030 and achieve a 100% cleaner energy bus fleet by 2040. 60 electric buses have been deployed as of end 2021 and 400 diesel buses are aimed to be replaced with electric buses by 2025. The taxi fleet operators also announced targets to electrify at least half of the total taxi fleet by 2030. Details of various taxi fleets adopting EVs are in Table 10-24.

Table 10-24 Taxi fleets adopting electric vehicles [R-91]

Taxi Fleet	EV Adaptive Approach
ComfortDelGro	By 2023, EV fleet is expected to be increases to up to 1,000 electric taxis, accounting to 10% of 10,000 taxis. Whereby another 70% will be petrol-electric hybrid taxis.
Strides Mobility	In 2021, Strides Mobility announced that it aims to change its entire taxi fleet to 100% electric within the next five years. SMRT's commitment to operate cleaner-energy taxis began in 2013. The fleet became 100% hybrid by 2020.
Grab	Pledges to transition to low-emission vehicles to achieve carbon neutrality by 2040, starting with replacing its ride-hailing fleet with cleaner vehicles by 2030. For private hire cars, 50% of Grab Rentals' fleet will aim to go electric by 2030.
GoJek	A fleet of about 300 EVs in Singapore and intends to operate a fully electric fleet by 2030.

Within the 250 m Study Area, the existing residential properties are mostly located at the west and southeast of the Project site, including landed properties and condominiums. There are also educational institutes located at the northwest and southeast of the Project site, (i.e., Chatsworth International School, Swiss School in Singapore, EtonHouse Pre-school (Vanda Road) and Chiltern House Turf Club Road). Typically, the pollutants of concern in a

traffic-related pollution tend to be CO, NO_x (NO/NO₂), PM₁₀ and PM_{2.5}. As the vehicles use low sulphur fuel, SO₂ is less of concern these days from vehicular exhaust.

Ecological Receptors

The particulates, viz. PM₁₀ and PM_{2.5} (dust) can have direct and indirect impacts on ecological receptors. Dust emissions can have direct adverse effects upon vegetation restricting photosynthesis, respiration and transpiration. It can also lead to phytotoxic gaseous pollutants penetrating the plants. The overall effect can be a decline in plant productivity, which may then have indirect effects on the quality of the affected habitats and associated fauna.

Nox can affect plants directly or indirectly. It may directly enter a plant via the stomata, where it has phytotoxic effects. Lower plants such as lichens and bryophytes (including mosses, landworts and hornworts) are particularly vulnerable to direct exposure to the gases in this way [W-11]. Since the biodiversity survey was focused on only vascular plants, there is limited information on the locations of these non-vascular species. However, based on empirical observation, rain trees are known to other biomes such as mosses. Specimens of large trees were recorded within 50 m from the construction footprint, approximately 72 (refer to Table 10-11 and Table 10-12).

Indirectly, Nox can also deposit onto soil and, following transformation to nitrate, enrich the soil, leading to increased amounts of nitrate ions drawn by the plants. The effects of elevated Nox concentrations on vegetation can be broadly categorised as [R-39]:

- growth effects: particularly increased biomass, changes in root to shoot ratio and growth of more competitive species, but also including growth suppression of some species;
- physiological effects: e.g. CO₂ assimilation and stomatal conductivity; and
- (bio)chemical effects: e.g. changes in enzyme activity and chlorophyll content (probably through the effects of increased nitrogen).

Indirectly in the long run, accumulation of nitrogen oxides (Nox) via acidic rain causes soil and water to become more acidic and hence, reducing the nutritional value of food sources for fauna [P-29]. There is no published evidence for any direct toxic effect of Nox on animals and therefore effects on animals are not included in ecological impact assessment [R-37].

Lichens / mosses are indicator of good air quality and high level of SO₂ emission might impact these plants tremendously. Although this is not seemingly a potential concern in the operation of a residential area. Other development within the residential estates, such as community centre, might employ generators which might emit high level of SO₂. In order to avoid this, low sulphur diesel fuel should be used as minimum control in line with NEA's latest regulations.

Human Receptors

As for impacts of pollutants on human, NO₂ increases the risk of respiratory infection and impairs lung functions in asthmatics. CO deprives body tissues of oxygen and causes nausea and impairs vigilance. Particulate matters can affect the heart and lungs, especially in people who already have chronic heart or lung disease (e.g., asthma). PM_{2.5} can cause decreased lung function, increased respiratory symptoms and heart attacks. PM₁₀ can cause respiratory impairment and aggravate existing respiratory and cardiovascular disease. Short term exposure to particulate matters may also cause irritation of the eyes, nose and throat in healthy individuals [W-38].

In 2010, the Health Effects Institute published their authoritative report titled "Traffic-related air pollution: a critical review of the literature on emissions, exposure, and health effect". This report has been used as the basis of WHO Technical Report on Review of evidence on health aspects of air pollution 2013 [R-90]. In this WHO Technical Report, Roorda-Knappe et al. (1998), Hitchins et al. (2000), Zhu et al. (2002), and Gilbert et al. (2003) reported a significant decrease of particulates and gases within 150 m – 200 m of a road. However, on the downwind side of a highway, concentrations do not generally reach background levels until at least 300 m – 500 m, though Zhu et al. (2002) found a 60% to 80% decrease of CO from roadside concentrations within 100m. In some studies, this was extended to up to 1500 m for NO₂ (Gilbert et al., 2003; Jerrett et al., 2007). At the moment, the vehicles are using low sulphur content fuel, hence the decrease of SO₂ with distance is not discussed.

From baseline findings, Table 10-15 shows that particulate matter (PM₁₀ and PM_{2.5}) have consistently exceeded the Singapore Long Term Air Quality Targets over the period 2018 – 2022. The five-year average result of 59 µg/m³ and 34 µg/m³ exceeded the Singapore Long Term Air Quality Targets of 50 µg/m³ and 25 µg/m³ for PM₁₀ and PM_{2.5}.

respectively. Moreover, the baseline survey findings in Section 10.5.2.3 also deduces slight exceedances in the PM_{2.5} concentration over a small survey period of seven (7) days. This indicates the existing concern of high particulate matter concentrations in Singapore. As such, with the removal of trees and increase in vehicular traffic volume, there are concerns of particulate matter concentrations exceeding the Singapore Long Term Air Quality Targets locally during operational phase.

The potential source of operational air quality impacts would be due to the vehicular emissions from the high traffic volume along the existing Dunearn Road and Eng Neo Avenue at the south and southeast of the Project site and Pan Island Expressway (PIE) at the North of the Project Site. In addition, there will be future internal arterial roads that will be constructed within the Project site as per the proposed preliminary land use plan (see Figure 3-2). Hence, locally the traffic within and in the vicinity of the Project site is likely to increase. It should also be noted that currently there is a significant traffic volume along the Dunearn Road, Eng Neo Avenue and Pan Island Expressway. The exact numbers in terms of increase /change in volume of traffic to and from the worksites were not available. AECOM has monitored traffic along highways and smaller roads in several Singapore projects in the past. From our previous experience, the traffic volume at PIE can reach up to 12500 veh/hr and 3000 veh/hr for Dunearn Road and Eng Neo Avenue, while traffic volume within internal roads in residential estate vary between 1000-2000 veh/hr. The incremental traffic volume within residential estate is therefore, expected to be only 6-13% of the PIE traffic.

With consideration of all the discussed factors, including the implementation of Euro emission standard on new vehicles, current large base traffic volume along existing roads, the adaption of cleaner energy vehicles (including hybrid and electric vehicles), the 60% to 80% decrease over distance (by Zhu et al. (2002)) from the existing roads surrounding the project site (i.e., Dunearn Road, Eng Neo Avenue and PIE), insignificant increase in air quality pollutant levels for the existing human receptors, is expected during the operational phase of the Project. However, the proposed project has also planned the construction of future roads. Hence, locally the traffic in the vicinity of the project is likely to increase. The exact numbers in terms of increase /change in volume of traffic was not available. Hence, no detailed assessment could be carried out. Without any mitigation measures in place, the Likelihood of occurrence of impacts during the operational phase is classified as **Regular**.

Overall it seems that given the two factors above (i.e. the implementation of Euro emission standard on new vehicles and current large traffic volume along existing roads), insignificant increase in air quality pollutant levels in the vicinity of proposed project is expected during the operational phase. Some green areas will also not be disturbed as part of the project. Hence, the Impact Intensity is considered to be Negligible.

As discussed in Section 10.4.2, the Sensitivity of the receptors is classified to be Priority 1 and Priority 3. Thus, as per Table 6-7, the Impact Consequence is calculated to be Very Low. Based on the impact significance matrix in Table 10-7, the Impact Significance is predicted to be **Minor** (refer to Table 10-25). No mitigation measures are required during operational phase.

Table 10-25 Impacts of air quality impact assessment – operational phase

Impact Intensity	Sensitivity of the Area	Overall Consequence	Likelihood	Impact Significance
<u>Ecological Receptors</u>				
Negligible	Priority 1	Very Low	Regular	Minor
<u>Human Receptors</u>				
Negligible	Priority 1	Very Low	Regular	Minor
Negligible	Priority 3	Imperceptible	Regular	Minor

10.8 Recommended Mitigation Measures

10.8.1 Construction Phase

Based on the assessment in Section 10.7.1, the Impact Significance was determined to be **Major**. The range of dust mitigation measures to be implemented at the construction sites are outlined in Table 10-26. Upon the implementation of mitigation measures, the Impact Significance was determined to be **Minor**. This will be detailed in Section 10.9.1.

Table 10-26 Air quality mitigation measures (construction phase)

Mitigation Measures	
GENERAL MITIGATION MEASURES TO BE IMPLEMENTED THROUGH OUT CONSTRUCTION PERIOD	
<u>Communications</u>	
Develop and implement a stakeholder communications plan that includes community engagement before work commences on site.	Mandatory
Display the name and contact details of person(s) accountable for air quality and dust issues (ECO/ PRO) on the site boundary. This may be the environment manager/engineer or the site manager.	Mandatory
Develop and implement an Air Pollution Control Plan (APCP) (see paragraph below for APCP details).	Mandatory
<u>Site Management</u>	
Record all dust and air quality complaints, identify cause(s), take appropriate measures to reduce emissions in a timely manner, and record the measures taken. Make the complaints log available to the local authority when asked.	Mandatory
Record any exceptional incidents that cause dust and/or air emissions, either on-site or off-site, and the action taken to resolve the situation in the log book.	Mandatory
Hold liaison meetings with other high-risk construction sites within 500 m of the site boundary, if any, to ensure plans are co-ordinated and dust and particulate matter emissions are minimised. This should be included in the toolbox meetings, if required.	Optional
<u>Monitoring</u>	
Undertake regular (daily frequency recommended) on-site and off-site inspections and record results. The log should be made available to the NEA or other Government Agencies if required. Inspections should include regular dust soiling checks of surfaces such as street furniture, cars, and window sills within 100 m of site boundary. Cleaning should be provided if necessary.	Recommended
Carry out regular site inspections to monitor and record compliance with the Air Pollution Control Plan. Increase the frequency of site inspections during prolonged dry or windy conditions.	Mandatory
Conduct monitoring for PM ₁₀ and PM _{2.5} at suitable locations (refer to Section 12.11.1)	Mandatory
<u>Preparing and maintaining the site</u>	
Plan site layout so that machinery and dust causing activities are located away from receptors, where possible.	Mandatory
Erect hoarding around dusty activities and at the site boundary wherever possible. Boundary screens should be at least as high as any stockpiles or dust emission sources on site.	Mandatory
Fully enclose specific activities where there is a known high potential for dust production and the site will be active for an extensive period of time.	Mandatory
Keep site fencing, barriers, and scaffolding clean by cleaning regularly using wet methods (dry methods may give rise to fugitive dust).	Mandatory
Remove materials that have the potential to produce dust from site as soon as possible, unless being re-used on site. If they are being re-used on-site, stockpiled material should be covered, seeded, fenced or enclosed to prevent fugitive dust formation.	Mandatory
<u>Operating vehicle/machinery and sustainable travel</u>	
Ensure all vehicles and engine powered equipment comply with the legislative requirements of Singapore.	Mandatory

Mitigation Measures	
Ensure all vehicles and equipment switch off their engines when stationary – i.e. no idling vehicles or engines. Clear signs shall be erected at site entrance to inform all visitors.	Mandatory
Where practicable, avoid the use of diesel- or petrol-powered generators and use mains electricity or battery powered equipment.	Mandatory
Impose and signpost a maximum-speed-limit of 25 km/hr on paved or surfaced haul roads and 15 km/hr on unpaved haul roads and work areas.	Mandatory
Produce a Construction Logistics Plan to manage the sustainable delivery of goods and materials.	Mandatory
<u>Construction Operations</u>	
Only use cutting, grinding or sawing equipment fitted with, or in conjunction with, suitable dust suppression techniques such as water sprays or local extraction e.g. local exhaust ventilation system.	Mandatory
Ensure an adequate water supply on the site for effective dust/particulate matter suppression/mitigation, using non-potable water where possible and appropriate.	Mandatory
Use enclosed chutes and conveyors and covered skips wherever possible.	Mandatory
Minimise drop heights from conveyors, loading shovels, hoppers, and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate.	Mandatory
A stringent “Clean as you go” Policy should be implemented on site to ensure no loose dry material is left exposed when not in use. Equipment should be readily available on site to clean any dry spillages, and cleaning should be conducted as soon as reasonably practicable after the event using wet cleaning methods.	Mandatory
<u>Waste Management</u>	
Avoid burning of waste or other materials.	Mandatory
MITIGATION MEASURES FOR EARTHWORKS	
Closed turbing to the exposed areas where possible and maintain proper storage of soil stockpiles to stabilise surfaces as soon as practicable. When a particular work is finished in an area, the soil will need to be reinstated upon completion, before moving on to different areas. This will reduce dust emission. In the air assessment it refers to reinstatement as a regrown area, it does not mean replanting same trees. It only refers to vegetation plantation which prevents erosion of soil to form dust.	Mandatory
Use Hessian, mulches or soil tackifiers where it is not possible to re-vegetate or cover with topsoil, as soon as practicable. Soil erosion blankets may also be used as an alternative. Only remove the cover in intended working areas and not all at once.	Mandatory
MITIGATION MEASURES FOR CONSTRUCTION	
Avoid scabbling (roughening of concrete surfaces) if possible.	Mandatory
Ensure sand and other aggregates are stored in bunded areas and are not allowed to dry out, unless this is required for a particular process, in which case ensure that appropriate additional control measures are in place.	Mandatory
Ensure bulk cement and other fine powder materials are delivered in enclosed tankers and stored in silos with suitable emission control systems to prevent escape of material and overfilling during delivery.	Mandatory
For smaller supplies of fine powder materials ensure bags are sealed after use and stored appropriately to prevent dust.	Mandatory
MITIGATION MEASURES FOR TRACKOUT	

Mitigation Measures	
Use water-assisted dust sweeper(s) on the access and affected local roads, to remove, as necessary, any material tracked out of the site. This may require the sweeper being continuously in use. Avoid dry sweeping of large areas.	Mandatory
Ensure vehicles entering and leaving sites are covered to prevent escape of materials during transport.	Mandatory
Install hard surfaced haul routes, which are regularly damped down with fixed or mobile sprinkler systems, or mobile water bowsers and regularly cleaned.	Mandatory
Inspect on-site haul routes for integrity and instigate necessary repairs to the surface as soon as reasonably practicable. Record all inspections of haul routes and any subsequent action in a site log book.	Mandatory
Implement a wheel washing system (with rumble grids to dislodge accumulated dust and mud prior to leaving the site where reasonably practicable).	Mandatory
Ensure there is an adequate area of hard surfaced road between the wheel wash facility and the site exit, wherever site size and layout permits.	Mandatory
Site access gates to be located at least 10 m from receptors where possible.	Mandatory

The APCP shall include the following information as a minimum:

- Summary of all work to be carried out including breakdown of phases and individual activities that may give rise to fugitive dust formation;
- Project title, project location and area, description of the site layout and locations of areas where dust is most likely to be generated such as haulage routes, excavation areas, etc. This description shall also include the location of the water supply or chemical suppressants for applying to the dust generating areas on site;
- List of each dust generating activity, the likely schedule for each activity and the dust control measures to be implemented and frequency for their implementation. The level of detail will depend on the overall Consequence classification identified in this report and should include as a minimum the mitigation measures listed as mandatory in this document;
- Summary of the air monitoring to be undertaken including monitoring location and schedule. The air monitoring results shall be recorded, and trends observed to determine the efficacy of dust control measures over the different construction stages;
- Details and procedures on using the site logbook which is used to record information on incidents such as dust episodes, the sources identified, and the action taken and its efficacy. Any complaints shall also be recorded within the logbook along with the subsequent mitigation implemented and time to close out the complaint. The logbook should also be used to keep track of the daily dust control measures implemented such as wheel washing, site watering, site inspections etc.;
- Details of the Superintending Officer (SO) should be included in this plan for managing dust management at the site. The responsibilities of the SO are listed in Section 12.4.3; and
- The air pollution control plan shall be reviewed at regular intervals during the construction phase to ensure the effectiveness of the procedures in place and to maintain the goal of minimisation of dust and emissions through the use of best practice and procedures.

10.8.1.1 Recommended Area of Conservation

This section acknowledges the Recommended Area of Conservation (RAC) recommended in Section 7.10.1.1 and highlights the air quality impacts. The recommended RAC (refer to Figure 7-80) does not differ greatly from the area indicated as Retained Forest with Trails in the proposed preliminary land use (refer to Figure 3-2). This area has been omitted from the earthworks and construction footprint during the air quality impact assessment.

However, there is a small area of RAC at the eastern part of the Project Site where additional ecological sensitive receptors are identified for air quality impact (refer to Figure 10-19). Table 10-27 summarises the species list that

are recommended to conserve which will be affected by the construction activities. As a result, any construction activities within 50 m from these ecological receptors that will have air quality impacts, shall also follow the recommended mitigation measures to reduce any adverse impacts on the plant species.

Table 10-27 Additional flora Species of High Value Identified within the RAC

Site	Identified Species	Status	Number of Species Identified
Conservation Species			
Site A	<i>Angiopteris evecta</i>	<i>Vulnerable</i>	1
	<i>Archidendron jiringa</i>	<i>Vulnerable</i>	24
	<i>Calophyllum tetrapterum</i> var. <i>tetrapterum</i>	<i>Vulnerable</i>	1
	<i>Canthiumera robusta</i>	<i>Endangered</i>	1
	<i>Epicharis cuneata</i>	<i>Vulnerable</i>	1
	<i>Goniophlebium percussum</i>	<i>Vulnerable</i>	1
	<i>Gymnacranthera farquhariana</i> var. <i>farquhariana</i>	<i>Endangered</i>	1
	<i>Horsfieldia polyspherula</i> var. <i>polyspherula</i>	<i>Vulnerable</i>	23
	<i>Litsea castanea</i>	<i>Endangered</i>	10
	<i>Macaranga griffithiana</i>	<i>Vulnerable</i>	1
	<i>Oncosperma horridum</i>	<i>Vulnerable</i>	3
	<i>Palaquium obovatum</i>	<i>Vulnerable</i>	2
	<i>Pternandra coerulescens</i>	<i>Vulnerable</i>	1
	<i>Santiria laevigata</i>	-	1
	<i>Uncaria longiflora</i> var. <i>pteropoda</i>	<i>Endangered</i>	1
	<i>Xanthophyllum ellipticum</i>	<i>Critically Endangered</i>	5
Large Specimen			
Site A	<i>Bambusa vulgaris</i>	<i>Casual</i>	2
	<i>Elaeis guineensis</i>	<i>Casual</i>	1
	<i>Falcataria falcata</i>	<i>Naturalised</i>	9
	<i>Ficus benjamina</i>	-	2
	<i>Khaya senegalensis</i>	<i>Cultivated only</i>	5
	<i>Peltophorum pterocarpum</i>	<i>Critically Endangered</i>	1
	<i>Spathodea campanulate</i>	<i>Naturalised</i>	3
	<i>Syzygium grande</i>	<i>Least Concern</i>	2



Figure 10-19 Additional ecological receptors identified within Recommended Area of Conservation

10.8.2 Operational Phase

No mitigation measures are required during operational phase as only Minor air quality impact significance is expected during project operational phase.

10.9 Residual Impacts

10.9.1 Construction Phase

Residual Impact Assessment assumes that the mitigation measures within Section 10.8.1 are implemented within the construction footprint.

The Likelihood of occurrence of a significant adverse impact would be classified as **Rare**, subject to relevant mitigation measures identified being implemented. This Likelihood is combined with Impact Consequence to provide the residual Impact Significance results for the construction footprint. The residual Impact Significance is listed in Table 10-28 to Table 10-31 below.

Based on the assessment, by implementing the proposed mitigation measures, the Likelihood of the impact is expected to reduce from Regular to Rare, resulting in **Minor** Impact Significance.

Table 10-28 Impacts of dust risk assessment – Demolition (after mitigation)

Key Parameter – Demolition			Impact Assessment							
Total Building Volume (m ³)	Construction Material	Height of Demolition Activities	Impact Intensity	Sensitivity of the Area		Overall Consequence / Dust Risk		Likelihood	Impact Significance	
				Ecological Receptor	Human Receptor	Ecological Receptor	Human Receptor		Ecological Receptor	Human Receptor
100,000 – 500,000	Potentially dusty construction material	10-20	High	Priority 1	Priority 1	High	High	Rare	Minor	Minor

Table 10-29 Impacts of dust risk assessment – Earthworks (after mitigation)

Key Parameter – Earthworks				Impact Assessment						
Total Earthworks Footprint (m²)	Earthwork Material	No. of heavy machineries during foundation work	Impact Intensity	Sensitivity of the Area		Overall Consequence / Dust Risk		Likelihood	Impact Significance	
				Ecological Receptor	Human Receptor	Ecological Receptor	Human Receptor		Ecological Receptor	Human Receptor
Phase 1										
500,000 – 1,000,000	Moderately dusty soil type	>10	High	Priority 1	Priority 1	High	High	Rare	Minor	Minor
Phase 2										
500,000 – 1,000,000	Moderately dusty soil type	>10	High	Priority 1	Priority 2	High	Medium	Rare	Minor	Minor

Table 10-30 Impacts of dust risk assessment – Construction (after mitigation)

Key Parameter – Construction			Impact Assessment							
Total Building Volume (m³)	Construction Material	No. of concrete batching plant	Impact Intensity	Sensitivity of the Area		Overall Consequence / Dust Risk		Likelihood	Impact Significance	
				Ecological Receptor	Human Receptor	Ecological Receptor	Human Receptor		Ecological Receptor	Human Receptor
Phase 1										
5,000,000 – 10,000,000	Potentially dusty (e.g. concrete)	1	High	Priority 1	Priority 1	High	High	Rare	Minor	Minor
Phase 2										
5,000,000 – 10,000,000	Potentially dusty (e.g. concrete)	1	High	Priority 1	Priority 2	High	Medium	Rare	Minor	Minor

Table 10-31 Impacts of dust risk assessment – Trackout (after mitigation)

Key Parameter – Trackout			Impact Assessment							
No. of outward trucks movement per day	Road surface material	Unpaved Road Length (m)	Impact Intensity	Sensitivity of the Area		Overall Consequence / Dust Risk		Likelihood	Impact Significance	
				Ecological Receptor	Human Receptor	Ecological Receptor	Human Receptor		Ecological Receptor	Human Receptor
Earthworks										
>50	Moderately dusty	5-100	High	Priority 1	Priority 1	High	High	Rare	Minor	Minor
Construction Phase 1										
>50	Moderately dusty	5-100	High	Priority 1	Priority 1	High	High	Rare	Minor	Minor
Construction Phase 2										
>50	Moderately dusty	5-100	High	Priority 1	Priority 1	High	High	Rare	Minor	Minor

10.9.2 Operational Phase

As discussed in Section 10.7.2, the potential impact significance due to increased traffic is considered to be Minor. No mitigation measures are required during operational phase.

10.10 Cumulative Impacts

It is known that during construction phase of this project, there would be concurrent development of the Turf City MRT Station within the Project Site. Hence, cumulative impacts from concurrent developments shall be assessed and considered.

10.10.1 Construction Phase

Due to the presence of the concurrent construction site for Turf City MRT Station, the construction footprint in this area is expected to be larger during Phase 1 of this Project. More vehicles moving within the site and more spoil to be moved as part of the excavation stage are also expected. With this concurrent construction activity, the Impact Significance is expected to remain as **Moderate to Major**. The range of dust mitigation measures to be implemented at the construction sites are outlined in Table 10-26. These can be implemented and aid in control of air impact at URA Project Site. However, this report recommends that air pollution mitigation measures recommended in the CRL2 EIA Study shall be implemented to similar, if not more stringent levels, so that cumulative impact can be reduced. It may be best for concurrent projects to plan especially pollutive phases to stagger in timeline such as earthworks, construction works and number of vehicles on trackouts or the condition of the trackout roads as a joint effort. Upon strict implementation of mitigation measures, the Impact Significance may be reduced to be **Minor to Moderate**.

Table 10-32 Cumulative air quality impact assessment (construction)

Construction Worksite	Impact Intensity	Sensitivity of the Area	Overall Consequence	Likelihood	Impact Significance
Before Mitigation					
Project	High	Priority 1 to Priority 2	Medium to High	Regular	Moderate to Major
Project + Concurrent Construction	High	Priority 1 to Priority 2	Medium to High	Regular	Moderate to Major
After Mitigation					
Project	High	Priority 1 to Priority 2	Medium to High	Rare	Minor
Project + Concurrent Construction	High	Priority 1 to Priority 2	Medium to High	Rare	Minor to Moderate

10.10.2 Operational Phase

Due to the presence of Turf City MRT Station development, the air quality impact during operational phase is expected to be larger. The Turf City MRT Station is expected to result in an increase of traffic volume around the station itself, but would potentially result in an overall decrease in traffic volume in the Project Site by providing alternative transport modes to future residents apart from private vehicles. Moreover, Turf City MRT operation will use electric trains which will not result in air quality impact. Therefore, the Impact Significance is expected to remain as **Minor**.

Table 10-33 Cumulative air quality impact assessment (operation)

Construction Worksite	Sensitivity of the Area	Overall Consequence	Likelihood	Impact Significance
Before Mitigation				
Project	Priority 1 to Priority 3	Imperceptible to Very Low	Regular	Minor
Project + Concurrent Construction	Priority 1 to Priority 3	Imperceptible to Very Low	Regular	Minor

10.11 Summary of Key Findings

Air quality impacts from the construction and operation of the proposed project were assessed on air sensitive receptors (ASRs) in the vicinity of the Study Area. Primary baseline air quality monitoring was conducted for 1 week each between 14 August 2023 and 14 September 2023 at eight (8) representative locations. All measured pollutant concentrations were well below the Singapore Ambient Air Quality Long Term Targets for both PM₁₀ and PM_{2.5} except for the maximum concentration of 24-hour average PM_{2.5} at AQ01, AQ04, AQ05 and AQ07 exceeded the Singapore Ambient Air Quality Long Term Targets. Analysis of baseline results are detailed in Section 10.5.2.2.

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, 50m and 350m Assessment 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 10.7 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 10.8, which when applied successfully, the significance of impacts is anticipated to be reduced to **Minor** (see Section 10.9 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.

The construction contractor is recommended to prepare an air quality management plan incorporating a range of monitoring and mitigation measures in line with Section 10.8, Section 12.11 and Section 12.13.

Table 10-34 Summary of air quality impact assessment

Potential Source of Impact	Impact Significance with Minimum Control	Key Mitigation Measures (if any)	Residual Impact Significance with Mitigation Measures (if required)
Construction Phase			
Dust emissions generated by earthworks processes and construction of new structures, as well as from the transport of dust and dirt by dumper trucks (trackout)	Moderate to Major	- Implement dust control measures e.g., dust screens, etc. - Install hard surfaced haul routes. - Only use cutting, grinding and sawing equipment with dust suppression water spray mechanisms. - Erect hoarding around dusty activities and site boundary min. 1.8m height in line with BCA guideline. - Impose and signpost maximum speed-limit of 25km/hr on paved roads and 15 km/hr on unpaved roads and work areas. - No burning of waste allowed on site.	Minor

Potential Source of Impact	Impact Significance with Minimum Control	Key Mitigation Measures (if any)	Residual Impact Significance with Mitigation Measures (if required)
		• Revegetate earthworks and exposed areas/ soil stockpiles.	
Operational Phase			
Gaseous and particulate emissions from vehicle exhaust due to the increased traffic	Minor	-	-

11 Airborne Noise

11.1 Introduction

This section presents the qualitative assessment of airborne noise impacts arising from the construction and operational phase of the Project to the identified ecological receptors and human receptors. Noise from construction and operational activities may be perceivable, especially to receptors in proximity and those having a direct line-of-sight to the noise sources from the proposed construction worksites within the Study Area provided by URA at the pre-design stage.

The key steps for conducting noise impact assessment are as follows:

- Review baseline noise monitoring data to assess the current baseline noise levels at locations within and surrounding the Study Area;
- Identify and classify the sensitivity of receptors surrounding the proposed construction worksites within the Study Area;
- Conduct noise impact assessment to qualitatively assess noise impacts during the construction phase and operational phase;
- Recommend minimum control and mitigation measures to be implemented; and
- Determine the overall significance of the residual noise impacts after the implementation of the mitigation measures.

11.2 Methodology and Assumptions

11.2.1 Assessment Area

The Assessment Area for airborne noise impact assessment of the construction phase was proposed to be 150 m from the proposed construction worksites in line with the *Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008* [R-27] to assess the noise impacts on ecological receptors and human receptors.

For the operational phase, two elements contribute to the noise impacts, namely arising from the operation of air conditioning and mechanical ventilation (ACMV) systems for non-industrial buildings proposed within the Study Area, and vehicular noise from road traffic at the Study Area which can be a result of noise emissions from new road networks within the Study Area and increased traffic volumes and traffic noise from existing roads near the proposed residential developments.

The area of assessment for operational noise arising from ACMV systems looks into the impacts on human receptors (i.e. buildings) at the immediate boundary of the operational footprint (i.e. non-industrial building) as defined by the *NEA Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Buildings, 2018* [R-32]. This may or may not apply to ecological receptors depending on whether the boundary of such installations face forested areas or not. For the ecological receptors the criteria of no worse off than baseline will be adopted as boundary noise criteria.

For operational noise arising from vehicular noise within the Study Area meant for new roads or new infrastructure planned near existing roads, the Assessment Area is recommended by the *NEA Technical Guideline for Land Traffic Noise Impact Assessment, 2016* [R-31] as 70 m from the land traffic noise sources (i.e. proposed new road networks) to assess the noise impacts on the human residential receptors and ecological receptors.

11.2.2 Baseline Airborne Noise Study

Baseline airborne noise study was used to establish the existing noise levels in the Assessment Area.

11.2.2.1 Desktop Research

Desktop research consists of a review of secondary data (including existing land use and development activities, satellite images, etc.) which aids in determining the baseline noise monitoring location. The information retrieved during the desktop research comprised of publicly available data from government and technical agencies, existing available data, relevant articles, and other online sources.

11.2.2.2 Field Survey and Assessment

A total of eleven (11) noise monitoring locations were proposed within Site A – Site E based on the following considerations:

- Identification of NSRs (hospitals, schools, childcare facilities, old age homes, residences, fauna, and habitats of high ecological value) nearest to the Assessment Area;
- Other NSRs away from the Assessment Area were eliminated;
- NSRs with areas having ongoing construction or temporary noisy activities were avoided; and
- The closest NSR to the Assessment Area was selected.

The noise monitoring locations are detailed in Table 11-1 and reflected in Figure 11-1. Noise monitoring was conducted for a period of one (1) week (inclusive of Weekdays and Weekends) to capture the baseline noise levels over periods of 12 hours (long term), 1 hour, and 5 minutes (short term) at each location. The NEA-approved 01dB FUSION Type 1 Sound Level Meter (SLM) was used to record the noise levels during the time periods. The method and results were detailed in the baseline noise monitoring report in Appendix S and will be further discussed in Section 11.5.2.

In determining the criteria for the construction noise at NSRs, the baseline noise level within the Project were included in the calculation to derive a background noise correction factor to establish the maximum permitted noise level from the construction activities in accordance with the noise legislation stated in *Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008* [R-27].

The criteria for operational noise arising from potential operational activities, namely land traffic noise and noise from air conditioning and mechanical ventilation (ACMV) systems at NSRs were established using the baseline noise levels captured at noise monitoring locations within Project site in accordance with the *NEA Technical Guideline for Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Buildings, 2018* [R-32] and *NEA Technical Guideline for Land Traffic Noise Impact Assessment, 2016* [R-31].

Table 11-1 Airborne noise baseline monitoring locations

S/N	Monitoring Location	Site	Justification	Relevant NSRs	Photo of Monitoring Location
NN01	Northern Part of Champions Golf near Turf Club	E	Representative baseline noise monitoring location for green field within Northern portion of Champions Golf Course.	The selected location represents the baseline noise levels experienced by ecological receptors found within Green Area near the northern side of Champions Golf Course and PIE.	

S/N	Monitoring Location	Site	Justification	Relevant NSRs	Photo of Monitoring Location
NN02	Southern Part of Champions Golf near Turf Club	E	Representative baseline noise monitoring location for green field within Southern portion of Champions Golf Course.	The selected location represents the baseline noise levels experienced by ecological receptors found within Green Area near the southern Champions Golf Course.	
NN03	Near Blue House International Pre-School	B		The selected location represents the baseline noise levels experienced by human receptors found along Eng Neo Avenue and Turf Club Road near Turf Club Bukit Timah Junkyard .	
NN04	Opposite Chiltern House Turf Club Road	E	Representative baseline noise monitoring location for educational institutions/ treatment centre near Chiltern House Turf Club Road.	The selected location represents the baseline noise levels experienced by human receptors found along Eng Neo Avenue and Turf Club Road.	
NN05	Along Dunearn Road, opposite EtonHouse Pre-School Vanda	E	Representative baseline noise monitoring location for Educational Institutions along Dunearn Road.	The selected location represents the baseline noise levels experienced by human receptors found along Eng Neo Avenue, Dunearn Road and Bukit Timah Road near Sixth Avenue MRT station.	

S/N	Monitoring Location	Site	Justification	Relevant NSRs	Photo of Monitoring Location
NN06	La Suisse 1	C	Representative baseline noise monitoring location for residences along Swiss View.	The selected location represents the baseline noise levels experienced by ecological receptors found within Green area, and human receptors found along Swiss View.	
NN07	Green Area in Chatsworth International School	C	Representative baseline noise monitoring location for Green Area near Chatsworth International School.	The selected location represents the baseline noise levels experienced by ecological receptors found within Green Area near Chatsworth International School.	
NN08	Near Newton Auto Keys Pte	E	Representative baseline noise monitoring location for Green Area, residences and commercial establishments along the eastern side of Swiss Club Road	The selected location represents the baseline noise levels experienced by ecological and human receptors found along the eastern side of Swiss Club Road.	
NN09	Green Area near Greenwood Terrace	F	Representative baseline noise monitoring location for Green Area and residences along Greenwood Terrace.	The selected location represents the baseline noise levels experienced by ecological receptors found within Green Area, and human receptors along Greenwood Terrace.	
NN10	Green Area near Linden Drive	F	Representative baseline noise monitoring location for Green Area and residences along Linden Drive.	The selected location represents the baseline noise levels experienced by ecological receptors found within Green Area,	

S/N	Monitoring Location	Site	Justification	Relevant NSRs	Photo of Monitoring Location
				and human receptors along Linden Drive.	
NN11	Green area near Eng Neo Avenue and Linden Drive	F	Representative baseline noise monitoring location for residences near Eng Neo Avenue and Linden Drive.	The selected location represents the baseline noise levels experienced by human receptors along Linden Drive and Eng Neo Avenue near the Conscious Choice Consultant.	



Legend

- Monitoring Location's from Previous Studies [R-2, R-3]
- Airborne Noise Monitoring Locations
- Airborne Noise Study Area (150m)
- Site Demarcation
- EIA Study Area
- Project Site

N

-	MAY 2024	SHA	Turf Club EIA	LAL	JAG
Rev.	Date	By	Description	Chk'd	App'd

Qualified Person Endorsement :
NA

URA Endorsement : NA

Consultant :

Project Title :
**CONTRACT URA/T/22/031
ENVIRONMENTAL IMPACT
ASSESSMENT (EIA) FOR
FORMER TURF CLUB AT BUKIT TIMAH**

Designed SHA	Checked LAL	Approved JAG
	Drawn SHA	Date MAY 2024

Client:

Figure Title :
**Baseline airborne noise monitoring locations
within/surrounding the Study Area**

Figure No. : 11- 1	Rev. -	Sheet 1 of 1
CAD File Name : NA		A3

Note: Source of basemap - Google Earth Map

THIS DRAWING IS COPYRIGHT

11.2.3 Classification of Noise Sensitive Receptors

The classification of both ecological and human receptors is described as follows. Further discussion on the identification of noise sensitive receptors (NSRs) are detailed in Section 11.4.

11.2.3.1 Ecological Receptors

Based on the assessment methodology in Table 6-2, the classification of ecological receptors was deduced based on the auditory sensitivities of the respective fauna species. Fauna species that vocalise during important life cycle stages such as courtship, territorial claims and/ or mating, were assigned Priority 1 due to their auditory sensitivity. Fauna species that have auditory sensory systems but do not necessarily need to vocalise during important life cycle stages were assigned Priority 2. While fauna species that are not likely to be affected by noise were assigned Priority 3. The classification of auditory sensitivities of the ecological receptors are applicable for both the construction and operational phase and shall be further discussed in Section 11.4.1.

11.2.3.2 Human Receptors

11.2.3.2.1 Construction Phase

Based on the assessment methodology in Table 6-2, there are three classifications (i.e. Priority 1, Priority 2, Priority 3) of human noise sensitive receptors (NSRs) which relates to the nature of the building, be it educational institution, residential space, commercial or industrial space and so on, that are further discussed in Section 11.4.2.1.

The list of human NSRs is presented in Table 11-15 in Section 11.4.2.1. It should be noted that the list of human NSRs do not include existing buildings within the Study Area since the existing buildings which will not be demolished are not occupied by any human receptors.

11.2.3.2.2 Operational Phase

While for the operational phase, two potential sources of operational noise as discussed in Section 11.2.4.2 should be considered when assessing human receptors. Human receptors subjected to operational noise impacts from ACMV systems are defined as buildings at the immediate boundary of the non-industrial building where the classification of the human receptors, similar to that of the construction phase, relates to the nature of the building as reflected in Table 11-15 and later discussed in Section 11.2.4.2. While human receptors subjected to traffic noise impacts due to emissions from existing/ new road networks, are defined as residential and noise sensitive developments in close proximity, within 70 m from, the traffic source. The classifications of the human receptors for the operational phase were deduced in accordance with the *NEA Technical Guideline for Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Buildings, 2018* [R-32] and *NEA Technical Guideline for Land Traffic Noise Impact Assessment, 2016* [R-31].

11.2.4 Assessment Criteria

As a part of the Project scope, qualitative noise impact assessment criteria adopted to assess airborne noise impacts on nearby noise sensitive receptors (NSRs) that may potentially arise from the construction phase and operational phase of the Project at the pre-design stage is outlined in this section. Baseline noise levels were also monitored to develop the specific construction and operation noise criteria for this Project.

11.2.4.1 Construction Noise Criteria (Construction Phase)

11.2.4.1.1 Ecological Receptors

The ecological impacts from airborne noise are species dependent and hence the assessment would be based on species identified during site surveys within and surrounding the Study Area for airborne noise sensitive receptors to align with the biodiversity study in Section 7. Species which are noise sensitive are those that use noise, for example for their communication or identification of their way, at certain times of the day. Construction and noisy activities during their active times can cause interference with their day-to-day activities. Therefore, at these times, construction noise criteria are made more stringent for ecological receptors than the human noise criteria.

At present, there are no established guidelines or standards for evaluating the noise generated by construction activities concerning ecological receptors. The existing criteria are designed solely for assessing noise impacts on humans and do not address the specific concerns related to ecological environments. Unlike human receptors, baseline monitoring results were chosen as a basis of comparison for ecological receptors because fauna species face a direct form of impact, given that the habitats where they reside in are directly impacted by the noises emitted

from the introduction of construction activities in the vicinity. Therefore, it is not advisable to adopt similar assessment criteria to human receptors where they operate in different nature.

For the purpose of noise impact assessment on ecological receptors in this EIA, a criterion of no-worse-off than baseline shall be adopted in absence of adequate research data on criteria and applied to the ecological receptors identified within and surrounding the Study Area as a part of the qualitative noise impact assessment.

11.2.4.1.2 Human Receptors

Specific construction noise criteria for the construction phase of this Project were developed with the baseline noise levels detailed in Section 11.5.2, included in the calculation to derive a background noise correction factor to establish the maximum noise level permitted from the construction activities in accordance with the *Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008* [R-27].

The legislative requirements for environmental noise arising from construction activities in Singapore contains three parts which specifies the applicable noise criteria for construction sites over different periods of time. The corresponding permissible noise criteria are provided in Table 11-2 to Table 11-4 for different periods of duration.

They are reflected in the order as follows:

- $L_{Aeq}(12 \text{ hours})$ refers to equivalent continuous noise level over a period of 12 hours;
- $L_{Aeq}(1 \text{ hour})$ refers to equivalent continuous noise level over a period of 1 hour within a 24-hour period; and
- $L_{Aeq}(5 \text{ mins})$ refers to equivalent continuous noise level over a period of 5 minutes within a 24-hour period.

Table 11-2 Maximum permissible noise levels for construction works over a period of 12 hours

Types of Affected Buildings	Days of the week	Maximum Permissible $L_{Aeq}(12 \text{ hours})$, dB	
		7am – 7pm	7pm – 7am
(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	All days	60	50
(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	All days	75	–
(c) Buildings (other than those in paragraphs (a) and (b))	All days	75	65

Table 11-3 Maximum permissible noise levels for construction works over a period of 1 hour

Types of affected buildings	Days of the week	Maximum Permissible $L_{Aeq} (1 \text{ hour})$ (dB)		
		7am – 7pm	7pm – 10pm	10pm – 7am
(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	Monday to Saturday	–	–	–
(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	Monday to Saturday	–	65	55
(c) Buildings (other than those in paragraphs (a) and (b))	Monday to Saturday	–	–	–

Table 11-4 Maximum permissible noise levels for construction works over a period of 5 minutes

Types of affected buildings	Days of the week	Maximum Permissible L _{Aeq} (5 mins) (dB)		
		7am – 7pm	7pm – 10pm	10pm – 7am
(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	All days	75	55	55
(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	Monday to Saturday	90	70	55
	Sunday and PH	75	55	55
(c) Buildings (other than those in paragraphs (a) and (b))	All days	90	70	70

As per the legislation, if there exists other sources of noise affecting the measurement of noise emitted from the construction site, the maximum permissible noise levels from the construction sites will be subjected to adjustments by the addition of a correction factor to account for the existing background noise levels in the area. The correction factor corresponds to the difference between the relevant permissible levels, and the background noise levels as presented in Table 11-5. The difference in noise levels are then added to the higher of the two noise levels (background noise/ criteria as appropriate) to deduce the applicable noise criteria for the specified construction area.

Table 11-5 Construction noise correction factor

Difference between Permissible & Background Noise Levels, dB (A)	Correction Factor to be Added to the Higher of the Two Noise Levels, dB (A)
Below 2	3
2 to less than 4	2
4 to less than 10	1
10 and above	Nil.

The corrected construction noise criteria will be presented and further elaborated in Section 11.5.2.

11.2.4.2 Operational Noise Criteria (Operational Phase)

For airborne noise arising from the operational phase, there exists two (2) aspects of impact for consideration:

1. Boundary noise from the operation of air conditioning and mechanical ventilation (ACMV) systems for proposed development (non-industrial) within the Study Area; and
2. Vehicular noise from road traffic at the Study Area.

11.2.4.2.1 Ecological Receptors

The ecological impacts from airborne noise is species dependent, hence the assessment will be based on the species identified by the fauna specialists during site surveys within and surrounding the Study Area as stated in Section 11.4.2.1, in sync with the biodiversity section of this report.

There are currently no guidelines or standards available to assess the noise from operational activities on the ecological receptors. The current guidelines and standards available are used to assess the respective noise impacts to humans only and do not account for the specific considerations associated with the ecological receptors.

In evaluating the noise impact on ecological receptors in this EIA, a criterion of no-worse-off than baseline shall be employed in absence of sufficient research data on criteria and implemented to the ecological receptors identified within and surrounding the Study Area as a part of the qualitative noise impact assessment.

11.2.4.2.2 Human Receptors

11.2.4.2.2.1 Air Conditioning and Mechanical Ventilation Systems

According to the NEA Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Buildings, 2018 [R-32], non-industrial buildings refers to any permanent or temporary building or structure used for the purposes of trade, business or commerce and includes any shopping complex, financial institution, office tower, hotel, educational institution, hospital, transport infrastructures, community infrastructure, sport and recreational infrastructure but does not include any factory and residential premises.

Based on the proposed preliminary land use plan provided by URA, the Project Site has been proposed to be used for “Residential with supporting amenities”, “Urban Vegetation”, “Retained Forest with Trails” (refer to Figure 3-2). At this stage, detailed design such as footprint of different types of buildings and their locations, the position of façade, design of ACMV systems etc. are unavailable. Hence, the study will take into account the noise effects generated by ACMV systems within the Study Area on nearby receptors considering only the information available at the time of writing and a more detailed study may be required when more information is available.”. The noise limits for ACMV systems are outlined in Table 11-6 below.

Table 11-6 NEA boundary noise limits for ACMV within non-industrial building expressed as the equivalent noise level over the 15 minutes.

Type of Affected Premises	Boundary Noise Limits (reckoned as the equivalent continuous noise level over 15 minutes), dB(A)		
	Day 7am – 7pm	Evening 7pm – 11pm	Night 11pm – 7 am
Noise Sensitive Premises e.g. hospital, home for the aged sick, library.	60	55	50
Residential Premises	65	60	55
Others	70	65	60

As part of the assessment during the pre-design stage, baseline noise results derived during noise monitoring are used to derive the operational noise criteria for noise impacts over a continuous period of 15 minutes. However, at the current pre-design stage given that the proposed developments within the Study Area are still ‘Subject to Detailed Planning’, proper baseline noise for operational phase impact assessment could not be captured due to the lack of information of defined building boundaries required to conduct impact assessment as per the NEA Guidelines. Due to this, the baseline noise results recorded for $L_{Aeq}(15 \text{ mins})$ reflected in Section 11.5.2.1.2 for the operational phase shall only serve to reflect the indicative operational baseline noise conditions.

According to the guideline:

“Where a noise source contains certain characteristics such as tonality, impulsiveness, intermittency, irregularity or dominant low frequency content, there is evidence to suggest that it can cause greater annoyance than other noise at the same level and a penalty of 5 dB (A) shall be added for each of the following characteristics, up to a maximum to 10 dB (A).”

At this stage, noise correction factors can be applied to the baseline noise results to determine the operational noise criteria for the ACMV utilising public buildings planned in future. The maximum permissible noise levels for the Project are deduced and adjusted by the correction factor reflected in Table 11-7 below to account for the existing noise levels measured at defined boundaries of the non-industrial buildings. The correction factor corresponds to the difference between maximum permitted level (see Table 11-6) and the baseline noise levels (see Section 11.5.2), to the higher of the two (2) noise levels. The adjusted value for the maximum permissible noise limit shall form the operational noise criteria for future users.

Table 11-7 ACMV correction factor (operational phase)

Difference between 2 noise levels in decibels (A)	Correction factor in decibels (A)
Below 2	3
2 to less than 4	2
4 to less than 10	1
10 and above	Nil.

11.2.4.2.2.2 Land Traffic Noise

The Technical Guideline for Land Traffic Noise Impact Assessment provides guidance to conduct for the following:

- Part 1 – Land traffic Noise Impact Assessment on new residential and noise sensitive developments located in close proximity to existing land traffic noise sources/hotspots (e.g. expressways/major arterial roads/MRT tracks); and
- Part 2 – Land traffic Noise Impact Assessment on existing residential and noise sensitive developments located in close proximity to new transport-related developments (e.g. expressway/major arterial roads/MRT track/bus interchanges/bus depots), inclusive of the expansion of existing transport-related infrastructures.

The noise emissions due to movement of traffic can be assessed against the *NEA Technical Guideline for Land Traffic Noise Impact Assessment, 2016* [R-31] for the proposed development for operation of transportation networks in the Study Area. The noise levels of the new residential and noise sensitive development shall comply with the following NEA's noise requirement.

NEA's noise requirements are as follows:

- The noise levels at 1 m from the façade of the new residential/noise sensitive building shall not exceed $L_{Aeq(1hr)}$ 67 dB; and
- The indoor noise level of the new residential/noise sensitive building under natural ventilation shall not exceed $L_{Aeq(1hr)}$ 57 dB.

11.2.4.3 Airborne Noise Impact Assessment Criteria

This section reflects the qualitative airborne noise impact assessment criteria adopted for the qualitative assessment of both construction and operational noise impacts on the noise sensitive receptors (NSRs) identified (refer to Section 11.4) for this Project.

As observed in Table 11-8 and Table 11-9 below, impact intensity, defined as the magnitude of the impact and status of the impact in relation to regulations (e.g. discharge limits), standards (e.g. environmental quality criteria) and guidelines (see Section 6.4), is defined based on the perceivability and noticeability of the noise impacts experienced by the NSRs.

The purpose of conducting qualitative impact assessment at the pre-design stage is to aid in decision making during the master planning phase where potential noise impacts could be deduced and mitigated at an early stage to streamline the eventual design of the proposed developments and establishments within the Study Area/ proposed construction worksites at the detailed design stage.

Please note that as only qualitative impact assessment is conducted currently at the pre-design stage (as per Project Scope), quantitative noise impact assessment must be conducted as mandated by law in accordance with the *Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008* [R-27] and *NEA Construction Noise Control [W-2]* regulations for construction noise impacts, and *NEA Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Buildings, 2018* [R-32] and *NEA Technical Guideline for Land Traffic Noise Impact Assessment, 2016* [R-31] for operational noise impacts. As such, AECOM recommends that the developer/ developing agent appoint Noise Consultant(s) to conduct quantitative noise impact assessments for the proposed developments of this Project upon solidifying design plans at the detailed design stage.

The following sections details the qualitative impact assessment matrices adopted to deduce the impact intensity of the construction and operational noise on the NSRs.

11.2.4.3.1 Ecological Receptors

As observed below in Table 11-8 (and also in Table 6-4), the impact intensity of airborne noise on the ecological receptors are dependent on the perceivable and noticeable impacts to fauna, such as whether are there detectable changes in behaviours (e.g. stress), longevity of the perceived impacts (e.g. short term vs long term), reversibility of these impacts (e.g. whether ecological receptors will temporarily/ permanently abandon their habitats) with or without compensatory measures, and their respective auditory sensitivity to noise. These matrices shall be adopted for qualitative noise impact assessment discussed further down in Section 11.7.

Table 11-8 Qualitative evaluation of impact intensity for construction and operational noise for ecological receptors

Environmental Parameters	Impact Intensity			
	Negligible	Low	Medium	High
Airborne Noise (Construction and Operation Phase)	No detectable change to fauna.	Potential impacts last a short duration, are reversible and/or of a small magnitude for species with low auditory sensitivity level.	Potential impacts last for a moderate duration, are reversible with significant input and compensatory measures, and/or of a moderate magnitude for species with medium auditory sensitivity level.	Potential impacts last for a long time, are non-reversible, and/or of a significant magnitude for species with high auditory sensitivity level.

11.2.4.3.2 Human Receptors

As observed in Table 11-9 (also in Table 6-4), the impact intensity of airborne noise on human receptors are similarly dependent on perceivable and noticeable impacts of noise on human receptors, such as how intrusive the noise is, whether the noise can be heard and results in behavioural changes, if the noise will result in sleep disturbances, and whether the noise will result in depreciation of the perceived quality of life of the area. These matrices shall be adopted for qualitative noise impact assessment discussed further down in Section 11.7.

Table 11-9 Qualitative evaluation of impact intensity for construction and operational noise for human receptors

Environmental Parameters	Impact Intensity			
	Negligible	Low	Medium	High
Airborne Noise (Construction and Operational Phase)	Just noticeable, non-intrusive, increase in noise levels: - Noise can be heard but does not result in any change in behaviour or attitude. - Can slightly affect the character of the area but not such that there is a perceived change in quality of life.	Noticeable, mildly intrusive, increase in noise levels: - Noise can be heard and may cause small changes in behaviour and/or attitude. - Potential for non-awakening sleep disturbance. - Can slightly affect the character of the area but not such that there is a perceived change in quality of life.	Noticeable, disruptive, increase in noise levels: - Causes an important change in behaviour and/or attitude during periods of intrusion. - Potential for sleep disturbance resulting in difficulty in getting to sleep, premature awakening, and difficulty in getting back to sleep. - Quality of life diminished due to change in character of area.	Noticeable, very intrusive, increase in noise levels: Significant changes in behaviour and/or an inability to mitigate effect of noise leading to psychological stress or psychological effects.

11.2.5 Prediction and Evaluation of Impact Assessment

The airborne noise impact assessment includes the evaluation of construction and operational noise impacts on the respective noise sensitive receptors (NSRs) (i.e. ecological and human receptors).

11.2.5.1 Construction Phase

At this point in the report-writing process, there is only limited information on the construction activities scheduled for the proposed project's development. The anticipated future activities during the project's construction phase are subdivided into land preparation and construction activities (refer to Section 3.3).

The study on the construction noise impacts on the NSRs focussed on worst-case noisiest activities for the construction during certain construction schedules provided by URA (refer to Table 3-1, Figure 3-4 and Table 11-10). As per information communicated by URA, no night works will be involved in the construction phase and as legislated by NEA, no construction works should be conducted on the Weekends (Sunday/ Public Holidays) unless necessary and granted approval by relevant agencies. Hence, construction noise assessment was only conducted for the construction schedule of 7am – 7pm and for Weekdays (i.e. Monday – Saturday).

At this point of the report writing process, the detailed equipment inventory for different construction activities were not available. A tentative list of equipment was provided by URA (refer to Table 3-1). Nevertheless, important details such as the quantity of a specific construction machinery employed for the particular construction task and the daily operational hours of that particular equipment were not available. As a result, preliminary sound power levels were derived for various construction activities, assuming a singular unit of equipment will be utilised for the particular construction activity.

Of the six (6) construction activities detailed in the equipment list provided by URA (see Appendix T), construction activity "Activity 1: Foundation Works and Earthworks" for the project's construction phase (see Table 11-10 below) was deduced as having the highest 5 mins effective sound power level (SPL) for 7am – 7pm for Weekdays (i.e. Monday – Saturday).

The intent of selecting the worst-case activity for assessment was such that if noise can be controlled in this activity by permanent features during the entire construction, the noise from other less noisy construction activities will also be mitigated.

The respective sound power levels of the selected construction activity provide an insight into the potential magnitude of noise perceived by the ecological and human receptors and how noticeable these noise emissions may be to the receptors on the receiving end for the purposes of conducting qualitative impact assessment.

As detailed in the assessment methodology (see Section 6.2), NSRs were first identified and classified by the nature of the receptors as reflected in Table 6-2. Then, impact intensity was determined through the perceivability and noticeability of noise to the respective ecological and human receptors as detailed in Table 6-4. By considering both impact intensity and receptor sensitivity, impact consequence was obtained as per the matrix in Table 6-5. Thereafter, the likelihood of occurrence of the impact from the construction activities of this Project were calculated based on the working period over specified time period as shown in Table 6-6. By relating both impact consequence and likelihood of occurrence, the impact significance of airborne noise impacts were predicted with the consideration of minimum control measures (see Section 11.6).

Further analysis and evaluation was conducted to recommend additional mitigation measures (e.g. noise barriers, etc.) where necessary. At the end, a monitoring plan was established and triggers for action determined so that the impacts can be controlled within acceptable limits or as low as reasonably practicable.

Table 11-10 Construction activities of the construction phase

Pre-construction and Construction Activities	Tentative Duration*
Land Preparation Activities	
Activity 1: Site Clearance & Preliminary Works • Delivery of steel plates, scaffoldings and hoarding boards for safety nets and dust control curtains; • Surveying and Soil Investigation work • Demolition of existing structures and accompanying infrastructure within the Study Area which are not intended to be retained; • Hacking of minor and major structures; • Removal of abandoned steel elements, debris (e.g. damaged windows, frames, doors, internal & external building furnitures, etc); • Removal of foundation, spoils and debris; and • Removal of vegetation	Land preparation and construction will take approximately five (5) years
Activity 2: Earthworks • Soil excavation, cut and fill; • Site levelling to obtain planned platform levels; • Utility laying • Construction of drainage and sewage infrastructure • Utilities diversion; • Construction of roads (for both final and temporary access) and other infrastructure required for construction activities	Land preparation and construction will take approximately five (5) years
Construction Activities	
Activity 1: Foundation and Earthworks • Soil excavation, cut and fill; • Site levelling to obtain planned platform levels; • Delivery and erection of construction machinery (i.e. crawler crane for lifting operations and boring rig for soil drilling); • Soil dewatering; • Installation of bore casings; • Soil boring work; • Installation of rebar cage and tremie pipe; • Concreting works – construction of piles and pile caps; • Pile head hacking/removal; • Delivery of steel sections; • Hot works – welding of steel beams, brackets, etc.;	From approximately the 7th to the 16th month after land parcel is staged for development (10 months)

Pre-construction and Construction Activities	Tentative Duration*
• Stage excavation; • Hoisting of walers and struts; • Stage excavation with walers and struts; and • Spoil and slurry removal	
Activity 2: Superstructure Works (Prefab Installation) • Soil dewatering (i.e. groundwater extraction and pumping of rainwater); • Establishment of power supply (e.g. for lighting, pumps, temporary ventilation fans); • Excavation below ground surface (e.g. for working platform, for preparing of lean concrete); • Spoil removal; • Formwork construction and cleaning before casting; • Rebar handling and positioning; • Hoisting of falsework; • Casting of concrete; • Scaffolding; and • Finishing works (e.g. plastering)	From approximately the 16th to the 55th month after land parcel is staged for development (40 months/ 3 years and 4 months)
Activity 3: Landscape Works • General landscaping activities • Construction of landscape amenities/ constructions (e.g. gazebos, pathways)	From approximately the 37th to the 56th month after land parcel is staged for development (20 months/ 1 year and 8 months)
Activity 4: Removal of Temporary Structures and Reinstatement • Removal of Earth Retaining and Stabilising Structures (ERSS) • Reinstatement of the area to original (or required) condition	From approximately the 46th to the 55th month after land parcel is staged for development (10 months)
Note: * Due to the current pre-design stage of the Project, the construction schedules of each of the six (6) activities listed above are provided tentatively.	

11.2.5.2 Operational Phase

Referring to Section 11.2.4.2, it is mandatory for the proposed developments to comply with NEA's guidelines for boundary noise impact assessment for air conditioning and mechanical ventilation (ACMV) systems of non-industrial buildings and Traffic Noise Impact Assessment (TNIA) for existing/ new road networks for the developments within the Study Area. An evaluation of operational noise impact was conducted, taking into account that the planned developments would adhere to the guidelines set forth NEA.

11.3 Potential Sources of Airborne Noise Impact and Likelihood of Occurrence

11.3.1 Construction Phase

Construction activities will inevitably result in some degree of noise disturbances at locations in close proximity to the proposed construction worksites of the Project. This is, however, a temporary source of noise, albeit lasting up to few years in this case. The noise levels generated by the construction activities have a potential to impact the noise sensitive receptors (NSRs). Noise levels at the receptors depends on several factors such as the number and type of Powered Mechanical Equipment (PMEs) used, the distance between the NSRs and the construction worksites, and the level of attenuation likely due to ground absorption, air absorption or barrier effects.

The anticipated future activities during the project's construction phase were subdivided into land preparation and construction activities (refer to Section 3.3). The main objective of these activities is to prepare the land so that the main development and construction activities (i.e. building construction) can be carried out. These activities entail site clearance (i.e. demolition of existing buildings/structures and removal of resulting debris, removal of existing trees and vegetation), earthworks (e.g. soil excavation and filling within the site to achieve desirable platform levels, utilities diversion, etc.) and construction of new roads and utilities for future developments. It should be noted that activities such as site surveying, utilities surveying, trial trenching and other site investigations (e.g. geotechnical investigations) are also carried out as a part of pre-construction activities in localised areas in an ad hoc fashion based on the needs of the detailed design team's requirements at that time. However, at the time of writing this report no such information was available regarding these activities.

The main sources of noise originate from the PMEs used for the construction activities detailed in Section 3.3. The PMEs and their respective sound power levels (SPL) provided in this study by the Client are listed in the equipment inventory list in Appendix T. A summary of the six (6) construction activities and their overall effective SPLs derived from the PMEs engaged in each of these activities are reflected in Table 11-11 below.

Table 11-11 Effective sound power level (construction phase)

No.	Pre-construction and Construction Activities	Effective Sound Power Level L_{WA} , dB(A) from equipment list
		$L_{Aeq}(5 \text{ mins})$
		7am – 7pm
Land Preparation Activities		
1	Site Clearance & Preliminary Works	122
2	Earthworks	112
Construction Activities		
1	Foundation and Earthworks	123
2	Superstructure Works (Prefab Installation)	116
3	Landscape Works	117
4	Removal of Temporary Structures and Reinstatement	118

The activities chosen for assessment as discussed in Section 11.2.5.1 were based on the worst-case activities with the highest overall SPLs of the construction phase as reflected in Table 11-11 above in **bold** (i.e. Foundation Works). It is notable that the sound power levels (SPL) reflected in Table 11-11 above represents the levels of noise emitted from source (i.e. from PMEs within the proposed construction worksites) which serves as an indicator

towards the potential perceived level of noise experienced by the noise sensitive receptors in the vicinity of the Study Area at the receiving end and how noticeable the noise impacts may be, to the receptors.

Trunk sewer works with pipe-jacking will be carried out in Eng Neo Avenue along with the widening of Eng Neo Avenue. However, noise generated from the activities associated with the expansion of road and pipe-jacking will be lower than Construction Activity 1: Foundation and Earthworks. Therefore, Construction Activity 1: Foundation and Earthworks was selected as the worst-case scenario with the highest overall SPLs to carry out construction noise impact assessment on sensitive receptors.

11.3.1.1 Likelihood of occurrence of impacts

The likelihood of occurrence of the airborne noise impacts are determined based on the construction timeline and selected construction activities from Table 11-11.

11.3.1.1.1 Activity 1: Foundation and Earthworks (Construction Activities)

The Likelihood of Occurrence of airborne noise impacts were determined based on the equipment list for different pre-construction and construction activities of the proposed development provided by URA in Appendix I over the daily working period (e.g., 7am – 7pm, 7pm – 10pm, 10pm – 7am), detailed as frequency of exposure in Table 11-12.

It should be noted that in accordance with information provided by URA on the construction work schedules, construction works are only proposed to occur within the time period of 7am – 7pm on Weekdays (i.e., no night-works, no works on Weekends).

Based on the proposed equipment inventory (refer to Appendix T), the frequency of exposure of 1.0 (for $L_{Aeq}(5 \text{ mins})$, dB(A) and Day Time) corresponds to a Likelihood of Occurrence of 'Certain/Continuous' (see Table 6-6).

Table 11-12 Likelihood evaluation of construction activities for airborne noise impact assessment

Worksite	Assessment Scenario	L_{Aeq} , dB(A)	Frequency of Exposure	Likelihood of Occurrence
All proposed construction worksites	Activity 1: Foundation and Earthworks (Construction Activities)	$L_{Aeq}(5 \text{ mins})$, dB(A)	Working period over specified time period (Day-time) = 1.0 Active duration of equipment = 1.0 Frequency of exposure = $1.0 \times 1 = 1.0$	Certain/Continuous

11.3.2 Operational Phase

The typical potential noise sources during the operational phase of the Project includes the following:

- Air-conditioning and mechanical ventilation (ACMV) noise from services emitted from non-industrial buildings as part of the Project development; and
- Traffic noise due to increase in vehicular volume and new road networks due to the development of the Project and in the vicinity of the Study Area.

Operational noise arising from ACMV systems, if any, are expected to persist throughout the day, emitting from proposed non-industrial buildings depending on the nature of the eventual establishment.

The potential impacts due to the increase in noise levels from the above-mentioned sources includes noise disturbance to humans and in addition, disturbance to ecological receptors (i.e. fauna species) found within the nearby Eng Neo Avenue Forest, Green Area near Linden Drive, Green Area near Green Park Avenue, and forested patches adjacent to The British Club and Swiss Club such as the potential impacts of affecting ecological foraging behaviour, and intra-species and inter-species communication.

11.4 Identification of Airborne Noise Sensitive Receptors

This study focused on the noise impacts to the ecological receptors (i.e. fauna) and human receptors within the Assessment Area during the construction and operational phase of the Project. The classification of ecological receptors and human receptors was based on the auditory sensitivity of the respective species as described in Section 11.2.3. The identified ecological receptors and human receptors are further discussed respectively in Section 11.4.1 and Section 11.4.2.

11.4.1 Construction Phase

11.4.1.1 Ecological Receptors

11.4.1.1.1 Receptor Importance

The prioritization of the ecological receptors within and surrounding the Study Area follows the approach listed in the below factors:

- The actual presence or likely presence (from records) from faunistic field assessment conducted;
- The conservation significance or importance of the identified ecological receptors; and
- The ecological receptor's likelihood to be sensitive to airborne noise impacts.

Based on faunistic field assessment conducted within and surrounding the Study Area of the Project, a summary of the identified ecological receptors of concern in line with the biodiversity section are discussed below.

Priority 1, Priority 2 and Priority 3 fauna species have been identified within and surrounding the Study Area established in this Project as shown in Figure 11-2.

Species of conservation significance (CS) were also identified at these areas and listed in Table 11-14. These identified fauna species, mainly Priority 1 and Priority 2, are of particular concern due to their auditory sensitivities to airborne noise. Priority 3 fauna species of conservation significance, identified as not likely to be affected by noise (refer to Section 11.4.1.1.2 below), were also identified and reflected in Table 11-13 and discussed below.

11.4.1.1.2 Receptor Sensitivity to Airborne Noise

The following paragraphs discusses the ecological receptors and the rationale for their respective auditory sensitivity. The priority levels for auditory sensitivity reflected in Table 11-13 were assigned based on the following general framework provided by the biodiversity specialists of this Project:

- Priority 1: Animals that vocalise during important life cycle stages such as courtship, territorial claims and/or mating;

- Priority 2: Animals that have auditory sensory systems but do not necessarily need to vocalise during important life cycle stages; and
- Priority 3: Animals that are not likely to be affected by airborne noise.

Amphibians such as frogs are considered to have highly auditory sensitive as studies have demonstrated that anthropogenic noise is likely to substantially decrease the reproductive success in frogs [P-5]. Hence, amphibians are classified as Priority 1 ecological receptors.

Birds are considered to be highly auditory sensitive as most make use of sound for communication and breeding. Studies have also shown that birds are impacted negatively by anthropogenic noise [P-6]. Hence, birds are classified as Priority 1 ecological receptors.

Lepidoptera such as the butterflies are known to behaviourally respond to low-frequency vibrations and sounds to avoid insect predators and parasites [P-7]. Adult butterflies are known to make use of existing airborne noise in order to avoid predators [P-8]. Based on the above, lepidopterans are considered highly auditory. Hence, are classified as Priority 2 ecological receptors.

Non-volant mammals such as rodents are known to display stressed behaviour in response to sounds of heavy machinery which could be common occurrence from construction noise [P-11]. Hence, non-volant mammals are deemed to be highly auditory sensitive and classified as Priority 2 ecological receptors.

While for volant mammals such as bats, anthropogenic noise is known to impacts bats negatively by disrupting foraging patterns [P-14] and are hence classified as highly auditory sensitive. Hence, they are classified as Priority 1 ecological receptors. Based on faunistic surveys, two (2) bats (Cave nectar bat and Lesser bamboo bat) of conservation significance were observed for this Project (refer to Table 7-8).

It is documented that adult odonates appear to be able to hear however sound does not appear to cause significant behavioural change [P-10]. Odonates are consequently regarded as being less auditory sensitive. Hence, they are classified as Priority 3 ecological receptors, dependant on conservation significance.

Reptiles such as lizards are considered to be highly auditory sensitive due to studies showing these species exhibiting stress responses when exposed to anthropogenic noise [P-15]. For snakes, though not equipped with outer-ears and tympanic middle ear, have vestiges for hearing inside their heads and can feel low-frequency airborne sounds [P-12]. Turtles on the other hand, follows the classification of aquatic species such as decapod crustaceans and fish due to their ability to traverse land and water [P-13]. As such, reptiles are classified as Priority 2 sensitive ecological receptors.

Studies have been conducted on the transmission of noise energy across the air to water boundary. Research shows that the transmission of airborne noise energy to the water medium is low due to the difference in acoustic characteristic impedance of air to water by a ratio of 1:3600 [P-9]. Hence, aquatic/ marine species such as arthropods, cephalopods, cnidarians, decapods, echinoderms, marine worms, molluscs, and fishes that primarily dwell within water bodies are considered to be Priority 3 sensitive ecological receptors [P-16].

Table 11-13 Ecological receptors and airborne noise auditory sensitivity classification

Receptor Number	Receptors	Auditory Sensitivity Classification
Terrestrial Fauna		
1	Amphibians - Frogs - Toads	Priority 1
2	Bird	Priority 1
3	Butterfly	Priority 2
4	Non-volant Mammals	Priority 2
5	Volant Mammals (Bats)	Priority 1
6	Odonates - Damselfly - Dragonfly	Priority 3
7	Reptiles - Snakes - Turtles - Lizards	Priority 2
Marine/Aquatic Fauna		
1	Fish	Priority 3

Table 11-14 List of Ecological receptors of conservation significance

No.	Taxon	Species	Common Name	Local Status	Global Status	Auditory Sensitivity
1	Aculeata	<i>Amegilla insularis</i>	-	Vulnerable	Not Listed	Priority 1
2	Aculeata	<i>Anthidiellum smithii</i>	-	Vulnerable	Not Listed	Priority 1
3	Aculeata	<i>Ceratina fuliginosa</i>	-	Vulnerable	Not Listed	Priority 1
4	Aculeata	<i>Lipotriches takauensis</i>	-	Vulnerable	Not Listed	Priority 1
5	Aculeata	<i>Megachile indonesica</i>	-	Vulnerable	Not Listed	Priority 1
6	Aculeata	<i>Megachile ramera</i>	-	Vulnerable	Not Listed	Priority 1
7	Aculeata	<i>Parischnogaster unicuspata</i>	-	Vulnerable	Not Listed	Priority 1
8	Bird	<i>Alcedo atthis</i>	Common kingfisher	Vulnerable	Least Concern	Priority 1
9	Bird	<i>Alcedo meninting</i>	Blue-eared kingfisher	Endangered	Least Concern	Priority 1
10	Bird	<i>Apus nipalensis</i>	House swift	Vulnerable	Least Concern	Priority 1
11	Bird	<i>Ardea purpurea</i>	Purple heron	Endangered	Least Concern	Priority 1
12	Bird	<i>Chrysococcyx xanthorhynchus</i>	Violet cuckoo	Vulnerable	Least Concern	Priority 1
13	Bird	<i>Collocalia affinis</i>	Plume-toed swiftlet	Vulnerable	Least Concern	Priority 1
14	Bird	<i>Copsychus malabaricus</i>	White-rumped shama	Endangered	Least Concern	Priority 1
15	Bird	<i>Copsychus saularis</i>	Oriental magpie-robin	Vulnerable	Least Concern	Priority 1
16	Bird	<i>Corvus macrorhynchos</i>	Large-billed crow	Vulnerable	Least Concern	Priority 1
17	Bird	<i>Cyornis brunneatus</i>	Brown-chested jungle flycatcher	Vulnerable	Vulnerable	Priority 1
18	Bird	<i>Elanus caeruleus</i>	Black-winged kite	Vulnerable	Least Concern	Priority 1
19	Bird	<i>Halcyon coromanda</i>	Ruddy kingfisher	Critically Endangered	Least Concern	Priority 1
20	Bird	<i>Halcyon pileata</i>	Black-capped kingfisher	Vulnerable	Least Concern	Priority 1
21	Bird	<i>Ixobrychus sinensis</i>	Yellow bittern	Vulnerable	Least Concern	Priority 1
22	Bird	<i>Ketupa ketupu</i>	Buffy fish owl	Vulnerable	Least Concern	Priority 1

No.	Taxon	Species	Common Name	Local Status	Global Status	Auditory Sensitivity
23	Bird	<i>Lanius cristatus</i>	Brown shrike	Vulnerable	Least Concern	Priority 1
24	Bird	<i>Nisaetus cirrhatus</i>	Changeable hawk-eagle	Vulnerable	Least Concern	Priority 1
25	Bird	<i>Nycticorax nycticorax</i>	Black-crowned night heron	Endangered	Least Concern	Priority 1
26	Bird	<i>Ploceus philippinus</i>	Baya weaver	Vulnerable	Least Concern	Priority 1
27	Bird	<i>Psilopogon rafflesii</i>	Red-crowned barbet	Vulnerable	Near Threatened	Priority 1
28	Bird	<i>Psittacula longicauda</i>	Long-tailed parakeet	Near Threatened	Vulnerable	Priority 1
29	Bird	<i>Psittinus cyanurus</i>	Blue-rumped parrot	Endangered	Near Threatened	Priority 1
30	Bird	<i>Ptilinopus jambu</i>	Jambu fruit dove	Vulnerable	Near Threatened	Priority 1
31	Bird	<i>Pycnonotus brunneus</i>	Asian red-eyed bulbul	Vulnerable	Least Concern	Priority 1
32	Bird	<i>Pycnonotus zeylanicus</i>	Straw-headed bulbul	Endangered	Critically Endangered	Priority 1
33	Bird	<i>Spilornis cheela</i>	Crested serpent eagle	Critically Endangered	Least Concern	Priority 1
34	Bird	<i>Strix seloputo</i>	Spotted wood owl	Vulnerable	Least Concern	Priority 1
35	Bird	<i>Surniculus lugubris</i>	Square-tailed drongo-cuckoo	Vulnerable	Least Concern	Priority 1
36	Bird	<i>Treron curvirostra</i>	Thick-billed green pigeon	Vulnerable	Least Concern	Priority 1
37	Bird	<i>Zosterops simplex</i>	Sw'nhoe's white-eye	Vulnerable	Least Concern	Priority 1
38	Butterfly	<i>Astictopterus jama jama</i>	Forest hopper	Endangered	Not Listed	Priority 2
39	Butterfly	<i>Catochrysops strabo strabo</i>	Forget-me-not	Vulnerable	Not Listed	Priority 2
40	Butterfly	<i>Cephrenes acalle niasicus</i>	Plain palm dart	Vulnerable	Not Listed	Priority 2
41	Butterfly	<i>Everes lacturnus rileyi</i>	Indian cupid	Endangered	Not Listed	Priority 2
42	Butterfly	<i>Halpe ormenes vilasina</i>	Dark banded ace	Vulnerable	Not Listed	Priority 2
43	Butterfly	<i>Pelopidas assamensis</i>	Great swift	Endangered	Not Listed	Priority 2
44	Butterfly	<i>Pelopidas conjunctus conjunctus</i>	Conjoined swift	Endangered	Not Listed	Priority 2
45	Butterfly	<i>Pemara pugnans</i>	Pugnacious lancer	Vulnerable	Not Listed	Priority 2

No.	Taxon	Species	Common Name	Local Status	Global Status	Auditory Sensitivity
46	Butterfly	<i>Pseudocoladenia dan dhyana</i>	Fulvous pied flat	Vulnerable	Not Listed	Priority 2
47	Butterfly	<i>Rachana jalindra burbona</i>	Banded royal	Vulnerable	Not Listed	Priority 2
48	Butterfly	<i>Taractrocera ardonia lamia</i>	Spotted grass dart	Vulnerable	Not Listed	Priority 2
49	Butterfly	<i>Telicota augias augias</i>	Pale palm dart	Vulnerable	Not Listed	Priority 2
50	Butterfly	<i>Telicota linna</i>	Linna palm dart	Vulnerable	Not Listed	Priority 2
51	Butterfly	<i>Troides helena cerberus</i>	Common birdwing	Vulnerable	Not Listed	Priority 2
52	Butterfly	<i>Ypthima pandocus corticaria</i>	Common three-ring	Vulnerable	Not Listed	Priority 2
53	Fish	<i>Betta imbellis</i>	Crescent betta	Endangered	Least Concern	Priority 3
54	Mammal	<i>Macaca fascicularis</i>	Long-tailed macaque	Least Concern	Endangered	Priority 1
55	Mammal	<i>Manis javanica</i>	Sunda pangolin	Critically Endangered	Critically Endangered	Priority 1
56	Mammal	<i>Unidentified Sciuridae (flying)</i>	Flying squirrel	NA	NA	Priority 1
57	Mammal (bat)	<i>Eonycteris spelaea</i>	Cave nectar bat	Vulnerable	Least Concern	Priority 1
58	Mammal (bat)	<i>Tylonycteris fulvida</i>	Lesser bamboo bat	Vulnerable	Least Concern	Priority 1
59	Odonata	<i>Ceriagrion chaoi</i>	Fiery coral-tail	Vulnerable	Least Concern	Priority 2
60	Odonata	<i>Coeliccia octogesima</i>	Telephone sylvan	Vulnerable	Not Listed	Priority 2
61	Odonata	<i>Copera vittata</i>	Variable featherlegs	Vulnerable	Least Concern	Priority 2
62	Odonata	<i>Podolestes orientalis</i>	Blue-spotted flatwing	Vulnerable	Least Concern	Priority 2
63	Reptile	<i>Amyda cartilaginea</i>	Asian softshell turtle	Vulnerable	Vulnerable	Priority 2
64	Reptile	<i>Cuora couro</i>	Malayan box terrapin	Near Threatened	Endangered	Priority 2
65	Reptile	<i>Homalopsis buccata</i>	Puff-faced water snake	Vulnerable	Least Concern	Priority 2
66	Reptile	<i>Sibynophis melanocephalus</i>	Black-headed collared snake	Vulnerable	Least Concern	Priority 2

11.4.1.2 Human Receptors

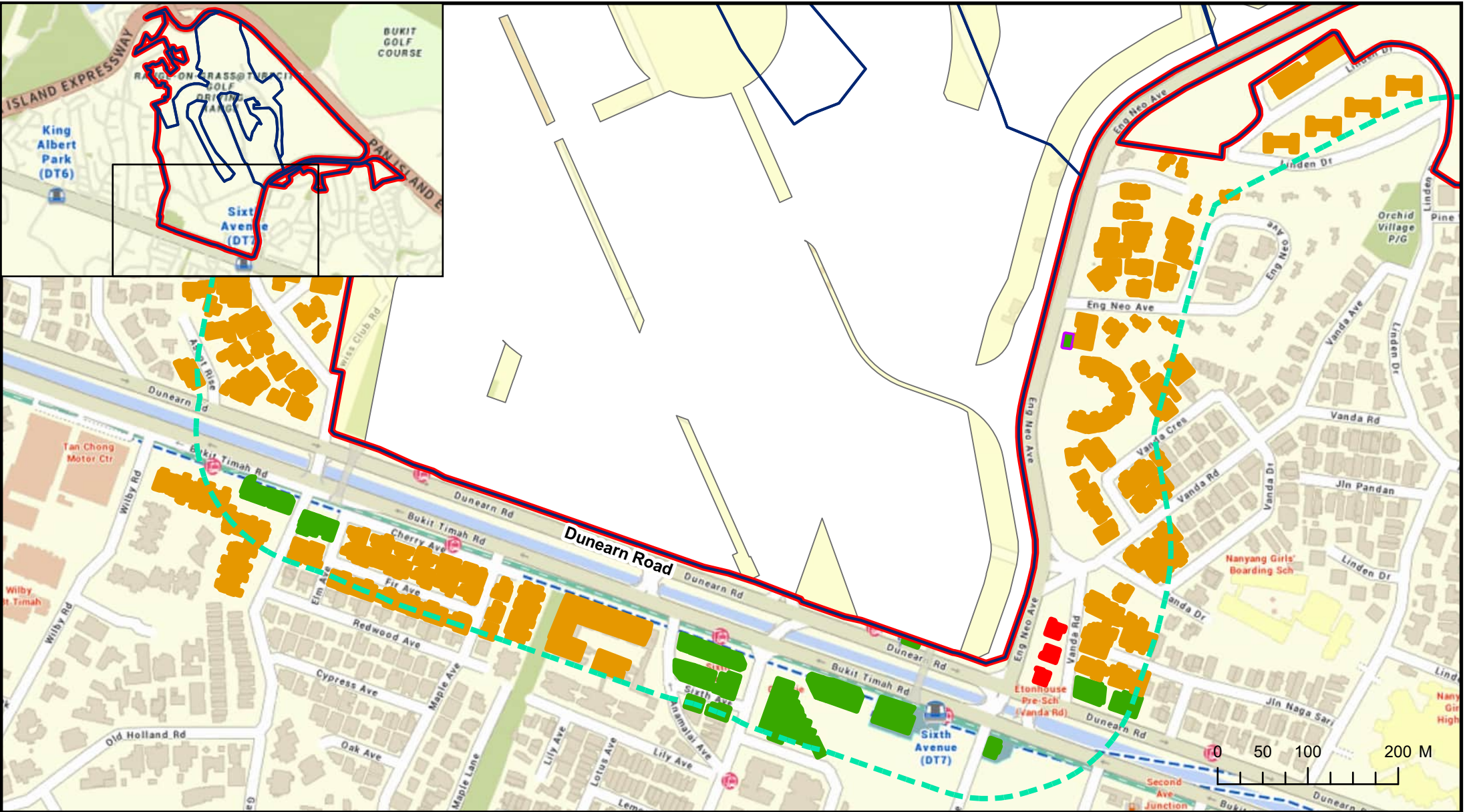
According to the *Environmental Project and Management Regulation, 2008* [R-27], the sensitive human receptors for the construction phase are buildings within 150 m from the proposed construction worksites within the Study Area. As an initial step of noise impact assessment, the buildings within the Assessment Area that may be potentially sensitive to the construction noise from the Project were analysed. As a result, the human noise sensitive receptors (NSRs) for the construction phase were identified and reflected in Figure 11-3 to Figure 11-6 and summarised in Table 11-15 where the respective sensitivity classifications are based on Table 6-2.

Information on the nearest sound level meter (SLM) to the human receptors where records of baseline noise levels representative of current environmental noise conditions experienced by the identified human receptors is also provided in Table 11-15, providing an insight to current baseline conditions experienced by the human receptors. This association plays an important role in noise impact assessment as the baseline noise levels recorded at different SLMs will result in differing noise criteria that human receptors will be assessed against as part of quantitative noise impact assessment to be conducted by a Noise Consultant(s) appointed by the developer/developing agent as part of the detailed design process of the Project as mandated by law.

For the purposes of qualitative impact assessment, the baseline noise levels recorded at SLMs associated with the different human receptors listed in Appendix U shall serve as a gauge towards the determination of the perceivability and noticeability of additional noise impacts on these receptors arising from the construction phase.

Table 11-15 Summary of Human noise sensitive receptors (construction phase)

Receptor Sensitivity	Building Type	No. of Receptors	Height (m)	Distance from the Project Sites (m)
Priority 1	School	5	3.0-16	6.0-151.0
	Civic and Community Institution	1	3.0	115.0
Priority 2	Residential	243	3.0-29.0	1.0-156.0
Priority 3	Commercial	37	3.0-18	1.0-149
	Recreational	5	3.0-10	6.0-141
	Service Facility	1	3.0	28.0



Legend

Site Demarcation

EIS Study Area

Project Site

Overall Construction Footprint

Airborne Noise Study Area (150m)

Sensitivity of the Receptors

Priority 1

Priority 2

Priority 3

Building Type

Commercial

Recreational

Residential

School

Service Facility

Rev.

Date

By

Description

Chk'd

App'd

MAY 2024

SHA

Turf Club EIA

LAL

JAG

Qualified Person Endorsement : NA

URA Endorsement : NA

AECOM

Project Title :
**CONTRACT URA/T/22/031
ENVIRONMENTAL IMPACT
ASSESSMENT (EIA) FOR
FORMER TURF CLUB AT BUKIT TIMAH**

Designed
SHA

Checked
LAL

Approved
JAG

Drawn
SHA

Date
MAY 2024

Client:

URBAN
REDEVELOPMENT
AUTHORITY

Figure Title :
**Noise Sensitive Receptors (Human)
Part 3 of 4**

Figure No. :
11- 5

Rev.
-

Sheet
1 of 1

CAD File Name : NA

A3

Note: Source of basemap - Google Earth Map

THIS DRAWING IS COPYRIGHT

11.4.2 Operational Phase

11.4.2.1 Ecological Receptors

Ecological receptors considered for assessment of noise impacts arising from the operational phase shall consider similar ecological receptors identified for the construction phase as discussed in Section 11.4.1.1 above. With necessary and adequate mitigation measures implemented for the construction phase to reduce noise impacts on the ecological receptors, similar fauna species identified surrounding the proposed construction worksites and within/ surrounding the Project Study Area prior to construction works, should continue to inhabit the surrounding areas.

It is advised that faunistic survey and baseline noise monitoring be conducted upon completion of the construction phase and commencement of the operational phase to determine the new baseline conditions and fauna species that remain in the vicinity of the proposed construction worksites to determine actual operational noise impacts.

11.4.2.2 Human Receptors

Apart from the human receptors identified in the Section 11.4.1.2, human receptors within the Project Site need to be considered for the operational phase and assessed as part of operational noise impacts arising from noise associated with the ACMV systems of non-industrial buildings, and as part of Traffic Noise Impact Assessment (TNIA). Both elements were considered to assess the operational noise impact within the Study Area.

11.5 Baseline Airborne Noise

11.5.1 Baseline Monitoring Personnel

The assessment and site surveys were conducted by the following personnel:

- Ms. Jagriti Dawra, AECOM (EIA Technical Lead)
- Mr. Hanzel Lalitan, AECOM (Air and Noise Consultant)
- Mr. Zay Phyo, AECOM (Noise Consultant)
- Ms. Sim Yi Ting, AECOM (Noise Consultant)
- Ms. Kameshwari Ravi, AECOM (Noise Consultant)
- Mr. Shayok Ghosh, AECOM (Noise Consultant)

To understand the ambient noise environment near the Study Area, site reconnaissance was conducted on 8 July 2021 during EBS stage. Furthermore, baseline noise monitoring was conducted between the dates listed below to obtain the baseline noise levels for the purposes of developing the specific construction noise criteria for this Project.

The baseline monitoring dates are as follows:

- 10th August 2023 to 16th August 2023 (for NN07, NN09, and NN11);
- 25th August 2023 to 31st August 2023 (for NN01, NN02, NN04, NN05);
- 04th September 2023 to 10th September 2023 (for NN03, NN06 and NN06) and
- 03rd October 2023 to 9th October 2023 (for NN10).

11.5.2 Baseline Monitoring Results

Baseline monitoring was conducted to understand the ambient noise levels at locations in proximity of the Study Area for the purposes of developing the corrected noise criteria.

11.5.2.1 Construction Phase

11.5.2.1.1 Primary Data

The baseline airborne noise monitoring results from NN01 – NN11 for L_{Aeq} (12 hour), L_{Aeq} (1 hour) and L_{Aeq} (5 min) of Weekdays (Monday – Saturday) and Sunday/ Public Holidays respectively are summarised in Table 11-16 below, in accordance with local noise guidelines for the construction phase.

Baseline noise monitoring results at NN01 and NN02 are primarily representative of noise levels within the green field on the Northern and the Southern portion of Champions Golf Course, respectively. While noise levels recorded at NN03 and NN04 are more representative of that experienced by human receptors residing near educational institutions/ recreational establishments near Blue House International Pre-School and educational institutions/ treatment centre near Chiltern House Turf Club Road respectively. Similarly, NN05 and NN06 primarily represents the human receptors from the Educational Institutions along Dunearn Road and from residences along Swiss View, respectively. NN07 measures the baseline noise levels within the Green area near Chatsworth International School. NN08 represents the noise level experienced by the human receptors along Swiss Road and the area near Kim Chuan Trading. NN09 and NN10 represents noise levels experienced by ecological receptors found within Green Area, and human receptors along Green Park Avenue and Linden Road respectively. NN11 captures the noise level experienced by the human receptors near Eng Neo Avenue and Linden Drive.

Baseline noise monitoring points NM01, and NM02 depict the ambient noise levels recorded in the Site A, specifically the Eng Neo Avenue Forest (Figure 11-1) [R-1]. Baseline noise monitoring location NM05 is representative of the ambient noise levels captured within the Site B – a forested area bounded by Eng Neo Avenue Forest and Fairways Quarters (Figure 11-1) [R-1]. Baseline noise monitoring location NM03 is representative of the ambient noise levels captured within Site D, a ravine in the centre of the former racetrack (Figure 11-1) [R-1]. Baseline noise monitoring point NM04 depicts the ambient noise levels recorded in the Site C, specifically the Eng Neo Avenue Forest (Figure 11-1) [R-1].

As observed in Table 11-16, noise levels recorded at NN01 is the highest in general. This is attributed to the dominant high traffic noise from PIE. While monitoring point at NN05 also recorded relatively higher noise levels than other locations due to traffic from Dunearn Road, Bukit Timah, and Eng Neo Avenue.

It is notable that maximum recorded noise levels at relatively quieter NN11 are higher on certain days as highlighted in Table 11-16. This could potentially be due higher human traffic volumes on certain days along Eng Neo Avenue and Linden Drive. For clearer insight to daily reported noise levels, please refer to the baseline noise monitoring report found in Appendix S.

As observed in Table 11-16, noise levels at NM04 were considerably higher at the night time (7pm – 7am) during Weekdays and Weekends. This is likely attributed to higher noise levels arising from operational activities in the nearby British Club and Champion's Golf Academy Pte Ltd frequented by visitors during the evening and night time in comparison to day time. NM02 showed higher noise levels compared to other noise locations of previous studies which is likely attributed to traffic noise from the nearby car park area frequented by golfers/ visitors of the Champion's Golf Academy at the end of 60 Fairways Drive (operational up to 11pm).

Table 11-16 Summary of baseline noise monitoring results for construction noise impact assessment (current study)

Location	Date of Monitoring	L _{Aeq} (12 hour), dB		L _{Aeq} (1 hour), dB						L _{Aeq} (5 min), dB								
		7am -7pm	7pm -7am^	7pm - 10pm^		10pm - 7am^		7am - 7pm			7pm - 10pm^			10pm - 7am^				
		Overall		Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
Weekdays (Monday – Saturday)																		
NN01: Northern Part of Champions Golf near Turf Club Road (Site E)	25 August - 31 August 2023	68	66	65	68	67	61	68	64	65	73	67	64	69	67	60	69	64
NN02: Southern Part of Champions Golf near Turf Club Road (Site E)	25 August - 31 August 2023	52	49	45	51	48	46	55	49	43	67	49	44	58	48	44	56	48
NN03: Near Blue House International Pre-School (Site B)	4 September - 10 September 2023	58	58	54	58	56	52	62	57	49	66	57	51	59	55	49	63	57
NN04: Opposite Chiltern House at Turf Club Road (Site E)	25 August - 31 August 2023	53	53	48	52	50	49	61	53	46	66	51	46	55	50	47	64	52
NN05: Along Dunearn Road, opposite EtonHouse Pre-School Vanda (Site E)	25 August - 31 August 2023	64	60	59	64	62	52	63	58	60	70	64	60	64	62	49	64	58
NN06: La Suisse 1 (Site C)	4 September - 10 September 2023	58	53	54	57	55	48	55	51	54	68	57	53	59	55	47	58	50

Location	Date of Monitoring	L _{Aeq} (12 hour), dB		L _{Aeq} (1 hour), dB						L _{Aeq} (5 min), dB								
		7am -7pm	7pm -7am^	7pm - 10pm^		10pm - 7am^		7am - 7pm			7pm - 10pm^			10pm - 7am^				
		Overall		Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
NN07: Green Area in Chatsworth International School (Site C)	10 August - 16 August 2023	57	57	47	76	56	41	70	49	43	74	53	43	79	56	40	70	49
NN08: Near Newton Auto Keys Pte (Site E)	4 September - 10 September 2023	56	53	56	61	59	40	54	47	42	67	52	44	60	53	38	57	47
NN09: Green Area near Greenwood Terrace (Site F)	10 August - 16 August 2023	57	54	47	61	54	48	59	52	47	74	55	50	62	55	48	60	52
NN10: Green Area near Linden Drive (Site F)	03 October - 9 October 2023	53	51	48	58	51	48	53	51	45	70	50	46	62	50	47	54	51
NN11: Green Area near Eng Neo Avenue and Linden Drive (Site F)	10 August - 16 August 2023	56	48	48	56	51	39	54	45	49	74/86*	53	47	54	51	39	59	45
NM01: Eng Neo Avenue Forest (Southern) ^a (Site A)	10 September - 16 September 2021	53	50	49	54	51	48	53	50	46	60	52	47	59	51	44	56	50
NM05: Forested area bounded by Eng Neo Avenue Forest and Fairway	10 September - 16 September 2021	57	49	50	55	52	41	52	46	49	66	56	49	58	52	37	56	46

Location	Date of Monitoring	L _{Aeq} (12 hour), dB		L _{Aeq} (1 hour), dB						L _{Aeq} (5 min), dB									
		7am -7pm	7pm -7am^	7pm - 10pm^		10pm - 7am^		7am - 7pm			7pm - 10pm^			10pm - 7am^					
		Overall		Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	
Quarters ^a (Site B)																			
NM03: Ravine in the centre of the former racetrack ^a (Site D)	18 October - 24 October 2021	56	55	47	71	57	45	59	48	48	74	54	47	74	56	45	67	48	
NM04: Forested area adjacent to The British Club/ Swiss Club ^a (Site C)	24 November - 30 November 2021	54	60	52	79	59	44	77	52	49	75	53	50	83	59	43	80	52	
NM02: Eng Neo Avenue Forest (Northern) ^a (Site A)	18 October - 24 October 2021	62	60	59	69	62	53	63	57	59	73	62	59	71	62	52	65	57	
Weekend/ Public Holidays (Sunday/ Public Holidays)																			
NN01: Northern Part of Champions Golf near Turf Club Road (Site E)	25 August - 31 August 2023			N.A.															
		67	65								65	67	67	66	68	67	60	69	63
NN02: Southern Part of Champions Golf near Turf Club	25 August - 31 August 2023	48	48								43	54	47	44	48	47	45	52	48

Location	Date of Monitoring	L _{Aeq} (12 hour), dB		L _{Aeq} (1 hour), dB						L _{Aeq} (5 min), dB								
		7am -7pm	7pm -7am^	7pm - 10pm^		10pm - 7am^		7am - 7pm			7pm - 10pm^			10pm - 7am^				
		Overall		Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
Road (Site E)																		
NN03: Near Blue House International Pre-School (Site B)	4 September - 10 September 2023	56	58							51	69	55	50	56	52	50	64	57
NN04: Opposite Chiltern House at Turf Club Road (Site E)	25 August - 31 August 2023	53	52							47	61	52	48	56	51	49	58	52
NN05: Along Dunearn Road, opposite EtonHouse Pre-School Vanda (Site E)	25 August - 31 August 2023	62	59							60	64	62	60	63	61	50	64	56
NN06: La Suisse 1 (Site C)	4 September - 10 September 2023	56	53							53	61	56	54	59	55	47	59	51
NN07: Green Area in Chatsworth International School (Site C)	10 August - 16 August 2023	53	54							45	64	51	44	68	51	41	52	47
NN08: Near Newton Auto Keys Pte (Site E)	4 September - 10 September 2023	52	46							41	62	49	39	57	47	40	48	43
NN09: Green Area near Greenwood Terrace (Site F)	10 August - 16 August 2023	55	51							46	60	53	46	55	50	48	55	51
NN10: Green Area near	03 October - 9 October 2023	58	51							46	70	55	46	53	49	49	54	51

Location	Date of Monitoring	L _{Aeq} (12 hour), dB		L _{Aeq} (1 hour), dB						L _{Aeq} (5 min), dB								
		7am -7pm	7pm -7am^	7pm - 10pm^		10pm - 7am^		7am - 7pm			7pm - 10pm^			10pm - 7am^				
		Overall		Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
Linden Drive (Site F)																		
NN11: Green Area near Eng Neo Avenue and Linden Drive (Site F)	10 August - 16 August 2023	51	46							47	57	51	47	50	48	39	52	44
NM01: Eng Neo Avenue Forest (Southern) ^a	10 September - 16 September 2021	53	50	N.A.						48	59	53	48	54	51	47	52	51
NM01: Eng Neo Avenue Forest (Southern) ^a (Site A)	10 September - 16 September 2021	57	49							51	63	56	49	55	52	41	55	50
NM05: Forested area bounded by Eng Neo Avenue Forest and Fairway Quarters ^a (Site B)	18 October - 24 October 2021	53	47							47	60	52	47	48	47	46	54	47
NM03: Ravine in the centre of the former racetrack ^a (Site D)	24 November - 30 November 2021	53	68							51	57	53	56	81	65	42	63	51
NM04: Forested	18 October - 24 October 2021	60	59							58	67	60	60	68	62	50	62	55

Location	Date of Monitoring	L _{Aeq} (12 hour), dB		L _{Aeq} (1 hour), dB						L _{Aeq} (5 min), dB								
		7am -7pm	7pm -7am^	7pm - 10pm^		10pm - 7am^		7am - 7pm			7pm - 10pm^			10pm - 7am^				
		Overall		Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
area adjacent to The British Club/ Swiss Club ^a (Site C)																		
NM02: Eng Neo Avenue Forest (Northern) ^a (Site A)	24 Feb – 02 Mar 2020	50	40							42	58	48	39	47	41	37	46	38
Note: N.A.– Not Applicable In accordance with the EPM 2008 Regulation, L_{Aeq}(1 hour) is not assessed for Weekend/ Public Holidays and is hence not applicable. * Significantly higher baseline noise levels were recorded for only one (1) day of the week of monitoring potentially due to higher volumes of human traffic at N1 and N4 on certain days during the Weekday. ^ No night works beyond the 7am – 7pm construction schedule or work on Weekend/ Public Holidays were proposed in this Project as per information provided by URA. Information of baseline noise levels measured at other timings are for purposes of reference. Night-works or works on Weekend/ Public Holidays will only be allowed if permission from relevant local agencies is sought and approved. ^a Data extracted from [R-1].																		

11.5.2.1.2 Secondary Data

As mentioned in the Inception Report [R-5], baseline noise levels captured in the previous studies [R-2,R-3] has been included in the calculation to derive a background noise correction factor to establish the maximum permitted noise level from the construction activities in accordance with the noise legislation stated in Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008 [R-68].

Baseline noise monitoring points N09 depicts the ambient noise levels recorded in the Site A, specifically the Eng Neo Avenue Forest (Figure 11-1). Baseline noise monitoring locations N12 and N13 are representative of the ambient noise levels captured within the Site B – a forested area bounded by Eng Neo Avenue Forest and Fairways Quarters (Figure 11-1). Baseline noise monitoring point N08 depicts the ambient noise levels recorded in the Site C, specifically the Eng Neo Avenue Forest (Figure 11-1).

Table 11-17 Summary of baseline noise monitoring results for construction noise impact assessment (previous studies)

Location	Date of Monitoring	L _{Aeq} (12 hour), dB			L _{Aeq} (1 hour), dB						L _{Aeq} (5 min), dB																						
		7am -7pm	7pm -7am^		7pm - 10pm^			10pm - 7am^			7am - 7pm			7pm - 10pm^			10pm - 7am^																
Overall																			Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
Weekdays (Monday – Saturday)																																	
N08: Swiss School ^a (Site C)	24 February – 02 March 2020	54	47		40	61	50	37	52	40	42	69	51	39	69	49	36	55	39														
N09: Within Eng Neo Avenue Forest ^a (Site A and E)	29 January – 05 February 2020	56	55		53	70	57	48	59	52	53	68	56	52	73	56	47	64	51														
N12 Forested Area adjacent to Fairway Quarters (north) ^a (Site B)	13 September - 19 September 2021	55	48		44	55	49	42	52	46	43	74	52	42	56	48	39	55	46														
N13 Forested Area adjacent to Fairway Quarters (south) ^a (Site B)	13 September - 19 September 2021	57	49		47	62	52	42	57	47	45	78	52	46	64	52	41	59	47														

Location	Date of Monitoring	L _{Aeq} (12 hour), dB		L _{Aeq} (1 hour), dB						L _{Aeq} (5 min), dB								
		7am -7pm	7pm -7am^	7pm - 10pm^			10pm - 7am^			7am - 7pm			7pm - 10pm^			10pm - 7am^		
		Overall		Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
Weekend/ Public Holidays (Sunday/ Public Holidays)																		
N08: Swiss School ^a (Site C)	29 Jan – 05 Feb 2020	50	40							42	58	48	39	47	41	37	46	38
N09: Within Eng Neo Avenue Forest ^{ba} (Site A and E)	13 September - 19 September 2021	55	53							53	59	55	53	59	55	48	58	51
N12 Forested Area adjacent to Fairway Quarters (north) ^a (Site B)	13 September - 19 September 2021	52	47							43	57	51	42	50	46	41	53	48
N13 Forested Area adjacent to Fairway Quarters (south) ^a (Site B)	13 September - 19 September 2021	57	49							46	62	52	46	50	48	42	53	48
Note: N.A.– Not Applicable In accordance with the EPM 2008 Regulation, L _{Aeq} (1 hour) is not assessed for Weekend/ Public Holidays and is hence not applicable. ^ No night works beyond the 7am – 7pm construction schedule or work on Weekend/ Public Holidays were proposed in this Project as per information provided by URA. Information of baseline noise levels measured at other timings are for purposes of reference. Night-works or works on Weekend/ Public Holidays will only be allowed if permission from relevant local agencies is sought and approved.																		
^a Secondary data extracted from previous studies [R-2, R-3, R-4].																		

In Site E, monitoring points NN01 and NN05 exhibited average L_{Aeq} (12 hours) and L_{Aeq} (5 mins) values exceeding 60 dB(A), whereas other locations (NN02, NN04, and NN08) ranged from 52 to 56 dB(A) for L_{Aeq} (12 hours) and 49 to 52 dB(A) for L_{Aeq} (5 mins) during Daytime – 7am - 7pm). NN01 experienced elevated noise levels due to heavy traffic on the PIE, while NN05 was impacted by traffic from Dunearn Road, Bukit Timah, and Eng Neo Avenue. For Site A, monitoring location NM02 recorded noise levels above 60 dB(A) attributed to PIE traffic, while other monitoring points (NM01 and N09) ranged from 53 to 56 dB(A) for L_{Aeq} (12 hours) and 52 to 56 dB(A) for L_{Aeq} (5 mins) during Daytime (7 am – 7 pm). Site B exhibited noise levels ranging from 55 to 58 dB(A) for L_{Aeq} (12 hours) and 52 to 57 dB(A) for L_{Aeq} (5 mins) at monitoring points NN03, NM05, and N12 during Daytime (7am -7pm). Site C showed variations in noise levels ranging from 54 to 58 dB(A) for L_{Aeq} (12 hours) and 51 to 57 dB(A) for L_{Aeq} (5 mins) at NN06, NN07, and NM04. The monitoring location (NM03) at Site D recorded average values of 56 dB(A) for L_{Aeq} (12 hours) and 54 dB(A) for L_{Aeq} (5 mins) during Daytime (7am -7pm). Within Site F, noise levels ranged from 53 to 57 dB(A) for L_{Aeq} (12 hours) and 50 to 55 dB(A) for L_{Aeq} (5 mins) at NN09, NN10, and NN11 during Daytime (7am – 7pm).

11.5.2.2 Operational Phase

11.5.2.2.1 Primary Data

The overall baseline airborne noise monitoring results from NN01 – NN11 for L_{Aeq} (15 mins) are summarised in Table 11-18 below, in accordance with local noise guidelines for the operational phase.

As observed in Section 11.5.2.1, the highest noise level was observed at NN01 followed by NN05 for L_{Aeq} (15 mins) (Table 11-18).

It should be noted that the recorded L_{Aeq} (15 mins) noise levels for the operational phase are only indicative at this stage. Hence, to meet requirements mandated by law, AECOM recommends that the developer/ developing agent appoint a Noise Consultant(s) upon finalising of design plans at the detailed design stage to determine baseline noise levels for the operational phase as part of quantitative operational phase noise impact assessment.

Table 11-18 Summary of baseline noise monitoring results for operational noise impact assessment (current study)

Location	Date of Monitoring	L _{Aeq} (15 mins), dB								
		Day 7am - 7pm			Evening 7pm - 11pm			Night 11pm - 7am		
		Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
NN01: Northern Part of Champions Golf near Turf Club Road (Site E)	25 August - 31 August 2023	60	71	67	65	69	67	60	69	64
NN02: Southern Part of Champions Golf near Turf Club Road (Site E)	25 August - 31 August 2023	43	65	50	44	57	48	44	55	48
NN03: Near Blue House International Pre-School (Site B)	4 September - 10 September 2023	49	69	57	48	62	55	48	65	57
NN04: Opposite Chiltern House at Turf Club Road (Site E)	25 August - 31 August 2023	46	65	51	47	58	51	47	63	53
NN05: Along Dunearn Road, opposite EtonHouse Pre-School Vanda (Site E)	25 August - 31 August 2023	52	68	63	60	64	62	50	64	57
NN06: La Suisse 1 (Site C)	4 September - 10 September 2023	47	69	57	51	60	55	46	57	50
NN07: Green Area in Chatsworth International School (Site C)	10 August - 16 August 2023	43	73	53	44	78	54	40	70	48
NN08: Near Newton Auto Keys Pte (Site E)	4 September - 10 September 2023	39	70	51	40	69	52	37	64	46
NN09: Green Area near Greenwood Terrace (Site F)	10 August - 16 August 2023	46	69	55	47	62	54	48	59	52
NN10: Green Area near Linden Drive (Site F)	03 October - 9 October 2023	46	67	51	46	60	50	47	54	51
NN11: Green Area near Eng Neo Avenue and Linden Drive (Site F)	10 August - 16 August 2023	40	82	52	47	57	50	39	52	44

Location	Date of Monitoring	L _{Aeq} (15 mins), dB								
		Day 7am - 7pm			Evening 7pm - 11pm			Night 11pm - 7am		
		Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
NM01: Eng Neo Avenue Forest (Southern) ^a (Site A)	10 September - 16 September 2021	48	58	53	49	56	51	46	54	50
NM05: Forested area bounded by Eng Neo Avenue Forest and Fairway Quarters ^a (Site B)	10 September - 16 September 2021	49	64	56	44	57	51	39	55	45
NM03: Ravine in the centre of the former racetrack ^a (Site D)	18 October - 24 October 2021	48	70	54	46	74	53	45	52	47
NM04: Forested area adjacent to The British Club/ Swiss Club ^a (Site C)	24 November - 30 November 2021	51	72	53	51	82	60	44	78	51
NM02: Eng Neo Avenue Forest (Northern) ^a (Site A)	18 October - 24 October 2021	58	71	61	57	68	61	51	64	56
Note: ^a Data extracted from [R-1].										

11.5.2.2.2 Secondary Data

The overall baseline airborne noise monitoring results from previous studies for L_{Aeq} (15 mins) are summarised in Table 11-19 below, in accordance with local noise guidelines for the operational phase.

As observed in 11.5.2.1, the highest noise level was observed at N09 for L_{Aeq} (15 mins) (Table 11-19) during Day-Time (7am-7pm).

Table 11-19 Summary of baseline noise monitoring results for operational noise impact assessment (previous studies)

Location	Date of Monitoring	L _{Aeq} (15 mins), dB								
		Day 7am - 7pm			Evening 7pm - 11pm			Night 11pm - 7am		
		Min	Max	Ave	Min	Max	Ave	Min	Max	Ave
N08: Swiss School ^a (Site C)	24 February – 02 March 2020	44	66	51	39	66	47	36	53	39
N09: Within Eng Neo Avenue Forest^a(Site A and E)	29 January – 05 February 2020	53	65	56	53	72	56	47	61	51
N12 Forested Area adjacent to Fairway Quarters (north)^a (Site B)	13 September - 19 September 2021	44	73	52	43	56	48	40	54	46
N13 Forested Area adjacent to Fairway Quarters (south)^a(Site B)	13 September - 19 September 2021	45	77	53	45	63	51	42	58	46
Note: ^a Secondary data extracted from previous studies [R-2, R-3, R-4].										

In Site E, monitoring points NN01 and NN05 exhibited average L_{Aeq} (15 mins) values exceeding 60 dB(A), whereas other locations (NN02, NN04, and NN08) ranged from 51 to 50 dB(A) for L_{Aeq} (15 mins) during Daytime –7am - 7pm). NN01 experienced elevated noise levels due to heavy traffic on the PIE, while NN05 was impacted by traffic from Dunearn Road, Bukit Timah, and Eng Neo Avenue. For Site A, monitoring location NM02 recorded noise levels above 60 dB(A) attributed to PIE traffic, while other monitoring points (NM01 and N09) ranged from 53 to 56 dB(A) for L_{Aeq} (15 mins) during Daytime (7am – 7 pm). Site B exhibited noise levels ranging from 52 to 57 dB(A) for L_{Aeq} (15 mins) at monitoring points NN03, NM05, and N12 during Daytime (7am -7pm). Site C showed variations in noise levels ranging from 51 to 57 dB(A) for L_{Aeq} (15 mins) at NN06, NN07, and NM04. The monitoring location (NM03) at Site D recorded average values 54 dB(A) for L_{Aeq} (15 mins) during Daytime (7am -7pm). Within Site F, noise levels ranged from 51 to 55 dB(A) for L_{Aeq} (15 mins) at NN09, NN10, and NN11 during Daytime (7am – 7pm).

11.5.2.3 Corrected Baseline Noise Criteria

Based on the baseline airborne noise monitoring results and correction noise factor introduced in accordance to the “adjusted maximum permissible noise level” explained in Section 11.2.4, the corrected noise criteria for airborne noise impact assessment on ecological and human receptors were deduced separately and reflected in this section for the construction phase.

11.5.2.3.1 Construction Phase

Construction noise criteria for L_{Aeq} (12 hours), L_{Aeq} (1 hour) and L_{Aeq} (5 mins) were deduced for the period of 7am – 7pm, 7pm – 7am, 7pm – 10pm and 10pm – 7am for Weekdays (Monday – Saturday) and Weekend/ Public Holidays according to regulations. It was noted from information provided by URA on the construction work schedule that construction work was only proposed for 7am – 7pm on Weekdays and no night-works or works on Weekend/ Public Holidays will be engaged. Following deduced corrected noise criterions for working hours beyond the 7am – 7pm work schedule shall serve as reference in the case if night-works or works on Weekend/ Public Holidays would be proposed in the future. However, it should be noted that the developer/developing agent will be required to seek approval from relevant local agencies if it wishes to conduct construction works beyond 7am – 7pm.

11.5.2.3.1.1 Ecological receptors

As mentioned in Section 11.2.4.1, there are currently no guidelines or standards available to assess construction noise impacts on the ecological receptors, thus the average baseline monitoring results in Table 11-16 and Table 11-17 was used to establish the assessment criteria for construction noise impact on ecological receptors as reflected in Table 11-20 below.

This approach was taken as part of a conservative means; that if no noise exceedances is predicted when compared to these stringent criteria, the airborne noise impact on fauna in the vicinity will also not experience noise levels exceeding the established criteria.

Table 11-20 Noise criterion established for ecological receptors (construction phase)

No	Location	Noise Criteria for L _{Aeq} (12 hour), dB		Noise Criteria for L _{Aeq} (1 hour), dB		Noise Criteria for L _{Aeq} (5 min), dB		
		7am - 7pm	7pm - 7am^	7pm - 7am^	10pm - 7am^	7am - 7pm	7pm - 10pm^	10pm - 7am^
Weekdays (Monday – Saturday)								
NN01	Northern Part of Champions Golf near Turf Club Road	68	66	67	64	67	67	64
NN02	Southern Part of Champions Golf near Turf Club Road	52	49	48	49	49	48	48
NN03	Near Blue House International Pre-School	58	58	56	57	57	55	57
NN04	Opposite Chiltern House at Turf Club Road	53	53	50	53	51	50	52

No	Location	Noise Criteria for L _{Aeq} (12 hour), dB		Noise Criteria for L _{Aeq} (1 hour), dB		Noise Criteria for L _{Aeq} (5 min), dB		
		7am - 7pm	7pm - 7am [^]	7pm - 7am [^]	10pm - 7am [^]	7am - 7pm	7pm - 10pm [^]	10pm - 7am [^]
NN05	Along Dunearn Road, opposite EtonHouse Pre-School Vanda	64	60	62	58	64	62	58
NN06	La Suisse 1	58	53	55	51	57	55	50
NN07	Green Area in Chatsworth International School	57	57	56	49	53	56	49
NN08	Near Newton Auto Keys Pte	56	53	59	47	52	53	47
NN09	Green Area near Greenwood Terrace	57	54	54	52	55	55	52
NN10	Green Area near Linden	53	51	51	51	50	50	51
NN11	Green Area near Eng Neo Avenue and Linden Drive	56	48	51	45	53	51	45
NM01	Eng Neo Avenue Forest (Southern)	53	50	51	50	52	51	50
NM05	Forested area bounded by Eng Neo Avenue Forest and Fairway Quarters ^a	57	49	52	46	56	52	46
NM03	Ravine in the centre of the former racetrack ^a	56	55	57	48	54	56	48
NM04	Forested area adjacent to The British Club/ Swiss Club ^a	54	60	59	52	53	59	52
NM02	Eng Neo Avenue Forest (Northern) ^a	62	60	62	57	62	62	57
N08	Swiss School ^b	54	47	50	40	51	49	39
N09	Within Eng Neo Avenue Forest ^b	56	55	57	52	56	56	51
N12	N12 Forested Area adjacent to Fairway Quarters (north) ^b	55	48	49	46	52	48	46
N13	N13 Forested Area adjacent to Fairway Quarters (south) ^b	57	49	52	47	52	52	47
Weekend/ Public Holidays (Sunday/ Public Holidays)								

No	Location	Noise Criteria for L _{Aeq} (12 hour), dB		Noise Criteria for L _{Aeq} (1 hour), dB		Noise Criteria for L _{Aeq} (5 min), dB		
		7am - 7pm	7pm - 7am [^]	7pm - 7am [^]	10pm - 7am [^]	7am - 7pm	7pm - 10pm [^]	10pm - 7am [^]
NN01	Northern Part of Champions Golf near Turf Club Road	67	65	67	63	67	67	63
NN02	Southern Part of Champions Golf near Turf Club Road	48	48	47	48	47	47	48
NN03	Near Blue House International Pre- School	56	58	52	58	55	52	57
NN04	Opposite Chiltern House at Turf Club Road	53	52	52	52	52	51	52
NN05	Along Dunearn Road, opposite EtonHouse Pre- School Vanda	62	59	61	56	62	61	56
NN06	La Suisse 1	56	53	55	51	56	55	51
NN07	Green Area in Chatsworth International School	53	54	53	47	51	51	47
NN08	Near Newton Auto Keys Pte	52	46	49	43	49	47	43
NN09	Green Area near Greenwood Terrace	55	51	50	52	53	50	51
NN10	Green Area near Linden	58	51	49	51	55	49	51
NN11	Green Area near Eng Neo Avenue and Linden Drive	51	46	48	44	51	48	44
NM01	Eng Neo Avenue Forest (Southern)	53	50	51	51	53	51	51
NM05	Forested area bounded by Eng Neo Avenue Forest and Fairway Quarters ^a	57	49	52	50	56	52	50
NM03	Ravine in the centre of the former racetrack ^a	53	47	47	47	52	47	47
NM04	Forested area adjacent to The British Club/ Swiss Club ^a	53	68	67	51	53	65	51
NM02	Eng Neo Avenue Forest (Northern) ^a	60	59	62	56	60	62	55
N08	Swiss School ^b	50	40	42	39	48	41	38

No	Location	Noise Criteria for L _{Aeq} (12 hour), dB		Noise Criteria for L _{Aeq} (1 hour), dB		Noise Criteria for L _{Aeq} (5 min), dB		
		7am - 7pm	7pm - 7am ^a	7pm - 7am ^a	10pm - 7am ^a	7am - 7pm	7pm - 10pm ^a	10pm - 7am ^a
N09	Within Eng Neo Avenue Forest ^b	55	53	55	51	55	55	51
N12	N12 Forested Area adjacent to Fairway Quarters (north) ^b	52	47	46	49	51	46	48
N13	N13 Forested Area adjacent to Fairway Quarters (south) ^b	57	49	48	49	52	48	48

Note: N.A. – Not Applicable

^a No night works beyond the 7am – 7pm construction schedule or work on Weekend/ Public Holidays were proposed in this Project as per information provided by URA. Information of baseline noise levels measured at other timings are for purposes of reference. Night-works or works on Weekend/ Public Holidays will only be allowed if permission from relevant local agencies is sought and approved.

^a Secondary data extracted from previous study [R-1].

^b Secondary data extracted from previous studies [R-2, R-3, R-4].

11.5.2.3.1.2 Human receptors

For human receptors, the corrected noise criteria was deduced from using the overall recorded baseline noise levels for L_{Aeq} (12 hours), L_{Aeq} (1 hour) and L_{Aeq} (5 mins) recorded at N1 – N4 to calculate the “adjusted maximum permissible noise level” as per the *Environmental Protection and Management (Control of Noise at Construction Sites) Regulation, 2008* [R-27]. Table 11-21 below reflects the corrected noise criteria for Weekdays (Monday – Saturday) and Weekend/Public Holidays according to EPM (2008)..

Table 11-21 Noise criterion established for Human receptors (construction phase)

No	Types of Affected Buildings	Noise Criteria for $L_{Aeq}(12\text{ hour}),\text{ dB}$		Noise Criteria for $L_{Aeq}(1\text{ hour}),\text{ dB}$		Noise Criteria for $L_{Aeq}(5\text{ min}),\text{ dB}$		
		7am - 7pm	7pm - 7am	7pm - 10pm	10pm - 7am	7am - 7pm	7pm - 10pm	10pm - 7am
Weekdays (Monday – Saturday)								
NN01	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	62	55	N.A.	N.A.	75	56	56
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	N.A.	65	56	90	70	56
	(c) Buildings (other than those in paragraphs (a) and (b))	75	65	N.A.	N.A.	90	70	70
NN02	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	64	55	N.A.	N.A.	75	59	57
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	N.A.	66	57	90	70	57
	(c) Buildings (other than those in paragraphs (a) and (b))	75	65	N.A.	N.A.	90	70	70
NN03	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	70	66	N.A.	N.A.	76	69	65
	(b) Residential buildings located less than 150 m	76	N.A.	70	65	90	73	65

No	Types of Affected Buildings	Noise Criteria for $L_{Aeq}(12 \text{ hour})$, dB		Noise Criteria for $L_{Aeq}(1 \text{ hour})$, dB		Noise Criteria for $L_{Aeq}(5 \text{ min})$, dB		
		7am - 7pm	7pm - 7am	7pm - 10pm	10pm - 7am	7am - 7pm	7pm - 10pm	10pm - 7am
	from the construction site where the noise is being emitted							
	(c) Buildings (other than those in paragraphs (a) and (b))	76	69	N.A.	N.A.	90	73	71
NN04	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	62	55	N.A.	N.A.	75	58	56
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	N.A.	65	57	90	70	56
	(c) Buildings (other than those in paragraphs (a) and (b))	75	65	N.A.	N.A.	90	70	70
NN05	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	65	61	N.A.	N.A.	75	63	60
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	N.A.	67	60	90	71	60
	(c) Buildings (other than those in paragraphs (a) and (b))	75	66	N.A.	N.A.	90	71	70
NN06	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	62	55	N.A.	N.A.	75	58	56
	(b) Residential buildings located less than 150 m from the construction	75	NA	66	56	90	70	56

No	Types of Affected Buildings	Noise Criteria for $L_{Aeq}(12 \text{ hour})$, dB		Noise Criteria for $L_{Aeq}(1 \text{ hour})$, dB		Noise Criteria for $L_{Aeq}(5 \text{ min})$, dB		
		7am - 7pm	7pm - 7am	7pm - 10pm	10pm - 7am	7am - 7pm	7pm - 10pm	10pm - 7am
	site where the noise is being emitted							
	(c) Buildings (other than those in paragraphs (a) and (b))	75	65	N.A.	N.A.	90	70	70
NN07	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	62	58	N.A.	N.A.	75	59	56
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	66	56	90	70	56
	(c) Buildings (other than those in paragraphs (a) and (b))	75	66	N.A.	N.A.	90	70	70
NN08	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	61	55	N.A.	N.A.	75	58	56
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	66	56	90	70	56
	(c) Buildings (other than those in paragraphs (a) and (b))	75	65	N.A.	N.A.	90	70	70
NN09	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	62	56	N.A.	N.A.	75	58	57
	(b) Residential buildings located less than 150 m from the construction site where	75	NA	65	57	90	70	57

No	Types of Affected Buildings	Noise Criteria for $L_{Aeq}(12 \text{ hour})$, dB		Noise Criteria for $L_{Aeq}(1 \text{ hour})$, dB		Noise Criteria for $L_{Aeq}(5 \text{ min})$, dB		
		7am - 7pm	7pm - 7am	7pm - 10pm	10pm - 7am	7am - 7pm	7pm - 10pm	10pm - 7am
	the noise is being emitted							
	(c) Buildings (other than those in paragraphs (a) and (b))	75	65	N.A.	N.A.	90	70	70
NN10	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	61	54	N.A.	N.A.	75	56	56
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	65	56	90	70	56
	(c) Buildings (other than those in paragraphs (a) and (b))	75	65	N.A.	N.A.	90	70	70
NN11	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	62	53	N.A.	N.A.	75	56	55
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	65	56	90	70	55
	(c) Buildings (other than those in paragraphs (a) and (b))	75	65	N.A.	N.A.	90	70	70
NM01	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	61	53	N.A.	N.A.	75	57	56
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	65	56	90	70	56

No	Types of Affected Buildings	Noise Criteria for $L_{Aeq}(12 \text{ hour})$, dB		Noise Criteria for $L_{Aeq}(1 \text{ hour})$, dB		Noise Criteria for $L_{Aeq}(5 \text{ min})$, dB		
		7am - 7pm	7pm - 7am	7pm - 10pm	10pm - 7am	7am - 7pm	7pm - 10pm	10pm - 7am
	(c) Buildings (other than those in paragraphs (a) and (b))	75	65	N.A.	N.A.	90	70	70
NM05	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	62	53	N.A.	N.A.	75	57	56
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	65	56	90	70	56
	(c) Buildings (other than those in paragraphs (a) and (b))	75	65	N.A.	N.A.	90	70	70
NM03	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	62	56	N.A.	N.A.	75	59	56
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	66	56	90	70	56
	(c) Buildings (other than those in paragraphs (a) and (b))	75	65	N.A.	N.A.	90	70	70
NM04	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	61	61	N.A.	N.A.	75	61	57
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	66	57	90	70	57
	(c) Buildings (other than those in paragraphs (a) and (b))	75	66	N.A.	N.A.	90	70	70

No	Types of Affected Buildings	Noise Criteria for $L_{Aeq}(12 \text{ hour})$, dB		Noise Criteria for $L_{Aeq}(1 \text{ hour})$, dB		Noise Criteria for $L_{Aeq}(5 \text{ min})$, dB		
		7am - 7pm	7pm - 7am	7pm - 10pm	10pm - 7am	7am - 7pm	7pm - 10pm	10pm - 7am
	those in paragraphs (a) and (b))							
NM02	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	65	61	N.A.	N.A.	75	63	60
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	67	60	90	71	60
	(c) Buildings (other than those in paragraphs (a) and (b))	75	66	N.A.	N.A.	90	71	70
N08	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	61	52	N.A.	N.A.	75	56	55
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	65	55	90	70	55
	(c) Buildings (other than those in paragraphs (a) and (b))	75	65	N.A.	N.A.	90	70	70
N09	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	61	56	N.A.	N.A.	75	59	57
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	66	57	90	70	57
	(c) Buildings (other than those in	75	65	N.A.	N.A.	90	70	70

No	Types of Affected Buildings	Noise Criteria for $L_{Aeq}(12 \text{ hour})$, dB		Noise Criteria for $L_{Aeq}(1 \text{ hour})$, dB		Noise Criteria for $L_{Aeq}(5 \text{ min})$, dB		
		7am - 7pm	7pm - 7am	7pm - 10pm	10pm - 7am	7am - 7pm	7pm - 10pm	10pm - 7am
	paragraphs (a) and (b))							
N12	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	61	52	N.A.	N.A.	75	56	56
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	65	56	90	70	56
	(c) Buildings (other than those in paragraphs (a) and (b))	75	65	N.A.	N.A.	90	70	70
N13	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	62	53	N.A.	N.A.	75	57	56
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	65	56	90	70	56
	(c) Buildings (other than those in paragraphs (a) and (b))	75	65	N.A.	N.A.	90	70	70
Weekend/ Public Holidays (Sunday/ Public Holidays)								
NN01	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	68	65	N.A.	N.A.	76	67	64
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	76	NA	N.A.	N.A.	76	67	64
	(c) Buildings (other than those in	76	68	N.A.	N.A.	90	72	71

No	Types of Affected Buildings	Noise Criteria for $L_{Aeq}(12 \text{ hour})$, dB		Noise Criteria for $L_{Aeq}(1 \text{ hour})$, dB		Noise Criteria for $L_{Aeq}(5 \text{ min})$, dB		
		7am - 7pm	7pm - 7am	7pm - 10pm	10pm - 7am	7am - 7pm	7pm - 10pm	10pm - 7am
	paragraphs (a) and (b))							
NN02	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	60	52	N.A.	N.A.	75	56	56
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	N.A.	N.A.	75	56	56
	(c) Buildings (other than those in paragraphs (a) and (b))	75	65	N.A.	N.A.	90	70	70
NN03	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	61	68	N.A.	N.A.	75	57	59
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	N.A.	N.A.	75	57	59
	(c) Buildings (other than those in paragraphs (a) and (b))	75	66	N.A.	N.A.	90	70	70
NN04	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	61	54	N.A.	N.A.	75	57	57
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	N.A.	N.A.	75	57	57
	(c) Buildings (other than those in paragraphs (a) and (b))	75	65	N.A.	N.A.	90	70	70

No	Types of Affected Buildings	Noise Criteria for $L_{Aeq}(12 \text{ hour})$, dB		Noise Criteria for $L_{Aeq}(1 \text{ hour})$, dB		Noise Criteria for $L_{Aeq}(5 \text{ min})$, dB		
		7am - 7pm	7pm - 7am	7pm - 10pm	10pm - 7am	7am - 7pm	7pm - 10pm	10pm - 7am
NN05	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	64	60	N.A.	N.A.	75	62	59
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	N.A.	N.A.	75	62	59
	(c) Buildings (other than those in paragraphs (a) and (b))	75	66	N.A.	N.A.	90	71	70
NN06	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	61	55	N.A.	N.A.	75	58	56
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	N.A.	N.A.	75	58	56
	(c) Buildings (other than those in paragraphs (a) and (b))	75	65	N.A.	N.A.	90	70	70
NN07	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	61	55	N.A.	N.A.	75	57	56
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	N.A.	N.A.	75	57	56
	(c) Buildings (other than those in paragraphs (a) and (b))	75	65	N.A.	N.A.	90	70	70
NN08	(a) Hospitals, schools,	61	51	N.A.	N.A.	75	56	55

No	Types of Affected Buildings	Noise Criteria for $L_{Aeq}(12 \text{ hour})$, dB		Noise Criteria for $L_{Aeq}(1 \text{ hour})$, dB		Noise Criteria for $L_{Aeq}(5 \text{ min})$, dB		
		7am - 7pm	7pm - 7am	7pm - 10pm	10pm - 7am	7am - 7pm	7pm - 10pm	10pm - 7am
	institutions of higher learning, homes for the aged or sick etc.							
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	N.A.	N.A.	75	56	55
	(c) Buildings (other than those in paragraphs (a) and (b))	75	65	N.A.	N.A.	90	70	70
NN09	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	61	54	N.A.	N.A.	75	56	57
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	N.A.	N.A.	75	56	57
	(c) Buildings (other than those in paragraphs (a) and (b))	75	65	N.A.	N.A.	90	70	70
NN10	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	62	54	N.A.	N.A.	75	56	57
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	N.A.	N.A.	75	56	57
	(c) Buildings (other than those in paragraphs (a) and (b))	75	65	N.A.	N.A.	90	70	70
NN11	(a) Hospitals, schools, institutions of higher	61	51	N.A.	N.A.	75	56	55

No	Types of Affected Buildings	Noise Criteria for $L_{Aeq}(12 \text{ hour})$, dB		Noise Criteria for $L_{Aeq}(1 \text{ hour})$, dB		Noise Criteria for $L_{Aeq}(5 \text{ min})$, dB		
		7am - 7pm	7pm - 7am	7pm - 10pm	10pm - 7am	7am - 7pm	7pm - 10pm	10pm - 7am
	learning, homes for the aged or sick etc.							
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	N.A.	N.A.	75	56	55
	(c) Buildings (other than those in paragraphs (a) and (b))	75	65	N.A.	N.A.	90	70	70
NM01	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	61	53	N.A.	N.A.	75	56	56
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	N.A.	N.A.	75	56	56
	(c) Buildings (other than those in paragraphs (a) and (b))	75	65	N.A.	N.A.	90	70	70
NM05	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	62	53	N.A.	N.A.	75	57	56
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	N.A.	N.A.	75	57	56
	(c) Buildings (other than those in paragraphs (a) and (b))	75	65	N.A.	N.A.	90	70	70
NM03	(a) Hospitals, schools, institutions of higher learning, homes for	61	52	N.A.	N.A.	75	56	56

No	Types of Affected Buildings	Noise Criteria for $L_{Aeq}(12 \text{ hour}), \text{ dB}$		Noise Criteria for $L_{Aeq}(1 \text{ hour}), \text{ dB}$		Noise Criteria for $L_{Aeq}(5 \text{ min}), \text{ dB}$		
		7am - 7pm	7pm - 7am	7pm - 10pm	10pm - 7am	7am - 7pm	7pm - 10pm	10pm - 7am
	the aged or sick etc.							
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	N.A.	N.A.	75	56	56
	(c) Buildings (other than those in paragraphs (a) and (b))	75	65	N.A.	N.A.	90	70	70
NM04	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	61	68	N.A.	N.A.	75	65	56
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	N.A.	N.A.	75	65	56
	(c) Buildings (other than those in paragraphs (a) and (b))	75	70	N.A.	N.A.	90	71	70
NM02	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	63	60	N.A.	N.A.	75	63	58
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	N.A.	N.A.	75	63	58
	(c) Buildings (other than those in paragraphs (a) and (b))	75	66	N.A.	N.A.	90	71	70
N08	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	60	50	N.A.	N.A.	75	55	55

No	Types of Affected Buildings	Noise Criteria for $L_{Aeq}(12 \text{ hour})$, dB		Noise Criteria for $L_{Aeq}(1 \text{ hour})$, dB		Noise Criteria for $L_{Aeq}(5 \text{ min})$, dB		
		7am - 7pm	7pm - 7am	7pm - 10pm	10pm - 7am	7am - 7pm	7pm - 10pm	10pm - 7am
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	N.A.	N.A.	75	55	55
	(c) Buildings (other than those in paragraphs (a) and (b))	75	65	N.A.	N.A.	90	70	70
N09	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	61	55	N.A.	N.A.	75	58	56
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	NA	N.A.	N.A.	75	58	56
	(c) Buildings (other than those in paragraphs (a) and (b))	75	65	N.A.	N.A.	90	70	70
N12	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	60	52	N.A.	N.A.	75	56	56
	(b) Residential buildings located less than 150 m from the construction site where the noise is being emitted	75	N.A.	N.A.	N.A.	75	56	56
	(c) Buildings (other than those in paragraphs (a) and (b))	75	65	N.A.	N.A.	90	70	70
N13	(a) Hospitals, schools, institutions of higher learning, homes for the aged or sick etc.	60	53	N.A.	N.A.	75	56	56
	(b) Residential	75	N.A.	N.A.	N.A.	75	56	56

No	Types of Affected Buildings	Noise Criteria for $L_{Aeq}(12 \text{ hour})$, dB		Noise Criteria for $L_{Aeq}(1 \text{ hour})$, dB		Noise Criteria for $L_{Aeq}(5 \text{ min})$, dB		
		7am - 7pm	7pm - 7am	7pm - 10pm	10pm - 7am	7am - 7pm	7pm - 10pm	10pm - 7am
	buildings located less than 150 m from the construction site where the noise is being emitted							
	(c) Buildings (other than those in paragraphs (a) and (b))	75	65	N.A.	N.A.	90	70	70

Note: N.A. – Not Applicable

In accordance with the EPM 2008 Regulation, $L_{Aeq}(1 \text{ hour})$ is not assessed for Weekend/ Public Holidays and is hence not applicable.

* Significantly higher baseline noise levels were recorded for only one (1) day of the week of monitoring potentially due to higher volumes of human traffic at N1 and N4 on certain days during the Weekday.

^ No night works beyond the 7am – 7pm construction schedule or work on Weekend/ Public Holidays were proposed in this Project as per information provided by Client. Information of baseline noise levels measured at other timings are for purposes of reference. Night-works or works on Weekend/ Public Holidays will only be allowed if permission from relevant local agencies is sought and approved.

11.5.2.3.2 Operational Phase

At the current pre-design stage, detailed information such as footprint of different types of buildings and their locations, the position of façade, design of ACMV systems etc. are unavailable. Operational noise baseline has been deduced understanding the limitation above. However, proper baseline noise for operational impact assessment may need to be re-captured when more detail is available. Please note that the baseline noise levels reflected in Section 11.5.2.1.2 for $L_{Aeq}(15 \text{ mins})$ shall only serve as indicative operational baseline noise levels for reference purposes of potential baseline conditions experienced by the noise sensitive receptors prior to any establishment of permanent facilities that may contribute to operational noise (i.e. new road network/ non-industrial building ACMV systems).

As such, an appointed Noise Consultant(s) should be engaged by the developer/ developing agent to conduct baseline noise monitoring once the non-industrial buildings and associated air conditioning and mechanical ventilation (ACMV) systems or new road networks are laid out with which the corresponding corrected noise criteria for the operational phase shall be determined and used for quantitative operational noise impact assessment as mandated by law at the detailed design stage.

11.6 Minimum Control Measures

This section proposes minimum controls or standard practices commonly implemented in Singapore for the purposes of impact assessment.

11.6.1 Construction Phase

The list below is non-exhaustive and should be practised as minimum control to reduce noise levels during the construction phase of the Project:

- It is recommended to reduce noise impact to avifauna by various administrative controls at the Study Area. For example, avoid breeding seasons for the activity, or to avoid early morning daytime noisy activities between 7 – 9 am as far as possible on site. This may reduce some impacts on this fauna on behavioural aspects and communication. Machines (such as trucks) that may be in intermittent use should be shut down between work periods or should be throttled down to a minimum;
- Only well-maintained construction plants should be utilised on-site, and construction plants should be serviced regularly during the entire construction period;
- The number of PMEs should be reduced as far as practicable when construction works are carried out at areas close to the noise sensitive receivers:

- Silencers or mufflers on construction equipment if incorporated in a machine should be properly maintained;
- Behavioural practices including no shouting, no loud stereos/ radios on site, no dropping of materials from height, no throwing of metal items should be ensured;
- Construction respite: Restrict high noise generating drilling activities only in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block, if possible;
- Periodic noise monitoring by an independent third party, to establish compliance with requirements and to advise on equipment causing concern, and additional potential mitigation measures;
- Night works, apart from advance works/ site clearance if approved by Agencies, will be prohibited after 6 pm to minimise noise disturbance to nocturnal animals;
- Plan the layout of the site by considering using materials and other large structural equipment as noise barriers;
- Construction plants known to emit noise strongly in one direction should, wherever possible, be orientated so that the noise is directed away from the nearby noise sensitive receptors;
- Material stockpiles and other structures will be effectively utilised, wherever practicable, in screening noise from on-site construction activities;
- All handheld percussive breakers and air compressors used on site will comply with local legislation and requirements;
- Activities may be scheduled to minimise noise generated at certain areas during periods which may be particularly sensitive to noise;
- Works using machines or vehicles that generate noise should be prohibited in the night and the dawn;
- Appropriate hearing protectors should be used by personnel operation the plant or equipment, the hearing protector must attenuate the exposure of the user to sound pressure levels below 85dB (A). Signage to remind personnel to put on hearing protection will be put up at work areas that emit excessive noise. Choice of hearing protector such as ear plugs (for < 100 dB (A)), earmuffs (for 100 dB (A) to 120 dB (A), ear plugs and earmuffs (for > 120dB (A)) in various noise exposure level;
- Noise awareness briefing should be conducted regularly and highlighted the noise mitigation measures such as position of machinery, making use of portable noise barriers and dos and don'ts for use of machinery at night; and
- If noise remains an issue even after implementation of recommended mitigation measures such as noise barriers, contractor should consider implementation of proprietary noise barriers of high noise reduction capabilities to further reduce noise to acceptable levels.

11.6.2 Operational Phase

Mechanical ventilation would be designed and sited appropriately during detailed design phases to ensure that boundary noise levels are in compliance with the adjusted boundary noise limits to be derived by an appointed Noise Consultant as part of quantitative operational noise impact assessment at the detailed design stage as mandated by law. Some noise sources might be located close to the boundary and might require special attention for boundary noise limits compliance, and if necessary, be equipped with additional mitigation measures. These are to be provided upon assessment of noise arising from the operational phase.

Minimum control measures for noise emissions arising from the operational phase such as originating from air conditioning and mechanical ventilation (ACMV) and land traffic noise are listed below. This list is non-exhaustive and should be practised as minimum control to reduce noise levels during the operational phase of the Project:

- Use low noise ACMV system equipment;
- Ensure that exhaust outlets or intakes from the mechanical ventilation system is designed to be adequately set back as far as possible from the boundary line of the development;
- Acoustic treatment if any to be designed and implemented;
- Air conditioning systems should be designed with the air handling units (AHUs) placed at appropriate locations, set as back from the boundary line of the development as possible;

- Acoustic enclosures should be provided for outdoor equipment;
- Road design should be considered as part of land use planning to minimise potential impact of land traffic noise on existing residential buildings;
- Alternative siting/ alignment of roads should be considered during road design to propose road siting/ alignment away from existing noise sensitive development; and
- Use of low-noise pavement mix for sections of new road networks near NSRs should be considered;
- Screening should be done to identify noise tolerant buildings (e.g. multi-storey car park building) and placing noise tolerant buildings between road traffic and existing residential buildings during road design phase.
- Screening by noise tolerant buildings where to assign road prior to construction such as choosing to construction road along noise tolerant buildings away from existing residential buildings, placing noise tolerant building in between road traffic and existing residential building e.g. use of multi-storey carpark building.

11.7 Prediction and Evaluation of Airborne Noise Impacts

11.7.1 Construction Phase

In this section, construction noise impacts arising from Activity 3: Foundation Works, identified for assessment in Section 11.2.5.1, are presented for the noise sensitive receptors (i.e. ecological and human receptors).

11.7.1.1 Ecological Receptors

Visualised in Figure 11-2, ecological receptors assessed for construction noise impacts (i.e. within 150 m from proposed construction worksites) are primarily found in the forested area near Champions Golf Club, Eng Neo Avenue, Swiss Club, and Swiss Club Road.

As shown in Figure 11-2, fauna species were also recorded within the Project site, proposed for the siting of construction worksites. Hence, under the assumption that when construction work commences and land is cleared in preparation for construction activities, habitats frequented by the fauna species within the turf club will be removed and no fauna species will remain within the proposed construction worksites.

As part of airborne noise impact assessment for the ecological receptors, assessment was conducted for terrestrial fauna species found at ground level (i.e. ground-dwelling fauna) observed along the proposed construction worksite areas (i.e. along Turf Club) during site reconnaissance. This is because noise impacts on ground level will differ from that at higher elevation even at the same location resulting in variation of response from ecological receptors according to the noise impact intensity as well as type of fauna inhabiting or present at the different levels.

The findings of the impacts of construction noise on the identified ecological receptors are further discussed below.

11.7.1.1.1 Findings for Ecological Impacts on Ecological Receptors

The forested areas inhabited by fauna species at existing Project Site (within 150 m Assessment Area) are near the proposed construction worksites. During the construction phase, due to the potential of noise impacts from high noise sources emitting from the worksites, terrestrial ecological receptors found at all elevations were predicted through qualitative means of assessment to face potential noise impact intensity that are **High** attributed to their proximity to the noise sources and direct exposure to noise via the air medium (refer to Table 11-22).

Fauna species at ground level are typically ground dwellers comprising of odonates and mammals such as identified monkey species reflected in Table 11-14. Noise impact on these species of fauna is not yet clearly known but it is possible that these fauna species will avoid the immediate vicinity of the proposed construction worksites, seeking refuge in nearby Reserves.

For fauna species found at higher levels from the ground, it can be expected that fauna species that are highly mobile are able to move away from noisier locations to seek refuge in quieter nearby areas, away from the construction noise. Mammals and avian species impacted are likely to be able to find alternative habitats in the surrounding irrespective of construction noise, driven away largely due to presence of human activities. Hence, bird species will likely move away temporarily/ permanently during the construction period and may or may not return due to the clearance of their habitats.

Butterflies are perturbed by intermittent noise. Therefore, as a minimum control for the Project's proposed construction worksites, it is recommended that high intermittent noises be avoided as much as possible while not compromising human safety.

Reptiles such as snakes, and turtles were also observed in these areas. Snakes, though not equipped with outer-ears and the tympanic middle ear, have vestiges for hearing inside their heads and can feel low-frequency airborne sounds.

For the bat species identified in this area (see Table 11-14), two bat species of Conservation Significance was recorded during faunistic field surveys. There exists a couple of bamboo clusters near the Project area that may serve as roosting sites and potential refugia for bamboo bats such as Lesser bamboo bat (see Table 11-14), which are nationally threatened bat species of Conservation Significance. At the current stage, it is likely that these bat species will be forced to move away from their roosting sites during the construction period temporarily or potentially abandoning these sites to seek refuge in quieter areas.

It is notable that the powered mechanical equipment (PMEs) associated with **Construction Activity 1: Foundation and Earthworks** contribute to significantly high noise levels due to the high effective sound power level (SPL) as reflected in Appendix T. As established in Table 11-20, noise criteria for ecological receptors are ranged from 67 to 49 dB(A) for $L_{Aeq}(5 \text{ mins})$ for Day Time (7 am to 7 pm). With the considerations of current pre-existing conditions and noise contributing factors from **Construction Activity 1: Foundation and Earthworks**, the impact intensity was qualitatively assessed as **High** for ecological receptors (refer to Table 11-22). This corresponds to overall Impact Consequences to be **High** for Priority 1, **Medium** for Priority 2, and **Low** for Priority 3 (refer to Table 6-5). When assessing the Impact Consequence in relation to the Likelihood of Occurrence being **Certain/Continuous**, it was deduced that the maximum overall Impact Significance stemming from the proposed construction activities associated with the assessment scenario (**Construction Activity 1: Foundation and Earthworks**) would fall within Major for Priority 1 and Priority 2 and **Moderate** for Priority 3 (refer to Table 6-7).

It is noted that the majority of noise-sensitive ecological receptors were observed to be concentrated in Site A, Site F, and Site C (refer to Figure 11-2). Site F and the northern part of Site C fall outside the Project Site area (refer to Section 3.2 above). As per the proposed preliminary land use plan, the remaining sections of Site C and Site A are earmarked for preservation as forested areas. During the construction activities carried out near the southwestern area of Site E, the impact of construction noise is expected to be **Negligible** to **Minor** since the sensitive ecological receptors were sighted far away from the southwestern part of Site E. However, when the construction takes place closer to Site A, Site F, and Site C, the significance of the impact significance stemming from the construction activities is anticipated to escalate to a **Moderate** to **Major** level.

Summary of the unmitigated qualitative construction noise impacts on ecological receptors is illustrated in Table 11-22 and detailed unmitigated construction noise impacts on ecological receptors have been included in Appendix V.

However, due to limited information available during this preliminary phase, accurately estimating the noise impact is not possible. AECOM recommends that quantitative noise impact assessment for ecological receptors through noise modelling by a 3D simulating software such as SoundPLAN and CadnaA conducted by Noise Consultant(s) appointed by Contractor (s) be it roadworks/ earthworks/ construction contractor prior to commencement of construction works.

Table 11-22 Summary of unmitigated construction noise impact on Ecological receptors

Nearest Sound Level Meter No. for Baseline Monitoring Result	Receptor Priority	Criteria	Impact Intensity	Impact Consequence	Likelihood	Impact Significance
NN01: Northern Part of Champions Golf near Turf Club Rd	Priority 1	67	High	High	Certain/ Continuous	Major
	Priority 2		High	Medium	Certain/ Continuous	Major
NN02: Southern Part of champions Golf near Turf Club Rd	Priority 1	49	High	High	Certain/ Continuous	Major
	Priority 2		High	Medium	Certain/ Continuous	Major
NN03: Along Bukit Chermin Road	Priority 1	57	High	High	Certain/ Continuous	Major
	Priority 2		High	Medium	Certain/ Continuous	Major
NN04: Near Dayspring Resi Treatment Ctr	Priority 1	51	High	High	Certain/ Continuous	Major
NN06: Near residential along Swiss view	Priority 1	57	High	High	Certain/ Continuous	Major
NN07: Near Chatsworth International	Priority 1	53	High	High	Certain/ Continuous	Major
NN08: Near Newton Auto Keys Pte	Priority 1	52	High	High	Certain/ Continuous	Major
NN09: Within green area and resi along Green Park Ave	Priority 1	55	High	High	Certain/ Continuous	Major
NN10: Near residential along Cassia Dr	Priority 1	50	High	High	Certain/ Continuous	Major
	Priority 2		High	Medium	Certain/ Continuous	Major
	Priority 3		High	Low	Certain/ Continuous	Moderate

Nearest Sound Level Meter No. for Baseline Monitoring Result	Receptor Priority	Criteria	Impact Intensity	Impact Consequence	Likelihood	Impact Significance
NN11: Near Eng Neo Ave and Linden Dr	Priority 1	53	High	High	Certain/ Continuous	Major
	Priority 2		High	Medium	Certain/ Continuous	Major

Table 11-23 Summary of unmitigated noise impacts to focal Ecological receptors of conservation significance

No.	Faunal Group	Common name	Auditory Sensitivity	Greatest Impact Significance
1	Bird	Asian red-eyed bulbul	Priority 1	Major
2	Bird	Changeable hawk-eagle	Priority 1	Major
3	Bird	Jambu fruit dove	Priority 1	Major
4	Bird	Long-tailed parakeet	Priority 1	Major
7	Bird	Oriental magpie-robin	Priority 1	Major
8	Bird	Plume-toed swiftlet	Priority 1	Major
9	Bird	Swinhoe's white-eye	Priority 1	Major
10	Bird	Straw-headed bulbul	Priority 1	Major
11	Bird	Thick-billed green pigeon	Priority 1	Major
12	Bird	White-rumped shama	Priority 1	Major
13	Mammal	Long-tailed macaque	Priority 1	Major
14	Mammal	Sunda colugo	Priority 1	Major
15	Mammal	Sunda pangolin	Priority 1	Major
16	Mammal	Unidentified bamboo bat	Priority 1	Major
17	Odonata	Fiery Coraltail	Priority 2	Major
18	Butterfly	Common birdwing	Priority 2	Major
19	Butterfly	Forest hopper	Priority 2	Major
20	Fish	Crescent betta	Priority 3	Moderate

11.7.1.2 Human Receptors

For human receptors, it is important that distinction be made to establish the current environmental conditions the receptors are subjected to, to allow for an understanding on the additional noise impacts arising from the proposed construction activities.

Noise levels recorded at monitoring locations representative of baseline conditions experienced by human receptors reflect relatively noise levels in comparison to maximum permissible noise levels for construction works in accordance with the noise legislation stated in *Environmental Protection and Management (Control of Noise at Construction Sites) Regulations, 2008* [R-27]. However, powered mechanical equipment (PMEs) associated with **Construction Activity 1: Foundation and Earthworks** contribute to significantly high noise levels due to the high effective sound power level (SPL) as reflected in Appendix T. Considering the maximum permissible noise criteria for construction activities established for different human receptors based on their sensitivities to noise (refer to Section 11.5.2.3.1.2) and relevant distances between the receptors and project sites, qualitative assessment was conducted to derive impact significance for construction phase.

The noise criteria established for Priority 1 receptors (schools and civic and community institution) for $L_{Aeq(5 \text{ mins})}$ (Day Time: 7 am to 7 pm) was 75 dB (A) (refer to Table 11-21). Therefore, if the shortest distance between the Priority 1 receptors and overall construction site was approximately less than 100m, the impact intensities were qualitatively deduced as **Low to High**. This corresponds to overall Impact Consequences from **Low to High** (refer to Table 6-5). When assessing the Impact Consequence in relation to the Likelihood of Occurrence being **Certain/Continuous**, it was deduced that the maximum overall Impact Significance stemming from the proposed construction activities associated with the assessment scenario (**Construction Activity 1: Foundation and Earthworks**) would fall within the range of **Moderate to Major** (refer to Table 6-7).

On the other hand, if the shortest distances between the Priority 1 receptors and the overall construction site were approximately greater than 100m, the impact intensities were qualitatively deduced as **Negligible to Very Low**. This corresponds to overall Impact Consequences from **Very Low** (refer to Table 6-5). When assessing the Impact Consequence in relation to the Likelihood of Occurrence being **Certain/Continuous**, it was deduced that the maximum overall Impact Significance stemming from the proposed construction activities associated with the assessment scenario (**Construction Activity 1: Foundation and Earthworks**) would fall within the range of **Negligible to Minor** (refer to Table 6-7).

The noise criteria established for Priority 2 receptors (residential) for $L_{Aeq(5 \text{ mins})}$ (Day Time: 7 am to 7 pm) was 90 dB (A) (refer to Table 11-21). Since the shortest distances between the Priority 2 receptors and the overall construction site were approximately greater than 15 m, the impact intensities were qualitatively deduced as **Negligible to Low**. This corresponds to overall Impact Consequences from **Imperceptible to Very Low** (refer to Table 6-5). When assessing the Impact Consequence in relation to the Likelihood of Occurrence being **Certain/Continuous**, it was deduced that the maximum overall Impact Significance stemming from the proposed construction activities associated with the assessment scenario (**Construction Activity 1: Foundation and Earthworks**) would fall within the range of **Negligible to Minor** (refer to Table 6-7).

The noise criteria established for Priority 3 receptors (residential) for $L_{Aeq(5 \text{ mins})}$ (Day Time: 7 am to 7 pm) was 90 dB (A) (refer to Table 11-21). Since the shortest distances between the Priority 3 receptors and the overall construction site were approximately greater than 10 m, the impact intensities were qualitatively deduced as **Negligible to Medium**. This corresponds to overall Impact Consequences from **Imperceptible to Very Low** (refer to Table 6-5). When assessing the Impact Consequence in relation to the Likelihood of Occurrence being **Certain/Continuous**, it was deduced that the maximum overall Impact Significance stemming from the proposed construction activities associated with the assessment scenario (**Construction Activity 1: Foundation and Earthworks**) would fall within the range of **Negligible to Minor** (refer to Table 6-7).

Due to the close proximity of Priority 1 receptors (educational institutions) to the Site E, the construction activities at Site E will cause Moderate - Major impact on Priority 1 receptors. Construction activities of other sites such as Site B and Site D are anticipated to cause **Negligible to Minor** impact because Priority 1 receptors are situated further away from the construction sites.

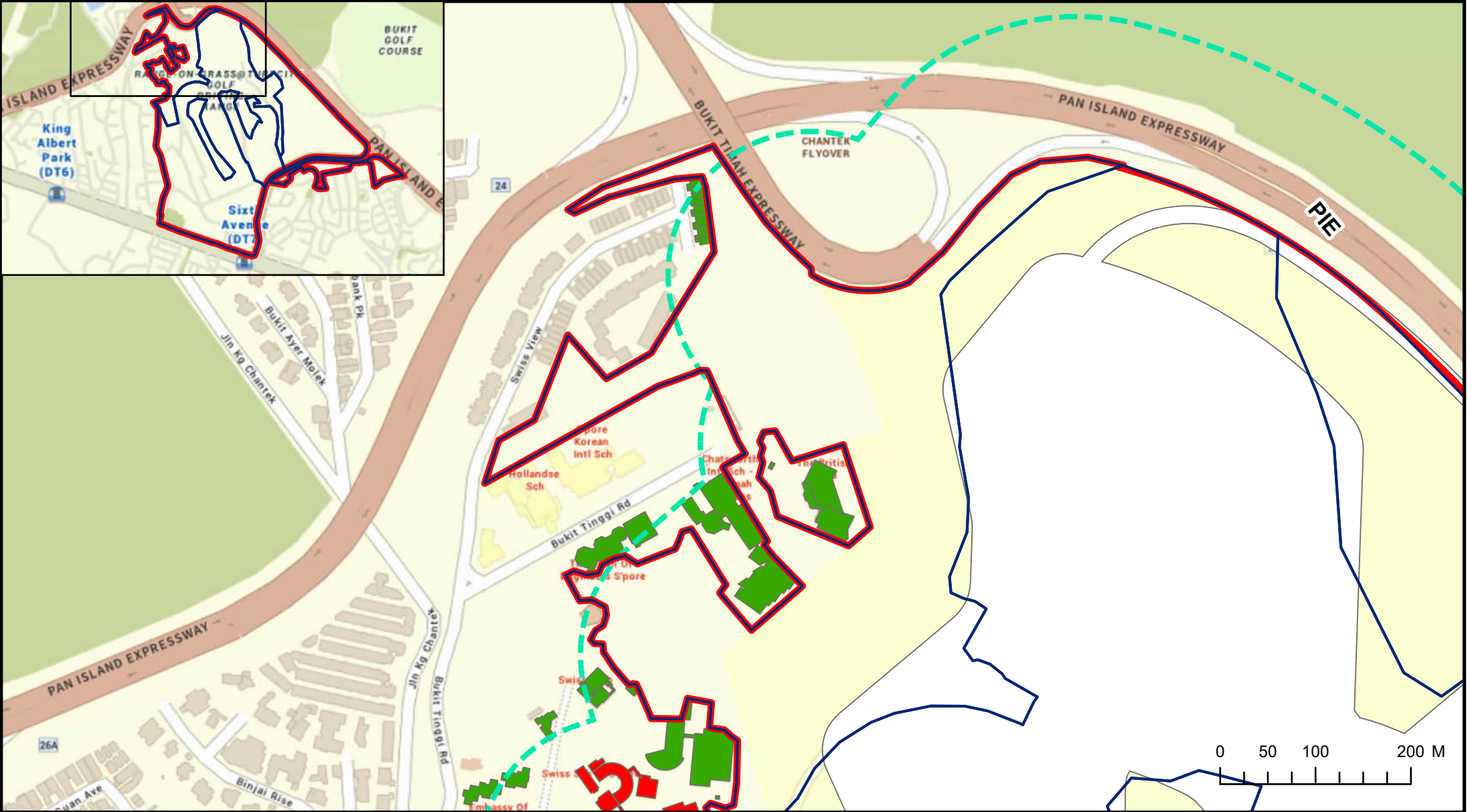
Summary of the unmitigated qualitative construction noise impacts on human receptors is illustrated in Table 11-24 and detailed unmitigated construction noise impacts on human receptors have been included in Appendix W.

However, due to limited information available during this preliminary phase, accurately estimating the noise impact is not possible. AECOM recommends that quantitative noise impact assessment through noise modelling by a 3D

simulating software such as SoundPLAN and CadnaA conducted by Noise Consultant(s) appointed by Contractor (s) be it roadworks/ earthworks/ construction contractor prior to commencement of construction works as required by NEA regulations for human impacts.

Table 11-24 Summary of unmitigated noise impact assessment on Human receptors (construction phase)

Receptor Sensitivity	Criteria (dB(A))	Approximate Distance between Receptor and Project Site	Impact Intensity	Receptor Sensitivity	Impact Consequence	Likelihood	Impact Significance
Priority 1	75.0	≤ ~100 m	Low to High	High Sensitivity	Low to High	Certain/Continuous	Moderate to Major
		> ~100 m	- Very Low	High Sensitivity	Very Low	Certain/Continuous	Negligible to Minor
Priority 2	90.0	>~15 m	Negligible to Low	Medium Sensitivity	Imperceptible to Very Low	Certain/Continuous	Negligible to Minor
Priority 3	90.0	>~15 m	Negligible to Medium	Low Sensitivity	Imperceptible to Very Low	Certain/Continuous	Negligible to Minor



Legend

Site Demarcation

EIS Study Area

Project Site

Overall Construction Footprint

Airborne Noise Study Area (150m)

Impact Significance

Moderate - Major

Moderate

Negligible - Minor

Rev.

Date

By

Description

Chk'd

App'd

-

MAY 2024

SHA

Turf Club EIA

LAL

JAG

Qualified Person Endorsement :
NA

URA Endorsement : NA

Consultant :
AECOM

Project Title :
**CONTRACT URA/T/22/031
ENVIRONMENTAL IMPACT
ASSESSMENT (EIA) FOR
FORMER TURF CLUB AT BUKIT TIMAH**

Designed
SHA

Checked
LAL

Approved
JAG

Drawn
SHA

Date
MAY 2024

Client:
URA URBAN
REDEVELOPMENT
AUTHORITY

Figure Title :
**Unmitigated Construction Noise Impacts
on Noise Sensitive Receptors (Human)
Part 1 of 4**

Figure No. :
11- 7

Rev.
-

Sheet
1 of 1

CAD File Name : NA

A3

Note: Source of basemap - Google Earth Map

THIS DRAWING IS COPYRIGHT



Legend

Site Demarcation

EIS Study Area

Project Site

Overall Construction Footprint

Airborne Noise Study Area (150m)

Impact Significance

Moderate - Major

Moderate

Negligible - Minor

Rev.

Date

By

Description

Chk'd

App'd

-

MAY 2024

SHA

Turf Club EIA

LAL

JAG

Qualified Person Endorsement :
NA

URA Endorsement : NA

Consultant :
AECOM

Project Title :
**CONTRACT URA/T/22/031
ENVIRONMENTAL IMPACT
ASSESSMENT (EIA) FOR
FORMER TURF CLUB AT BUKIT TIMAH**

Designed
SHA

Checked
LAL

Approved
JAG

Drawn
SHA

Date
MAY 2024

Client:
 URBAN REDEVELOPMENT AUTHORITY

Figure Title :
**Unmitigated Construction Noise Impacts
on Noise Sensitive Receptors (Human)
Part 3 out of 4**

Figure No. :
11- 9

Rev.
-

Sheet
1 of 1

CAD File Name : NA

A3

Note: Source of basemap - Google Earth Map

11.7.2 Operational Phase

11.7.2.1 Ecological Receptors

Forested areas and water bodies surrounding the proposed construction worksites is home to several ecological receptors identified in Section 11.4. For this study, operational noise impacts on ecological receptors were qualitatively assessed based on the auditory sensitivities of identified fauna species. Within the group of fauna species identified to reside within 150 m from the Study Area, Priority 1 (most sensitive) – Priority 3 fauna have been identified.

However, it should be noted that the larger impact on this area regardless of noise is due to urbanization and removal of the habitats where these identified fauna species reside in which impacts them directly. Whether the fauna species will eventually move north-eastwards and north-westwards to take shelter in less disturbed areas of Parks which will be retained with forests, Central Catchment Nature Reserve (CCNR) and Bukit Timah Nature Reserve or develop new habitats elsewhere is uncertain at this stage making it difficult to analyse the impact of noise on these fauna species.

For fauna species found to reside further away from the boundary of the proposed construction worksites, as noise propagation reduces with distance, it is possible that with time in the operational phase, that the fauna species may adapt itself to a continuous noise level (i.e. new baseline). As discussed in Section 11.2.4.2, the developer/developing agent should appoint a Noise Consultant(s) to assess the impacts arising from the operational phase to procure a more accurate understanding of noise impacts arising from operational conditions based on updated baseline conditions as required by NEA as part of the detailed design process. It is advised that faunistic survey and baseline noise monitoring be conducted upon completion of the construction phase and commencement of the operational phase to determine the new baseline conditions and fauna species that remain in the vicinity of the proposed construction worksites to determine actual operational noise impacts.

The noise monitoring location NN01 and NN11 are the nearest noise monitoring locations to the ecological receptors in the vicinity of the proposed construction worksites (refer to Table 11-22). The average baseline noise levels for $L_{Aeq}(15 \text{ mins})$ recorded at these locations ranged from 50 – 67 dB(A) for day, 44 – 64 dB(A) for the night (see Table 11-18). Comparing this to the *NEA Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Buildings, 2018* [R-32] for noise sensitive premises, current recorded baseline noise levels are relatively lower than the noise limits provided by NEA except at NN01 and NN05 (see Table 11-18). Assuming if the noise at boundary will be met by the contractors in accordance with the regulation, fauna species may still potentially face **Negligible to Moderate** impacts due detectable disturbances from increased noise levels in the surrounding nature areas if ACMV systems are designed to be fronting those noise sensitive areas. However, if a more conservative criteria (i.e. no worse off than baseline) was adopted, the operational noise impact significance on the ecological receptors can be qualitatively assessed as **Negligible to Minor**.

The Impact intensity if abiding by the conservative criteria would potentially range from **Negligible to Low** (refer to Table 6-4) and the corresponding impact consequence may range from **Imperceptible to Low** (see Table 6-5). The likelihood of noise levels exceeding the criteria would be **Possible/Occasional** (see Table 6-6), dependant on human activities and how frequently ACMV systems are engaged. Hence, the overall impact significance can be qualitatively assessed to range from **Negligible to Minor** (see Table 6-7) for ecological receptors found in forested areas and water bodies in vicinity of the proposed residential development site.

In accordance with the impact evaluation matrices in Section 6.4.2, the summary of operational noise impacts as assessed qualitatively are presented in Table 11-25 below.

Table 11-25 Summary of operational noise impacts on Ecological receptors

Auditory Sensitivity of Ecological Receptors	Impact Intensity	Impact Consequence	Likelihood	Impact Significance
Priority 1	Negligible to Low	Very Low to Low	Possible/Occasional	Minor
Priority 2	Negligible to Low	Imperceptible to Very Low	Possible/Occasional	Negligible to Minor

Auditory Sensitivity of Ecological Receptors	Impact Intensity	Impact Consequence	Likelihood	Impact Significance
Priority 3	Negligible to Low	Imperceptible to Very Low	Possible/Occasional	Negligible to Minor

11.7.2.2 Human Receptors

Referring to Section 11.2.4.2, it is mandatory for the proposed developments to comply with NEA's guidelines for boundary noise impact assessment for air conditioning and mechanical ventilation (ACMV) systems of non-industrial buildings and Traffic Noise Impact Assessment (TNIA) for existing/ new road networks for the developments within the Project proposed construction worksites. Usually conducted by an appointed Noise Consultant during the detailed design stage, AECOM recommends the works for ACMV boundary noise impact assessment and TNIA to be conducted in the later stages of the development in accordance with *NEA Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Buildings, 2018* [R-32] and *NEA Technical Guideline for Land Traffic Noise Impact Assessment, 2016* [R-31].

For the ACMV boundary noise impact assessment, the immediate boundary of the identified non-industrial buildings as part of the Project developments should be assessed against the corrected criteria in accordance to the guidelines, especially for boundaries fronting noise sensitive receptors. For TNIA, developers of the residential developments should assess noise impacts from the proposed new road networks and the widened Eng Neo Ave on the noise sensitive receptors as outlined by the guideline.

As part of qualitative impact assessment for operational noise impacts on human receptors, judging from the construction noise impacts which are considerably more significant compared to operational noise impacts in terms of magnitude of noise, size of/ area impacted by noise source, operational noise impacts should constitute lesser significance. Based on this, the impact intensity of operational noise on human receptors was qualitatively assessed as **Negligible to Low** (see Table 6-4), with the corresponding impact consequence deduced to range from **Imperceptible to Very Low** (refer to Table 6-5) depending on the sensitivity of the receptor (see Section 11.4.1.2). The likelihood of noise levels exceeding the criteria would be **Occasional** (see Table 6-6), dependant on human activities and how frequently ACMV systems are engaged. Hence, the overall impact significance can be qualitatively assessed to range from **Negligible to Minor** (see Table 6-7) for operational noise impacts on human receptors.

It should be noted that as regulated by NEA, the developer/ developing agent should appoint Noise Consultant(s) to conduct quantitative operational noise impact assessment duly in the later stages of the Project development as part of the detailed design process.

Table 11-26 Summary of operational noise impacts on Human receptors

Receptor Sensitivity	Impact Intensity	Impact Consequence	Likelihood	Impact Significance
Priority 1	Negligible to Low	Very Low to Low	Possible/Occasional	Minor
Priority 2	Negligible to Low	Imperceptible to Very Low	Possible/Occasional	Negligible to Minor
Priority 3	Negligible to Low	Imperceptible to Very Low	Possible/Occasional	Negligible to Minor

11.8 Recommended Mitigation Measures

11.8.1 Construction Phase

Due to the proximity of the noise sensitive receptors (NSRs) to the Project proposed construction worksites boundary, mitigation measures for the control of noise at source were recommended as per the mitigation principles outlined in Section 6.5.

11.8.1.1 Avoid

11.8.1.1.1 High Noise Powered Mechanical Equipment

The equipment inventory list shall be analysed to check the equipment (PME) causing high noise levels (higher quantity and/or longer working periods of PME can cause higher noise levels). The use of equipment with lower noise level shall be prioritised, as this is the most effective way to mitigate the noise level at the source.

11.8.1.1.2 Access Routes facing Noise Sensitive Receptors

Access routes to the worksites should avoid facing receptors in vicinity of the proposed construction worksites to reduce noise impacts arising from increased traffic noise from heavy duty vehicles (HDV), as well as to prevent noise escaping from noise barriers implemented to reduce noise impacts along the boundaries of proposed construction worksites facing the noise sensitive receptors.

11.8.1.1.3 Recommended Area Conservation (RAC)

Noise sensitive receptors were only sighted within the recommended area conservation (RAC) proposed in Section 7.10.1.1. (refer to Figure 11-2). However, the recommended RAC (refer to Figure 7-80) does not differ greatly from the area which are indicated as Retained Forest with Trails (such as Site A and some portions of Site B, C and E) and the lands outside of proposed preliminary land use footprint (such as Site F and northern portion of Site C) in the proposed land use plan (refer to Figure 3-2). This area has been omitted from construction footprint during the noise impact assessment. As much as possible temporary worksites such as equipment laydown areas, should not be constructed abutting the RAC area, as it can cause major impacts to the sensitive receptors.

Nevertheless, minimising the construction activities close to RAC will reduce the noise impact on the ecological sensitive receptors.



Legend

Auditory Sensitivity of Ecological Receptor

- 1
- 2
- 3

EIA Study Area

Site Demarcation

Project Site

Surrounding Vegetation outside Turf City

Recommended Area of Conservation (RAC)

N

-	MAY 2024	SHA	Turf Club EIA	LAL	JAG
Rev.	Date	By	Description	Chk'd	App'd

Qualified Person Endorsement :
NA

URA Endorsement : NA

Consultant :
AECOM

Project Title :
**CONTRACT URA/T/22/031
ENVIRONMENTAL IMPACT
ASSESSMENT (EIA) FOR
FORMER TURF CLUB AT BUKIT TIMAH**

Designed SHA	Checked LAL	Approved JAG
	Drawn SHA	Date MAY 2024

Client:
 **URBAN
REDEVELOPMENT
AUTHORITY**

Figure Title :
**Noise Sensitive Receptors (Ecological)
and Recommended Area of Conservation (RAC)**

Figure No. : 11 - 11	Rev. -	Sheet 1 of 1
CAD File Name : NA		A3

11.8.1.2 Minimise

11.8.1.2.1 Stagger Building Heights

To minimise construction noise impacts to nearby noise sensitive receptors, the construction of buildings of staggered heights with low-rise, low-mid rise, mid-high rise and high-rise buildings should be considered. Lower building heights may relate to shallower footings required as part of building foundation works (**Construction Activity 1: Foundation and Earthworks**). This may help to reduce construction noise impacts on nearby noise sensitive receptors by reducing the duration of noisy construction activities near the proposed construction worksite boundaries nearest to these receptors and thereby reducing the likelihood of occurrence of noise impacts and overall impact significance.

11.8.1.2.2 Install Noise Barriers

When substitution of noisy equipment is not applicable or feasible, installation of noise barriers should be considered. The barrier height and placement position of a noise barrier are the prime factors in determining its efficiency and are as follows:

- Noise barriers should be placed as close as possible to either the source, or the receiver position for maximum effectiveness; and
- Noise sensitive receptors within 150 m from construction worksites not predicted to experience exceedance may not require noise barriers.

The height of the barrier should be determined based on the heights of the receptors in the vicinity and the viability of implementation with consideration on space required to stabilise and install the barriers. Contractors should note that the installation of noise barriers must not result in additional clearance of vegetation beyond the bounds of the proposed construction worksites area. To deduce optimised barrier heights required at each site, AECOM recommends that quantitative noise impact assessment with noise modelling by a 3D simulating software such as SoundPLAN and CadnaA conducted by Noise Consultant(s) appointed by the Contractor (s) be it roadworks/ earthworks/ construction contractor prior to commencement of construction works as required by NEA regulations for human impacts for residents, but also for ecological receptors and embed that part in the CEMMP for this site to be submitted to NParks before commencement of construction works.

11.8.1.2.3 Source Noise Control

As a last resort for engineering control, when noise barriers are also not so effective in mitigating noise, or in order to manage complaints if there are intermittent noisy works, Table 11-27 below provides information on methods of quietening PME to be adopted for further mitigation on construction noise impact.

The maximum reduction in sound power level in Table 11-27 is achievable when all source control measures stated in this table are adopted. Noise enclosures should be used at the locations of the noise generating equipment at the construction site. Acoustic sheds should be provided at the locations of the noise generating activity such as operation of hand-held breaker. Sound pressure levels reduction ranging from 0 – 3 dB can be achieved by using all or combination of the following measures.

Table 11-27 Control of noise source from worksites

Type of Equipment	Equipment	Reduction in Sound Power Level, dB(A) ¹	Description of Source Control
Compressors & Generators	Generators	-20	Acoustic dampening of metal casing of body shell; acoustic enclosure or screen between the generator and receptor. The acoustic casing for the generator shall be proprietary product supplied by the generator manufacturer. The screen, if used, shall be as close as possible to the generator and it shall be of a solid construction (minimum STC 20 or surface density > 20kg/m ²) with no gaps at the bottom or in-between panels.
Hacking major structures	Excavator with Rock Breaker	-15	Use of an acoustic shed with adequate ventilation for the machine and bit.
Earth-moving Plant	Crane	-10	Manufactu'er" enclosure panels to be kept closed. The engines of these vehicles shall not be exposed and clad with the manufactu'er" enclosure to reduce noise break-out. Manufacturer-supplied silencers for the engine exhausts shall be installed and maintained.
	Dump Truck	-10	
	Excavator with Rock Breaker	-10	
	Excavator	-10	
	Concrete Mix Truck	-10	
	Lorry	-10	
Pumps	All Pumps	-10 to -20	Use of acoustic enclosure.
Note: ¹ The noise reduction level makes reference to BS 5228-1:2009 Code of practice for noise and vibration control on construction and open sites – Part 1: Noise			

Based on the Singapore Standards Code of Practice for Noise Control at Construction Sites, 2014 (SS602:2014), the typical materials used for noise barriers and acoustic shed/enclosures is given below:

Acoustic Shed/Enclosure:

A typical machine acoustic enclosure covers the machine as fully as possible (with/without ventilation), providing adequate sound insulation that noise energy does not readily pass through it. In addition, it could also have a sound absorbing material lining, to avoid the build-up of sound energy inside. In general, an acoustic enclosure could include:

- Outer cover material made up of brickwork, fibreboard, or plasterboard. Thickness of the insulating cover depends on the material used;
- Inner lining of sound absorbing material such as glass fibre, mineral wool, straw slabs, wood wool slabs can be used. A thickness of at least 25 mm is to be provided in case of high frequency sound, whereas a 12 mm thick lining would suffice for low frequency sound; and

- Perforated sheet coverings can be used to protect the inner lining material, especially if it is glass wool or mineral wool-based lining.

In the case of a more permanent or substantial machine enclosure or acoustic shed, concrete breezeblock and open textured blockwork can be more effective alternatives as these are known to be durable, inexpensive, and quick to assemble, and provide a useful degree of sound absorption.

In addition to the above measures, an EMMP with airborne noise monitoring program is proposed to assess the effectiveness of minimum control measures and recommended mitigation measures on site during construction phase of the Project, as detailed in Section 12.12.

11.8.2 Operational Phase

At this stage, following mitigation measures have been proposed for consideration as reflected in Table 11-28 below.

Table 11-28 Proposed mitigation measures— operational phase (Human impacts)

Potential Noise Sources	Proposed Mitigation Measures
Air conditioning and mechanical ventilation systems	Noise attenuators and other Best Available Technology (BAT) and Best Environmental Practice (BEP) noise control measures shall be utilised.
	Ample setback of developments with ACMV systems fronting noise sensitive receptors should be provided such as provision of park areas/ ecological setback to ensure that operational noise sources are at a distance away from the receptors.
Increase road traffic in vicinity of developments	Traffic noise at drop-off points and parking areas shall be mitigated with low-speed postings, speed humps and speed limit signages. The addition of these speed control measures will likely lower noise levels for traffic as the vehicles would be cruising at lower speeds.
Additional road traffic noise from new road networks	Alternative siting/ alignment of roads should be considered during road design to propose road siting/ alignment away from existing noise sensitive development

Due to the lack of literature regarding the possible impacts of operational noise arising from the operation of ACMV systems and increased traffic noise on the ecological receptors, the approach to mitigate operational noise impacts on human receptors have been adopted to mitigate noise impacts on the ecological receptors. It was assumed that due to the potential noise sources arising from human activities as part of the operational phase (see Table 11-28), it is likely that ecological receptors with higher mobility (e.g. birds, butterflies, bats) will migrate north-eastwards and north-westwards towards less disturbed areas of Parks which will be retained with forests, Central Catchment Nature Reserve (CCNR) and Bukit Timah Nature Reserve, away from the disturbances brought about by operational noise. The approach to mitigate noise arising from ACMV systems and increased road traffic as per Table 11-28 is recommended to be employed to mitigate operational noise where possible.

Noise monitoring programme for the operational phase have not been proposed as information required regarding ACMV system designs and traffic volumes are unavailable. Usually conducted by an appointed Noise Consultant during the detailed design stage, AECOM recommends the works for ACMV boundary noise impact assessment and TNIA to be conducted in the later stages of the development in accordance with *NEA Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Buildings, 2018* [R-32] and *NEA Technical Guideline for Land Traffic Noise Impact Assessment, 2016* [R-31].

11.9 Residual Impacts

The residual construction impact assessment assumes that the mitigation measures proposed in Section 11.8 are implemented at the proposed construction worksites, nearest to the receptors predicted to experience significant impact intensity through qualitative methods of assessment.

11.9.1 Construction Phase

11.9.1.1 Residual Ecological Impacts

This section discusses on the residual construction noise impacts on the identified ecological receptors, qualitatively assessed based on matrices defined in Section 11.2.4.3.1 under the assumption that mitigation measures proposed in Section 11.8 have been implemented. The proposed noise barriers would reduce the noise experienced by ground dwelling NSRs to some extent. However, the constructed noise barrier will be ineffective in achieving a significant noise reduction. The lack of effectiveness is due to the barrier's incapacity to completely block the direct line of sight to the intended construction areas, which is caused by the close proximity of these sites to receptors sensitive to noise. As a result, impact intensity will remain **High** (refer to Table 6 4) due to the predicted noise exceedances, corresponds to an overall Impact Consequence ranging from Low – High refer to Table 6 5). When relating the Impact Consequence to a Likelihood of Occurrence of **Certain/Continuous**, the maximum overall Impact Significance arising from the proposed construction activities associated with the assessment scenarios will range from **Moderate to Major** (refer to Table 6 7). It is worth mentioning that when construction works will be carried out predominantly in the southwestern area of Site E, the noise from construction is anticipated to have a **Negligible to Minor** impact on ecologically sensitive receptors since the noise sensitive receptors were sighted primarily in Site A, Site F, and Site C. However, when construction takes place closer to Site A, Site F, and Site C, the significance of the impact significance stemming from the construction activities is anticipated to escalate to a **Moderate to Major** level. Nevertheless, However, due to limited information available during this preliminary phase, accurately estimating the noise reduction provided by noise barriers is not feasible. AECOM recommends that quantitative noise impact assessment with and without barrier through noise modelling by a 3D simulating software such as SoundPLAN and CadnaA conducted by Noise Consultant(s) appointed by Contractor (s) be it roadworks/ earthworks/ construction contractor prior to commencement of construction works as required by NEA regulations for human impacts for residents, but also for ecological receptors and embed that part in the contract-specific EMMP for this site to be submitted to NParks before commencement of construction works.

Table 11-29 Summary of construction noise impact on Ecological receptors (mitigated)

Receptor Sensitivity	Impact Intensity	Receptor Sensitivity	Impact Consequence	Likelihood	Highest Impact Significance
Priority 1	Negligible to High	High Sensitivity	High	Certain/Continuous	Major
Priority 2	Negligible to High	Medium Sensitivity	Medium	Certain/Continuous	Major
Priority 3	Negligible to High	Low Sensitivity	Very Low	Certain/Continuous	Moderate

11.9.1.2 Residual Human Impacts

Residual Impact Assessment assumes that the mitigation measures within Section 11.8.1 are implemented within the construction footprint. However, the constructed noise barrier will be ineffective in achieving a noise reduction of 24 to 31 dB(A). This ineffectiveness is attributed to the barrier's inability to eliminate a direct line of sight to the planned construction sites due to proximity of construction sites to noise sensitive receptors. As a result, impact intensity will remain **Negligible to High** (refer to Table 6-4) due to the predicted noise exceedances, corresponds to an overall Impact Consequence ranging from **Low to High** (refer to Table 6-5). When relating the Impact Consequence to a Likelihood of Occurrence of **Certain/Continuous**, the maximum overall Impact Significance arising from the proposed construction activities associated with the assessment scenarios will range from **Moderate to Major** (refer to Table 6-7). However, due to limited information available during this preliminary phase, accurately estimating the noise reduction provided by noise barriers is not feasible. AECOM recommends that quantitative noise impact assessment with and without barrier through noise modelling by a 3D simulating software such as SoundPLAN and CadnaA conducted by Noise Consultant(s) appointed by Contractor (s) be it roadworks/ earthworks/ construction contractor prior to commencement of construction works as required by NEA regulations for human impacts for residents, but also for ecological receptors and embed that part in the contract-specific EMMP for this site to be submitted to NParks before commencement of construction works.

Table 11-30 Summary of construction noise impact on Human receptors (mitigated)

Receptor Sensitivity	Impact Intensity	Receptor Sensitivity	Impact Consequence	Likelihood	Impact Significance
Priority 1	Negligible to High	High Sensitivity	Very Low to High	Certain/Continuous	Negligible to Major
Priority 2	Negligible to High	Medium Sensitivity	Imperceptible to Very Low	Certain/Continuous	Negligible to Minor
Priority 3	Negligible to High	Low Sensitivity	Imperceptible to Very Low	Certain/Continuous	Negligible to Minor

11.9.2 Operational Phase

11.9.2.1 Ecological Impacts

The residual operational noise impact assessment assumes that the mitigation measures proposed within Section 11.8.2 have been implemented at developments identified as potential sources for operational noise. The impact intensity at the receptors are expected to be reduced with the adoption of Best Available Technology (BAT) and Best Environmental Practice (BEP) noise control measures for ACMV systems, and measures to reduce traffic noise by introducing speed postings, humps and speed limit signages to slow down traffic. Furthermore, it was assumed the ecological receptors with higher mobility would potentially migrate north-eastwards and north-westwards towards less disturbed areas of Parks which will be retained with forests, Central Catchment Nature Reserve (CCNR) and Bukit Timah Nature Reserve to distant themselves from the disturbances arising from operational noise impacts.

Based on the above assumptions, the residual operational noise impacts on the ecological receptors could be deduced to be reduced to **Negligible**.

11.9.2.2 Human Impacts

As discussed in Section 11.2.4.2, it is mandatory that the proposed developments comply with the *NEA Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Buildings, 2018* [R-32] and *NEA Technical Guideline for Land Traffic Noise Impact Assessment, 2016* [R-31]. This is usually conducted by an appointed Noise Consultant during the detailed design stage. Hence, AECOM recommends that the developer/ developing agent to appoint a Noise Consultant(s) to assess the impacts arising from the operational phase at later stages of the development, to procure a more accurate understanding of noise impacts arising from operational conditions based on updated baseline conditions.

Following the implementation of proposed mitigation measures in Section 11.8.2, the residual impact significance on human receptors can be qualitatively deduced to be **Negligible**.

11.10 Cumulative Impacts

11.10.1 Construction Phase

There is no information on any future developments within or surrounding the surrounding Project Site, except for Turf City MRT station, which has been assessed in a separate study. To note that due to the presence of the concurrent construction site for Turf City MRT Station, the construction footprint in this area is expected to be larger. Therefore, with this concurrent construction activity, the Impact Significance is expected to remain as **Negligible to Major**. However, it may be best for concurrent projects to plan especially for the construction activities with higher SPLs to stagger in timeline such as Foundation and Earthworks as a joint effort. Nevertheless, due to proximity of construction sites to noise sensitive receptors, the residual Impact Significance will remain as **Negligible to Major**.

11.10.2 Operational Phase

Cumulative impacts from the operational activities from concurrent projects are deemed to be not significantly different from the operational impacts discussed in 11.7.2 in terms of airborne noise. Therefore, the impact significance for concurrent developments during operational phase is expected to be **Negligible to Minor**.

11.11 Summary of Key Findings

Noise impacts from the construction and operation of the proposed project were assessed on noise sensitive receptors (NSRs) in the vicinity of the Study Area. Primary baseline noise monitoring was conducted for 1 week each between 10 August 2023 and 09 October 2023 at eleven (11) representative locations.

For the construction phase, qualitative noise impact assessment was carried out for the worst-case noisiest construction activity deduced as **Construction Activity 1: Foundation and Earthworks** as outlined in Section 11.2.5.1, deduced based on the construction activities and construction schedules to assess noise impacts arising from proposed developments within the proposed construction worksites. This assessment was divided to assess the impact on both ecological and human receptors identified in Section 11.4 with both receptors separated into distinct groups aimed at providing fair assessment of noise impacts on receptors subjected to different conditions. The airborne noise assessment area for the construction phase was defined as 150 m from the Project proposed construction worksite viz Project area. Baseline airborne noise monitoring was also carried out for the construction phase at four (4) locations within the defined Assessment Area as reflected in Table 11-1 and Figure 11-1.

AECOM strived to develop project specific construction noise criteria through baseline monitoring and analysis to identify $L_{Aeq}(12 \text{ hours})$, $L_{Aeq}(1 \text{ hour})$ and $L_{Aeq}(5 \text{ mins})$ baseline noise levels and therefore develop the corresponding criteria that need to be met at construction stage as informed by the NEA guidelines [W-2]. The Project specific construction noise criteria was used to inform the noise impact assessment to assess noise impacts arising from construction activities on the noise sensitive receptors. Due to very early stages of development of design and hence the construction methodology, only qualitative noise impact assessment was carried out in this report. Hence, when the design firms up in more detail in the detailed design stage, AECOM recommends that the developer/ developing agent Noise Consultant(s) to conduct quantitative studies on construction noise impacts assessment.

Following the agreement to conduct qualitative noise impact assessment at this stage, a set of assessment matrix relating the perceivability and noticeability of noise emissions to the impact intensity of noise experienced by the noise sensitive receptors (NSRs) were defined in Section 11.2.4.3 for ecological and human receptors respectively. As discussed in Section 11.2.5.1, the distance of receptors to the proposed construction worksites (i.e. noise source) as well as overall effective sound power levels of the powered mechanical equipment involved in Construction Activity 1: Foundation and Earthworks were considered as a gauge to determine how perceivable and noticeable noise levels would be experienced by the different receptors at varying locations with considerations of current existing conditions such as existing road noise.

Ecological receptors were predicted to experience noise levels ranged from 63.0-112.0 dB(A) for $L_{Aeq}(5 \text{ mins})$. This resulted in exceedances up to 59 dB(A) from established criteria. This resulted in Impact Intensity of **High** which corresponded to Impact Consequence from **Low to High**. When assessing the Impact Consequence in relation to the Likelihood of Occurrence being **Certain/Continuous**, it was deduced that the maximum overall Impact Significance stemming from the proposed construction activities associated with the assessment scenario (**Construction Activity 1: Foundation and Earthworks**) would fall within the range of **Moderate to Major**.

Human receptors were predicted to experience noise levels ranged from 71.0-121.0 dB(A) for $L_{Aeq}(5 \text{ mins})$. This resulted in exceedances up to 31 dB(A) from established criteria. This resulted in Impact Intensity from **Negligible to High** which corresponded to Impact Consequence from **Imperceptible to High**. When assessing the Impact Consequence in relation to the Likelihood of Occurrence being **Certain/Continuous**, it was deduced that the maximum overall Impact Significance stemming from the proposed construction activities associated with the assessment scenario (**Construction Activity 1: Foundation and Earthworks**) would fall within the range of **Negligible to Major**.

Various mitigation strategies, including constructing buildings of varying heights, installing noise barriers, and implementing noise control at the source, have been proposed. However, it is anticipated that despite the implementation of these noise barriers, the reduction in noise levels experienced by Noise Sensitive Receptors (NSRs) will be minimal due to the proximity of NSRs from project sites. Consequently, the expected impact significance is unlikely to be altered. However, due to limited information available during this preliminary phase, accurately estimating the noise reduction provided by noise barriers is not feasible. AECOM recommends that quantitative noise impact assessment with and without barrier through noise modelling by a 3D simulating software such as SoundPLAN and CadnaA conducted by Noise Consultant(s) appointed by Contractor (s) be it roadworks/ earthworks/ construction contractor prior to commencement of construction works as required by NEA regulations for human impacts for residents, but also for ecological receptors and embed that part in the contract-specific EMMP for this site to be submitted to NParks before commencement of construction works.

As part of qualitative impact assessment for operational noise impacts on ecological and human receptors, the impact intensity was deduced to be **Negligible** with corresponding impact consequence determined to range from **Imperceptible to Very Low**. The consequent impact significance of operational noise on human receptors was deduced to range from **Negligible to Minor** following a **Possible/Occasional** likelihood dependant on human activities and frequency of use of ACMV systems and roads. It should be noted that this qualitative assessment for operation phase is not definitive and as re-emphasised, it is mandatory for proposed developments to comply with NEA's guidelines. Hence, AECOM recommends that the developer/ developing agent to perform installations of ACMV systems at later stages of the Project development, conduct a boundary noise impact assessment and monitoring at the operational stage for non-industrial buildings with ACMV systems in accordance with NEA regulations.

Table 11-31 Summary of airborne noise impact assessment (overall)

Potential Source of Impact	Impact Significance with Minimum Control	Residual Impact Significance with Mitigation Measures (if required)
Construction Phase		
Ecological Receptors	Moderate to Major	Moderate to Major
Human Receptors	Negligible to Major	Negligible to Major
Operational Phase		
Ecological Receptors	Negligible to Minor	N.A.
Human Receptors	Negligible to Minor	N.A.

12 Environmental Monitoring and Management Plan

The proposed Environmental Monitoring and Management Plan (EMMP) is prepared for environmental impacts of the construction and operational phases associated with the Project, and that were assessed in this EIA Study, namely biodiversity, surface water resources, soil and groundwater, air quality and airborne noise. The EMMP details how the recommended mitigation measures prepared for the impact assessment are to be implemented and specifies recommended monitoring measures to assess the effectiveness of the mitigation measures. This document is also intended to provide a broad framework for the various parties involved in the project to develop a more contract-specific EMMP (cEMMP), as per their responsibilities in Section 12.4.5. Since the project will evolve over time, the cEMMP is an adaptive document meant to be amended where necessary. Copies of the cEMMP must be kept on-site for reference at all times.

This section outlines the objectives of the EMMP, the project organisation, describes the roles and responsibilities relevant to implementation of the EMMP, and summarises the EMMP requirements for each discipline. It should be noted that at the time of Report writing, no detailed Project plan is available, this section serves as general requirement of EMMP for this Project. The following EMMP sections will be subject to potential minor variations in terms of responsible parties, final roles to be engaged, frequency of monitoring and inspection plans during different phases of Project development, etc.

12.1 EMMP Objectives

The EMMP details the implementation and deliverables of the recommended mitigation measures identified from the impact assessment for each technical discipline. The EMMP progressively scrutinises construction and operational activities as they ensue and applies flexible monitoring and management procedures to protect the Project's environmental values throughout the construction and operational phases. The objective of the EMMP is twofold:

- a) Environmental monitoring focuses on overseeing that impacts to the Project's environmental values from construction and operation are within the anticipated level and tackle unforeseen impacts that may arise; and
- b) It also tracks the effectiveness of the recommended mitigation measures to allow amendment or review of the mitigation measures to better address any issues faced during construction and operation of the Project.

Environmental management employs a more active approach to ensure that impacts to biodiversity and humans are directly avoided through documentation, auditing and enforcement.

12.2 Project Organisation during the Construction Phase

The roles and responsibilities of the various parties responsible for implementing the EMMP during the construction phase are outlined below. The proposed Project organisation and lines of communication with respect to environmental protection works are presented in Figure 12-1.

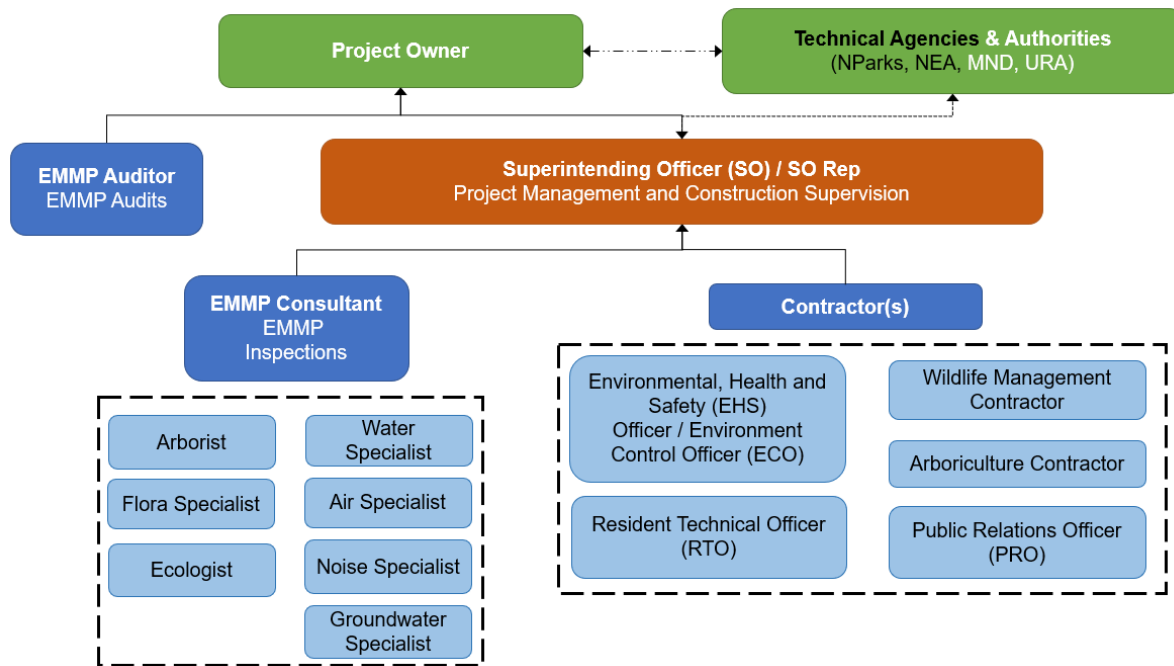


Figure 12-1 Project organization and lines of communication during the construction phase

12.3 Project Organisation during the Operational Phase

The roles and responsibilities of the various parties responsible for implementing the EMMP during the operational phase are outlined below. EMMP during operational phase is highly recommended at sites close to ecologically sensitive locations (such as Eng Neo Avenue Forest and Bukit Tinggi). The proposed project organisation and lines of communication with respect to environmental protection works are presented in Figure 12-2.

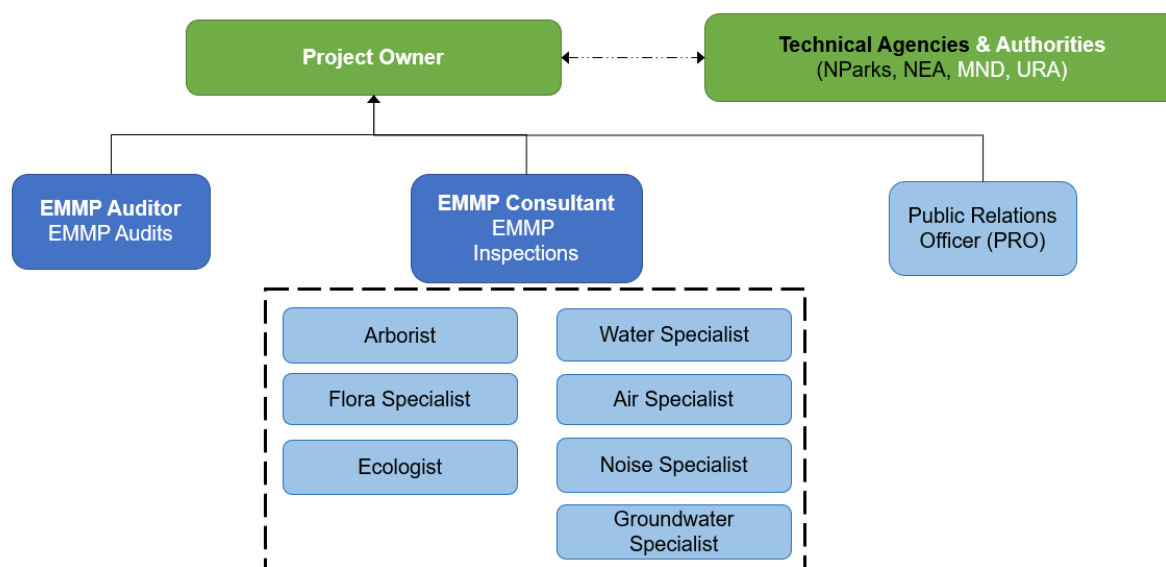


Figure 12-2 Project organization and lines of communication during the operational phase

12.4 Roles and Responsibilities of the EMMP for the Construction Phase

12.4.1 Technical Agencies/Authorities

Technical Agencies /Authorities constitute but are not limited to URA/MND, NParks, and NEA. NParks and NEA shall assess and approve the cEMMP for the construction and operational phases prior to commencement of works and where required during the course of the project.

12.4.2 Project Owner and Resident Technical Officer

The developer/ developing agency, being the Project Owner, will oversee the construction phase of the project in accordance with the design. In conjunction with the Resident Technical Officer (RTO) (Contractor), the developer/ developing agency is required to:

- Ensure resources are available to achieve the requirements of the EMMP;
- Provide leadership in the development and implementation of the EMMP;
- Engage EMMP Consultant for development and implementation of the EMMP;
- Ensure all environmental incidents and near misses are promptly investigated and reported;
- Resolve any non-compliance issues;
- Record, respond to, and action any complaints from members of the public, if any, with inputs from the Technical Agencies, if required; and
- Reporting to the Technical Agencies regarding implementation of the EMMP.

12.4.3 The Superintending Officer (SO) or SO Representative (SO Rep)

The Superintending Officer (SO) or its hired SO Rep is responsible for overseeing the construction works undertaken by various staff, contractors and sub-contractors. The SO/SO Rep should ensure that the construction works are performed by the contractors and personnel in accordance with the specification, contractual requirements, and cEMMP. The SO/SO Rep should also:

- Communicate the requirements of this plan to all staff, contractors and sub-contractors
- Monitor all staff, contractor's and sub-contractor's compliance with contract specifications and regulatory requirements, including the implementation of the environmental mitigation and monitoring measures and ensure their effectiveness, and other aspects of the environmental audit program;
- Coordinate with the Project's Environmental, Health and Safety (EHS) Officer and ECO Officer to monitor and participate in the implementation of the environmental audit program, and ensure that the requirements in the environmental audit program are correctly followed;
- Implement measures to reduce impacts where emission/discharge levels are exceeded;
- Coordinate with the Project Owner and RTO for submission of environmental audit reports;
- Carry out any complaint investigations as per Section 12.7;
- Resolve any non-compliance issues; and
- Promote environmental awareness and responsibility and lead by example.

12.4.4 The Contractor

The term "Contractor" refers to all construction contractors and sub-contractors working onsite at any time. In addition to reporting to the SO/SO Rep, the Contractor should:

- Work under the relevant contract scope, specifications, and other tender conditions;
- Ensure that the roles of RTO, Environmental Control Officer (ECO) and Certified Arborist are adequately resourced, under guidance of the Contractor and/or the SO/SO Rep when necessary;
- Participate in the required environmental site audits undertaken by the ECO/EMMP auditor and undertake any corrective actions;
- Provide up-to-date information to the RTO, ECO, Certified Arborist, and EMMP Consultant regarding any work activities which may contribute or continuously create adverse environmental conditions, or any changes to the work plan;
- Implement measures to reduce impacts where emission/discharge levels are exceeded;
- Support and provide inputs for a c EMMP to be prepared by EMMP Consultant, incorporating the relevant mitigation measures and monitoring works recommended in this EIA report and seek Technical Agencies' approval prior to the commencement of any works together with EMMP Consultant. This cEMMP shall include, as a minimum, a Standard Operating Procedure (SOP) detailing:
 - Handling and storage of hazardous chemicals;
 - Biodiversity management plan;
 - Individual environmental management plans as detailed in the NEA's SHE Specifications (air, vector, waste, noise, water pollution management plans);
 - Monitoring plans (including but not limited to noise, air, waste, ecology and water pollution);
 - Existing legislation and environmental best practices to be implemented; and
 - Contingency planning during emergency situations.

Besides, for site and/or vegetation clearance before the commencement of actual construction, the Contractor shall engage a certified Qualified Erosion Control Professional (QECP) to prepare an Erosion Control Plan (ECP) and obtain approval from the Public Utilities Board (PUB).

For tree-felling, the Contractor shall also map the trees on site and the trees planned for removal or retention and NParks' approval, where the Contractor shall consider the following requirements:

- 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 must be transplanted, this should be done prior to commencing site clearance;

- If the area is rich in wildlife, the contractor shall consult Ecologist under EMMP Consultant and prepare a wildlife shepherding plan, obtain NParks' approval and execute it prior to/ along the site clearance process.

12.4.5 The Environmental Control Officer (ECO)

The ECO shall be employed by the Contractor but may not be in any way an associated body of the Contractor, the SO/SO Rep, or the Project's EHS team. The ECO is responsible for implementing the elements of the environmental monitoring program that fall within their responsibilities as outlined in the Code of Practice for Environmental Control Officers (Environmental Health Department, 2000). He/she should be a registered ECO with NEA and has at least two years' experience in environmental monitoring and auditing works. Resources to implement the environmental monitoring program should be allocated time to fulfil the environmental audit requirements during construction works as specified in the EIA Report. The ECO's duties include but not limited:

- Prepare and submit a Site Environmental Control Programme based on the latest required format in Appendix 2 of Code of Practice for Environmental Control Officers, within one month after the commencement of works on the construction site to NEA (after reviewed by the Project Owner);
- Prepare and submit the Site Environmental Control Report(s) based on the latest required format in Appendix 3 of Code of Practice for Environmental Control Officers, after the commencement of construction works, and at least once a month or any other frequency required by NEA and/or Project Owner throughout the construction phase;
- Coordinate with the SO/SO Rep regarding equipment, locations, and schedule of monitoring and auditing works, with assistance from the EHS Officer;
- Assist the SO/SO Rep with the resolution of near misses/ incidents, non-compliance issues, and complaint management;
- Assist the EHS Officer with reporting of monitoring results to the SO/SO Rep;
- Assist the EMMP Consultant to prepare and submit the cEMMP report;
- Assist the SO/SO Rep for implementing the cEMMP on site;
- Identify and attend to all environmental issues, inform the Occupier of the construction site accordingly, and recommend measures to rectify the irregularities;
- Assist the Project Owner to investigate environmental issues and outbreaks of infectious, vector-borne or food-borne diseases on the construction site;
- Organise campaigns, training, toolbox briefings and other relevant courses to develop the capability of all relevant workers in implementing EMMP, as well as to raise their environmental and biodiversity awareness in maintaining good environmental performance on site.
- Resources to implement the environmental monitoring program should be allocated time to fulfil the environmental inspection requirements during construction works. The ECO shall work closely with EMMP Consultant to ensure environmental compliance of the construction sites, as well as to ensure proper and safe working condition of relevant construction facilities and equipment:
- Oversee and manage the implementation of minimum control measures, mitigation measures and EMMP on site;
- Coordinate with various parties with respective to EMMP, which include:
 - Liaise with the SO/SO Rep and/or WSHO regarding equipment, locations, and schedule of monitoring and auditing works; and
 - Coordinate among the Project Owner, Contractor, and EMMP Consultant for the implementation of the EMMP measures.
 - Formulate and implement the environmental monitoring and inspection program as required in this document;
 - Monitor compliance with conditions in the cEMMP, relevant environmental protection, pollution prevention and control regulations and contract specifications;
 - Analyse environmental monitoring data and inspection findings, review the adequacy of implementation of mitigation measures, identify adverse environmental impacts, and liaise with the SO/SO Rep;

- Carry out weekly site audits/ inspections against the Contractor's site practices, equipment and work methodologies with respect to pollution control and environmental mitigation, and effect proactive actions to pre-empt problems in coordination with the SO/SO Rep;
- Report the results of the environmental monitoring works and audit program, and any required changes to meet the requirements of the cEMMP and legal obligations to the SO/SO Rep in a timely manner;
- Coordinate the investigation of biodiversity-related incidents;
- Provide solutions and address complaints related to environmental noncompliances or related incidents, with cooperation from SO/SO Rep and/or WSHO; and
- Compile and submit the updated findings, along with completed remedial actions supported by photographs to Project Owner/SO/SO Rep fortnightly in the form of an Environmental Performance Report (also known as Environmental Inspection Report).

12.4.6 Arboriculture Contractor

The Arboriculture Contractor employed by Contractor should meet NParks' safety requirements for work at height and LTA's requirements for temporary works along roadsides. All arboriculture workers engaged by the Arboriculture Contractor to perform tree climbing and chainsaw work shall possess a valid basic tree climbing certification based upon demonstrated competence in the Workforce Skills Qualifications (WSQ) module conducted by Centre for Urban Greenery and Ecology (CUGE) or an equivalent WSQ-approved training organisation; and

The arboriculture crew deployed by the Arboriculture Contractor for the Contract shall possess the following valid competences:

- Operation of chainsaw for ground work (LS-MT-103E-1);
- Chainsaw safety and maintenance (LS-MT-102E-1);
- Perform formative pruning of young trees (LS-MT-114E-1);
- Provide Arboriculture support on site (LS-MT-116E-1);
- Workplace safety and health – operators (ES-WSH-101G-1);
- Respond to Emergency (LS-HM-208E-1);
- Perform advance rigging and climbing techniques (LS-HM-308S-1);
- Perform aerial tree access and aerial rescue skills (LS-HM-204S-1);
- Implement and apply appropriate risk and safety management to sector practices (LS- BP-301S-1);
- Prepare risk assessment report (LS-HM-406S-1); and
- Operate and work from an elevated work platform (CUGE-ARB-3501).

The certified arboriculture contractor shall be responsible for pruning and maintenance of retained trees, as well as felling of trees during the construction phase of this Project.

12.4.7 Wildlife Management Contractor

For this Project, the wildlife management contractor employed by Contractor (with at least one veterinary professional with experience within the team) would be responsible in carrying out animal rescue, trapping and transport of large fauna if any human-wildlife conflicts are encountered during construction phase on site. The wildlife management contractor shall be listed under NParks' public register of certified wildlife management contractors and have experience carrying out animal rescue, trapping and transport of large fauna.

A detailed description of biodiversity monitoring programme is provided in Section 12.9, where the key responsibilities of the wildlife management contractor are listed as follows:

Construction Phase

The key responsibilities of a qualified Wildlife Management Contractor during construction phase include but not limited to:

- Carry out fauna rescue and translocation in consultation with attending Ecologist and NParks; and
- Propose trapping of fauna in consultation with attending Ecologist and NParks to satisfy Section 10 Wildlife Act.

12.4.8 EMMP Consultant

The EMMP Consultant should be engaged by Project Owner to develop a cEMMP for implementation by all parties, including ECO and relevant workers on site. The appointed EMMP Consultant may be required to re-establish baseline environmental conditions and perform the recommended environmental monitoring works throughout the construction phase, as well as to provide environmental advisory services for the Project Owner, and to liaise with the Contractor, Technical Agencies, authorities, stakeholders and/or any EMMP Auditor from Project Owner during external audit (see Sections 12.6 and 12.6.2), when necessary.

The key responsibilities of an EMMP Consultant during construction phase include but not limited to:

- Ensure that the roles of required Environmental Consultant Team (e.g. Flora Specialist, Ecologist, Certified Arborist, Surface Water Resource Specialist, Air Quality Specialist, Airborne Noise Specialist, and Groundwater Specialist, if required) are adequately resourced. However, it should be noted at the time of Report writing, the Project is at master planning stage. Therefore, all potentially required specialists are listed here. Depending on the actual development and its location, the requirement of different specialists may vary;
- Lead the development and submission of a c EMMP Report for its approval by Project Owner, Technical Agencies, Authorities if required;
- Carry out or support Contractor to carry out the pre-construction baseline monitoring works;
- Carry out or support Contractor to carry out the routine monitoring works during construction phase;
- Carry out the routine site inspection and prepare the monthly EMMP Report for Project Owner and relevant Technical Agencies' approval during construction phase; and
- Liaise with Project Owner, Contractor, relevant Technical Agencies, authorities, stakeholders, etc. for any EMMP related matters.

12.4.8.1 Flora Specialist

For this Project, a Flora Specialist (if required especially for development near the green areas) plays an important role in the implementation of flora-related EMMP measures (e.g. Flora Management Plans) as part of the biodiversity monitoring program during construction phase of this Project. He/She shall possess previous work experience in developments of similar size or complexity who is able to demonstrate capability in implementing flora management plans. A detailed description of biodiversity monitoring programme is provided in Section 12.14, where the key responsibilities of the Flora Specialist are listed as follows:

The key responsibilities of a qualified Flora Specialist during construction phase include but not limited to:

- Review soil investigation locations (if any) and proposed site access to minimise excessive vegetation removal;
- Identify plant species (e.g., climbers, shrubs, epiphytes, ferns) of value that can be extracted for propagation and harvesting;
- Recommend weed and invasive species management if necessary;
- Review planting palette of reforestation works and ensure that the specifications for planting are met; and
- Carry out monthly flora inspection and reporting.

12.4.8.2 Ecologist

For this Project, an Ecologist (if required especially for development near the green areas) plays an important role in the implementation of fauna-related EMMP measures as part of the biodiversity monitoring program during both construction and operational phases of this Project, who can also be known as a Fauna Specialist. He/She shall possess a degree (or equivalent) in ecology-related fields with experience in implementing fauna management plans. In addition, at least two (2) valid certifications of the following:

- Animal Management Professional Certification Programme (PCP) – Basic Module (CUGE-PCP-7006A)
- Animal Management PCP – Intermediate Elective Module – Mammals (CUGE-PCP-7006C)
- Animal Management PCP – Intermediate Elective Module – Reptiles (CUGE-PCP-7006B)

A detailed description of biodiversity monitoring programme is provided in Section 12.14, where the key responsibilities of the Ecologist are listed as follows:

The key responsibilities of a qualified Ecologist during construction phase include but not limited to:

- Implement fauna management during site clearance;
- Carry out pre-felling fauna inspections;
- Carry out monthly fauna inspection and reporting; and
- Facilitate the implementation of the fauna response plan.

12.4.8.3 Arborist

An Arborist certified by the International Society of Arboriculture (ISA) plays an important role as part of the biodiversity monitoring programme during construction phase of this Project. An Arborist should be employed by EMMP Consultant (if required especially for development with any activities of tree assessment involved). He/She shall possess previous work experience in developments of similar size or complexity who is able to demonstrate capability in monitoring and managing all matters related to the adequate and successful conservation of trees and flora within and adjacent to the contract boundary. A detailed description of biodiversity monitoring programme is provided in Section 12.9, where the key responsibilities of the Arborist are listed as follows:

The key responsibilities of an ISA-certified Arborist during construction phase include but not limited to:

- Carry out tree mapping and assessment;
- Implement tree protection plans;
- Provide advice on tree transplanting;
- Review Contractor's method statements for site clearance, tree felling and setting up of tree protection zones (TPZ);
- Assess forest edge effects and its associated changes;
- Implement tree maintenance and care; and
- Carry out monthly tree inspection and reporting.

12.4.8.4 Surface Water Resource Specialist

Surface Water Resource Specialist (if required) should be employed by EMMP Consultant. Such Surface Water Resource Specialist, with strong and relevant experiences, to oversee/ lead/ guide hydrology and surface water quality monitoring and inspection on the construction site, and to ensure it is carried out according to guidelines and standards. He/She should, who shall assist the ECO, to perform and/or ensure implementation of EMMP, mitigation measures and minimum control measures related to hydrology and surface water quality on site (refer to Section 12.10).

12.4.8.5 Air Quality Specialist

Air Quality Specialist (if required) should be employed by EMMP Consultant. Such Air Quality Specialist, with strong and relevant experiences, to oversee/ lead/ guide air quality monitoring and inspection on the construction site, and to ensure it is carried out according to guidelines and standards. He/She should, who shall assist the ECO, to perform and/or ensure implementation of EMMP, mitigation measures and minimum control measures related to air quality on site (refer to Section 12.11).

12.4.8.6 Airborne Noise Specialist

Airborne Noise Specialist (if required) should be employed by EMMP Consultant. Such Airborne Noise Specialist, with strong and relevant experiences, to oversee/ lead/ guide airborne noise quality monitoring and inspection on the construction site, and to ensure it is carried out according to guidelines and standards. He/She should, who

shall assist the ECO, to perform and/or ensure implementation of EMMP, mitigation measures and minimum control measures related to airborne noise on site (refer to Section 12.12).

12.4.8.7 Groundwater Specialist

Groundwater Specialist (if required) should be employed by EMMP Consultant. Such Groundwater Specialist, with strong and relevant experiences, to oversee/ lead/ guide groundwater monitoring and inspection on the construction site, and to ensure it is carried out according to guidelines and standards. He/She should, who shall assist the ECO, to perform and/or ensure implementation of EMMP, mitigation measures and minimum control measures related to groundwater on site.

12.5 Roles and Responsibilities of the EMMP for the Operational Phase

During operational phase, depending on the actual development and its locations, the EMMP may or may not be required and its required duration may vary during operational phase. For example, if the development is in the vicinity of any green areas in this EIA Study Area, it may require three (3) to twelve (12) months' EMMP implementation during operational phase. If the development is far away from any green areas in this EIA Study Area, EMMP may not be required.

12.5.1 Technical Agencies/Authorities

Technical Agencies/Authorities constitute but are not limited to NParks, NEA, and MND/ URA. NParks and NEA shall assess and approve the cEMMP for the construction and operational phases, prior to commencement of works and, where required, during the course of the Project.

12.5.2 Project Owner

The developer/ developing agent is responsible for overseeing and managing the environmental monitoring detailed in the EMMP for the operational phase. The developer/ developing agent is required to:

- Ensure resources and appropriate personnel are available to achieve the requirements of the EMMP;
- Provide leadership in the implementation of the EMMP;
- Ensure all environmental incidents and near misses are promptly investigated and reported;
- Resolve any non-compliance issues;
- Record, respond to, and action any complaints from members of the public, if any, with inputs from the Technical Agencies, if required; and
- Reporting to the Technical Agencies regarding implementation of the EMMP.

12.5.3 EMMP Consultant

The EMMP Consultant should be engaged by Project Owner to develop a CEMMP for implementation by all parties on site. The appointed EMMP Consultant shall perform the recommended environmental monitoring works throughout the operational phase, as well as to provide environmental advisory services for the Project Owner, and to liaise with Technical Agencies, authorities, stakeholders and/or any EMMP Auditor from Project Owner during external audit (see Sections 12.6 and 12.6.2), when necessary.

The key responsibilities of an EMMP Consultant during operational phase include but not limited to:

- Ensure that the roles of required Environmental Consultant Team (e.g. Flora Specialist, Ecologist, Certified Arborist, Surface Water Resource Specialist, Air Quality Specialist, Airborne Noise Specialist, and Groundwater Specialist, if required) are adequately resourced. However, it should be noted at the time of Report writing, the Project is at master planning stage. Therefore, all potentially required specialists are listed here. Depending on the actual development and its location, the requirement of different specialists may vary;
- Lead the development and submission of a contract-specific EMMP Report for its approval by Project Owner, Technical Agencies, Authorities if required;

- Carry out or support Project Owner to carry out the routine monitoring works during operational phase;
- Carry out the routine site inspection and prepare the monthly EMMP Report for Project Owner and relevant Technical Agencies' approval during operational phase; and
- Liaise with Project Owner, relevant Technical Agencies, authorities, stakeholders, etc. for any EMMP related matters.

12.5.3.1 Flora Specialist

For this Project, a Flora Specialist (if required especially for development near the green areas) plays an important role in the implementation of flora-related EMMP measures (e.g. Flora Management Plans) as part of the biodiversity monitoring program during operational phase of this Project. He/She shall possess previous work experience in developments of similar size or complexity who is able to demonstrate capability in implementing flora management plans. A detailed description of biodiversity monitoring programme is provided in Section 12.14, where the key responsibilities of the Flora Specialist are listed as follows:

The key responsibilities of a qualified Flora Specialist during operational phase include but not limited to:

- Recommend additional weed and invasive species management if necessary; and
- Carry out monthly flora inspection and reporting.

12.5.3.2 Ecologist

For this Project, an Ecologist (if required especially for development near the green areas) plays an important role in the implementation of fauna-related EMMP measures as part of the biodiversity monitoring program during operational phase of this Project, who can also be known as a Fauna Specialist. He/She shall possess a degree (or equivalent) in ecology-related fields with experience in implementing fauna management plans. In addition, at least two (2) valid certifications of the following:

- Animal Management Professional Certification Programme (PCP) – Basic Module (CUGE-PCP-7006A)
- Animal Management PCP – Intermediate Elective Module – Mammals (CUGE-PCP-7006C)
- Animal Management PCP – Intermediate Elective Module – Reptiles (CUGE-PCP-7006B)

A detailed description of biodiversity monitoring programme is provided in Section 12.14, where the key responsibilities of the Ecologist are listed as follows:

The key responsibilities of a qualified Ecologist during operational phase include but not limited to:

- Carry out fauna monitoring surveys including terrestrial transect surveys, aquatic sampling and camera trapping; and
- Carry out monthly fauna inspection and reporting.

12.5.3.3 Arborist

An Arborist certified by the International Society of Arboriculture (ISA) plays an important role as part of the biodiversity monitoring programme during operational phase of this Project. An Arborist should be employed by EMMP Consultant (if required especially for development with any activities of tree assessment involved). He/She shall possess previous work experience in developments of similar size or complexity who is able to demonstrate capability in monitoring and managing all matters related to the adequate and successful conservation of trees and flora within and adjacent to the contract boundary. A detailed description of biodiversity monitoring programme is provided in Section 12.9, where the key responsibilities of the Arborist are listed as follows:

The key responsibilities of an ISA-certified Arborist during operational phase include but not limited to:

- Implement tree maintenance and care; and
- Carry out monthly tree inspection and reporting.

12.5.3.4 Surface Water Resource Specialist

Surface Water Resource Specialist (if required) should be employed by EMMP Consultant. Such Surface Water Resource Specialist, with strong and relevant experiences, to oversee/ lead/ guide hydrology and surface water quality monitoring and inspection on the development site, and to ensure it is carried out according to guidelines

and standards. He/She should, who shall assist the ECO, to perform and/or ensure implementation of EMMP, mitigation measures and minimum control measures related to hydrology and surface water quality on site (refer to Section 12.10).

12.5.3.5 Air Quality Specialist

Air Quality Specialist (if required) should be employed by EMMP Consultant. Such Air Quality Specialist, with strong and relevant experiences, to oversee/ lead/ guide air quality monitoring and inspection on the development site, and to ensure it is carried out according to guidelines and standards. He/She should, who shall assist the ECO, to perform and/or ensure implementation of EMMP, mitigation measures and minimum control measures related to air quality on site (refer to Section 12.11).

12.5.3.6 Airborne Noise Specialist

Airborne Noise Specialist (if required) should be employed by EMMP Consultant. Such Airborne Noise Specialist, with strong and relevant experiences, to oversee/ lead/ guide airborne noise quality monitoring and inspection on the development site, and to ensure it is carried out according to guidelines and standards. He/She should, who shall assist the ECO, to perform and/or ensure implementation of EMMP, mitigation measures and minimum control measures related to airborne noise on site (refer to Section 12.12).

12.5.3.7 Groundwater Specialist

Groundwater Specialist (if required) should be employed by EMMP Consultant. Such Groundwater Specialist, with strong and relevant experiences, to oversee/ lead/ guide groundwater monitoring and inspection on the development site, and to ensure it is carried out according to guidelines and standards. He/She should, who shall assist the ECO, to perform and/or ensure implementation of EMMP, mitigation measures and minimum control measures related to groundwater on site.

12.6 Environmental Audit

12.6.1 Construction Phase

12.6.1.1 Internal Site Inspection by ECO

Site surveillance provides a direct means to assess and ensure the Project's environmental protection and pollution control measures are in compliance with the contract specifications and the EMMP. The ECO should inspect the construction activities regularly and routinely to ensure that the appropriate environmental protection and pollution control mitigation measures are properly and timely implemented, based on the EMMP's recommendations. With well-defined pollution control and impact mitigation measures outlined, and a well-established efficient remedial action reporting system, the site inspection is an effective "tool" to ensure acceptable environmental performance at the construction site.

The ECO is responsible to formulate environmental site inspections, deficiencies and the remedial action reporting system, and to carry out the site inspections. After consultation with project's SO/SO Rep, the ECO should prepare a procedure for the site inspections, deficiencies, remedial action, and reporting requirements. This documentation shall be agreed to by the RTO and Contractor representative and approved by the Project Owner within 21 days of the commencement of the construction contract.

Regular site inspections should be carried out at least once weekly for all the work areas during the construction phase. The inspections should cover the onsite environmental situation, pollution control and mitigation measures. Offsite environmental situations, which may be affected by onsite activities, (directly or indirectly) should also be reviewed. Observed site conditions, with regards to defined environmental parameters will be noted, collated and submitted to the Project Owner (inclusive of recommendations for improvements to the protection and pollution control and for taking corrective actions, if any).

12.6.1.2 External Site Audit by EMMP Auditor (if required)

A third party EMMP Auditor shall be engaged to perform routine environmental audit/ verification checks of the EMMP implementation by the Contractor and EMMP Consultant (for all assessed environmental parameters) throughout the construction period. The routine audit includes but not limited to reviewing relevant documents prepared by EMMP consultant, providing ad-hoc advice, assisting in resolving complaints with the Contractor, etc.

The external environmental audit exercise would also include the documentation review of on-site monitoring records against the proposed measures and findings in the approved contract-specific EMMP. This is to ensure proper implementation of minimum control measures, mitigation measures and EMMP proposed in this report, as well as to identify and/or resolve potential environmental incompliances and potential gaps with the findings in report, if any observed during the audit.

12.6.2 Operational Phase

Environmental audit by EMMP Auditor may or may not be required during the operational phase of this Project, depending on if EMMP implementation is required for each development of this Project. If required, the Project Owner and EMMP Consultant shall manage the overall environmental performance and ensure implementation of minimum control measures and mitigation measures proposed in this report.

12.7 Complaint Handling

The Public Relation Officer (PRO) is responsible for handling complaints and managing feedback and investigative work.

12.7.1 Construction Phase

The PRO shall be supported by the Project Owner, RTO, SO/SO Rep, ECO, Contractor, and any other relevant parties.

During the construction phase, upon receipt of complaints, the PRO should undertake the following procedures:

- Log the complaint and record the date when the complaint is received onto the complaint database and inform the Project Owner, SO/SO Rep and ECO immediately;
 - Investigate the complaint with the ECO to determine its validity and assess whether the source of the problem is due to construction works;
 - If a complaint is valid and due to construction works, liaise with the ECO on the mitigation measures and seek agreement from SO/SO Rep;
- Review the current situation and the ECO's and SO/SO Rep's implementation of the mitigation measures;
 - Engage the ECO to undertake additional monitoring and inspection to verify the complaint if necessary. Ensure that any valid reasons for complaints do not re-occur by revising the work methods, procedures, machines and/or equipment, etc.;
 - Submit a complaint report (as well as the implementation of mitigation measures and the effectiveness of the mitigation measures as advised by the ECO) to the Project Owner, RTO and the SO/SO Rep; and
 - Log a record of the complaint, investigation, follow-up actions and the results in the environmental audit reports.

The ECO and SO/SO Rep should provide all the necessary information and assistance to the PRO in order to complete the complaint investigation. Following the investigation, the Contractor should promptly undertake the mitigation measures. The PRO and SO/SO Rep should ensure that the measures have been appropriately implemented. The Contractor, RTO, and SO/SO Rep should also be responsible for the reporting of complaint investigation results and followed up actions to the Project Owner. The complaint investigation report and corrective action plan should be prepared and approved by Project Owner and/or other relevant Authorities within 24 hr upon receipt of complaints.

12.7.2 Operational Phase

The PRO shall be supported by the Project Owner, EMMP Consultant and any other relevant parties.

During the operational phase, upon receipt of complaints, the PRO should undertake the following procedures:

- Log the complaint and record the date when the complaint is received onto the complaint database and inform the Project Owner and EMMP Consultant immediately;
- Investigate the complaint with the Project Owner and EMMP Consultant to determine its validity and assess whether the source of the problem is due to operational works;

- If a complaint is valid and due to operational works, liaise with the EMMP Consultant on the mitigation measures and seek agreement from the Project Owner;
- Review the current situation and the implementation of the mitigation measures;
- Engage the EMMP Consultant to undertake monitoring works for inspection purpose as well as to verify the complaint if necessary. Ensure that any valid reasons for complaints do not re-occur by revising the work methods, procedures, machines and/or equipment, etc.;
- Submit a complaint report (as well as the implementation of mitigation measures and the effectiveness of the mitigation measures as advised by the EMMP Consultant) to the Project Owner; and
- Log a record of the complaint, investigation, follow-up actions and the results in the environmental inspection report.

The PRO should work with the Project Owner and EMMP Consultant to gather all the necessary information and resources necessary to complete a complaint investigation. Following the investigation, the Project Owner and EMMP Consultant shall undertake appropriate mitigation measures. Follow-up is required by the PRO to ensure that the mitigation measures have been appropriately implemented. The complaint investigation report and corrective action plan should be prepared and approved by Project Owner and/or other relevant Authorities within 24 hr upon receipt of complaints.

12.8 Submission of Monthly Reports to Technical Agencies

During the construction phase, monthly reports on the implementation of construction EMMP and operational EMMP (if any) should be submitted by EMMP Consultant to Technical Agencies for record purposes. The reports shall include, but is not limited to the following:

- Results of environmental monitoring programme, or any required changes to meet the requirements of the EMMP;
- Results of monthly tree, flora and fauna inspections;
- Records of environmental site inspections, deficiencies/non-compliance issues and its corresponding remedial action;
- Records of all environmental incidents and near-misses, as well as their investigation and follow-up; and
- Records of complaints, as well as the investigation, follow-up actions/implementation of mitigation measures and the effectiveness of these measures.

12.9 Biodiversity Requirement Monitoring Programme

12.9.1 Construction Phase

At the construction phase, EMMP for both flora and fauna are essential in minimising and managing construction impacts, especially if the development is in the vicinity of any forested sites within the EIA Study Area.

12.9.1.1 Flora and Arboriculture Monitoring Programme

The flora and arboriculture monitoring aims to assess the impacts of construction to vegetation and habitat, such as tree health, unauthorised and/or excessive vegetation removal, edge effects, habitat degradation from soil erosion, and rubbish dumping.

Arboriculture Monitoring Programme should include the following:

- Monitoring of the condition of trees at the new forest edge to determine the physiological health and structural stability of trees as edge effects can lead to die back of canopies, and branch and structural failures.
- Review of method statements of construction works in proximity to retained trees within the Project worksite, if any, to determine if additional tree removal is required post-site clearance.
- Recommendation of solutions such as design changes, reduction of working space, reduction of TPZ area and reassessment of trees in cases of conflict with proposed works.
- Assessment of physiological health, vigour and structural stability of retained trees. Recommend additional mitigating measures if necessary.
- Assessment of the condition of retained trees, if any, to ensure that there has been no deterioration or mechanical damage and to determine if additional tree removal is required.
- Where a tree exhibits signs of stress, the Arborist should inspect the tree and advise on strategies to reduce further impacts and rehabilitation measures. Where monitoring indicates that drying out or edge impacts are occurring, remediation measures shall be undertaken. These measures may be temporary (such as carrying out watering when there is seven continuous days without rainfall). Long-term solutions shall be investigated and implemented.
- Inspection of the integrity of TPZs.
- Identification of excessive or unauthorised tree removal.

Flora Monitoring Programme should include the following works:

- Monthly flora inspections shall be conducted within the worksite boundary and in forested areas adjacent to the worksite up to 15 m from the hoarding.
- Identification of any unauthorised removal of flora within areas of conservation or beyond the demarcated Project worksite (Figure 12-3).
- Identification of direct/indirect impacts to sensitive vegetation and habitats. Such impacts include soil erosion and degradation that have resulted from construction activities, and unauthorised dumping of waste material, construction debris or oil/chemical leakage.
- Identification of forest edge effects and recommendation of mitigation measures where necessary.
- Assessment of the status of invasive flora species and weeds and recommendation to remove them where necessary.
- Inspection of areas cleared of weeds to detect any seedlings of invasive species.
- Monitoring of the health of all retained and planted flora, including identification of diseases and recommendations for treatment.



Figure 12-3 Monitoring of vegetation and trees along the hoarding line for unauthorised vegetation clearance and forest edge effects

12.9.1.2 Flora and Arboriculture Management Programme

The flora and arboriculture management programme aims to manage all matters related to the adequate and successful conservation of trees and vegetation within and adjacent to the contract boundary (up to 15 m from the contract boundary). The programme should include the following works:

Arboriculture Management Programme should include the following works:

- Tree Mapping and Assessment
 1. Trees within the worksite boundary, including any construction access roads, shall be mapped and assessed by the Arborist before work commencement.
 2. Trees within the worksite boundary, including any construction access roads, shall be mapped and assessed by the Arborist. These specimens shall be tagged with a unique serial number.
 3. The physiological health, presence of pests and diseases, and structural stability shall be assessed for all trees, single-stemmed palms and strangling Ficus species of ≥ 1.0 m girth or spread, respectively.
 4. Species of conservation significance—i.e., listed in Red data book 3 as nationally Vulnerable, Endangered, Critically Endangered or Presumed Extinct (which indicates a rediscovery)—of ≥ 0.3 m girth or spread shall also be assessed. The locations, girth/spread, and height of these specimens shall also be recorded. These specimens shall be tagged with a unique serial number.
 5. The trees to be felled or retained shall be determined by the Arborist.
 6. A photographic report shall be provided for the trees affected by the proposed works.
 7. No trees shall be felled without prior approval from NParks.
- Tree Protection
 1. Where there are trees to be retained within the worksite, specifications shall be formulated by the Arborist for the setting up of tree protection zones (TPZ) to meet NParks requirements (Appendix Y);
- Sapling Harvesting

1. Viable saplings and conservation significant trees that are suitable for harvesting shall be identified by the Arborist. Saplings or trees suitable for transplanting should:
 - 1) Exhibit good physiological health and vigour
 - 2) Have no structural defects
 - 3) Have good branch form
 2. The root ball size to be extracted shall be based on the girth of the saplings or trees to be harvested as specified in Table 12-1.
 3. Prior to transplanting, dead branches and climbers shall be cleared from the plant and canopy load and spread will be reduced where necessary, in consultation with the Arborist.
 4. Manual trenching shall be carried out to determine the shape and size of root ball to be extracted. Where possible, feeder roots shall be retained without cutting.
 5. The root ball shall be burlapped with cellophane sheet to reduce desiccation effects. When directed by the Flora specialist or Arborist, leaves of the canopy may also need to be enclosed and covered by cellophane or clear plastic bags.
 6. The root ball shall be secured to the trunk to reduce risk of root ball disintegrating.
 7. When handling/carrying the plant, care shall be taken not to damage any vegetative parts.
- Tree Transplanting
 1. Where trees and vegetation are moved or translocated within the Project area, the Arborist shall review the method statement proposed by the tree transplanting contractor and advise on additional recommendations necessary to ensure the tree's health during transplanting. The transplanting contract shall ensure in their best effort, intact and secured root balls at the point of extraction, during the lifting processes and during the installation at the receiving site. The transplant effort shall be documented for each individual tree to show intact root balls at all the stages mentioned. Transplanted trees shall be managed through adequate watering and monitoring of their health to ensure their long-term survival. Advice shall be sought from the Arborist if the tree exhibit signs of stress, e.g. peeling bark, withered leaves.
 - Site Clearance and Tree Felling
 1. The Contractor's method statements for site clearance, tree felling and setting up of TPZ shall be reviewed by the Arborist to ensure compliance to the specifications. The site clearance and tree removal method statements shall consider directional felling methods with a hinge and back cut. Trees shall not be removed by pushing with an excavator or other heavy machinery. Cranes shall be deployed to offset the tension of trunks in the direction of the drop. Interlocking canopy branches shall be pruned prior to tree felling.
 2. In cases where design changes may affect additional trees or the retained trees, the Arborist shall work with the structural engineers and recommend solutions that will meet NParks guidelines.
 3. Whenever reasonable and practicable, cleared vegetation at sloped areas shall be covered with mulch or with 100% biodegradable fauna-friendly ECBs to control erosion of exposed soil. Closed turving to the exposed areas where possible and maintain proper storage of soil stockpiles to stabilise surfaces and minimise re-entrainment of dust and potential for erosion of waste spoil to watercourses.
 4. Clearance activities on-site shall not occur during rainfall or when storm events are forecast to occur within the vicinity to protect forest edge from wind throw. Where forest edges are exposed to wind, temporary measures (e.g., additional hoarding) shall be discussed with the Arborist, and put in place to protect the forest edge during storm events.
 5. During site clearance, care will be taken when removing trees in riparian zones to reduce impacts to the bed and banks of waterways.
 6. Where practicable, saplings, seeds and seed banks will be retained within the soil profiles for use in forest restoration.

7. Horticultural waste shall be removed on the same day. This is essential to reduce risk of fauna taking refuge within the cleared waste if left overnight.
- **Tree Maintenance and Care**
 1. Where disease outbreaks are identified, the Arborist and/or Flora Specialist shall advise measures to manage them. Measures can include using selected insecticides/fungicides to control outbreaks; reduction of stressors (dust, water, etc.). The plant may be removed or quarantined if it poses a threat to surrounding individuals.
 2. Where forest edges are exposed following site clearance and where impacts to vegetation are evident (e.g., vegetation shows signs of drying out), additional watering shall be carried out to improve moisture differentials around forest edges.
 3. The use of herbicides, pesticide shall be minimised. If herbicides or pesticides are used within the Project area, techniques that limit spray or non-target spray drift shall be used. These techniques include but are not limited to cut and paint techniques and drilling injection. All use of herbicides and pesticides shall be conducted in accordance with the relevant Material Safety Data Sheet (MSDS). Any incidents of off label use, spillage or damage to non-target species shall be reported and investigated.
 4. When the site experiences seven continuous days without rainfall, the Contractor shall carry out additional watering of conserved trees within the TPZs and at the forest edge (up to 10 m) around the development boundary.

Post heavy rainfall, any snapped hanging branches that pose imminent hazards to workers within the site should be removed immediately.

Table 12-1 Minimum root ball diameter to girth requirements

Girth (m)	Minimum root ball diameter to extract (m)
<0.1	0.4
0.1–0.2	0.6
0.2–0.3	0.8
0.3–0.4	1.2
0.4–0.5	1.5
>0.5	To be determined by Arborist

Flora Management Programme should include the following works:

- **Verification and Review of Footprints for Hoarding, Access Roads and Soil Investigation Works**
 1. After the worksite hoarding has been installed, the Flora Specialist shall conduct an inspection to verify that the footprint is as proposed, and that no excessive vegetation and tree removal has occurred because of deviations in the hoarding alignment.
 2. The Flora Specialist shall review the proposed locations for the soil investigation works and the alignment of the construction access roads with the Client/Contractor. Feasible alternatives, if possible, shall be proposed to minimise vegetation and tree clearance.
- **Weed and Invasive Species Management**
 1. Weeds and invasive species shall be cleared from the Project area progressively and shall be separated and transported to an appropriate disposal location. Transport shall occur within a covered vehicle to ensure seed/vegetative matter does not dislodge. All vegetative matter and seeds will be rendered inert at the disposal location through incineration at a licensed waste disposal facility. The Project area shall be carefully cleared of all remaining vegetative matter from the weeds/invasive species. Herbicides may be used to render any stumps/root systems inert. The cleared area shall be inspected monthly to detect any seedlings of invasive species. These seedlings shall be killed using approved herbicides or removed by hand weeding. Any seedlings or vegetative matter that may sprout will be disposed of at a licensed waste management facility.
 2. Specific measures shall be undertaken to control and manage flora species within the Project area that have been identified to be invasive (i.e., *Spathodea campanulata*, *Cecropia*

pachystachya, *Falcataria falcata*). The Ecologist shall be consulted when managing *Falcataria falcata* groves as tall trees may serve as nesting sites for birds of prey. The Ecologist shall also be consulted for other weed and invasive species that may also provide important foraging resources. Material imported into the Project area shall be checked for contamination from weeds/invasive species seeds/vegetative matter at source. This is particularly important for imported building materials, such as clay and soil. Source site shall be inspected to determine presence of weeds/invasive species. Where weeds or invasive species are identified, alternative supply sources or decontamination shall occur before the material is transported to site.

- Reforestation Planting Palette and Plant Salvaging for Reforestation And Landscaping
 1. The planting palette including all flora and grasses used for reforestation and other landscape planting shall be from native indigenous stock or non-native species that are not listed as weeds or invasive species or have a low seeding rate.
 2. All trees transplanted into the Project area shall have local provenance or will be from within the Johor region for all SRDB and IUCN listed species. Other species shall be obtained within the larger Sunda region. Due diligence shall be conducted on suppliers to ensure that the trees are obtained by legal means and are able to be exported/imported to Singapore. All imported trees shall be inspected and/or undergo quarantine if required to reduce the chance of transmission of weeds and soil pathogens.
 3. The success of planting within landscape features shall be monitored. Where a planting strategy is not working, an alternative planting strategy shall be developed suitable for the location. Temporary measures shall be employed to reduce stress on planted individuals. The removal of sources of stress (such as dust) may also be required. If disease outbreaks are present, methods shall be used to control the outbreak or remove the diseased individual.
 4. The flora specialist shall also identify other plant material, including ferns, epiphytes, orchids, shrubs, grasses, etc. that are of conservation value and work with NParks for the extraction of these plants by NParks to other sites.
 5. The flora specialist shall formulate a salvaging protocol in consultation with NParks if salvaging of plant material is being carried out on site.

The flora specialists, arborists and the arboriculture contractor engaged should meet the expected qualifications as described in Section 12.4.8.1, Section 12.4.8.3 and Section 12.4.6 respectively.

Additionally, the Contractor should fulfil the following:

- The Contractor and the attending arborist shall complete the 'Verification of Tree Protection Checklist' prior to the start of site clearance; and
- The Contractor shall instil discipline and raise awareness amongst all personnel on measures and mitigations to prevent damage to retained and protected trees throughout construction by including reminders on tree conservation guidelines within their daily toolbox briefings to workers and crane/excavator operators.

12.9.1.3 Fauna Monitoring Programme

Fauna monitoring surveys should comprise of transect surveys and site inspection surveys conducted together, at within and outside of hoarded areas. The programme should include the conducting of monthly diurnal and nocturnal fauna and site inspection surveys beginning one month prior to construction and ending two months after reinstatement. This includes both faunistic surveys and site inspections. However, it should be noted at the time of Report writing, the Project is at master planning stage. Depending on the actual development and its location, the requirement or necessity of the type and taxon to be surveyed should be decided in consultation with NParks.

Faunistic Surveys

Faunistic surveys are recommended to be conducted along terrestrial sampling routes and aquatic sampling points, and should target the following fauna groups: odonates (dragonflies and damselflies), fish, decapoda, butterflies, herpetofauna (amphibians and reptiles), birds, and mammals. Comparison of species presence can be made with the baseline studies, where appropriate, to provide an indication of the changes in fauna diversity.

The methodology for the faunistic surveys should closely follow that implemented for this EIA, so as to ensure that the data collected can be used to compare against the baseline data.

Further details of the surveys should be determined in consultation with NParks and should take into account construction phases, final construction footprint, final development hoarding plan, and baseline studies.

Site Inspections

The following should be inspected for during monthly fauna site inspections (Figure 12-4):

- Visual inspection of sensitive habitats in the vicinity (e.g., streams, forests) to determine if the construction has damaged or affected them
- Presence of trapped/injured/dead fauna
- Potential fauna entrapments (e.g., ECBs, TPZs, pits, drains, ponds, trenches, tanks)
- Gaps in hoarding that may allow entry of ground-dwelling fauna
- Improperly disposed/stored food and food packaging
- Degradation of adjacent sensitive habitats (e.g., streams, forest)
- Daily roadkill surveys shall be conducted by the ECO along roads adjacent to the worksite, up to 500 m from the worksite boundary. A roadkill and investigation register shall be maintained. Appropriate mitigation measures shall be implemented where necessary.
- Reporting and documentation of all findings and recommendations



Figure 12-4 Photographs showing monthly fauna monitoring and inspection on-site

12.9.1.4 Fauna Management Programme

Fauna management will consist of managing fauna within and around all designated work areas. It consists of pre-site clearance inspections and continued biodiversity awareness training for the site team, tree felling inspections, and fauna response plan in event of animal encounters. The objectives of fauna management are as follows:

- Minimise negative impacts to fauna, particularly to species of conservation interest;
- Inspect hoarded areas for any compromises that may allow smaller-sized animals to enter;
- Prevent human-wildlife conflicts;
- Monitor presence of trapped/injured/dead fauna inside hoarded areas;
- Monitor and compare presence of targeted fauna groups within and outside of hoarded areas; and
- During each survey, fill out Fauna Inspection Form.

Biodiversity Awareness Training

The Ecologist shall conduct toolbox briefings on biodiversity awareness to inform site personnel of but not limited to the following:

- Ecological value of the site and its surrounding habitats
- Types of fauna present
- Biodiversity protection strategies
- Site personnel's responsibilities towards biodiversity
- How to respond to fauna encounters
- No feeding of wildlife
- Prevention of roadkills
- Inspection of trees before felling

All site personnel shall undergo biodiversity awareness training prior to commencing work at on-site, and regularly (every six months) throughout the duration of the construction. Documentation of such trainings and briefings shall be maintained.

Pre-site Clearance Inspection

Pre-site clearance inspection should be adopted together with mitigating measures of directional clearance. Part of pre-site clearance involves pre-felling inspections. This is to minimize fauna injury and mortality during tree felling and vegetation clearance. Subsequently, site clearance should be executed outside of the key bird breeding season (March to July) where possible. Refer to Figure 12-5 for pre-felling inspection protocol. Refer to Appendix Z for Pre-felling Inspection Form.

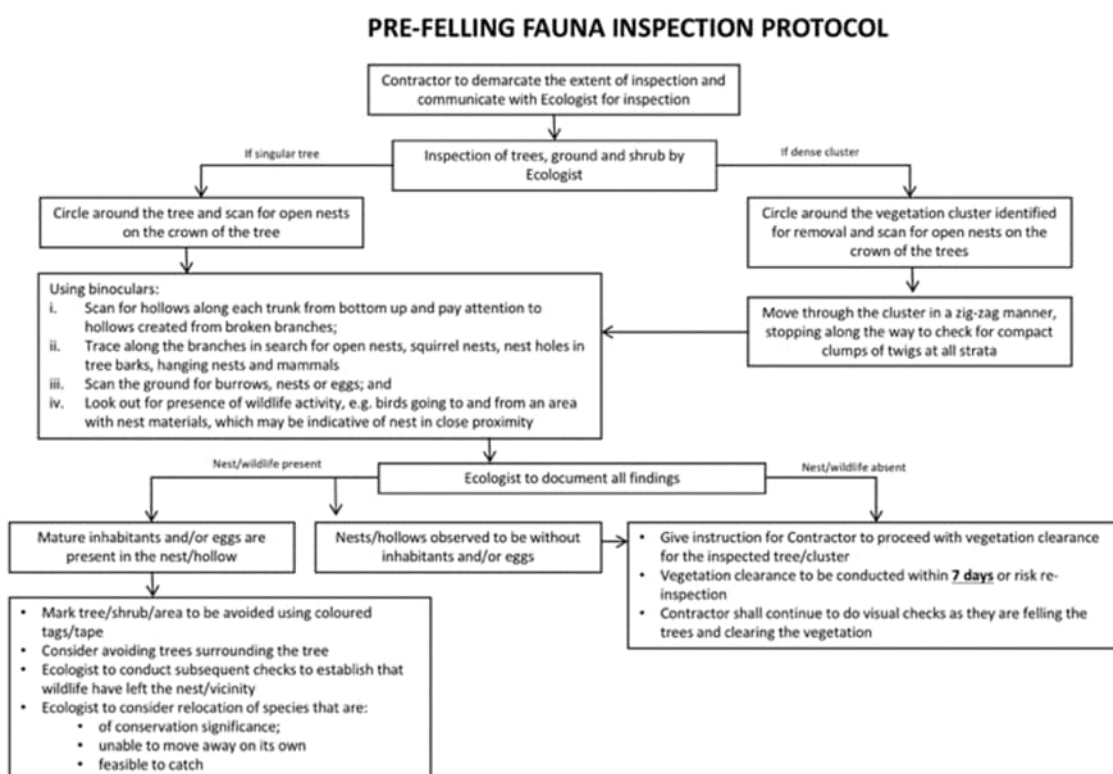


Figure 12-5 Pre-felling inspection protocol

Fauna Response and Rescue Plan

The Fauna Response and Rescue Plan (Appendix AA) should be enacted when a trapped/injured/dead/dangerous animal is encountered around or within the worksite. The objective of the wildlife response plan is to minimise animal injury and mortality by responding appropriately to the different scenarios in Figure 12-6. This should be

emphasised during the toolbox briefings. All wildlife encounters are to be documented within 24 h using the Wildlife Incident Form (Appendix BB).

Where species of conservation significance are affected by the development, relocation works should be planned (e.g., bamboo bats). Where fauna is trapped on-site, options should be explored to remove them from site (e.g., partitioning worksite, use of one-way exit door) (Figure 12-7).

In scenarios where certain animal groups are encountered around or within the worksite, external specialists may be contacted to handle the animal. These scenarios are shown below:

- For encounters with snakes that require relocation/handling, a snake specialist should be contacted.
- For animal carcasses that require disposal, an animal carcass disposal service should be contacted.
- For injured animals that require medical attention, a veterinarian should be contacted.

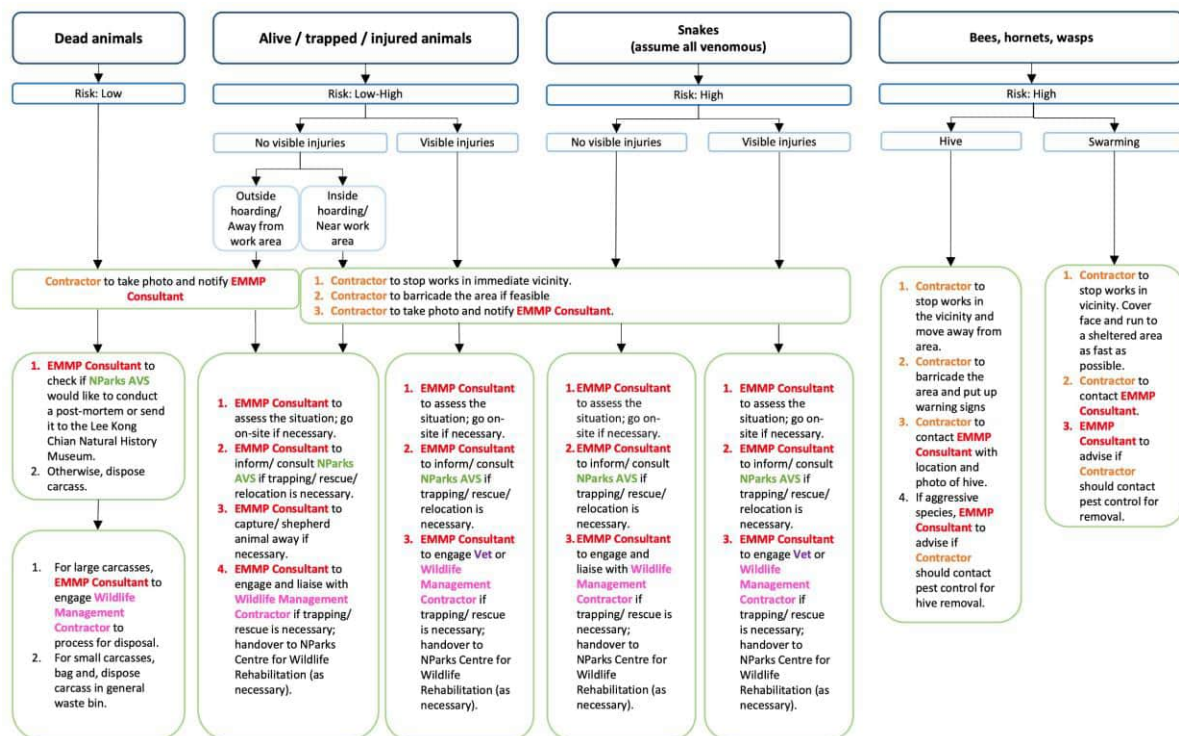


Figure 12-6 A flowchart of the wildlife response plan



Figure 12-7 Example of one-way flap door to allow fauna to exit independently

12.9.2 Operational Phase

The implementation of biodiversity related operational EMMP only be required when the development site is in the vicinity of green areas in this EIA Study Area.

At the operational phase, arboricultural services are normally not under the Contractor. Subsequently, the management of flora and fauna are also not expected of the Contractor. However, flora and fauna monitoring might still be expected of Contractor. More importantly, it is still important to monitor flora and fauna during post-construction through to at least a year into the operational phase to account for seasonality. This will allow contractor to review the effectiveness of mitigation measures proposed during design phase and rectify biodiversity problems that arise due to operational works.

12.9.2.1 Flora Monitoring Programme

The flora monitoring aims to assess the impacts of operational works to surrounding vegetation and/or adjacent forest, and rectify issues when identified. The programme should include the following:

- Assess impact of operational on the physiological health and structural stability of vegetation and trees at proximity to the development;
- Determine whether there has been excessive and unauthorised removal of vegetation and trees beyond the development boundary;
- Monitor and assess potential edge effects (e.g., predictable failures, accelerated growth of climbers on canopy, change in species composition at the edge) within vegetation adjacent to the development;
- Determine if there was unauthorised dumping of rubbish (e.g., food materials), construction debris and materials, oil/chemical leakage that may contaminate soil waterbodies, from post-construction water bodies post-construction.

12.9.2.2 Fauna Monitoring Programme

The fauna monitoring aims to assess the impacts of operational works to fauna residing within adjacent forest, and rectify issues when identified. The programme should include faunistic surveys. Faunistic surveys are recommended to be conducted along terrestrial sampling routes and aquatic sampling points, and should target the following fauna groups: odonates (dragonflies and damselflies), fish, butterflies, herpetofauna (amphibians and reptiles), birds, and mammals. The methodology for the faunistic surveys should closely follow that implemented for this EIA, so as to ensure that the data collected can be used to compare against the baseline data and data from construction monitoring. Comparison of species presence can be made with the baseline studies, where appropriate, to provide an indication of the changes in fauna diversity.

However, it should be noted that at the time of report writing, the Project is at master planning stage. Depending on the actual development and its location, the requirement of monitoring may vary and should be decided in consultation with NParks.

12.10 Hydrology and Surface Water Quality Monitoring Programme Requirement

12.10.1 Construction Phase

In order to ensure that procedures are followed appropriately, the construction phase of the projects should be accompanied by an EMMP.

Water quality monitoring is essential as discharge of excess contaminants, especially pH, nutrients and heavy metals, may lead to severe consequences (e.g. algae blooms).

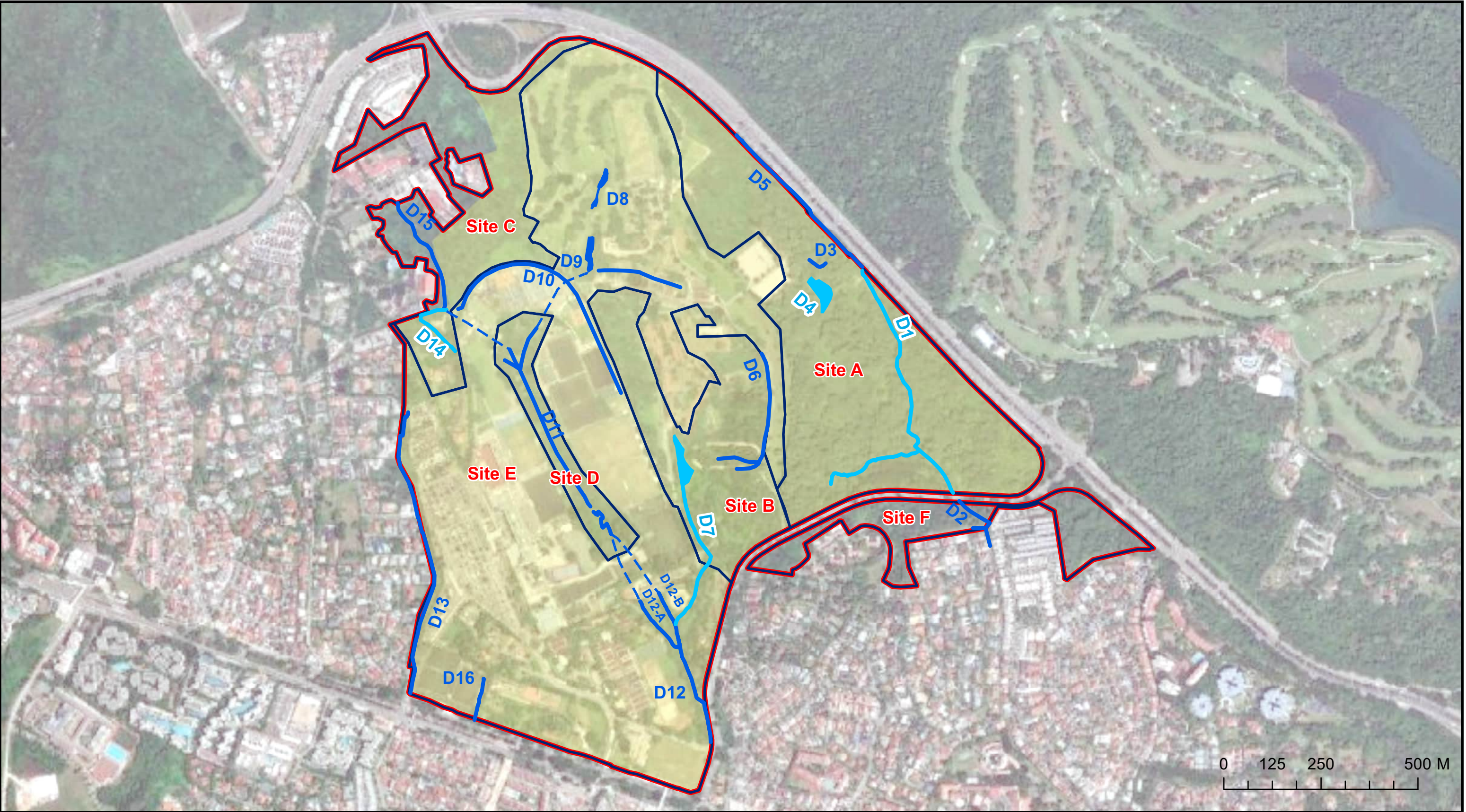
Discharges via settling ponds will take place during the construction phase, therefore monitoring of ECM discharge waters was recommended to be undertaken to ensure compliance with the relevant standards. It was also recommended to monitor their water quality throughout the construction period to ensure minor construction impacts on their water quality. For all discharge points from construction worksites, it is recommended to monitor water quality following Singapore NEA's Allowable Limits for Trade Effluent Discharge to Sewer/Watercourse/Controlled Watercourse. Meanwhile, the water quality of sensitive natural streams should also be recorded and compared with the water quality criteria for aquatic life as listed in Table 8-1 to make sure the aquatic condition will not be impacted by the construction activities.

Table 12-2 Recommended monitoring program during construction phase (surface water quality)

Test	Parameters	Monitoring Recommendation and Frequency
In-situ	Temperature	- Online real time monitoring for TSS at the discharge point location(s) at all the construction sites throughout the construction period. - Monthly monitoring for temperature, pH, conductivity, TDS and DO at all the discharge point locations at the construction sites throughout the construction period and also at nearby ecologically sensitive watercourses/bodies (refer to Figure 12-8).
	pH	
	Conductivity	
	Total Dissolved Solids (TDS)	
	Turbidity and Total Suspended Solids (TSS)	
	Dissolved Oxygen (DO)	
Ex-situ	Biochemical Oxygen Demand (BOD ₅)	Monthly monitoring for all the ex-situ parameters at the discharge point location(s) if discharging during the construction period and also at nearby ecologically sensitive watercourses/bodies (refer to Figure 12-8).
	Chemical Oxygen Demand (COD)	
	Total Ammonia Nitrogen (NH ₄ -N and NH ₃ -N)	
	Total Nitrogen (TN)	
	Nitrate (NO ₃ -N)	
	Total Phosphorus (TP)	
	Orthophosphate (PO ₄)	
	Total Organic Carbon (TOC)	
	Oil & Grease (Total)	
	Oil & Grease (Hydrocarbon)	
	Lead (Pb)	
	Zinc (Zn)	
	Mercury (Hg)	
	Aluminium (Al)	
	Antimony (Sb)	
	Arsenic (As)	
	Barium (Ba)	
	Beryllium (Be)	
	Boron (B)	
	Cadmium (Cd)	
	Chromium (Cr)	
	Copper (Cu)	
	Cyanide	

Test	Parameters	Monitoring Recommendation and Frequency
	Iron (Fe)	
	Manganese (Mn)	
	Molybdenum (Mo)	
	Nickel (Ni)	
	Selenium (Se)	
	Silver (Ag)	
	Sulphide	
	Tin (Sn)	
	<i>Enterococcus</i>	

Beside the water quality monitoring, hydrological conditions of drainage system within construction site and at immediate vicinity should also be closely monitored during construction phase. Before draining to public drains or waterbodies, surface runoff from the construction site should be drained to the ECM treatment system to be filtered and to reduce peak runoff. The hoarding and perimeter drains should be inspected daily to ensure no surface runoff flowing out from the site untreated and no clogging which would affect the flow capacity of the drains/streams. During heavy storm event, site inspection should be carried out to ensure no flooding. Monthly inspection on the site should also be carried out by EMMP Consultant.



Legend

Site Demarcation

EIA Study Area

Project Site

Monitoring required

No

Yes

Underground connection

N

							Qualified Person Endorsement : NA
							URA Endorsement : NA
-	MAY 2024	HBS	Turf Club EIA	LAL	JAG		
Rev.	Date	By	Description	Chk'd	App'd		

Consultant :

AECOM

Project Title :

CONTRACT URA/T/22/031
ENVIRONMENTAL IMPACT
ASSESSMENT (EIA) FOR
FORMER TURF CLUB AT BUKIT TIMAH

Designed
HBS

Checked
LAL

Approved
JAG

Drawn
HBS

Date
MAY 2024

Client:

URA

URBAN
REDEVELOPMENT
AUTHORITY

Figure Title :

Watercourses to monitor during
construction phase

Figure No. :

12 - 8

Rev.

-

Sheet
1 of 1

CAD File Name : NA

A3

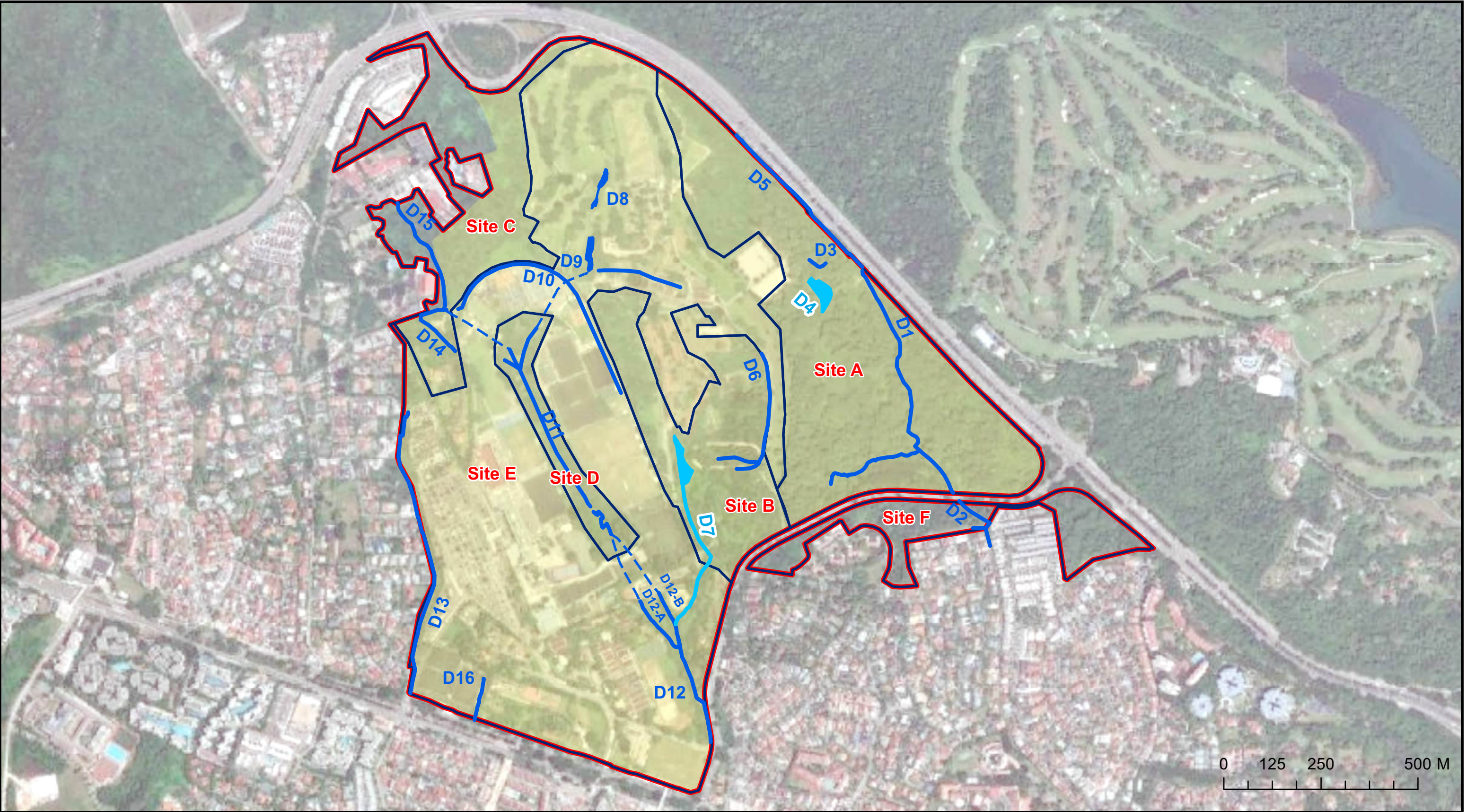
12.10.2 Operational Phase

The operational phase of the projects should be accompanied by an EMMP to ensure the proposed development will have minor impact on the surrounding watercourses, which will only be required when the development site is in the vicinity of green areas in this EIA Study Area. Water quality monitoring is essential as discharge of excess contaminants, especially pH and suspended solids may lead to severe consequences (e.g. water with less clearance) due to the operational activities. It was recommended to monitor their water quality during the first three (3) months of operational period to ensure minor operational impacts on their water quality. For main outlets/drains of the Project footprint, it is recommended to monitor water quality following Singapore NEA's Allowable Limits for Trade Effluent Discharge to Sewer/Controlled Watercourse. Meanwhile, the water quality of sensitive natural streams should also be recorded and compared with the water quality criteria for aquatic life as listed in Table 8-1 to make sure the aquatic condition will not be impact by the operational activities.

Table 12-3 Recommended Monitoring Program during Operational Phase (Surface Water Quality)

Test	Parameters	Monitoring Recommendation and Frequency
In-situ	Temperature	Monthly monitoring for all the in-situ parameters at the main outlets/drains and at ecologically-sensitive watercourses/bodies of the Project Site (refer to Figure 12-9), during the first three (3) months of operation period.
	pH	
	Conductivity	
	Total Dissolved Solids (TDS)	
	Turbidity and Total Suspended Solids (TSS)	
	Dissolved Oxygen (DO)	
Ex-situ	Biochemical Oxygen Demand (BOD ₅)	Monthly monitoring for all the ex-situ parameters at the main outlets/drains and at ecologically-sensitive watercourses/bodies of the Project Site during the first three (3) months of operation period.
	Chemical Oxygen Demand (COD)	
	Total Ammonia Nitrogen (NH ₄ -N and NH ₃ -N)	
	Total Nitrogen (TN)	
	Nitrate (NO ₃ -N)	
	Total Phosphorus (TP)	
	Orthophosphate (PO ₄)	
	Total Organic Carbon (TOC)	
	Lead (Pb)	
	<i>Enterococcus</i>	

For the hydrological condition monitoring during operational phase, drainage system within the site and at immediate vicinity should be inspected especially during heavy storm event to ensure no flooding. Monthly inspection on the site should be carried out by EMMP consultant during the first three (3) months of operation period if required.



Legend

Site Demarcation

EIA Study Area

Project Site

Monitoring required

No

Yes

Underground connection

N

							Qualified Person Endorsement : NA	Consultant : AECOM	Client: URBAN REDEVELOPMENT AUTHORITY					
							URA Endorsement : NA	Project Title : CONTRACT URA/T/22/031 ENVIRONMENTAL IMPACT ASSESSMENT (EIA) FOR FORMER TURF CLUB AT BUKIT TIMAH	Figure Title : Watercourses to monitor during operational phase					
								Designed HBS	Checked LAL	Approved JAG	Figure No. : 12 - 9	Rev. -	Sheet 1 of 1	
									Drawn HBS	Date MAY 2024	CAD File Name : NA		A3	
Rev.	Date	By	Description	Chk'd	App'd									

Note: Source of basemap - Google Earth Map

THIS DRAWING IS COPYRIGHT

12.11 Air Quality Monitoring Programme Requirement

12.11.1 Construction Phase

As noted in the mitigation measures (Section 10.8.1), continuous dust monitoring shall be undertaken during the construction phase. Continuous PM₁₀ and PM_{2.5} monitoring is recommended due to the potential of High consequence dust impact conducted within the ecological sensitive receptors and also a few human receptors during construction phase. Based on a review of sensitive receptors around the construction worksite areas, a continuous monitoring program as per Table 12-4 is proposed to be conducted during project construction.

Table 12-4 Recommended monitoring program during construction phase (air quality)

Location	Parameters	Frequency and Duration	Triggers
Monitoring at the following locations: - Near Eng Neo Avenue and Linden Drive - Ecological area at the north of Project Site (Retained Forested Area) - Chiltern House Turf Club Road - Near EtonHouse Pre-School (Vanda Road) - Near Residential Properties along Swiss Club Road	PM ₁₀ and PM _{2.5}	<u>1-week</u> monitoring of mentioned parameters at each selection location before commencement of construction phase <u>Continuous</u> monitoring of mentioned parameters during site clearance and earthworks stages <u>Bi-annual</u> 1-month monitoring of mentioned parameters at each selected location during construction phase after completion of earthworks and site clearance stages (i.e., during roadworks and building construction works)	Investigation and corrective actions to be taken, when - Any of the following documentation are found inadequate / missing: Air Pollution Control Plan; Compliance certificate of an Off-Road Diesel engine; or Monitoring Log. - If the monitored parameters exceed Singapore long term air quality targets. - If complaints are received due to project activities. - If visual non-compliance to any of the minimum control or mitigation measures are observed on-site.

12.11.2 Operational Phase

During operational phase, ambient air quality monitoring may not be required.

12.12 Airborne Noise Monitoring Programme Requirement

12.12.1 Construction Phase

As noted in Section 11.8, airborne noise monitoring programme can be implemented if required. Based on a review of sensitive receptors around the Project construction worksite, a continuous monitoring program as per Table 12-5 is proposed to be conducted at the minimum during Project construction. As quantitative noise impact assessment was not conducted at the pre-design stage, AECOM recommends that the developer/ developing agent engage a Airborne Noise Consultant(s) to conduct quantitative noise impact assessment as mandated by law at the detailed design stage.

Table 12-5 Recommended airborne noise monitoring programme during construction phase

No.	Location	Parameters	Frequency and Duration
1	Opposite Chiltern House at Turf Club Road	LAeq(12 hours), LAeq(1 hour) and LAeq(5 mins)	For construction phase: pre-construction baseline and continuous monitoring for the entire duration of the construction phase of the aforementioned parameters at all locations.
2	Along Dunearn Road, opposite EtonHouse Pre-School Vanda		
3	Green Area in Chatsworth International School		
4	Near Newton Auto Keys Pte		
5	Northern of Eng Neo Avenue, near Champions Golf Club adjacent to Turf Club		

12.12.2 Operational Phase

No noise monitoring programme were proposed for the operational phase due to the lack of information required regarding the air conditioning and mechanical ventilation (ACMV) system designs and traffic volumes. Usually conducted by an appointed Noise Consultant, AECOM recommends that the works for ACMV boundary noise impact assessment and traffic noise impact assessment be conducted as part of the detailed design process of the Project in accordance with the NEA guidelines as discussed in Section 11.8.2.

12.13 Vector Monitoring Programme Requirement

This section provides a vector monitoring programme to minimise the occurrence of potential impacts of vector populations near the Project Site during the construction and operational phase, whose occurrence and growth may be a result of the Project activities. Vectors are defined as any insect, including its egg, larva or pupa, and any rodent, including its young, carrying or causing, or capable of carrying or causing any disease to human beings. As such, they pose a risk to public health and should be controlled and eliminated.

In recent years, virulent vector problems have been mostly attributed to mosquitoes and rats. Mosquitoes are the most widely known disease vector, that can transmit the dengue virus. The common breeding habitats in a construction site that can cause the accumulation of stagnant water would include material storage area, site office, empty containers at workers area, water tanks at construction area and so on. If left uncontrolled, it may lead to mosquito breeding. Hence, as an effective and targeted approach, it is important to reduce/eliminate conditions that create these suitable breeding habitats in order to control the mosquito population within the Project Site. Rodent (including rats) infestations are problematic as they can spread diseases through their urine and droppings and chew up wires, pipes and insulation [W-12]. They tend to find new habitats easily and can repopulate quickly at locations with ample food, water and shelter available – which are typically found in hawker centres and vicinity of food waste bins. The removal of potential food sources and areas of harbourages can help prevent the nesting and breeding of rodents, and thus prevents rodent infestations [W-13]. At a construction worksite, there may be poorly maintained food-waste bins, poor refuse management and a lack of housekeeping practices onsite. As such, rodents may thrive in these environments as food, water and shelter are readily available. This section will focus on preventing the creation of such breeding grounds for these two types of vectors.

12.13.1 Construction Phase

This vector monitoring program is dedicated for the construction worksites of this Project only. Areas outside of the Project Site is not within the Project's authority and minimum control measures shall be carried out by each household or its housing/ school/ building/ public committee and other relevant party according to the stipulated legislations and guidelines. All construction worksites were identified to be the potential sources of vector impact due to accumulation of stagnant water, poor housekeeping and improper waste handling, transfer and storage of waste onsite. Vector-breeding may lead to severe consequences such as the spread of virulent diseases (e.g. dengue fever) both to the workers onsite and to other people near the worksite.

Aligning with NEA's Code of Practice for Vector Control Operator, Technician and Worker [W-16] and NEA's Mosquito and Rodent Control Measures [W-14, W-13], the Contractor shall submit a site-specific Vector Control Plan upon contract award, which encompassing the following elements:

- **Pre-existing Conditions:** To conduct a site assessment and establish vector baseline, which serves to identify high-risk areas for vectors-breeding and eliminate pre-existing vector issues before starting work. Information on the existing dengue clusters and areas with higher *Aedes aegypti* mosquito population can be reviewed on NEA's websites [W-17, W-18].
- **Vector Control Plan:** To develop plan in case that any person found on site is discovered to be a carrier of vector-borne disease, and when outbreak of dengue or mosquito breeding ground is detected on site.

For the implementation of Vector Control Plan, the Contractor shall provide competent personnel on site as follows:

- **A registered ECO** who undergone relevant trainings (e.g. Joint ITE-NEA Certificate in Pest Management for ECO or equivalent) shall be appointed by the Contractor to assist in investigating vector-borne disease on site as part of the ECO's responsibilities stated in NEA's Code of Practice for Environmental Control Officers (ECO) [W-16W-16].
- **An in-house pest control team** with competent personnel who have undergone relevant trainings (e.g. ITE-NEA Certificate in Control for in-house pest control team or equivalent) shall be formed to carry out vector control and surveillance at least once a week. The in-house pest control team shall be able to identify potential vector-breeding grounds and propose measures to prevent propagation of vectors on site.
- **An external NEA-licensed PCO** shall be engaged to supplement the weekly in-house vector control and surveillance routine.

The in-house pest control team shall develop a vector control program to conduct a daily routine of “Search and Destroy”⁹ activities at each construction site.

The recommended monitoring program for vectors is summarised in Table 12-6 below.

Table 12-6 Recommended vector monitoring programme

Location	Parameters	Frequency and Duration
All construction worksites (including storage and resting areas).	Inspection of potential mosquito breeding grounds (stagnant water), rodent burrows and droppings of other vectors (e.g. cockroaches, flies).	- Daily inspection and housekeeping to be conducted across the construction site; and - Weekly inspection by an external NEA-licensed Pest Control Operator.

12.13.2 Operational Phase

Minimum control measures shall be carried out by each household or its housing/ school/ building/ public committee and other relevant party according to the Control of Vectors and Pesticides Act and NEA guidelines [R-40,W-13, W-15].

⁹ This refers to the search for and destruction of potential mosquito breeding grounds. This includes clearing of stagnant water, removal of unwanted water-bearing receptacles and eliminating conditions that are prone to water stagnation.

12.14 Proposed EMMP

The framework for the proposed EMMP is detailed below; however, it is important to note that this is not an exhaustive list of potential impacts, monitoring requirements, and triggers. This EMMP is intended to be a living document and should be reviewed thoroughly by the Client/ Project Owner and the Contractor (CT) prior to implementation. Development of the following inputs, that have not been addressed in this report, by the CT are also required, including but not limited to:

- Stakeholder Communications Plan;
- Air Pollution Control Plan;
- Waste Management Plan;
- Erosion Control Plan;
- Noise Management Plan;
- Site log for all monitoring activities and complaints;
- Construction Logistics Plan;
- Standard Operating Procedures for processes identified in Table 12-7 and Table 12-8 below;
- Emergency Response Plan;
- Inventory of wastewater streams;
- Training protocols for staff, where appropriate; and
- Maintenance and Audit Schedules.

12.14.1 Construction Phase

The EMMP for construction phase of the Project is described in table below.

Table 12-7 Proposed environmental monitoring and management plan for the construction phase

Environment al Parameter	Environmenta l Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Monthly Reporting	Site Responsibilit y	Triggers ^{10,11}
Biodiversity	Minimisation of construction impacts to flora/vegetation	- Mark out site boundary - Set up Tree Protection Zones (TPZs) around trees or other plant specimens to be retained within the worksites - Tag trees (with or without TPZs) meant to be protected or transplanted to avoid accidental removal	Record locations, species and quantity of transplant candidates that are affected by construction	Flora and Arboriculture	Within development boundary	Prior to site clearance	-	CT, ECO, Floral Specialist	N/A
		- Establishment of TPZs - Inspect the integrity of the TPZ hoarding - Assess tree physiological health and vigour - Check for mechanical damage on trees that may impair stability - Review method statements of construction works in proximity to retained trees - Implement soil erosion control measures as soon as vegetation has been removed and soil is exposed - A TPZ of radius 15 m should be set up around the large <i>Ficus kerkhovenii</i> strangling fig of a recorded 14 m spread in Site B. The TPZ boundary should be at least 8 m away from the peripheral pillar roots. A detailed evaluation of the fig size should be carried out at the contract-specific EMMP phase.	- Identify excessive or unauthorized tree removal - Identify trees that require management and maintenance such as tree care and pruning - Determine if there are any unauthorized removal of flora within areas of conservation (if any) or beyond the demarcated worksite - Identify areas with soil erosion and degradation that have resulted from construction activities - Determine if there are unauthorized dumping of waste material, construction debris or oil/chemical leakage that may contaminate the soil and waterbodies, and/or be detrimental to the vegetation - Identify areas that are responding poorly due to the development impacts		Within development boundary and 15m beyond hoarding line	Monthly for duration of construction	To be included in monthly report	CT, ECO, Floral Specialist, Arborist	
	Minimisation of construction impacts to fauna	-	- Implementation of directional clearing - Implementation of pre-site clearance fauna inspection	Fauna	Within development boundary	Prior to site clearance	To be included in monthly report	CT, ECO, Ecologist	
		- Ensure proper storage of machineries likely to leech harmful chemicals and fuel-powered equipment; - Store the aforementioned equipment away from waterbodies and/or sensitive habitats.	- Assess habitat quality (e.g., water quality, excessive vegetation removal); - Check for presence of trapped/injured/dead fauna, potential fauna entrapments and gaps in site hoarding; and - Conduct toolbox briefings on biodiversity awareness.		Within development boundary	Monthly for duration of construction	To be included in monthly reports.	CT, ECO, Ecologist	
		Ensure that noise minimum control measures (as detailed in the Airborne Noise section below) are adhered to.	Conduct biodiversity survey to monitor construction impacts on fauna activity and presence		Adjacent to development boundary	Monthly for duration of construction	To be included in monthly report	CT, ECO, Ecologist	
			Recording of number of number of occurrences of human-wildlife conflict		Within development boundary	Daily monitoring and record-keeping	To be included in monthly report	CT, ECO	When fauna is encountered within development boundary
Hydrology and Surface Water Quality	- Stormwater runoff generation and contamination - Chemical substances - Domestic wastes - Construction wastewater - Solid wastes	- Runoff within, upstream of, and adjacent to the work site will be effectively drained away without causing flooding in the vicinity. - Potential increase of peak-flow due to the change in the land use at the worksite can be mitigated by providing detention tanks or ponds within the worksite. Detention tanks or ponds can capture stormwater during heavy storm events to reduce the peak runoff. - Geotechnical aspect of site's slope stability (such as Earth Retaining and Stabilising structures (ERSS)) to be included in detailed design engineering for the construction stage. - The design engineers for detailed design may need to ensure that ERSS are proposed when the site is cleared and excavated. Concurrently the ECO must ensure that these measures are implemented in the construction phase, as cutting of slopes may result in slope instability. - ECM measures include but are not limited to minimisation of formation of bare soil, coverage of all bare/erodible surfaces , concrete cut-off drains, silt fences/traps along the perimeter cut-off	- Redirect clean water into retained ecologically sensitive watercourses/bodies with significant catchment loss (i.e. pond D4, naturalised stream D7, and earth drain D14) - Prohibit any discharges from construction site into retained ecologically sensitive watercourses/bodies (i.e. D1, D4, D7, D14 and D15) - Build a berm structure or equivalent at the upstream of tributary of natural stream D1 and earth drain D14 prior to construction works (e.g. backfilling) - Complete drain diversion construction prior to connection with naturalised stream D7 - Provide silt curtains or equivalent when connecting naturalised stream D7 to the drain diversion - Coverage of all bare/erodible surfaces are to be done as soon as possible when works are complete or at the start of heavy rain and cessation of works are necessary, implying that tarp or other coverage material should always be on standby next to bare soil	All water quality parameters identified in Table 12-2. And any flooding issues should be recorded and inspected.	At discharge outlet(s) and at the nearby sensitive natural watercourses/ bodies (refer to Figure 12-8).	- Permanent TSS monitor installed at every discharge outlet; - Implementation of CCTV including a SIDS at every discharge outlet to monitor the surface run-off discharges from the sites; - Monthly water quality monitoring for all discharge point locations and nearby drains/streams during construction phase;	To be included in monthly report	CT, ECO	Investigation and corrective actions to be taken, when: - The following documentation are found inadequate/missing: - ECM Plan; - Monitoring Log; - Training Log; - Audit Reports; - If the monitored parameters

¹⁰ Resident Technical Officer (RTO) and Site Officers (SO, WSHO and ECO) check the Study Area for construction progress and implementation of environmental mitigation measures.
¹¹ If there is trigger then all the mitigation and management measures should be audited in detail for compliance and corrective action must be taken in liaison with the Project Owner.

Environment al Parameter	Environmenta l Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Monthly Reporting	Site Responsibilit y	Triggers ^{10,11}
		drain, turbidity curtains for works adjacent to watercourses (drains and streams), etc. - Adequate drainage, piping and/or channelling of stormwater runoff to be assured through detailed design for capture and treatment at ECM tanks/ponds before discharge into watercourses. - Regular and dedicated procedures for the inspection and maintenance of stormwater collection, storage, and treatment infrastructure, such as pipes, oil water separation, silt screens, etc. - Regular and dedicated procedures for the management of stormwater collection, settling, testing and eventual discharge of 'clean' water to watercourses. This should also include associated measures required to prevent high sediment concentration stormwater drainage to watercourses. - Development of Standard Operation Procedure (SOP) for safe handling, transfer and storage of toxic waste; housekeeping checks once a day to ensure all toxic waste is cleared from site. - Appropriate tests to ascertain the presence/absence of contamination of the excavated earth and sand. - Appropriate fully sheltered storage area with storage volume to be 110% of the largest volume of chemical substances to be stored (kerb up and enclosed on at least 3 sides, covered and with adequate ventilation). - Appropriate construction material for toxic waste storage containers with leak detection tests conducted periodically. - Provision of secondary containment for all toxic waste stored in bulk as per the requirements in the COPPC/SS593. - Preparation of an emergency response plan, training of the emergency response team (ERT) to be competent in the response mechanism and provision of response kits for any spillages. - Consignment notification/tracking system and transport emergency response plan for transport of toxic waste. - Appropriate disposal of toxic waste as per required in the Environmental Public Health (Toxic Industrial Waste) Regulations by licensed waste operator/collector. - Provision of portable toilets and on-site septic tank. - Regular cleaning of the portable toilets and clearing of sanitary waste. - Appropriate location of toilet facilities away from any nearby watercourse. - Inspections and audits to ascertain the hygienic conditions on-site. - The toilet facilities will be placed at least 30 m away from any nearby watercourse. - Training of workers on the best practices to contribute to environmental protection. - Appropriate disposal of any waste listed in the Environmental Public Health (General Waste Collection) Regulations by licensed waste operator/collector regardless the wastes to be disposed off-site or discharged to public sewer. - No unmanaged discharge of wastewater stream permitted. - Reduce, reuse, and recycle hierarchy principle to be applied to wastewater on-site. - Regular audits on environmental management procedures will be carried out on-site. - No hazardous liquids to be sent to the detention pond/tank. - Hazardous wastewater, such as oily water, thinners, solvents, or paints, should be stored on hard stand, under shelter with a kerb around the storage area. The wastewater should be removed for treatment and disposal off-site by an approved Waste Management Contractor. Hazardous liquids to be handled as Hazardous Waste. - Containment pond/kerbs will be of impervious material and be designed with sufficient capacity to hold volumes of wastewater produced on-site and potential fire-fighting wastewater. - ECM tanks/ponds will be designed in sufficient capacity to hold the turbid stormwater prior to treatment at the ECM treatment plant.				- Intensity of the laboratory analysis will be increased (e.g. fortnightly, weekly) if in-situ measurements and/or monthly laboratory results indicate deterioration in the water quality. Intensified monitoring will be carried out until in-situ measurements and/or laboratory results indicate 'normality'/consistency with earlier monitored conditions; and - Daily inspection on perimeter drains to ensure no surface runoff flowing out from the site untreated done by the site officer with monthly inspection done by EMMP consultant.			- exceed applicable values of NEA Trade Effluent Discharge Limits at discharge point(s) (refer to Table 8-1); - If the monitored parameters exceed applicable values of Aquatic Criteria or the baseline (whichever is higher) at natural/naturalised stream/ponds (refer to Table 8-1); - If any flooding or clogging issues observed; - If complaints are received due to project activities; and - If visual non-compliance to any of the minimum control or mitigation measures are observed on-site.

Environment al Parameter	Environmenta l Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Monthly Reporting	Site Responsibilit y	Triggers ^{10,11}
		- Temporary storage volumes should be provided for overflow situations of untreated wastewater. Temporary storage with sufficient capacity will capture any expected additional volumes ensure untreated wastewater is not released to watercourses unless it complies with Singapore NEA Guidelines on trade effluent discharge concentrations. - A responsible person (e.g. ECO) to be assigned to oversee the efficient operation of the containment pond/kerbs where 'Good Housekeeping' practices would be adhered to. Also, the area would be carefully managed to avoid spills, leaks, and odour issues, with the containment pond/kerbs checked at least daily to ensure proper functionality. - Daily record volume of wastewater, as well as volumes of sludge and other produced wastes. - Contractor will need to seek approval from relevant authorities (i.e. PUB & NEA) as per PUB Sewerage and Drainage (Trade Effluent) Regulations if the wastewater will be disposed to public sewer or NEA's Trade Effluent Discharge Limits to controlled watercourse if the treated trade effluent will be disposed to surface watercourses. If such discharges are not approved, the trade effluent will be stored, treated or recycled on site and finally disposed off-site. - Contractor will seek for comment and approval from relevant authorities (e.g. SCDF and NEA) on the treated wastewater to be used for firefighting purposes. - The discharge of pumped dewatered groundwater or other wastewaters to sensitive aquatic habitats will be prohibited. - Tunnel washing effluent should be discharged to containment pond/kerbs that are manually collected by operator assigned private wastewater collector to be transferred to wastewater treatment plant. - The containment pond/kerbs, as well as wastewater generating areas on-site, to be equipped with spill clean-up kits. - Adequate drainage, cut-off drains sump pit, road kerb, piping and toe wall will be designed for channelling of construction process wastewater streams (e.g., concrete batching, wash water, etc.) and stormwater runoff separately through detailed design for capture and treatment in the containment pond/kerbs. Where applicable (e.g., in the vicinity of liquid storage or refuelling areas), this infrastructure will include oil-water separators to capture inadvertent spills or leaked oils or greases. - Implement a construction EMMP and ensure full preparation of associated plans and procedures including the following: - EMMP to include SOPs, an Emergency Response Plan (ERP), an inventory of wastewater streams, training of staff as well as an inspection, maintenance and audit schedule; and - Full development of EMMP Wastewater Management Procedures to include dedicated management and monitoring procedures that covers all eventualities related to the proper operation of containment pond/kerbs, or any other wastewater discharge location/equipment. - Regular and dedicated procedures for the inspection and maintenance of wastewater (i.e. trade effluent) collection, storage, and treatment infrastructure, such as pipes, oil water separators, silt screens, etc. - A training programme for all on-site workers, including sub-contractors, in relation to their obligations for ensuring proper water quality management. - Development of a SOP for safe handling, transfer, storage and disposal of solid waste. - Effective ECM and monitoring implemented as recommended in the Code of Practice on Surface Water Drainage to ensure that discharge into the stormwater drainage system does not contain TSS in concentrations greater than the prescribed limits under the Sewerage and Drainage (Surface Water Drainage) Regulations. - ECM measures include but are not limited to minimisation of formation of bare soil, coverage of all bare/erodible surfaces, slope stability, concrete cut-off drains, silt fences/traps along the							

Environment al Parameter	Environmenta l Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Monthly Reporting	Site Responsibilit y	Triggers ^{10,11}
		perimeter cut-off drain, turbidity curtains for works adjacent to watercourses, etc. - Implementation of CCTV including SIDS at the public drain to monitor the surface runoff discharges from the sites as per the PUB's circular on Preventing Muddy Waters from the Construction Sites (October 2015). - Provision of enclosed bins and waste disposal facilities cleared up as often as necessary to prevent build-up. Housekeeping checks will be carried out once a day to ensure all litter is cleared from site. - Hazardous substances and toxic wastes should be stored on hard stand, under shelter with a kerb around the storage area. - All wastes will be disposed only in the designated waste disposal facilities and appropriately separated, i.e. by trained workers to properly sort and label the different types of waste (reusable and recyclable waste, toxic and non-toxic waste, etc.). - Surface Water Drainage, to be endorsed by a QECP and submitted to PUB. - Implementation of the ECM plan before the start of any construction work. - Manholes should always be adequately covered and temporarily sealed. - Protection of stockpiles with erosion blanket coverage and proper scheduling of the demolition and earthworks to reduce the quantity of stockpiles to be stored on-site. - Coverage of temporary/open storage of excavated materials. - All vehicles should run via wheel washing process before leaving the site to ensure no earth, mud, debris, etc., is deposited on roads; and the wastewater hence generated should be stored and removed for treatment and disposal off-site by an approved Waste Management Contractor.							
Soil and Groundwater	- Imported and excavated soil/stockpile - Extracted groundwater - Runoff generation and contamination - Chemical substances - Domestic wastes - Construction wastewater - Solid wastes - Leaks/spills from construction equipment and vehicles	- Identify all types of solid waste and implement comprehensive waste management system at the site in order to ensure proper disposal and prevent pollution to the environment. This contractor should conduct a construction risk assessment and prepare a comprehensive construction health, safety and environment plan. If health impacts to workers are foreseen due to the handling of such waste, necessary precautionary measures as per the safety data sheets (SDS) including personal protective equipment should be implemented on site. - Use approved materials, of the same or better quality as the surrounding area, for backfilling works. All backfilled material shall be free of debris, and of good material soil. - Handle and dispose excavated soil following the procedure shown in Figure 9-3. This flow chart explains how to handle excavated soils, and identify potential areas of contamination in excavated soils. Should an area be identified as a PAC, soils are to be tested for exceedance in DIVs. If the soils are tested for exceedance in DIVs, the soils can be disposed of to toxic waste collectors or undergo soil treatment. If contaminated soils were sent for treatment to an acceptable standard such as the DIV, the treated soil can be disposed in the staging ground or through a general waste collector, depending on the level of the contaminants during the staging ground testing. - Upon receipt of results on the tested parameters (chemicals, heavy metals) exceeding the regulatory limits, the construction contractor should further assess the potential inhalation and dermal contact impacts of the exceeded parameters to the site workers exposed to areas where soil and/or groundwater contamination is identified. The risk assessment should be conducted before the commencement of construction activities and the findings incorporated into the contractors' construction risk assessment and health, safety and environment plan. If health impacts to workers are foreseen, necessary precautionary measures, as per the respective chemical SDS, should be implemented on site.	No additional mitigation measures needed.	Records on waste generated and hazardous chemicals used at the construction site should be properly kept and records produced when requested.	- At locations where toxic and solid wastes are generated and store. - At locations where hazardous chemicals/ substances are used and stored	- Monitoring records of the amount and type of toxic chemical waste generated, once a week. - Inspection of hazardous chemical/substances storage conditions, once a week. - Environmental audits, quarterly.		CT, ECO	Investigation and corrective actions to be taken, when: There is evidence of poor handling/storage of toxic chemical waste and hazardous chemical.

Environment al Parameter	Environmenta l Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Monthly Reporting	Site Responsibilit y	Triggers ^{10,11}
		• A site management plan should include plans of safe handling, transfer and storage of excavated soils following the procedure in Figure 9-3. • Discharge of extracted groundwater shall be to an area approved for such disposal by the NEA and the proposed location as identified in Figure 9-3 and following the process set out in Figure 9-4. Based on the results of the soil and groundwater baseline study, the detected concentrations in groundwater do not exceed the DIVs. However, it is recommended that the construction contractor to be vigilant of site conditions and extracted groundwater to be tested at regular intervals, especially for extracted groundwater with oily sheens or noticeable odour. If a contaminant concentration in excess of the DIV is detected, the contractor shall assess the potential inhalation and dermal impacts of the chemical identified and assess potential health and safety considerations for exposure to groundwater before commencement of construction activities. Such contaminated wastewater may need to be disposed of to a licenced toxic waste collector. • Bentonite slurry used in the TBM will be pumped into the slurry treatment plant for recycling, cleaning and removal of native cut material. Treatment methodologies in the slurry treatment plant will include de-sanding (e.g., cyclones) and filtration. Handling and disposal of spoils for disposal after the treatment shall follow the procedure in Figure 9-3. • Identify all types of toxic chemical waste and implement comprehensive waste management system at the site in order to ensure proper disposal and prevent pollution to the environment. This contractor should conduct a construction risk assessment and prepare a comprehensive construction health, safety and environment plan. If health impacts to workers are foreseen due to the handling of such waste, necessary precautionary measures as per the safety data sheets (SDS) including personal protective equipment should be implemented on site. • Inspect all equipment prior to entering the site for fuel/hydraulic lines, leaking tanks, and other potential faulty parts that could potentially cause contamination to soil or groundwater. • Dispose all construction debris (under category C&D) at the gazetted Government dumping grounds or at such other sites or locations as directed by NEA. • Store generated toxic chemical waste under shelter within concrete bund walls or in storage containers with good ventilation. Spill trays shall be provided for all waste containers Spill trays shall be regularly maintained to prevent rain from washing out the pollutive substances. • Note that the Earth Control Measures (ECM) is for the containment and treatment of silty discharge due to the impact of rainwater. ECM is not meant for the treatment of wastewater due to construction activities (such as pipe-jacking and bore-piling works) which shall be treated to comply with the requirements under prevailing legislation. • The wastewater from construction activities should be stored and removed for treatment and disposal off-site by an approved Waste Management Contractor. • Remove any hazardous substance or chemical if there are safer alternatives. • Ensure all hazardous substance and chemical containers are labelled its movement is recorded and returned to the designated storage areas when not in use. • Assess the SDS of all the hazardous substances and chemicals prior to its entry to site for its suitability in terms of SHE hazards and consider safer alternatives. • Ensure no trade effluent other than that of a nature or type approved by NEA Director-General shall be discharged into any watercourse or land. • Ensure all activities involving repair, servicing, engine overhaul works, etc. shall be carried out on an area which is appropriately contained (e.g. concreted area and with proper							

Environment al Parameter	Environmenta l Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Monthly Reporting	Site Responsibilit y	Triggers ^{10,11}
		containment/sumps) and all wastes are channelled for appropriate treatment or disposal to meet the regulations. - Store chemicals stored under shelter within concrete bund walls or in storage containers with good ventilation. Spill trays shall be provided for all drums, plants and machinery and potential pollutive substances used on site. Spill trays shall be regularly maintained to prevent rain from washing out the pollutive substances. - Provide emergency spill kits on site in the event of any chemical spillages. The emergency response team shall also be competent in the use of these spill kits							
Air Quality	Air quality impact from dust nuisance from the construction activities and gaseous emissions from the construction equipment and vehicles	- The construction footprint shall be hoarded on all sides; - No concrete batching plant to be located on-site; and - Access road construction or expansion is recommended to be completed first and paved before the construction of other development commences.	General mitigation measures to be implemented by the Contractor throughout construction period. Communications: - Develop and implement a <u>stakeholder communications plan</u> that includes community engagement before work commences on site. - Display the name and contact details of person(s) accountable for air quality and dust issues on the site boundary. This may be the environment manager/engineer or the site manager. - Develop and implement an <u>Air Pollution Control Plan (APCP)</u>, <u>refer to Section 10.8 for details on APCP.</u> Site Management: - Record all dust and air quality complaints, identify cause(s), take appropriate measures to reduce emissions in a timely manner, and record the measures taken. - Make the complaints log available to the local authority when asked. - Record any exceptional incidents that cause dust and/or air emissions, either on-site or off- site, and the action taken to resolve the situation in the logbook. - Hold liaison meetings with other high-risk construction sites within 500m of the site boundary, if any, to ensure plans are co-ordinated and dust and particulate matter emissions are minimised. Monitoring: - Undertake regular (daily frequency recommended) on-site and off-site inspections and record results. The log should be made available to the NEA or other Government Agencies if required. Inspections should include regular dust soiling checks of surfaces such as street furniture, cars and windowsills within 100m of site boundary. Cleaning should be provided if necessary. - Carry out regular site inspections to monitor and record compliance with the Air Pollution Control Plan. - Increase the frequency of site inspections during prolonged dry or windy conditions. - Conduct monitoring for PM₁₀ and PM_{2.5} at suitable locations (refer to Section 12.11.1) Preparing and maintaining the site: - Plan site layout so that machinery and dust causing activities are located away from receptors, where possible. - Erect hoarding around dusty activities and at the site boundary wherever possible. Boundary screens should be at least as high as any stockpiles or dust emission sources on site. - Fully enclose specific activities where there is a known high potential for dust production and the site will be active for an extensive period of time. - Keep site fencing, barriers, and scaffolding clean by cleaning regularly using wet methods (dry methods may give rise to fugitive dust). - Remove materials that have the potential to produce dust from site as soon as possible, unless being re-used on site. If they are being re-used on-site, stockpiled material should be	PM ₁₀ , PM _{2.5}	- Near Eng Neo Avenue and Linden Drive - Ecological area at the north of Project Site (Retained Forested Area) - Chiltern House Turf Club Road - Near EtonHouse Pre-School (Vanda Road) - Near Residential Properties along Swiss Club Road	1-week monitoring of mentioned parameters at each selection location before commencement of construction phase - Continuous monitoring of mentioned parameters during site clearance and earthworks stages - Bi-annual 1-month monitoring of mentioned parameters at each selected location during construction phase, except for earthworks and site clearance stages	To be included in monthly report	CT, ECO	Investigation and corrective actions to be taken, when - Any of the following documentation are found inadequate / missing: Air Pollution Control Plan; Compliance certificate of an Off-Road Diesel engine; or Monitoring Log. - If the monitored parameters exceed Singapore long term air quality targets. - If complaints are received due to project activities. - If visual non-compliance to any of the minimum control or mitigation measures are observed on-site.

Environment al Parameter	Environmenta l Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Monthly Reporting	Site Responsibilit y	Triggers ^{10,11}
			covered, seeded, fenced or enclosed to prevent fugitive dust formation. Operating vehicle/machinery and sustainable travel: • Impose and signpost a maximum-speed-limit of 25 km/hr on paved or surfaced haul roads and 15 km/hr on unpaved haul roads and work areas. • Produce a Construction Logistics Plan to manage the sustainable delivery of goods and materials. • Ensure all vehicles and engine powered equipment comply with the legislative requirements of Singapore • Ensure all vehicles and equipment switch off their engines when stationary – i.e. no idling vehicles or engines. Clear signs shall be erected at site entrance to inform all visitors. • Where practicable, avoid the use of diesel- or petrol-powered generators and use mains electricity or battery powered equipment Construction: • Only use cutting, grinding or sawing equipment fitted with, or in conjunction with, suitable dust suppression techniques such as water sprays or local extraction e.g. local exhaust ventilation system. • Ensure an adequate water supply on the site for effective dust/particulate matter suppression/mitigation, using non-potable water where possible and appropriate. • Use enclosed chutes and conveyors and covered skips wherever possible. • Minimise drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate. • A stringent "Clean as you go" Policy should be implemented on site to ensure no loose dry material is left exposed when not in use. Equipment should be readily available on site to clean and dry spillages, and cleaning should be conducted as soon as reasonably practicable after the event using wet cleaning methods. Waste Management: Avoid burning of waste or other materials MITIGATION MEASURES FOR EARTHWORKS • Closed turfing to the exposed areas where possible and maintain proper storage of soil stockpiles to stabilise surfaces as soon as practicable. • Use Hessian, mulches or soil tackifiers where it is not possible to re-vegetate or cover with topsoil, as soon as practicable. Soil erosion blankets may also be used as an alternative. • Only remove the cover in intended working areas and not all at once. MITIGATION MEASURES FOR CONSTRUCTION • Avoid scabbling (roughening of concrete surfaces) if possible. • Ensure sand and other aggregates are stored in bunded areas and are not allowed to dry out, unless this is required for a particular process, in which case ensure that appropriate additional control measures are in place. • Ensure bulk cement and other fine powder materials are delivered in enclosed tankers and stored in silos with suitable emission control systems to prevent escape of material and overfilling during delivery. • For smaller supplies of fine power materials ensure bags are sealed after use and stored appropriately to prevent dust. MITIGATION MEASURES FOR TRACKOUT • Use water-assisted dust sweeper(s) on the access and affected local roads, to remove, as necessary, any material tracked out of the site. This may require the sweeper being continuously in use. • Avoid dry sweeping of large areas.						

Environment al Parameter	Environmenta l Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Monthly Reporting	Site Responsibilit y	Triggers ^{10,11}
			• Ensure vehicles entering and leaving sites are covered to prevent escape of materials during transport. • Inspect on-site haul routes for integrity and instigate necessary repairs to the surface as soon as reasonably practicable. • Record all inspections of haul routes and any subsequent action in a site log book. • Install hard surfaced haul routes, which are regularly damped down with fixed or mobile sprinkler systems, or mobile water bowsters and regularly cleaned. • Implement a wheel washing system (with rumble grids to dislodge accumulated dust and mud prior to leaving the site where reasonably practicable). • Ensure there is an adequate area of hard surfaced road between the wheel wash facility and the site exit, wherever site size and layout permits. • Site access gates to be located at least 10m from receptors where possible						
Airborne Noise	Noise from construction machines and equipment, especially rotational and vibratory equipment (e.g. dozers, cranes, excavators, trailers, generators, etc.)	• It is recommended to reduce noise impact to avifauna by various administrative controls at the Study Area. For example, avoid breeding seasons for the activity, or to avoid early morning daytime noisy activities between 7 – 9 am as far as possible on site. This may reduce some impacts on this fauna on behavioural aspects and communication. • Machines (such as trucks) that may be in intermittent use should be shut down between work periods or should be throttled down to a minimum; • Only well-maintained construction plants should be utilised on-site, and construction plants should be serviced regularly during the entire construction period; • The number of PMEs should be reduced as far as practicable when construction works are carried out at areas close to the noise sensitive receivers: • Silencers or mufflers on construction equipment should be utilised and should be properly maintained during the construction programme; • Behavioural practices including no shouting, no loud stereos/ radios on site, no dropping of materials from height, no throwing of metal items should be ensured; • Construction respite: Restrict high noise generating drilling activities only in continuous blocks, not exceeding 3 hours each, with a minimum respite period of one hour between each block, if possible; • Periodic noise monitoring by an independent third party, to establish compliance with requirements and to advise on equipment causing concern, and additional potential mitigation measures; • Night works, apart from advance works/ site clearance if approved by Agencies, will be prohibited after 6 pm to minimise noise disturbance to nocturnal animals; • Plan the layout of the site by considering using materials and other large structural equipment as noise barriers; • Construction plants known to emit noise strongly in one direction should, wherever possible, be orientated so that the noise is directed away from the nearby noise sensitive receptors; • Material stockpiles and other structures will be effectively utilised, wherever practicable, in screening noise from on-site construction activities; • All handheld percussive breakers and air compressors used on site will comply with local legislation and requirements; • Activities may be scheduled to minimize noise generated at certain areas during periods which may be particularly sensitive to noise; • Works using machines or vehicles that generate noise should be prohibited in the night and the dawn; • Appropriate hearing protectors should be used by personnel operation the plant or equipment, the hearing protector must	MITIGATION MEASURES FOR GENERAL CONSTRUCTION NOISE CONTROL: • Control of noise sources at the source from construction site – Analyse construction inventory list and check equipment causing high noise levels. The equipment with lower noise level shall be prioritised; and • Where controlling noise sources at the source is not feasible, acoustic enclosures or sheds are to be introduced to mitigate noise at the source. Typical acoustic enclosure covers the machine as fully as possible (with or without ventilation where applicable) to provide sound insulation. MITIGATION MEASURES FOR CONSTRUCTION NOISE: During design strategies: • Consider buildings of staggered heights with lower buildings designed for build near noise sensitive areas to reduce duration of noise impacts; and • Avoid placement of access routes near noise sensitive receptors or facing noise sensitive receptors to prevent sound leak along worksite boundaries with proposed noise barriers and prevent increase in noise from road traffic by potential increase of heavy-duty vehicles (HDVs) volume. During construction: • Noise barriers should be proposed at the construction boundary fronting noise sensitive receptors or RAC areas based on noise modelling and management plan submitted for contract specific purposes;	L_{Aeq}(12 hours), L_{Aeq}(1hour) and L_{Aeq}(5 mins)	• Opposite Chiltern House at Turf Club Road • Along Dunearn Road, opposite Eton House Pre-School Vanda • Green Area in Chatsworth International School • Near Newton Auto Keys Pte • Swiss School	Records on noise levels from construction sites should be properly kept and produced when requested.	To be included in monthly report	CT, ECO	Investigation and corrective actions to be taken, when Any of the following documentation are found inadequate / missing: • Construction Noise Management Plan; • Monitoring Log. 1. If the monitored parameters exceed applicable values of EPM regulations. 2. If complaints are received due to project activities. 3. If visual non-compliance to any of the minimum control or mitigation measures are observed on-site. 4. If there are any cracks / leaks present on the noise barrier erected.

Environment al Parameter	Environmenta l Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Monthly Reporting	Site Responsibilit y	Triggers ^{10,11}
		attenuate the exposure of the user to sound pressure levels below 85dB (A). Signage to remind personnel to put on hearing protection will be put up at work areas that emit excessive noise. Choice of hearing protector such as ear plugs (for < 100 dB (A)), earmuffs (for 100 dB (A) to 120 dB (A), ear plugs and earmuffs (for > 120dB (A)) in various noise exposure level; - Noise awareness briefing should be conducted regularly and highlighted the noise mitigation measures such as position of machinery, making use of portable noise barriers and dos and don'ts for use of machinery at night; and - If noise remains an issue even after implementation of recommended mitigation measures such as noise barriers, contractor should consider implementation of proprietary noise barriers of high noise reduction capabilities to further reduce noise to acceptable levels. Note: As current means of noise impact assessment were only performed qualitatively, quantitative noise impact assessment must be conducted the developer/ developing agent at a later stage to assess noise impacts arising from the construction phase related activities as mandated by law at later stages of the Project.							
Vectors	Accumulation of stagnant water, poor housekeeping and improper handling/ disposal of solid waste (especially food waste)	- Adhere to Control of Vector and Pesticide Act (CVPA) and ensure good housekeeping on-site. - Preparation and implementation of an effective vector control plan and measures as required under NEA's Code of Practice for Environmental Control Officers. (See Section 12.13.1) - Ensure water-bearing receptacles, gaps on grounds and equipment (e.g. openings at concrete barriers), as well as stockpiled areas are covered or sheltered, especially during the northeast monsoon season between November to January. - Scheduled daily housekeeping to ensure clearance of stagnant water and unwanted items are discarded properly. - Site entrance shall be paved to avoid ground depression. - Milled waste can be used to level the ground before laying steel plates. - Provide movable roof over shaft to prevent rainwater ingress. - Pump shall be deployed to clear water at areas where drainage is not possible, as well as for larger recessed surfaces. - Install pitched roof on top and/or seal up bottom of site container office. - After trees clearance, top of tree stumps has to be either removed thoroughly or patched up. - Pipette can be used for larvae-checking at the hard-to-reach parts of a tree. - Food disposal should be clearly allocated and disposed of on a daily basis to discourage rodents from establishing nests on site and to prevent cockroaches/ flies' infestation. - Store food in rodent proof storage containers/ cabinets with at least 60 cm clearance above ground level. - Thermal Fogging is not recommended onsite, due to its proximity to areas of high ecological value. Instead, preventive methods such as inspection and good housekeeping practices should be adhered to instead, in order to ensure no mosquito breeding occurs onsite.	Not Applicable.	- Inspection of potential mosquito breeding grounds (water ponding) - Inspection of rodent burrows - Inspection of cockroaches and flies' droppings	Within and/or at boundary of construction worksites, as well as any other temporary and permanent utilities diversion work areas or any other relevant work areas associated with this Project.	- Daily inspection and housekeeping to be conducted across the construction site; and - Weekly inspection by an external NEA-licensed PCO.	To be included in monthly report	ECO personnel, CT	Investigation and corrective actions (i.e. Stop Work Orders) to be taken, when: a. Worksite is found to have vector-breeding habitats. b. There is an occurrence of suspected dengue outbreak cases.

12.14.2 Operational Phase

The EMMP for operational phase of the Project is described in Table 12-8.

Table 12-8 Proposed environmental monitoring and management plan for the operational phase

Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers ^{12,13}
Biodiversity	Minimisation of operational impacts to flora/vegetation	-	- Identify of areas that are responding poorly due to operational activities - Ensure that post-construction planting is responding well to development surrounding	Flora and Arboriculture	Softscape of operational boundary	Monthly for duration of 1 year	Project Owner	N.A.
		-	- Ensure integrity of adjacent forest (if any) - Identify signs of edge effects on new forest edge of adjacent forest (if any)		Adjacent forest to development boundary			
	Minimisation of operational impacts to fauna	Ensure water quality minimum control measures listed below are adhered to.	- Assessment of habitat quality (e.g., water quality, excessive vegetation removal) - Inspection for presence of trapped/injured/dead fauna, potential fauna entrapments and gaps in site hoarding - Recording of number of number of occurrences of human-wildlife conflict - Conduct biodiversity survey to monitor construction impacts on fauna activity and presence	Fauna	Adjacent forest to development boundary		Project Owner	
Hydrology and Surface Water Quality	- Stormwater run-off generation and contamination - Improper management of liquid and solid wastes	- Regular and dedicated procedures for the inspection and maintenance of stormwater collection, storage, and treatment infrastructure, such as pipes, oil water separation, silt screens, etc.; - Regular and dedicated procedures for the management of stormwater collection, settling, testing and eventual discharge of 'clean' water to surface waters. This should also include associated measures required to prevent high sediment concentration stormwater drainage to surface waters; - Potential increase of peak-flow due to the change in the land use at the new developments can be mitigated by providing detention ponds within the Project Site. Detention ponds can capture stormwater during heavy storm events to reduce the peak runoff. Stored water can then be discharged back to the system after the storm event. As required by PUB, the storage system needs to be in place to reduce the peak flow at the operational phase to be the same or less than that of the existing condition. - Providing more softscape area should be considered in the design of the development to reduce the run-off coefficient which will help to reduce the peak flow and reduce flood risk at downstream area; - Provide more pervious areas to increase the seepage of surface water into the soil; - Geotechnical aspect of site's slope stability (such as ERSS) to be included in detailed design engineering for the operational stage; - To prepare sufficient disposal bins surrounding of the Project to avoid improper disposal of waste; - To conduct regular inspection on wastes' storage system of the Project; - To monitor the proposed water features and its surroundings with CCTV surveillance regularly to ensure no contamination occurred; - To develop an emergency response plan and conduct adequate training to maintenance workers to cope the accidental water contamination; and	Redirect clean water into retained ecologically sensitive watercourses/bodies with significant catchment loss (i.e. pond D4, naturalised stream D7, earth drain D14) to increase the flow into these watercourses/bodies. If possible, the water can be from ABC Waters Design features	All parameters identified in Table 12-3. And any flooding issues should be recorded and inspected.	At the main outlets/drains of the Project Site, as well as the sensitive natural streams in the vicinity of proposed project.	Monthly inspection for the surface water quality and hydrology, especially during heavy storm event for hydrological conditions during first three (3) month of operational period.	Project Owner	Investigation and corrective actions to be taken, when: - If the monitored parameters of all discharge points exceed applicable values of NEA Limits at discharge point (refer to Table 8-1); - If the monitored parameters of natural streams/pond exceed applicable values of Aquatic Criteria natural stream (refer to Table 8-1) or its baseline, the higher of the two; - If any flooding issues observed; - If complaints are received due to project activities; and - If visual non-compliance to any of the minimum control or mitigation measures are observed on-site.

¹² Resident Technical Officer (RTO) and Site Officers (SO, WSHO and ECO) check the Study Area for construction progress and implementation of environmental mitigation measures.
¹³ If there is trigger then all the mitigation and management measures should be audited in detail for compliance and corrective action must be taken in liaison with the Project Owner.

Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers ^{12,13}
		Raising awareness of various stakeholders with community/stakeholder engagement (e.g. signage boards, warning signs, etc.).						
Soil and Groundwater	More areas with impervious surfaces in the new development leading to decrease in infiltration of surface water/ stormwater into the soil	Incorporate more pervious surfaces in the development plan	No additional mitigation measures needed.	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable
	- Heavy rain and stormwater wash-off pollutants built-up in the new development area and discharge to surrounding soil and groundwater - Discharge or leakage of waste and chemicals into the soil	- Ensure no trade effluent other than that of a nature or type approved by NEA Director-General shall be discharged into any watercourse or land. - Store all toxic chemical waste and hazardous substances/chemicals (if any) at designated sheltered area provided with access-controlled entrance and concrete bund walls or in storage of containers with good ventilation. Spill trays shall be provided for all chemical drums and potentially pollutive substances. Spill trays shall be regularly maintained to prevent the rain from washing out the pollutive substances - Dispose all toxic waste chemicals (if any) to licensed Toxic Industrial Waste (TIW) collectors for treatment - Ensure all hazardous chemicals/substances are labelled, its movement is recorded and returned to the designated storage areas when not in use - Ensure all activities including repair, servicing, engine overhaul works, etc. involving the use of hazardous chemicals/substances are carried out on an area which is appropriately contained (e.g. concreted area and with proper containment/sumps). - Provide emergency spill kits on site in the event of any chemical spillages. The emergency response team shall also be competent in the use of these spill kits	No additional mitigation measures needed.	Records on waste generated and hazardous chemicals used at the Study Area should be properly kept and records produced when requested.	- At locations where toxic chemical waste are generated and store. - At locations where hazardous chemicals/subst ances are used and stored.	- Monitoring records of the amount and type of waste generated, monthly. - Inspection of hazardous chemical/substances storage conditions, monthly.	Project Owner	- Investigation and corrective actions to be taken, when: - There is evidence of poor handling/storage of toxic chemical waste and hazardous chemical.
Air Quality	Air Quality impact from dust nuisance from emissions from vehicle exhaust due to increased traffic volume	No minimum control has been assumed.	No additional mitigation measures needed.	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Airborne Noise	Noise from Air-conditioning and Mechanical Ventilation, Traffic Noise	MINIMUM CONTROLS FOR ACMV NOISE: Minimum Controls below should be applied at the prelim design stage of the development by the appointed M&E consultants. An appointed Noise consultant should validate the noise in accordance with <i>NEA's Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Building</i>. In addition, mitigation measures will be provided by the appointed Noise Consultants during the prelim design stage. - Use low air-conditioning and mechanical ventilation system equipment; - Ensure that any exhaust outlet or intake from the mechanical ventilation system is designed to be adequately set back as far as possible from the boundary line of the development; - Acoustic treatment if any to be designed and implemented; - AC system to be designed with the AHU units placed at appropriate locations as set back from the boundary line of the development as possible; and - Acoustic enclosures for outdoor equipment. MINIMUM CONTROLS FOR TRAFFIC NOISE: - Consider alternative siting of new road networks away from noise sensitive receptors at pre-design stage; - Use of low-noise pavement mix for sections of new road networks near NSRs should be considered; - Due to the lack of information at this juncture of reporting, assessment, minimum controls, and mitigation will be	MITIGATION MEASURES FOR ACMV NOISE: - Noise attenuators and other Best Available Technology (BAT) and Best Environmental Practice (BEP) noise control measures shall be utilised; and - Ample setback of developments with ACMV systems fronting noise sensitive receptors should be provided such as provision of park areas to ensure that operational noise sources are at a distance away from the receptors. MITIGATION MEASURES FOR TRAFFIC NOISE: - Traffic noise at drop-off points and parking areas shall be mitigated with low speed postings, speed humps and speed limit signages. The addition of these speed control measures will likely lower noise levels for traffic as the vehicles would be cruising at lower speeds; and - Consider alternative siting of roads away from areas with noise sensitive receptors.	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable

Environmental Parameter	Environmental Issue	Minimum Control Measures	Mitigation Measures	Monitoring Parameter	Monitoring Locations	Recommended Frequency of Monitoring	Site Responsibility	Triggers ^{12,13}
		provided by the appointed Noise Consultant during the prelim design stage and in accordance with Technical Guideline for Land Traffic Noise Impact Assessment. Note: As current means of noise impact assessment were only performed qualitatively, quantitative noise impact assessment must be conducted by the developer/ developing agent at a later stage to assess noise impacts arising from the operational phase related activities as mandated by law at later stages of the Project.						
Vector	Accumulation of stagnant water, poor housekeeping and improper handling/ disposal of solid waste (especially food waste)	- Adhere to Control of Vector and Pesticide Act (CVPA) and ensure good housekeeping on-site/in the development. - Weekly inspections for potential breeding sites should be conducted for areas such as unused containers in open areas and under bushes, open and closed drains, gully traps, tree holes and bifurcations between branches, leaf axils of banana trees, Travellers Palms and other palms, outdoor litter bins etc; - Fortnightly application of sand granular insecticides gully traps, manhole cover handle depressions, lightning conductor pits, stop-cock pits, valve chambers, and sumps; - Immediate application of insecticide should be conducted to destroy breeding habitats identified during inspections and to immediately eliminate the identified potential breeding habitats (i.e. source of stagnant water or waste). Proper recording of these incidents should also be conducted once the breeding habitats or potential breeding grounds have been eliminated; - Thermal Fogging is not recommended, due to its proximity to areas of high ecological value. Instead, preventive methods such as inspections and good housekeeping practices should be adhered to instead, in order to ensure no mosquito breeding occurs onsite. Monthly routine pest control checks should be conducted at all locations; - Fortnightly application of sand granular insecticide to sources of stagnant water in schools and boarding schools (e.g. toilet bowls, cisterns, and gully traps in toilets), during school vacation.	No mitigation measures required to be proposed, as minimum controls for vectors should be practised as advised by NEA.	Not applicable	Not applicable	Not applicable	Each household or its housing/ school/ building/ public committee and other relevant party	Not applicable

13 Conclusion

This section will present the summary of conclusions and recommendations from the assessed potential environmental impacts. The unmitigated impact significance and potential residual impact significance of the assessed environmental aspects are summarised in tables below.

Table 13-1 Summary of potential residual impact significance during construction phase

Environmental Parameter	EIA Section	Unmitigated Impact Significance	Key Mitigation Measures (if any)	Residual Impact Significance
Biodiversity	Section 7	Negligible to Major	- Retain and create a 100m forested corridor at the periphery of the former Champions Golf Course for ecological connectivity between Eng Neo Ave Forest and Bukit Tinggi - Begin habitat enhancement and creation before development where possible - Avoid plant removal or salvage if unavoidable - Consider the retention of large trees as part of design where possible - Design for urban greenery such as street scape trees, flowering shrubs and roof top garden where possible - Keep building height near forested area low where possible - Bird friendly building designs - Study and build connectivity structures (e.g. culverts, colugo poles, grade separated crossing, potential ecolink) to facilitate the safe movement of wildlife across roads - Implement road calming measures - Use lighting strategies to reduce light spill into retained forest - Avoid night works and keep working hours to 0800h – 1800h where possible - Restrict entry to TPZ and retained forested area outside of worksite - Biodiversity awareness training for site personnel - Conduct site inspection to ensure no vegetation clearance occurs outside the agreed working space - Pre-felling fauna inspection should be conducted before felling any trees or removing any vegetation - Wildlife shepherding via directional clearing should be adopted	Negligible to Major
Hydrology and Surface Water Quality	Section 8	<u>Human Receptors</u> Negligible	- Redirect clean water into pond D4, naturalised stream D7 and earth drain D14. - Provide berm structure or equivalent when constructing on the upstream of tributary of natural stream D1. - Complete drain diversions for D7 prior to connection. - Provide silt curtains or similar when connecting drain diversions to D7.	<u>Human Receptors</u> N.A

Environmental Parameter	EIA Section	Unmitigated Impact Significance	Key Mitigation Measures (if any)	Residual Impact Significance
		<u>Ecological Receptors</u> Negligible to Major	No discharging from construction sites in retained watercourses/bodies (D1, D4, D7, D14 and D15). Coverage of all bare/erodible surfaces are to be done as soon as possible when works are complete or at the start of heavy rain and cessation of works are necessary, implying that tarp or other coverage material should always be on standby next to bare soil.	<u>Ecological Receptors</u> Negligible to Moderate
Soil and Groundwater	Section 9	Negligible to Minor	<u>No mitigation measures to be proposed</u>, provided the minimum control measures during construction phase are in place (refer to Section 9.6.1)	N.A.
Air Quality	Section 10	<u>Human Receptors</u> Moderate to Major	- Implement dust control measures e.g. dust screens, etc. - Install hard surfaced haul routes. - Only use cutting, grinding and sawing equipment with dust suppression water spray mechanisms. - Erect hoarding around dusty activities and site boundary. - Impose and signpost maximum speed-limit of 25km/hr on paved roads and 15 km/hr on unpaved roads and work areas. - No burning of waste allowed on site. - Closed turbing to the exposed areas where possible and maintain proper storage of soil stockpiles.	<u>Human Receptors</u> Minor
		<u>Ecological Receptors</u> Major		<u>Ecological Receptors</u> Minor
Airborne Noise	Section 11	<u>Human Receptors</u> Negligible to Major	During design Strategies: - Staggered building heights should be considered to reduce duration of noisy activities near receptors; and - Access routes should avoid facing receptors; During construction: - Use equipment with lower noise levels; and - Noise barriers should be installed along boundary of worksites facing noise sensitive receptors (where necessary) Note: As current means of noise impact assessment were only performed qualitatively, quantitative noise impact assessment must be conducted by the developer/ developing agent at a later stage to assess noise impacts arising from the construction phase related activities as mandated by law at later stages of the Project.	<u>Human Receptors</u> Negligible to Major
		<u>Ecological Receptors</u> Moderate to Major		<u>Ecological Receptors</u> Moderate to Major

Table 13-2 Summary of potential residual impact significance during operational phase

Environmental Parameter	EIA Section	Unmitigated Impact Significance	Key Mitigation Measures (if any)	Residual Impact Significance
Biodiversity	Section 7	Negligible to Major	- Incorporate urban greenery such as street scape trees, flowering shrubs and roof top garden where possible - Regular park maintenance and signages to remind park visitors of the common park etiquette - Road calming measures near retained forested areas - Conduct random patrols to deter undesirable behaviours in parks	Negligible to Moderate

Environmental Parameter	EIA Section	Unmitigated Impact Significance	Key Mitigation Measures (if any)	Residual Impact Significance
			Employ lighting strategies to minimise light disturbance	
Hydrology and Surface Water Quality	Section 8	<u>Human Receptors</u> Negligible to Minor	- Provide ABC Waters Design features within the development (wetlands, bioretention swales, rain garden, etc.) or more softscape areas and pervious areas within the development to increase seepage of surface water into the soil to reduce peak flow and flooding risks within the development, and to purify the runoff water - Redirect cleansed water from ABC Water features (if possible) into pond D4, naturalised stream D7 and earth drain D14	<u>Human Receptors</u> N.A.
		<u>Ecological Receptors</u> Negligible to Major		<u>Ecological Receptors</u> Negligible to Minor
Soil and Groundwater	Section 9	Negligible to Minor	<u>No mitigation measures to be proposed</u>, provided the minimum control measures during operational phase are in place (refer to Section 9.6.2).	N.A.
Air Quality	Section 10	<u>Human Receptors</u> Minor	<u>No mitigation measures to be proposed</u> as the predicted increase in air quality pollutant levels is likely to be insignificant, due to: - Current large traffic volume along existing roads, and thus, any increase in traffic due to the development will not lead to a significant change in air quality. - Continued implementation of increasingly stringent Euro emission standards on new vehicles.	N.A.
		<u>Ecological Receptors</u> Minor		
Airborne Noise	Section 11	<u>Human receptors</u> Negligible to Minor	- Utilise noise attenuators and other Best Available Technology (BAT) and Best Environmental Practice (BEP) to mitigate potential noise from air conditioning and mechanical ventilation (ACMV) systems; - Utilise low speed postings, speed humps, speed limit signages at drop-off points and parking areas to mitigate noise from increased road traffic; and - Consider alternative siting of roads away from areas with noise sensitive receptors.	N.A.
		<u>Ecological receptors</u> Negligible to Minor		
			Note: As current means of noise impact assessment were only performed qualitatively, quantitative noise impact assessment must be conducted by the developer/ developing agent at a later stage to assess noise impacts arising from the operational phase related activities as mandated by law at later stages of the Project.	

14 References

14.1 Reports, Legislation Guidelines and Standards

- R-1. AECOM, Environmental Baseline Survey (EBS) for Former Turf Club (Bukit Timah Planning Area) Final Report (Revision 04). Report prepared for URA, Singapore 2022
- R-2. AECOM, CR2001/DOC/DES/0045/C, Environmental Impact Study – Turf City & Holland Plain Final Report (Revision C). Report prepared for LTA, Singapore 2022
https://www.lta.gov.sg/content/ltagov/en/who_we_are/statistics_and_publications/reports.html
- R-3. AECOM, CR2001/DOC/DES/0050/B, Project Environmental Study Package 1 Final Report (Revision B). Report prepared for LTA, Singapore 2022
- R-4. AECOM, CR2001/DOC/DES/0027/J, Environmental Impact Study – Windsor & Eng Neo Avenue Forest (Revision J). Report prepared for LTA, Singapore 2022
- R-5. AECOM, Inception Report for Environmental Impact Assessment for Former Turf Club at Bukit Timah (Revision 04). Prepared for URA, Singapore 2023
- R-6. IUCN I (2012) Red List of Threatened Species: Version 2011.2.
- R-7. National Parks Board, 2020. Biodiversity Impact Assessment (BIA) Guidelines.
<https://www.nparks.gov.sg/-/media/nparks-real-content/biodiversity/bia-guidelines.pdf?la=en&hash=67BBB6F740AE7CCE941D82B261BB3DAF9CF537B1>
- R-8. Legislation Division of Attorney General's Chambers of Singapore. Environmental Protection and Management Act. 2020
<https://sso.agc.gov.sg/Act/EPMA1999>
- R-9. Legislation Division of Attorney General's Chambers of Singapore. Environmental Protection and Management (Trade Effluent) Regulations. 2008.
<https://sso.agc.gov.sg/SL/EPMA1999-RG5>
- R-10. Legislation Division of Attorney General's Chambers of Singapore. Sewerage and Drainage Act (Chapter 294). 2001.
<https://sso.agc.gov.sg/Act/SDA1999>
- R-11. Legislation Division of Attorney General's Chambers of Singapore. Sewerage and Drainage (Trade Effluent) Regulations. 2007.
<https://sso.agc.gov.sg/SL/SDA1999-RG5?DocDate=20161003>
- R-12. Legislation Division of Attorney General's Chambers of Singapore. Sewerage and Drainage (Surface Water Drainage) Regulations. 2007.
<https://sso.agc.gov.sg/SL/SDA1999-RG4?DocDate=20070515>
- R-13. Public Utilities Board (PUB). Code of Practice on Surface Water Drainage. 2023.
[COP Surface Water Drainage 7th Ed Add. 2.pdf](#)
- R-14. Public Utilities Board, Singapore (PUB), 2015, Preventing Muddy Waters from the Construction Sites.
<https://www.pub.gov.sg/Documents/Circular2015Oct28.pdf>
- R-15. United Nations Economic Commission for Europe, United Nations (UNECE), 1994, Standard Statistical Classification of Surface Freshwater Quality for the Maintenance of Aquatic Life, New York and Geneva.
- R-16. World Health Organization (WHO), n.d., Water Quality Requirements.
https://www.who.int/water_sanitation_health/resourcesquality/wpcchap2.pdf
- R-17. United States Environmental Protection Agency, United States (USEPA), 2017, Water Quality Standards Handbook.

- <https://www.epa.gov/wqs-tech/water-quality-standards-handbook>
- R-18. United States Environmental Protection Agency, United States (USEPA), 2017, National Recommended Water Quality Criteria – Aquatic Life Criteria.
<https://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table>
- R-19. Australian and New Zealand Environment and Conservation Council (ANZECC) & Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ). Guidelines for Fresh and Marine Water Quality. 2000.
<https://www.waterquality.gov.au/anz-guidelines/resources/previous-guidelines/anzecc-armcanz-2000>
- R-20. Canadian Council of Ministers of the Environment. Canadian Water Quality Guidelines for the Protection of Aquatic Life. 2007.
<https://ccme.ca/en/summary-table#void>
- R-21. Mitigating Impact from Aquaculture in the Philippines (PHILMINAQ), n.d. Water Quality Criteria and Standards for Freshwater and Marine Aquaculture
<http://aquaculture.asia/files/PMNQ%20WQ%20standard%202.pdf>
- R-22. Department of Environment, Malaysia (DOE). National Water Quality Standards for Malaysia. n.d.
<https://www.doe.gov.my/wp-content/uploads/2021/11/Standard-Kualiti-Air-Kebangsaan.pdf>
- R-23. National Environment Agency (NEA). Allowable Limits for Trade Effluent Discharge to Watercourse or Controlled Watercourse, 2008
<https://www.nea.gov.sg/our-services/pollution-control/water-quality/allowable-limits-for-trade-effluent-discharge-to-watercourse-or-controlled-watercourse>
- R-24. Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer. Target Values, Soil Remediation Intervention Values and Indicative Levels for Serious Contamination. 2020.
<https://zoek.officielebekendmakingen.nl/stcrt-2013-16675.pdf>
- R-25. Legislation Division of Attorney General's Chambers of Singapore. Environmental Protection and Management (Air Impurities) Regulations (Amendment). 2015.
<https://sso.agc.gov.sg/SL/EPMA1999-RG8>
- R-26. Institute of Air Quality Management (IAQM). Guidance on the Assessment of Dust from Demolition and Construction. 2014.
<https://iaqm.co.uk/text/guidance/construction-dust-2014.pdf>
- R-27. Legislation Division of Attorney General's Chambers of Singapore. Environmental Protection and Management (Control of Noise at Construction Sites) Regulations. 2008.
<https://sso.agc.gov.sg/SL/EPMA1999-RG2>
- R-28. Department for Environment Food and Rural Affairs, 2011, Biodiversity 2020: A strategy for England's wildlife and ecosystem services
- R-29. Ecological Impact Assessment (EcIA). EIANZ Guidelines for use in New Zealand: terrestrial and freshwater ecosystems. 2nd Edition. May 2018.
<https://www.eianz.org/document/item/4447>
- R-30. CIEEM (2018). Guidelines for ecological impact assessment in the UK and Ireland: Terrestrial, Freshwater and Coastal. September 2018.
<https://cieem.net/wp-content/uploads/2019/02/Combined-EcIA-guidelines-2018-compressed.pdf>
- R-31. National Environment Agency (NEA). Technical Guideline for Land Traffic Noise Impact Assessment. 2016.
<https://www.nea.gov.sg/docs/default-source/our-services/technical-guidelines-for-noise-impact-assessment-.pdf>

- R-32. National Environment Agency (NEA). Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Buildings. 2018.
<https://www.nea.gov.sg/docs/default-source/default-document-library/technical-guideline-on-boundary-noise-limit-for-air-conditioning-and-mechanical-ventilation-systems-in-non-industrial-buildings---feb-2018.pdf>
- R-33. Fatal Lights Out Program (2007). City of Toronto green development standard. March 2007.
<https://www.rasc.ca/sites/default/files/Bird%20Friendly%20Development%20Guidelines.pdf>
- R-34. Crosher I, Gold S, Heaver M, Heydon M, Moore L, Panks S, Scott S, Stone D & White N (2019) The Biodiversity Metric 2.0: auditing and accounting for biodiversity value. User guide (Beta version, July 2019). Natural England.
- R-35. Hong Kong Environmental Protection Department. Environmental Impact Assessment Ordinance - Technical Memorandum. 2011.
<https://www.epd.gov.hk/eia/english/legis/index3.html>
- R-36. National Environment Agency (NEA). NEA Environmental Protection Division Annual Report (2018).
[https://www.nea.gov.sg/docs/default-source/resource/publications/environmental-protection-division-annual-report/epd-report-2018-v4-\(compressed\).pdf](https://www.nea.gov.sg/docs/default-source/resource/publications/environmental-protection-division-annual-report/epd-report-2018-v4-(compressed).pdf)
- R-37. Institute of Air Quality Management (IAQM). A Guide to the Assessment of Air Quality Impacts on Designated Nature Conservation Sites. 2020.
<https://iaqm.co.uk/text/guidance/air-quality-impacts-on-nature-sites-2020.pdf>
- R-38. Department of Statistics, Ministry of Trade & Industry (MTI). Yearbook of Statistics Singapore, 2019.
https://www.singstat.gov.sg/-/media/files/publications/reference/yearbook_2019/yos2019.pdf
- R-39. WHO Regional Office for Europe, Copenhagen, Denmark, 2000. Air Quality Guidelines – Second Edition. Chapter 11 Effects of nitrogen containing air pollutants: critical levels.
https://www.euro.who.int/_data/assets/pdf_file/0005/74732/E71922.pdf#page=244
- R-40. Legislation Division of Attorney General's Chambers of Singapore. Control of Vectors and Pesticides Act. 2002.
<https://sso.agc.gov.sg/Act/CVPA1998>
- R-41. National Parks Board, 2020. Biodiversity Impact Assessment (BIA) Guidelines.
<https://www.nparks.gov.sg/-/media/nparks-real-content/biodiversity/bia-guidelines.pdf?la=en&hash=67BBB6F740AE7CCE941D82B261BB3DAF9CF537B1>
- R-42. Legislation Division of Attorney General's Chambers of Singapore. Environmental Protection and Management Act. 2020
<https://sso.agc.gov.sg/Act/EPMA1999>
- R-43. Legislation Division of Attorney General's Chambers of Singapore. Environmental Protection and Management (Trade Effluent) Regulations. 1999 (Revised Edition 2008).
<https://sso.agc.gov.sg/SL/EPMA1999-RG5>
- R-44. World Health Organization (WHO), n.d., Water Quality Requirements.
https://www.who.int/water_sanitation_health/resourcesquality/wpcchap2.pdf
- R-45. United States Environmental Protection Agency, United States (USEPA), 2017, Water Quality Standards Handbook.
<https://www.epa.gov/wqs-tech/water-quality-standards-handbook>
- R-46. Australian and New Zealand Environment and Conservation Council (ANZECC) & Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ). Guidelines for Fresh and Marine Water Quality. 2000.
<https://www.waterquality.gov.au/anz-guidelines/resources/previous-guidelines/anzecc-armcanz-2000>

- R-47. Canadian Council of Ministers of the Environment. Canadian Water Quality Guidelines for the Protection of Aquatic Life. 2007.
<http://ceqg-rcqe.ccme.ca/en/index.html#void>
- R-48. Mitigating Impact from Aquaculture in the Philippines (PHILMINAQ), n.d. Water Quality Criteria and Standards for Freshwater and Marine Aquaculture
<http://aquaculture.asia/files/PMNQ%20WQ%20standard%202.pdf>
- R-49. Department of Environment, Malaysia (DOE). National Water Quality Standards for Malaysia. n.d.
<https://www.doe.gov.my/portaltv1/wp-content/uploads/2019/05/Standard-Kualiti-Air-Kebangsaan.pdf>
- R-50. National Environment Agency, Singapore (NEA). Allowable Limits for Trade Effluent Discharge to Watercourse or Controlled Watercourse
<https://www.nea.gov.sg/our-services/pollution-control/water-quality/allowable-limits-for-trade-effluent-discharge-to-watercourse-or-controlled-watercourse>
- R-51. Legislation Division of Attorney General's Chambers of Singapore. Environmental Protection and Management (Chapter 94A). 2018.
<https://sso.agc.gov.sg/Act/EPMA1999#xv->
- R-52. Singapore Standards SS593:2013. Code of Practice for Pollution Control (COPPC). 2013.
- R-53. Association of Southeast Asian Nations (ASEAN). ASEAN Strategic Plan of Action on Water Resources Management. 2005.
<https://environment.asean.org/files/ASEAN%20Strategic%20Plan%20of%20Action%20on%20Water%20Resources%20Management.pdf>
- R-54. Legislation Division of Attorney General's Chambers of Singapore. Sewerage and Drainage Act (Chapter 294). 1999 (2020 Revised Edition)
<https://sso.agc.gov.sg/Act/SDA1999>
- R-55. Legislation Division of Attorney General's Chambers of Singapore. Sewerage and Drainage Act (Chapter 294, Section 74). Sewerage and Drainage (Surface Water Drainage) Regulations. 1999 (Revised Edition 2007).
<https://sso.agc.gov.sg/SL/SDA1999-RG4?DocDate=20070515>
- R-56. Legislation Division of Attorney General's Chambers of Singapore. Sewerage and Drainage (Trade Effluent) Regulations. 1999 (Revised Edition 2007).
<https://sso.agc.gov.sg/SL/SDA1999-RG5?DocDate=20161003>
- R-57. Public Utilities Board (PUB). Code of Practice on Surface Water Drainage. 2018 (Addendum 2021).
https://www.pub.gov.sg/Documents/COP_Surface%20Water%20Drainage_7th%20Ed%20Add.%201.pdf
- R-58. Public Utilities Board, Singapore (PUB), 2015, Preventing Muddy Waters from the Construction Sites.
<https://www.pub.gov.sg/Documents/Circular2015Oct28.pdf>
- R-59. United Nations Economic Commission for Europe, United Nations (UNECE), 1994, Standard Statistical Classification of Surface Freshwater Quality for the Maintenance of Aquatic Life, New York and Geneva.
- R-60. Institute of Air Quality Management (IAQM). Guidance on the Assessment of Dust from Demolition and Construction, United Kingdom. 2014.
<https://iaqm.co.uk/text/guidance/construction-dust-2014.pdf>
- R-61. Legislation Division of Attorney General's Chambers of Singapore. Environmental Protection and Management (Air Impurities) Regulations (Amendment). 2015.
<https://sso.agc.gov.sg/SL/EPMA1999-RG8>
- R-62. Legislation Division of Attorney General's Chambers of Singapore. Environmental Protection and Management (Off-Road Diesel Engine Emissions) Regulations. 2012.

- R-63. National Environmental Agency. Code of Practice for Licensed General Waste Collectors. 2019
<https://sso.agc.gov.sg/SL/EPMA1999-S299-2012>
- R-64. National Environmental Agency. Code of Practice on Environmental Health. 2021
<https://www.nea.gov.sg/docs/default-source/resource/practices-/copeh-2021.pdf>
- R-65. Legislation Division of Attorney General's Chambers of Singapore. Energy Conservation Act 2012 (2020 Revised Edition)
<https://sso.agc.gov.sg/Act/ECA2012>
- R-66. Legislation Division of Attorney General's Chambers of Singapore. Environmental Public Health Act 1987 (2020 Revised Edition)
<https://sso.agc.gov.sg/Act/EPHA1987>
- R-67. Legislation Division of Attorney General's Chambers of Singapore. Radiation Protection Act 2007 (2020 Revised Edition)
<https://sso.agc.gov.sg/Act/EPHA1987>
- R-68. Legislation Division of Attorney General's Chambers of Singapore. Environmental Protection and Management (Control of Noise at Construction Sites) Regulations. 2008.
<https://sso.agc.gov.sg/SL/EPMA1999-RG2>
- R-69. National Environment Agency (NEA). Technical Guideline on Boundary Noise Limits for Air Conditioning and Mechanical Ventilation Systems in Non-Industrial Buildings. 2018.
<https://www.nea.gov.sg/docs/default-source/default-document-library/technical-guideline-on-boundary-noise-limit-for-air-conditioning-and-mechanical-ventilation-systems-in-non-industrial-buildings---feb-2018.pdf>
- R-70. National Environment Agency (NEA). Technical Guideline for Land Traffic Noise Impact Assessment. 2023.
<https://www.nea.gov.sg/docs/default-source/our-services/building-planning/technical-guideline-for-land-traffic-noise-impact-assessment.pdf>
- R-71. National Environment Agency (NEA). Air Quality Targets. 2019.
<https://www.nea.gov.sg/our-services/pollution-control/air-pollution/air-quality>
- R-72. Ecological Impact Assessment (EcIA). EIANZ Guidelines for use in New Zealand: terrestrial and freshwater ecosystems. 2nd Edition. May 2018.
<https://www.eianz.org/document/item/4447>
- R-73. Chartered Institute of Ecology and Environmental Management (CIEEM). Guidelines for ecological impact assessment in the UK and Ireland: Terrestrial, Freshwater and Coastal. September 2018.
<https://cieem.net/wp-content/uploads/2019/02/Combined-EcIA-guidelines-2018-compressed.pdf>
- R-74. National Parks Board (NParks). Conserving Our Biodiversity – Singapore's National Biodiversity Strategy and Action Plan (NBSAP). 2019.
https://www.nparks.gov.sg/-/media/nparks-real-content/biodiversity/national-plan/singapore_2009-nbsap_updated-may-2019_national-targets.pdf
- R-75. Legislation Division of Attorney General's Chambers of Singapore. Wildlife Act. 2020.
<https://sso.agc.gov.sg/Act/WA1965#pr10->
- R-76. Legislation Division of Attorney General's Chambers of Singapore. Parks and Trees Act. 2020.
<https://sso.agc.gov.sg/Act/PTA2005>
- R-77. Legislation Division of Attorney General's Chambers of Singapore. Parks and Trees (Heritage Road and Green Buffers) Order. 2006.
<https://sso.agc.gov.sg/SL/PTA2005-OR2?DocDate=20061130&ValidDate=20061130>

- R-78. Legislation Division of Attorney General's Chambers of Singapore. Parks and Trees (Preservation of Trees) Order. 1998.
<https://sso.agc.gov.sg/SL/PTA2005-OR1?DocDate=20171117>
- R-79. Singapore Standards SS602:2014 Code of Practice for Noise Control on Construction and Demolition Sites. 2014.
- R-80. Department for Environment Food and Rural Affairs, 2011, Biodiversity 2020: A strategy for England's wildlife and ecosystem services
- R-81. IUCN. (2012) Red List of Threatened Species: Version 2011.2.
- R-82. Hong Kong Environmental Protection Department. Environmental Impact Assessment Ordinance - Technical Memorandum. 2011.
<https://www.epd.gov.hk/eia/english/legis/index3.html>
- R-83. Legislation Division of Attorney General's Chambers of Singapore. Environmental Protection and Management Act. 2020.
<https://sso.agc.gov.sg/Act/EPMA1999>
- R-84. Legislation Division of Attorney General's Chambers of Singapore. Environmental Protection and Management (Trade Effluent) Regulations. 2008.
<https://sso.agc.gov.sg/SL/EPMA1999-RG5>
- R-85. Legislation Division of Attorney General's Chambers of Singapore. Sewerage and Drainage Act (Chapter 294). 2001.
<https://sso.agc.gov.sg/Act/SDA1999>
- R-86. Legislation Division of Attorney General's Chambers of Singapore. Sewerage and Drainage (Surface Water Drainage) Regulations. 2007.
<https://sso.agc.gov.sg/SL/SDA1999-RG4?DocDate=20070515>
- R-87. JTC Corporation. Guideline on Environmental Baseline Study. 2015.
<https://www.jtc.gov.sg/documents/EBSGuidelines.pdf>
- R-88. Soil Remediation Circular 2013
<http://enviroeng.eu/wp-content/uploads/2022/01/LISTA-HOLANDESA-2013.pdf>
- R-89. Soil Remediation Circular 2013
- R-90. WHO Regional Office for Europe Technical Report. Review of evidence on health aspects of air pollution – REVIHAAP. 2013.
https://www.euro.who.int/_data/assets/pdf_file/0004/193108/REVIHAAP-Final-technical-report-final-version.pdf
- R-91. Singapore EV Landscape. Evreporter.com 2022.
https://evreporter.com/wp-content/uploads/2022/10/Singapore-EV-Landscape_2022_EVreporter.pdf
- R-92. AECOM. Contract C2005 Environmental Impact Study (Turf City and Holland Plan). 2022.

14.2 Websites

- W-1. Public Utilities Board (PUB). Water from Local Catchment
<https://www.pub.gov.sg/Public/WaterLoop/OurWaterStory/Local-Catchment-Water>
- W-2. National Environment Agency (NEA). Construction Noise Control. 2020.
<https://www.nea.gov.sg/our-services/pollution-control/noise-pollution/construction-noise-control>
- W-3. Fatal Lights Out Program (n.d.)

- <https://flap.org/stop-birds-from-hitting-windows/>. Accessed on 12 July 2021.
- W-4. Meteorological Service Singapore (MSS). Climate of Singapore
<http://www.weather.gov.sg/climate-climate-of-singapore>
- W-5. Meteorological Service Singapore (MSS). 2022 Climate and Weather: The Year in Review
<http://www.weather.gov.sg/wp-content/uploads/2023/01/The-Year-in-Review-2022.pdf>
- W-6. Meteorological Service Singapore (MSS). Past Climate Trends
<http://www.weather.gov.sg/climate-past-climate-trends/>
- W-7. Meteorological Service Singapore (MSS). Annual Climate Assessment Report 2021
<http://www.weather.gov.sg/wp-content/uploads/2021/03/Annual-Climate-Assessment-Report-2020-updated-3.pdf>
- W-8. Government of Singapore. Pollutant Standards Index (PSI) Dataset.
<https://data.gov.sg/dataset/psi>
- W-9. Meteorological Service Singapore. Historical Daily Record.
<http://www.weather.gov.sg/climate-historical-daily/>
- W-10. DieselNet. EU Emission Standards. April 2019.
<https://dieselnet.com/standards/eu/ld.php>
- W-11. Air Pollution Information System. NOx: Lichens (general). August 2011.
<http://www.apis.ac.uk/node/1071>
- W-12. Rentokil. Rat Problem in Singapore: Is the Situation Getting Real? 2016
<https://www.rentokil.com.sg/news/2016/07/07/rat-problem-in-singapore-is-the-situation-getting-real.html>
- W-13. National Environment Agency (NEA). Rodent Control. 2020.
<https://www.nea.gov.sg/our-services/pest-control/rodent-control>
- W-14. National Environment Agency (NEA). Mosquito Control in Construction Sites. 2020.
<https://www.nea.gov.sg/our-services/pest-control/mosquito-control/mosquito-control-in-construction-sites>
- W-15. National Environment Agency (NEA). Mosquito Control. 2020.
<https://www.nea.gov.sg/our-services/pest-control/mosquito-control>
- W-16. NEA Code of Practice for Vector Control Operator, Technician and Worker. 2020.
<https://www.nea.gov.sg/docs/default-source/default-document-library/code-of-practice-for-vector-control-operator-technician-and-workerc389567ff0204788b175a24fa36085a8.pdf>
- W-17. NEA Areas with Higher Aedes aegypti Mosquito Population (One Map). 2021.
<https://www.nea.gov.sg/dengue-zika/Aedes>
- W-18. NEA Dengue Clusters (One Map). 2021.
<https://www.nea.gov.sg/dengue-zika/dengue/dengue-clusters>
- W-19. National Environment Agency (NEA). Singapore's Water Quality Guidelines for Recreational Beaches. 2021.
<https://www.nea.gov.sg/our-services/pollution-control/water-quality/recreational-beaches>
- W-20. National Parks Board (2022) Species List (Red Data Book List).
<https://www.nparks.gov.sg/biodiversity/wildlife-in-singapore/species-list/>.
- W-21. National University of Singapore Libraries (2020) Historical Maps of Singapore. Historical maps of 1943 through 2010.

- <https://libmaps.nus.edu.sg/>.
- W-22. Land Authority (2015) Height Datum & Height Determination using GNSS in Singapore.
https://fig.net/resources/proceedings/2015/2015_07_vrfp_comm5/5A_Khoo_Singapore_Height_Datum.pdf
- W-23. Tan B (2019) Singapore Turf Club. Singapore infopedia.
- W-24. Lee Kong Chian Natural History Museum (2023) Biodiversity of Singapore.
<https://singapore.biodiversity.online>
- W-25. National Parks Board (2023) Flora and Fauna Web.
<https://www.nparks.gov.sg/florafaunaweb/>
- W-26. iNaturalist (2023) iNaturalist
<https://www.inaturalist.org/>
- W-27. National University of Singapore Lee Kong Chian Natural History Museum (2023) Singapore Biodiversity Records Archives.
<https://lkcnhm.nus.edu.sg/publications/nature-in-singapore/singapore-biodiversity-records-archives/>
- W-28. Royal Botanic Gardens, Kew (2023) Plants of the World Online.
<https://powo.science.kew.org/>
- W-29. Flora and Fauna Web. (2022).
- W-30. <https://www.nparks.gov.sg/florafaunaweb/fauna/2/7/270>
- W-31. International (2022) Species factsheet: *Belocercus longicaudus*.
- W-32. <http://www.birdlife.org>
- W-33. Hsieh TC, Ma KH & Chao A (2021) Package 'iNEXT'.
<https://cran.r-project.org/web/packages/iNEXT/iNEXT.pdf>
- W-34. USEPA. Aquatic Life Criteria – Aluminium.
<https://www.epa.gov/wqc/aquatic-life-criteria-aluminum>
- W-35. The Watershed Center (2018). What's that orange gooey stringy stuff on the bottom of the creek?
<https://watershed.center/2018/04/04/whats-that-orange-gooey-stringy-stuff-on-the-bottom-of-the-creek/>
- W-36. Total Organic Carbon in Drinking Water.
http://www.apolloinstruments.fr/AutoFiles/doc/5012_AN_EN-03001_TOC_in_Drinking_water%5b1%5d.pdf
- W-37. National Environmental Agency. Singapore's Water Quality Guidelines for Popular Recreational Beaches.
<https://www.nea.gov.sg/our-services/pollution-control/water-quality/recreational-beaches>
- W-38. National Environment Agency (NEA). Reducing Pollution From In-Use Vehicles To Achieve Better Air Quality. 2017.
<https://www.nea.gov.sg/media/news/news/reducing-pollution-from-in-use-vehicles-to-achieve-better-air-quality>
- W-39. Land Transport Authority (LTA). Industries & Innovations, Technologies, Electric Vehicles, Our EV Vision.
https://www.lta.gov.sg/content/ltagov/en/industry_innovations/technologies/electric_vehicles/our_ev_vision.html
- W-40. Land Transport Authority (LTA). Joint News Release by the Land Transport Authority (LTA) & NEA - Sustained Government Support to Encourage Vehicle Electrification. 21 Sep 2023.
https://www.lta.gov.sg/content/ltagov/en/newsroom/2023/9/news-releases/sustained_govt_support_to_encourage_vehicle_electrification.html
- W-41. Iron and Manganese in Groundwater.

<https://www.rdn.bc.ca/cms/wpattachments/wplD2284atID3808.pdf>

14.3 Publications

- P-1. Yee ATK, Corlett RT, Liew SC, Tan HTW (2011) The vegetation of Singapore—an updated map. *Gardens' Bulletin Singapore*, 63(1 & 2): 205–212.
- P-2. Chong KY, Tan HT, & Corlett RT (2009) A checklist of the total vascular plant flora of Singapore: native, naturalised and cultivated species. Raffles Museum of Biodiversity Research, Singapore.
- P-3. Baker N and Lim KKP (2012) *Wild Animals of Singapore: A Photographic Guide to Mammals, Reptiles, Amphibians and Freshwater Fishes* (2nd edition). Draco Pub and Distribution, Singapore.
- P-4. Khew SK (2015) *A Field Guide to the Butterflies of Singapore* (2nd edition). Ink Communications Pte Ltd, Singapore.
- P-5. Kaiser, K., Scofield, D.G., Alloush, M., Jones, R. M., Marczak, S., Martineau, K., Olivia, M. A. & Narins, P. M. (2011). When sounds collide: the effect of anthropogenic noise on a breeding assemblage of frogs in Belize, Central America. *Behaviour*, 148(2), 215-232.
- P-6. Arévalo, J. E., & Newhard, K. (2011). Traffic noise affects forest bird species in a protected tropical forest. *Revista de Biología Tropical*, 59(2), 969-980.
- P-7. Taylor, C. J. (2009). Hearing in larvae of the monarch butterfly, *Danaus plexippus*, and selected other Lepidoptera (Doctoral dissertation, Carleton University).
- P-8. Fournier, J. P. (2011). If a bird flies in the forest, does anyone hear it?: Avian flight sound cues and hearing in Lepidoptera (Doctoral dissertation, Carleton University).
- P-9. Peng, Z. Zhang, L (2016). A review of research progress in air-to-water sound transmission: http://cpb.iphy.ac.cn/article/2016/1861/cpb_25_12_124306.html
- P-10. Shaw, B. (2018). The Exploration of Neuronal Responses to Auditory Stimuli in the Dragonflies, *Anax junius* and *Aeshna Constricta*.
- P-11. Mancera, K. F., Lisle, A., Allavena, R., & Phillips, C. J. (2017a). The effects of mining machinery noise of different frequencies on the behaviour, faecal corticosterone and tissue morphology of wild mice (*Mus musculus*). *Applied animal behaviour science*, 197, 81-89.
- P-12. Christian, B. C., Jakob, C-D, Christian, B, Peter, T. M (2012). Hearing with an atympanic ear: good vibration and poor sound-pressure detecting in the royal python, *Python regius*. *Journal of Experimental Biology*, 2012 215: 331 – 342; doi: 10.1242/jeb.062539.
- P-13. Gulick WL and Zwick H (2017) Auditory sensitivity of the Turtle. *The psychological record*, 16, pp. 47-53.
- P-14. Voigt, C. C., & Kingston, T. (2016). *Bats in the Anthropocene: conservation of bats in a changing world*. Springer Science+ Business Media.
- P-15. Mancera, K. F., Murray, P. J., Lisle, A., Dupont, C., Faucheux, F., & Phillips, C. J. C. (2017b). The effects of acute exposure to mining machinery noise on the behaviour of eastern blue-tongued lizards (*Tiliqua scincoides*). *Animal Welfare*, 26(1), 11-24
- P-16. A review of crustacean sensitivity to high amplitude underwater noise: Data needs for effective risk assessment in relation to UK commercial species, *Marine Pollution Bulletin*, Volume 108, Issues 1–2, 2016, Pages 5-11, ISSN 0025-326X, <https://doi.org/10.1016/j.marpolbul.2016.05.006>
- P-17. Corlett RT (1997) The vegetation in nature reserves of Singapore. *Gardens' Bulletin Singapore*, 49: 147–159.
- P-18. Lok AFSL, Ang WF, Ng BYQ, Leong TM, Yeo CK, & Tan HT (2013) Native fig species as a keystone resource for the Singapore urban environment. Singapore: Raffles Museum of Biodiversity Research, National University of Singapore.

- P-19. Yang S, Lim RLF, Sheue C-R & Yong JWH (2013) The current status of mangrove forests in Singapore. *Proceedings of Nature Society, Singapore's Conference on 'Nature Conservation for a Sustainable Singapore'*, 19–120.
- P-20. Sheppard C, Phillips G, Law A, & Parr M (2015) Bird-friendly building design. *American Bird Conservancy*.
- P-21. Didham RK (1997) An overview of invertebrate responses to forest fragmentation. *Forests and insects*, 303-320.
- P-22. Laurance WF and Bierregaard RO (1997) *Tropical forest remnants: ecology, management, and conservation of fragmented communities*. University of Chicago Press, Chicago.
- P-23. Paton PW (1994) The effect of edge on avian nest success: how strong is the evidence?. *Conservation biology*, 8(1), 17-26.
- P-24. Murcia C (1995) Edge effects in fragmented forests: implications for conservation. *Trends in Ecology & Evolution*, 10(2): 58–62.
- P-25. Jusuf, S. K., Wong N.H., Hagen E., Anggoro, R., & Hong, Y. (2007). The influence of land use on the urban heat island in Singapore. *Habitat International*, 31, 232-242.
- P-26. Wong, NY & Yu, C (2005). Study of green areas and urban heat island in a tropical city. *Habitat International*, 29, 547-558
- P-27. Ho JK, Ramchunder SJ, Memory A, Theng M, Li T, Clews E, Cai Y, Tan HH, & Yeo DC (2016) *A Guide to the Freshwater Fauna of Nee Soon Swamp Forest*. Lee Kong Chian Natural History Museum & Tropical Marine Science Institute, National University of Singapore.
- P-28. Farmer, A. (1993). The effects of dust on vegetation--a review. *Environmental Pollution*, 79(1), 63-75. Retrieved from [https://doi.org/10.1016/0269-7491\(93\)90179-R](https://doi.org/10.1016/0269-7491(93)90179-R)
- P-29. Qin, K. (2015). Birds suffer from air pollution, just like we do. Retrieved from California: <https://ca.audubon.org/news/birds-suffer-air-pollution-just-we-do>
- P-30. Voigt C, Azam C, Dekker J, Ferguson J (2018) Guidelines for Considerations of Bats in Lighting Projects, 9, 153-158
- P-31. Bat Conservation Trust (2018). Bats and Artificial Lighting in the UK, 19(3), 451-454. Retrieved from: <https://theilp.org.uk/publication/guidance-note-8-bats-and-artificial-lighting/>
- P-32. Cannon CH & Leighton M (1994) Comparative locomotor ecology of gibbons and macaques: selection of canopy elements for crossing gaps. *Am J Phys Anthropol* 93:505–524.
- P-33. Cant JG (1988) Positional behavior of long-tailed macaques (*Macaca fascicularis*) in northern Sumatra. *American Journal of Physical Anthropology*, 76(1), 29-37.
- P-34. Jones-Engel L, Riley CM, Gumert MD & Fuentes A (2011) *Monkeys on the Edge: Ecology and Management of Long-Tailed Macaques and Their Interface with Humans*.
- P-35. Bayne, E. M., L. Habib and S. Boutin. 2008. Impacts of chronic anthropogenic noise from energy-sector activity on abundance of songbirds in the boreal forest. *Conservation Biology*, Vol. 22, Issue 5, pp. 1186-1193.
- P-36. National Agroforestry Centre, Biodiversity Conservation Buffer Guidelines, Corridor Widths Section 2.9. Retrieve from: https://www.fs.usda.gov/nac/buffers/guidelines/2_biodiversity/9.html
- P-37. Matlack, G. 1993. Microenvironment variation within and among forest edge sites in the eastern United States. *Biological Conservation* 66:185-194
- P-38. Wenger, S. 1999. A Review of the Scientific Literature on Riparian Buffer Width, Extent and Vegetation. Office of Public Service and Outreach, Institute of Ecology, University of Georgia.
- P-39. Brothers, T., and A. Spingarn. 1992. Forest fragmentation and alien plant invasion of central Indiana old-growth forests. *Conservation Biology* 6(1):91-100.
- P-40. Burke, D.M. and E. Nol. 1998. Edge and fragment size effects on the vegetation of deciduous forests in Ontario, Canada. *NaturalAreas Journal*, Vol. 18, Issue 1, pp. 45-53.

- P-41. Azam, C., Le Viol, I., Bas, Y., Zissis, G., Vernet, A., Julien, J.-F., & Kerbiriou, C. (2018). Evidence for distance and illuminance thresholds in the effects of artificial lighting on bat activity. *Landscape and Urban Planning*, 175, 123–135. doi:10.1016/j.landurbplan.2018.02.011
- P-42. Johnson, A. W. and D. M. Ryba. 1992. A literature review of recommended buffer widths to maintain various functions of stream riparian areas. King County Surface Water Management Division, Seattle, Washington.
- P-43. Murnihv. M. L. 1995. Forestry impacts on freshwater habitat of anadromous salmonids in the Pacific Northwest and Alaska: Requirements for protection and restoration. NOAA Coastal Ocean Programme decision analysis series Number 1. U.S. Department of Commerce. National Oceanic and Atmospheric Administration. National Marine Fisheries Service. Coastal Ocean Program. Juneau, Alaska.
- P-44. Paton, P. 1994. The effect of edge on avian nest success: How strong is the evidence? *Conservation Biology* 8:17-26.
- P-45. Groffman, P., A. Gold, T. Husband, R. Simmons, and W. Eddleman. 1990. An investigation into multiple uses of vegetated buffer strips. Publication No. NBP-90-44. Dept. of Nat. Res. Sci., University of Rhode Island, Kingston, RI.
- P-46. Houlahan J. E. and C. S. Findlay. 2003. The effects of adjacent land use on wetland amphibian species richness and community composition. *Can. J. Fish. Aquat. Sci.*, Vol. 60, pp. 1078-1094.
- P-47. Forman, R. T. T. and R. D. Deblinger. 2000. The ecological road-effect zone of Massachusetts (USA) suburban highway. *Conservation Biology*, Vol. 14, Issue 1, pp 36-49
- P-48. The Environmental Law Institute (2003). Conservation thresholds for land use planners.
- P-49. Beschta, R.L., R.E. Bilby, G.W. Brown, L.B. Holtby, and T.D. Hofstra. 1987. Stream temperature and aquatic habitat: Fisheries and forestry interactions. pages 191-232, in E.O. Salo and T.W. Cundy, eds. *Streamside management: Forestry and Fishery Interactions*. University of Washington, Seattle, WA.
- P-50. PUB (2018) Active, Beautiful, Clean Waters Design Guidelines (4th Edition).
https://info.pub.gov.sg/Documents/ABC_Waters_Design_Guidelines.pdf
- P-51. Chong KY, Tan HT, & Corlett RT (2009) A checklist of the total vascular plant flora of Singapore: native, naturalised and cultivated species. Raffles Museum of Biodiversity Research, Singapore.
- P-52. Lindsay S et al, (2022) Flora of Singapore: Checklist and bibliography. *Gardens' Bulletin Singapore*, 74 (Supplement 1): 3–860.
- P-53. Royal Botanic Gardens Kew (2023b) Plants of the World Online.
<https://powo.science.kew.org/>
- P-54. Global Biodiversity Information Facility (GBIF) (2023) World Checklist of Selected Plant Families.
<https://www.gbif.org/dataset/d43f62e9-d697-41c5-ba9d-0328d7b4571c>
- P-55. Ascher JS, Soh ZWW, Chui SX, Soh EJY, Ho BM, Lee JXQ, Gajanur AR and Ong AR (2022). The bees of Singapore (Hymenoptera: Apoidea: Anthophila): First comprehensive country checklist and conservation assessment for a Southeast Asian bee faunal. *Raffles Bulletin of Zoology* 70: 39–64.
- P-56. Ngiam RWJ & Davison GWH (2011) A checklist of dragonflies in Singapore parks (Odonata: Anisoptera, Zygoptera). *Nature in Singapore*, 4: 349–353.
- P-57. Jain A, Khew SK, Gan CW & Webb EL (2018) Butterfly extirpations, discoveries and rediscoveries in Singapore over 28 years. *Raffles Bulletin of Zoology*, 66: 217–257.
- P-58. Khew SK (2015) A Field Guide to the Butterflies of Singapore (2nd edition). Ink Communications Pte Ltd, Singapore.
- P-59. Ng PKL (1997) The conservation status of freshwater prawns and crabs in Singapore with emphasis on the nature reserves. *Gardens' Bulletin Singapore*, 49: 267–272.
- P-60. Cai Y, Ng PKL & Choy S (2007) Freshwater shrimps of the family Atyidae (Crustacea: Decapoda: Caridea) from Peninsular Malaysia and Singapore. *Raffles Bulletin of Zoology*, 55: 277–309.
- P-61. Kottelat M (2013) The fishes of the inland waters of southeast Asia: a catalogue and core bibliography of the fishes known to occur in freshwaters, mangroves and estuaries. *Raffles Bulletin of Zoology*.

- P-62. Suzuki T, Shibukawa K, Senou H, Chen I-S (2015) [issued 2016] Redescription of *Rhinogobius similis* Gill 1859 (Gobiidae: Gobionellinae), the type species of the genus *Rhinogobius* Gill 1859, with designation of the neotype. *Ichthyological Research*, 63: 227–238.
- P-63. Ho JK, Ramchunder SJ, Memory A, Theng M, Li T, Clews E, Cai Y, Tan HH, & Yeo DC (2016) A Guide to the Freshwater Fauna of Nee Soon Swamp Forest. Lee Kong Chian Natural History Museum & Tropical Marine Science Institute, National University of Singapore.
- P-64. Tan SK, Chan SY & Clements GR (2012) A guide to snails and other non-marine molluscs of Singapore. Science Centre, Singapore. 176 pp.
- P-65. Gill F & Donsker D (2022) IOC World Bird List (V12.1).
[Http://www.worldbirdnames.org](http://www.worldbirdnames.org)
- P-66. Davison G H, Ng PKL, Chew HH (2008) The Singapore Red Book: Threatened plants and animals of Singapore. Nature Society (Singapore), Singapore. 285 pp.
- P-67. Yee ATK, Chong KY, Neo L & Tan HT (2016) Updating the classification system for the secondary forests of Singapore. *Raffles Bulletin of Zoology*.
- P-68. National Heritage Board (2018) Bukit Timah Heritage Trail: A Companion Guide. National Heritage Board.
- P-69. Nor ANM, Corstanje R, Harris JA, Grafius DR & Siriwardena GM (2017) Ecological connectivity networks in rapidly expanding cities. *Heliyon*, 3(6), e00325.
- P-70. Ng PKL, Corlett R and Hugh TW Tan (2011). Singapore Biodiversity: An Encyclopedia of the Natural Environment and Sustainable Development. Raffles Museum of Biodiversity Research, National University of Singapore.
- P-71. Koh JK, Court DJ, Ang CSP & Ng PYC (2022) A Photographic Guide to Singapore Spiders. National Parks Board.
- P-72. Lim KS (2009) The avifauna of Singapore. Nature Society (Singapore), Singapore.
- P-73. Pottie SA, Lane DJW, Kingston T, and Lee BPY-H (2005) The microchiropteran bat fauna of Singapore. *Acta Chiropterologica*, 7(2): 237–247.
- P-74. Collen AL (2012) The evolution of echolocation in bats: a comparative approach (Doctoral dissertation, UCL (University College London)).
- P-75. Hughes AC, Satasook C, Bates PJ, Soisook P, Sritongchuay T, Jones G & Bumrungsri S (2011) Using echolocation calls to identify Thai bat species: Vespertilionidae, Emballonuridae, Nycteridae and Megadermatidae. *Acta Chiropterologica*, 13(2), 447–455.
- P-76. Chao A & Jost L (2012) Coverage-based rarefaction and extrapolation: standardizing samples by completeness rather than size. *Ecology*, 93(12): 2533–2547.
- P-77. Hsieh TC, Ma KH & Chao A (2019) iNEXT: Interpolation and extrapolation for species diversity. R Package Version 2.0.19. <https://cran.r-project.org/web/packages/iNEXT/iNEXT.pdf>.
- P-78. Chao A (1987) Estimating the population size for capture-recapture data with unequal catchability. *Biometrics*, 43: 783–791.
- P-79. Chao A & Jost L (2012) Coverage-based rarefaction and extrapolation: standardizing samples by completeness rather than size. *Ecology*, 93(12): 2533–2547.
- P-80. Oksanen J, Blanchet FG, Friendly M, Kindt R, Legendre P, McGlinn D, Minchin PR, O'Hara RB, Simpson GL, Solymos P, Stevens MHH, Szoecs E & Wagner H (2019) vegan: Community Ecology Package. R Package Version 2.5-6. <https://cran.r-project.org/web/packages/vegan/vegan.pdf>
- P-81. Centers for Disease Control and Prevention (CDC), Arsenic (2009) https://www.cdc.gov/biomonitoring/pdf/arsenic_factsheet.pdf
- P-82. Ascher JS & Pickering J (2018) Discover Life bee species guide and world checklist (Hymenoptera: Apoidea: Anthophila).
- P-83. Ascher JS & Pickering J (2018) Discover Life bee species guide and world checklist (Hymenoptera: Apoidea: Anthophila).

- P-84. Baker N and Lim KKP (2012) Wild Animals of Singapore: A Photographic Guide to Mammals, Reptiles, Amphibians and Freshwater Fishes (2nd edition). Draco Pub and Distribution, Singapore.
- P-85. Black, S. H., M. Sheperd, M. Vaughan, C. LaBar & Hodges N. (2009). Pollination Conservation Strategy. Yolo Natural Heritage Program, The Xerces Society, Sacramento, California.
- P-86. Blakely TJ, Eikaas HS & Harding J (2014) The Singapore: a macro invertebrate biotic index for assessing the health of Singapore's streams and canals. Raffles Bulletin of Zoology 62: 540–548.
- P-87. Blakely TJ, Eikaas, HS & Harding J (2014) The Singscore: A macroinvertebrate biotic index for assessing the health of Singapore's streams and canals. The Raffles bulletin of zoology. 62. 540-548.
- P-88. Bromley, J. (2019). Sighting of Sunda colugos at Wessex Estat
- P-89. Brook BW, Sodhi NS & Ng PK (2003) Catastrophic extinctions follow deforestation in Singapore. Nature, 424(6947): 420-426.
- P-90. Cai Y, Ng PKL & Choy S (2007) Freshwater shrimps of the family Atyidae (Crustacea: Decapoda: Caridea) from Peninsular Malaysia and Singapore. Raffles Bulletin of Zoology, 55: 277–309.
- P-91. Chong KY, Tan HT, & Corlett RT (2009) A checklist of the total vascular plant flora of Singapore: native, naturalised and cultivated species. Raffles Museum of Biodiversity Research, Singapore.
- P-92. Chua MAH & Lim KKP (2011) Mammals: A – Z entries. In: Ng PKL, Corlett RT & Tan HTW (eds.) Singapore Biodiversity: An Encyclopedia of the Natural Environment and Sustainable Development. Editions Didier Millet (Singapore), pp. 552.
- P-93. Collar N, Sharpe CJ & Boesman P (2020) Long-tailed Parakeet (*Psittacula longicauda*). In: del
- P-94. Collen, A. L. (2012). The evolution of echolocation in bats: a comparative approach (Doctoral dissertation, UCL (University College London)).
- P-95. Corlett RT (1992) The ecological transformation of Singapore. Journal of Biogeography, 19: 411–420. P-42.
- P-96. Davison GWH, Ng PKL & Ho HC (2008) The Singapore Red Data Book: Threatened Plants and Animals of Singapore. 2nd edition. Nature Society (Singapore), Singapore.
- P-97. Gaw LY-F, Yee ATK & Richards DR (2019) A high-resolution map of Singapore's terrestrial ecosystems. Data, 4(3):116.
- P-98. Giam XL, Ng TH, Lok AFS & Ng HH (2011) Local geographic range predicts freshwater fish extinctions in Singapore. Journal of Applied Ecology, 48(2): 356-363.
- P-99. Ho JK, Ramchunder SJ, Memory A, Theng M, Li T, Clews E, Cai Y, Tan HH, & Yeo DC (2016) A Guide to the Freshwater Fauna of Nee Soon Swamp Forest. Lee Kong Chian Natural History Museum & Tropical Marine Science Institute, National University of Singapore.
- P-100. Ho BC, Lua HK, Bazilah Ibrahim, Yeo RSW, Athen P, Leong PKF, Ali Ibrahim, Koh SL, Hassan Ibrahim, Lindsay S, Chin LL, Seah WW & Middleton DJ (2019). The plant diversity in Bukit Timah Nature Reserve, Singapore. Gardens' Bulletin Singapore, 71: 41–134.
- P-101. Hughes, A. C., Satasook, C., Bates, P. J., Soisook, P., Sritongchuay, T., Jones, G., & Bumrungsri, S. (2011). Using echolocation calls to identify Thai bat species: Vespertilionidae, Emballonuridae, Nycteridae and Megadermatidae. Acta Chiropterologica, 13(2), 447-455.
- P-102. Hung SMX, Chong KY, Yee ATK, Lim RCJ, Loh JW, Neo L, Seah WW, Tan SY & Tan HTW (2017). The vascular plant flora and vegetation of the islands associated with Singapore's first Marine Park (III): St. John's Island. Nature in Singapore, 10: 37–48.

- P-103. Hypericaceae with comments on the Kiehmeyeroideae (Clusiaceae). *Thai Forest Bulletin (Botany)*, 46(2):162–216. <https://doi.org/10.20531/tfb.2018.46.2.08>
- P-104. Jain A, Khew SK, Cheong WG & Webb EL (2018) Butterfly extirpations, discoveries and rediscoveries in Singapore over 28 years. *Raffles Bulletin of Zoology*, 66: 217–257.
- P-105. Khew SK (2015) *A Field Guide to the Butterflies of Singapore* (2nd edition). Ink Communications Pte Ltd, Singapore.
- P-106. Khew, S. K., & Tan, H. (2019). Butterflies of the Bukit Timah Nature Reserve, Singapore, and its vicinity. *Gard. Bull. Singapore*, 71(Suppl 1), 273-292.
- P-107. Koh, L. P., & Sodhi, N. S. (2004). Importance of reserves, fragments, and parks for butterfly conservation in a tropical urban landscape. *Ecological Applications*, 14(6), 1695-1708.
- P-108. Kottelat M (2013) The fishes of the inland waters of Southeast Asia. A catalogue and core bibliography of the fishes known to occur in freshwaters, mangroves and estuaries. *Raffles Bulletin of Zoology*, Supplement 27: 1–663.
- P-109. Lam WN, Loh JW, Chong R, Ting YY, Chan PJ, Rahman NE and Chong KY (2022). Towards a field guide to the trees of the Nee Soon Swamp Forest (VIII): Phyllanthaceae. *Nature in Singapore*.
- P-110. Lane DJW, Kingston T & Lee BPYH (2006) Dramatic decline in bat species richness in Singapore, with implications for Southeast Asia. *Biological Conservation*, 131: 584–593.
- P-111. Lim, K. S. and Yong, D. L. (2011) Recent trends of nationally threatened birds in Singapore. In Leong, T. M. and Ho, H. C., eds. *Proceedings of Nature Society Singapore's Conference on 'Nature Conservation for a Sustainable Singapore'*. Singapore: Nature Society (Singapore)
- P-112. Lim, N.T-L., 2007. *Colugo: The Flying Lemur of South-east Asia*. Draco Publishing, Singapore.
- P-113. Liow LH, Sodhi NS & Elmqvist T (2001) Bee diversity along a disturbance gradient in tropical lowland forests of south-east Asia. *Journal of Applied Ecology*, 180-192.
- P-114. National Heritage Board (2018) *Bukit Timah Heritage Trail: A Companion Guide*. National Heritage Board.
- P-115. NSS. (2021). *NSS Report on the Turf City 'Ravine' Forest: An Overview*.
- P-116. Neo L, Yee ATK, Chong KY, Kee CY & Tan HTW (2013). The vascular plant flora of Admiralty Forest, Singapore. *Nature in Singapore*, 6: 61–72.
- P-117. Ng H. H., B. W. Low, J. T. B. Kwik & D. C. J. Yeo, 2014. The tables are turned: an invasive species under threat. *Biological Invasions*. DOI: 10.1007/s10530-013-0618-5
- P-118. Ngiam RWJ & Cheong LF (2016) The dragonflies of Singapore: an updated checklist and revision of the national conservation statuses. *Nature in Singapore*, 9: 149–163.
- P-119. Ng PKL (1997) The conservation status of freshwater prawns and crabs in Singapore with emphasis on the nature reserves. *Gardens' Bulletin Singapore*, 49: 267–272.
- P-120. Ng PKL & Lim KKP (1997) The diversity and conservation status of fishes in the nature reserves of Singapore. *Gardens' Bulletin Singapore*, 49(2): 245–265.
- P-121. Ng PKL, Corlett R and Hugh TW Tan (2011). *Singapore Biodiversity: An Encyclopedia of the Natural Environment and Sustainable Development*. Raffles Museum of Biodiversity Research, National University of Singapore.

- P-122. Nor ANM, Corstanje R, Harris JA, Grafius DR & Siriwardena GM (2017) Ecological connectivity networks in rapidly expanding cities. *Heliyon*, 3(6), e00325.
- P-123. Piggott AG (1996). *Ferns of Malaysia in Colour*. Tropical Press 1988. 458 pp.
- P-124. Pottie SA, Lane DJW, Kingston T, and Lee BPY-H (2005) The microchiropteran bat fauna of Singapore. *Acta Chiropterologica*, 7(2): 237–247.
- P-125. Pyšek, P, DM Richardson, M Rejmánek, GL Webster, M Williamson & J Kirschner (2004) Alien plants in checklists and floras: towards better communication between taxonomists and ecologists. *Taxon*, 53 (1): 131–143.
- P-126. Senze M, Kowalska-Górska M, Czyż K (2021) Availability of aluminium in river water suppling dam reservoirs in Lower Silesia considering the hydrochemical conditions, *Environmental Nanotechnology, Monitoring & Management*, vol. 16. <https://doi.org/10.1016/j.enmm.2021.100535>
- P-127. Soh ZWW & Ascher JS (2020) *A Guide to the Bees of Singapore*. National Parks Board, Singapore.
- P-128. Soh ZWW & Ngiam RWJ (2013) Flower-visiting bees and wasps in Singapore Parks (Insecta: Hymenoptera). *Nat. Singapore* 6: 153–172.
- P-129. Soh M, Ng M & Ngiam RWJ (2019) New Singapore record of a dragonfly, *Indothemis carnatica* with an updated Singapore Odonata checklist. *Singapore Biodiversity Records*, 2019: 10–17.
- P-130. Souza, Rodrigo & De Marco Júnior, Paulo. (2014). The use of species distribution models to predict the spatial distribution of deforestation in the western Brazilian Amazon. *Ecological Modelling*. 291. 250–259. [10.1016/j.ecolmodel.2014.07.007](https://doi.org/10.1016/j.ecolmodel.2014.07.007).
- P-131. Suwanphakdee C, Simpson DA, Hodgkinson TR, & Chantaranonthai P (2018) Typification of *Piper* species (Piperaceae) in Southeast Asia, especially Thailand. *Kew Bulletin*, 73(3): 1–18. <http://www.jstor.org/stable/44989912>
- P-132. Suwanphakdee C & Chantaranonthai P (2008). A Further Note on the Genus *Piper* L. (Piperaceae) from Thailand. *The Natural History Journal of Chulalongkorn University*, 8(2):205-209.
- P-133. Suzuki T, Shibukawa K, Senou H, Chen I-S (2015) [issued 2016] Redescription of *Rhinogobius similis* Gill 1859 (Gobiidae: Gobionellinae), the type species of the genus *Rhinogobius* Gill 1859, with designation of the neotype. *Ichthyological Research*, 63: 227–238.
- P-134. Tan HH, Lim KKP, Liew JH, Low BW, Lim RBH, Kwik JTB & Yeo DCJ (2020) The non-native freshwater fishes of Singapore: an annotated compilation. *Raffles Bulletin of Zoology*, 68: 150–195.
- P-135. Tan, M. K., Yeo, H., & Lee, J. X. (2015). Diversity of entomofauna (Orthoptera, Reduviidae and Aculeata) in the Mandai-Lake Road area, Singapore. *Nature in Singapore*, 8, 37-51.
- P-136. Tang HB, Wang LK & Hämäläinen M (2010) *A Photographic Guide to the Dragonflies of Singapore*. Raffles Museum of Biodiversity Research, National University of Singapore.
- P-137. Tan Sy, Chong KY, Neo L, Koh CY, Lim RCJ, Loh JW, Ng WQ, Seah WW, Yee ATK & Tan HTW (2016) Towards a field guide to the trees of the Nee Soon Swamp Forest (IC): *Xanthophyllum* (Polygalaceae). *Nature in Singapore*, 9: 139–147.
- P-138. Teo RCH & Rajathurai S (1997) Mammals, reptiles and amphibians in the nature reserves of Singapore – diversity, abundance and distribution. *The Gardens' Bulletin Singapore*, 49(4): 353–425.
- P-139. Theng M, Jusoh WFA, Jain A, Huertas B, Tan DJX, Tan HZ, Kristensen NP, Meier R & Chisholm RA (2020) A comprehensive assessment of diversity loss in a well-documented tropical insect fauna: almost half of Singapore's butterfly species extirpated in 160 years. *Biological Conservation*, 242(108401).

- P-140. Tyler RH, Boyer TP, Minami T, Zweng MM & Reagan JR (2017) Electrical conductivity of the global ocean. *Earth, Planets and Space* 69: 156.
- <https://earth-planets-space.springeropen.com/articles/10.1186/s40623-017-0739-7>
- P-141. Wowor D & Ng PKL (2010) On two new genera of Asian prawns previously assigned to *Macrobrachium* (Crustacea: Decapoda: Caridea: Palaemonidae). *Zootaxa*, 2372, 37–52.
- P-142. Yam TW & Thame A (2005). Conservation and reintroduction of the native orchids of Singapore. *Selbyana*, 75–80.
- P-143. Yap, Francis & Yong, D. L., Low, W. B., Cros, E., Foley, C., Lim, K. K. & Rheindt, E. F. (2014). “First wintering record of the Sakhalin Leaf Warbler.” *Phylloscopus borealoides* in South- East Asia, with notes on vocalisations. *BirdingAsia*. 21. 76-81.
- P-144. Yee ATK, Chong KY, Neo L & Tan HT (2016) Updating the classification system for the secondary forests of Singapore. *Raffles Bulletin of Zoology*.
- P-145. Yee ATK, Corlett RT, Liew SC & Tan HTW (2011) The vegetation of Singapore—an updated map. *Gardens' Bulletin Singapore*, 63(1 & 2): 205–212.
- P-146. Yee ATK, Chong KY, Seah WW, Lua HK & Yang S (2019) Vegetation of Singapore. *Flora of Singapore* (1): 47-70.
- P-147. Yeo DCJ (2010) Introduced decapod crustaceans in Singapore's reservoirs. *Cosmos* 6(1):85–90.
- P-148. Yong DL, Lim KC and Lee TK (2016) *A Naturalist's Guide to the Birds of Singapore* (2nd edition). John Beaufoy Publishing, United States.
- P-149. Yong, D. L., Lee, B. P. Y. H., Ang, A., & Tan, K. H. (2010). The status on Singapore island of the Eurasian wild pig *Sus scrofa* (Mammalia: Suidae). *Nat Sing*, 3, 227-237.
- P-150. Pawlowicz, R. (2013) Key Physical Variables in the Ocean: Temperature, Salinity, and Density. *Nature Education Knowledge* 4(4):13,
- <https://www.nature.com/scitable/knowledge/library/key-physical-variables-in-the-ocean-temperature-102805293/>
- P-151. Blakely HS, Eikaas HS & Harding J (2014) The Singapore: a macro invertebrate biotic index for assessing the health of Singapore's streams and canals. *Raffles Bulletin of Zoology* 62: 540–548.
- P-152. Chao A. (1987). Estimating the population size for capture-recapture data with unequal catchability. *Biometrics*, 43: 783–791.
- P-153. Chao A. & Jost L. (2012). Coverage-based rarefaction and extrapolation: standardizing samples by completeness rather than size. *Ecology*, 93(12): 2533–2547.
- P-154. Chiu C. H., Wang Y. T., Walther B. A. & Chao A. (2014). An improved nonparametric lower bound of species richness via a modified Good-Turing frequency formula. *Biometrics*, 70: 671–682.
- P-155. Colwell R.K. & Coddington J.A. (1994). Estimating terrestrial biodiversity through extrapolation. *Phil. Trans. Roy. Soc. London*, 345: 101–118.
- P-156. Heish T. C., Ma K. H. & Chao A. (2019) iNEXT: Interpolation and extrapolation for species diversity. R Package Version 2.0.19. <https://cran.r-project.org/web/packages/iNEXT/iNEXT.pdf>
- P-157. Oksanen J., Blanchet F. G., Friendly M., Kindt R., Legendre P., McGlinn D., Minchin P. R., O'Hara R. B., Simpson G. L., Solymos P., Stevens M. H. H., Szoecs E. & Wagner H. (2019) vegan: Community Ecology Package. R Package Version 2.5-6. <https://cran.r-project.org/web/packages/vegan/vegan.pdf>

- P-158. Palmer, M.W. (1990). The estimation of species richness by extrapolation. *Ecology*, 71: 1195–1198.
- P-159. Smith E. P. & van Belle G. (1984). Nonparametric estimation of species richness. *Biometrics*, 40: 119–129.
- P-160. Wee YC & Corlett RT (1986) *The City and the Forest: Plant Life in Urban Singapore*. Singapore University Press, Singapore, 8 + 186 pp.
- P-161. Wong YK, Chew PT & Ali Bin Ibrahim (1994) The tree communities of the Central Catchment Nature Reserve, Singapore. *Gardens' Bulletin*, 46(2): 37–78.
- P-162. Voigt C, Azam C, Dekker J, Ferguson J (2018) Guidelines for Considerations of Bats in Lighting Projects, 9, 153-158
- P-163. Lim NT & Ng PK (2008) Home range, activity cycle and natal den usage of a female Sunda pangolin *Manis javanica* (Mammalia: Pholidota) in Singapore. *Endangered Species Research*, 4(1-2), 233-240.
- P-164. Kennedy C (2003) Conservation thresholds for land use planners. Environmental Law Institute.
- P-165. Diana M, Allan JD & Infante D (2006) The influence of physical habitat and land use on stream fish assemblages in southeastern Michigan. *In American Fisheries Society Symposium* (Vol. 48, pp. 359-374).
- P-166. Hadley CG (2003) AND STREAM BUFFER RECOMMENDATIONS.
- P-167. Luke SH, Slade EM, Gray CL, Annammala KV, Drewer J, Williamson J, ... & Struebig MJ (2019) Riparian buffers in tropical agriculture: Scientific support, effectiveness and directions for policy. *Journal of Applied Ecology*, 56(1), 85-92.
- P-168. Fischer RA & Fischenich JC (2000) Design recommendations for riparian corridors and vegetated buffer strips. Army engineer waterways experiment station vicksburg ms engineer research and development center.
- P-169. G. Le Roux, S.V. Hansson, A. Claustres (2016). Chapter 3 - Inorganic Chemistry in the Mountain Critical Zone: Are the Mountain Water Towers of Contemporary Society Under Threat by Trace Contaminants?. *Developments in Earth Surface Processes*, 21, 131 – 154. <https://doi.org/10.1016/B978-0-444-63787-1.00003-2>
- P-170. Fardiansah, R., Dupérré, N., Widyastuti, R., Potapov, A., Scheu, S., & Harms, D. (2018). Description of three new species of *Aposphragisma* Thoma, 2014 (Araneae: Oonopidae) from Sumatra, Indonesia. *Zookeys*, 797, 71-85. <https://doi.org/10.3897/zookeys.797.29364>
- P-171. Platnick, N.I. & Berniker, L. (2014). The Neotropical Goblin Spiders of the New Genus *Reductoonops* (Araneae, Oonopidae). *American Museum Novitates*, 3811, 1-75. <https://doi.org/10.1206/3811.1>
- P-172. Abbott, J.C.. (2009). Odonata (Dragonflies and Damselflies). 10.1016/B978-012370626-3.00183-6.
- P-173. May M. L. (2019). Odonata: Who They Are and What They Have Done for Us Lately: Classification and Ecosystem Services of Dragonflies. *Insects*, 10(3), 62. <https://doi.org/10.3390/insects10030062>.
- P-174. Macalintal E. A. & Starr C.K. (1996). Comparative morphology of the stinger in the social wasp genus *Ropalidia* (Hymenoptera: Vespidae).
- P-175. Black, S. H., M. Sheperd, M. Vaughan, C. LaBar & N. Hodges, 2009. Pollination Conservation Strategy. Yolo Natural Heritage Program, The Xerces Society, Sacramento, California.
- P-176. Waterhouse, D. F., 1998. Biological Control of Insect Pests: Southeast Asian Prospects. Australian Center for International Agricultural Research, Canberra. 548 pp.
- P-177. Ascher, J. S. & J. Pickering, 2012. Discover Life Bee Species Guide and World Checklist (Hymenoptera: Apoidea:Anthophila). Discover Life. http://www.discoverlife.org/mp/20q?guide=Apoidea_species. (Accessed 28 Dec.2012).

- P-178. deMaynadier, P.G. and Hunter Jr., M.L. (1995) 'The relationship between forest management and Amphibian Ecology: A review of the North American literature', *Environmental Reviews*, 3(3–4), pp. 230–261. doi:10.1139/a95-012.
- P-179. Bickford, David & Howard, Sam & Ng, Daniel & Sheridan, Jennifer. (2010). Impacts of climate change on the amphibians and reptiles of Southeast Asia. *Biodiversity and Conservation*. 19. 1043-1062. 10.1007/s10531-010-9782-4.
- P-180. Valencia-Aguilar, Anyelet & Cortés-Gómez, Angela & Ruiz-Agudelo, Cesar. (2013). Ecosystem services provided by amphibians and reptiles in Neotropical ecosystems. *International Journal of Biodiversity Science*. 9. 10.1080/21513732.2013.821168.
- P-181. Baker, N. & K. K. P. Lim, 2012. *Wild Animals of Singapore. A Photographic Guide to Mammals, Reptiles, Amphibians and Freshwater Fishes*. Updated edition. Draco Publishing and Distribution Pte Ltd. & Nature Society (Singapore). 180 pp.
- P-182. Whelan, Christopher & Sekercioglu, Cagan & Wenny, Dan. (2015). Why Birds Matter: From Economic Ornithology to Ecosystem Services. *Journal of Ornithology*. In press. 10.1007/s10336-015-1229-y.
- P-183. Davison, Geoffrey & Rajathurai, Subaraj. (2012). Special Ecology Feature: Conserving Our Native Birds. *CITYGREEN*. 01. 124. 10.3850/S2382581212010642.
- P-184. Yong, Ding Li & Lim, Kim & Lim, Kim & Tan, Trixie & Teo, Siyang & Ho, Hua. (2017). Significance of the globally threatened Straw-headed Bulbul (*Pycnonotus zeylanicus*) populations in Singapore: a last straw for the species?. *Bird Conservation International*. 28. 10.1017/S0959270917000028.
- P-185. Ng T. H., S. K. Tan, W. H. Wong, R. Meier, S.-Y. Chan, H. H. Tan & D. C. J. Yeo, 2016. Molluscs for sale: assessment of freshwater gastropods and bivalves in the ornamental pet trade. *PLoS ONE* 11(8): e0161130.doi:10.1371/journal.pone.0161130.
- P-186. Contract CR2005 (2022). Provision of Services to conduct environmental impact study. Environmental Impact Study (Windsor & Eng Neo Avenue Forest). Final Report.

14.4 Maps

- M-1. Google Earth Maps.
- M-2. National Archives of Singapore (2021) Maps and Building Plans.
https://www.nas.gov.sg/archivesonline/maps_building_plans/
- M-3. National University of Singapore Libraries (2020) Historical Maps of Singapore.
<https://libmaps.nus.edu.sg/>
- M-4. URA Master Plan Map (2019).
<https://www.ura.gov.sg/maps/?service=MP>
- M-5. Building and Construction Authority. Geological Map of Singapore 2021.
- M-6. OneMap Singapore
<https://www.onemap.gov.sg/main/v2/>
- M-7. Public Utilities Board Drainage Map
<https://www.pub.gov.sg/Documents/DrainageMap.pdf>

14.5 Others

- O-1. Google Inc. (2013) Google Earth 7.1.2.2041. Google Inc., California
- O-2. R Development Core Team (2018) R Development Core Team R: A Language and Environment for Statistical Computing R Foundation for Statistical Computing, Vienna, Austria (<http://www.R-project.org>).

aecom.com